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Exposure Duration to Quarry Dust and Disease Burden among Quarry Workers in Akamkpa LGA, Cross River State

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Abstract

This study examined the relationship between quarry dust exposure intensity, exposure duration, and disease burden among quarry workers in Akamkpa Local Government Area, Cross River State, Nigeria. A descriptive cross-sectional survey design was adopted using a quantitative research approach. Data were collected from 359 quarry workers selected through multistage sampling across major quarry sites in the study area. Structured questionnaires were used to gather information on socio-demographic characteristics, occupational categories, daily exposure in hours, weekly and monthly exposure patterns, cumulative years of exposure, and self-reported health conditions. Data were analyzed using descriptive statistics and crosstabulation. Findings revealed that a majority of workers (60.4 percent) spent 5 to 8 hours daily at quarry sites, while 17.3 percent were exposed for more than 8 hours. Exposure was highest during morning and afternoon shifts, which represent peak operational and dust-generating periods. Occupational analysis showed that high-risk groups such as drillers, blasters, and crusher operators experienced the highest exposure intensity and cumulative exposure over time. Respiratory conditions, particularly catarrh, cough, and nasal infection, were the most frequently reported illnesses across all exposure categories. The results further demonstrated a clear increase in disease burden with longer and more intense exposure, indicating a dose-response relationship between quarry dust exposure and adverse health outcomes. The study concludes that prolonged and high-intensity exposure to quarry dust significantly increases the burden of respiratory and related occupational diseases among quarry workers. It recommends strict enforcement of occupational safety measures, consistent use of personal protective equipment, reduction of working hours in high-dust zones through shift rotation, and regular medical surveillance to mitigate exposure-related health risks in quarry environments.

Key words: Quarry dust exposure, Exposure duration, Disease burden, Quarry workers, Respiratory diseases, Occupational health

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Introduction

Exposure duration to quarry dust is a critical occupational health concern that significantly influences the disease burden experienced by quarry workers (Rajanayagam et al., 2023; Chimutso, 2023; Oko et al., 2023). Quarrying operations such as drilling, blasting, crushing, grinding, and transportation of rocks generate large quantities of airborne dust particles, particularly respirable crystalline silica and other fine particulate matter, which remain suspended in the air and are easily inhaled by workers (Ferreira et al., 2023; Oko et al., 2024). The health effects of quarry dust are often cumulative, meaning that the risk and severity of occupational diseases increase with the length and frequency of exposure (Ike-Samuel et al., 2025; Hamzah et al., 2023). Workers who spend prolonged periods in dusty quarry environments are more likely to develop respiratory disorders, including chronic cough, bronchitis, asthma, silicosis, restrictive lung disease, and reduced pulmonary function (Rajanayagam et al., 2023; Chimutso, 2023). According to Rajanayagam et al. (2023), the cumulative impact of long-term quarry dust exposure contributes significantly to deteriorating respiratory health, with workers exposed for several years showing greater prevalence of respiratory symptoms and impaired lung capacity than those with shorter exposure histories (Amuyou et al., 2013; Oko et al., 2021). Similarly, Chimutso (2023) reported that extended occupational exposure to quarry dust was strongly associated with respiratory symptoms such as persistent coughing, wheezing, chest tightness, and breathlessness among quarry workers in South Africa (Omang et al., 2023).

Studies have also shown that prolonged exposure to respirable dust particles can result in progressive lung tissue damage and chronic inflammation, thereby increasing the overall disease burden among workers (Ferreira et al., 2023; Oko et al., 2024). In Nigeria, Ike-Samuel et al. (2025) identified a high prevalence of restrictive lung disorders among quarry workers and noted that the likelihood of developing such conditions increased with years of occupational exposure (Oko et al., 2023; Oko et al., 2021). Likewise, Hamzah et al. (2023) found that granite quarry workers exposed to respirable dust over extended periods experienced significantly poorer respiratory health outcomes than workers with shorter exposure durations (Isong et al., 2025). Therefore, exposure duration remains a key determinant of occupational disease burden in quarry environments, underscoring the importance of effective dust control measures, personal protective equipment usage, regular health surveillance, and workplace safety interventions aimed at reducing long-term health risks among quarry workers (Amuyou et al., 2013; Oko et al., 2024).

Quarrying activities are the most important economic ventures in Akamkpa Local Government Area of Cross River State, providing employment opportunities and contributing significantly to local and regional development (Oko et al., 2021; Oko et al., 2023). Despite these benefits, quarry workers are continuously exposed to large quantities of airborne dust generated during drilling, blasting, crushing, loading, and transportation of rocks (Oko et al., 2024; Omang et al., 2023). Prolonged inhalation of quarry dust, particularly respirable particulate matter and silica-containing particles, has been associated with numerous occupational health problems, including chronic cough, respiratory irritation, reduced lung function, bronchitis, asthma, and other debilitating pulmonary disorders (Rajanayagam et al., 2023; Ferreira et al., 2023). Recent studies conducted in Akamkpa have highlighted growing occupational and environmental health concerns associated with quarry operations (Oko et al., 2021; Oko et al., 2024). Oko et al. (2025) reported varying levels of occupational exposure and health risks among quarry workers, indicating that workers operating in high dust accumulation areas are particularly vulnerable to adverse health outcomes (Ike-Samuel et al., 2025; Hamzah et al., 2023). Similarly, environmental investigations by Effiong et al. (2024), Anacleto et al. (2022), and Atsa (2026) revealed contamination of soils, water bodies, and agricultural products around quarry locations, suggesting a broader public health challenge associated with quarrying activities (Omang et al., 2023; Isong et al., 2025). However, while these studies provide valuable insights into environmental pollution and occupational hazards, there remains limited empirical evidence specifically linking the duration of workers' exposure to quarry dust with the magnitude of disease burden experienced among quarry workers in Akamkpa (Oko et al., 2023; Oko et al., 2021).

The absence of adequate data on the relationship between exposure duration and disease burden presents a significant challenge for occupational health planning and intervention (Amuyou et al., 2013; Oko et al., 2024). Many quarry workers spend several years in dust-laden environments without regular

health surveillance, effective respiratory protection, or comprehensive occupational safety programmes (Rajanayagam et al., 2023; Chimutso, 2023). Consequently, occupational diseases often remain undetected until they reach advanced stages, resulting in increased morbidity, reduced productivity, higher healthcare costs, and diminished quality of life (Ferreira et al., 2023; Ike-Samuel et al., 2025). Furthermore, existing studies have largely focused on environmental contamination, heavy metal exposure, and ecological impacts of quarrying activities (Anacleto et al., 2022; Bello et al., 2024; Atsa, 2026; Omang et al., 2023; Isong et al., 2025), with relatively little attention given to the cumulative health consequences of long-term dust exposure among workers themselves (Oko et al., 2021; Oko et al., 2023). This knowledge gap limits the ability of policymakers, health professionals, and quarry operators to design evidence-based interventions aimed at reducing occupational disease risks (Amuyou et al., 2013; Oko et al., 2024). Therefore, there is a pressing need to investigate how exposure duration to quarry dust influences disease burden among quarry workers in Akamkpa Local Government Area, Cross River State, with a view to generating empirical evidence for improved workplace safety policies, health monitoring programmes, and sustainable occupational health management (Rajanayagam et al., 2023; Chimutso, 2023; Oko et al., 2023).

A growing body of literature has examined the occupational, environmental, and socio-biological impacts of quarrying activities, particularly within Akamkpa Local Government Area. Ereh et al. (2025) provided a detailed assessment of occupational exposure and health risk stratification among quarry workers, revealing that workers in high-intensity quarry operations face elevated risks of respiratory and occupational illnesses due to prolonged exposure to dust and other hazardous agents. Complementing this, Roland and Emediong (2024) reported a high prevalence of ocular disorders among quarry workers, linking these conditions to inadequate use of protective eyewear and continuous exposure to airborne particulates. At a more advanced biological level, Wegwu et al. (2022) explored genetic susceptibility among populations residing near quarry environments, identifying TCF7L2 (rs7903146) gene polymorphism as a potential factor influencing disease vulnerability, thereby suggesting that health outcomes may be shaped by both environmental exposure and genetic predisposition.

Beyond occupational health, broader environmental and ecological studies have also highlighted the far-reaching impacts of quarrying activities. Enoch et al. (2023) demonstrated that quarry dust significantly affects plant health by reducing leaf weight and chlorophyll content in key agricultural crops such as cassava, pawpaw, and okra, indicating potential threats to food security in quarry-adjacent communities. Similarly, Bello et al. (2024) documented substantial environmental degradation associated with stone quarrying, including land disturbance, dust pollution, and ecosystem disruption, reinforcing concerns about the sustainability of quarry operations. Oshim et al. (2024) further expanded this discourse by reviewing the socioeconomic and environmental consequences of quarrying in Nigeria, emphasizing the need for sustainable quarrying practices and innovative mitigation technologies. Collectively, these studies highlight the multifaceted impacts of quarrying in Akamkpa and similar environments, but they also reveal a persistent gap in understanding the direct relationship between exposure duration and cumulative disease burden among quarry workers, which this study seeks to address.

Methodology

The study was conducted in Akamkpa Local Government Area of Cross River State, South-South Nigeria, located between Latitudes 5°45' to 5°56' North of the Equator and Longitudes 8°10' and 8°35' East of the Greenwich Meridian, with Akamkpa town serving as the administrative headquarters. A descriptive cross-sectional survey design was adopted to examine the relationship between duration of quarry dust exposure, intensity, and disease burden among quarry workers in the area. This design was considered appropriate because it allows for the simultaneous assessment of occupational roles, cumulative exposure patterns, and self-reported health outcomes across different categories of workers at a single point in time. The study adopted a quantitative approach, with primary data obtained through structured questionnaires administered to quarry workers across selected sites.

The study population comprised quarry workers aged 20 years and above obtained from major quarrying communities in Akamkpa, including Mfamosing, Old Netim, Nsan, and surrounding settlements actively engaged in quarry-related operations. Eight quarry sites were purposively selected from these

communities, including Xin-Xin Quarry, Fuhua Quarry, Two Brothers Quarry, Wings of Heaven Quarry, Japaul Mines and Product, Amitech Quarry Company, Abi-Mfam Limestone Mining Site, and Setraco Granite Quarry Oban. Data were collected on socio-demographic characteristics, occupational categories and job roles, daily hours of exposure, weekly and monthly exposure patterns, cumulative years of exposure, and the types and frequency of reported health conditions. A multistage sampling technique was employed to select both quarry sites and respondents across various occupational groups, ensuring adequate representation of high, moderate, and low exposure categories. The sample size was determined using Cochran's formula, yielding 384 respondents, including 359 valid questionnaire, which were retrieved and used for analysis. Data were analyzed using SPSS version 22, employing descriptive statistics such as frequencies, percentages, and composite exposure indices, while inferential statistics, including the Independent Samples Test and one-way ANOVA were used to examine relationships between exposure intensity, duration, and disease burden among quarry workers.

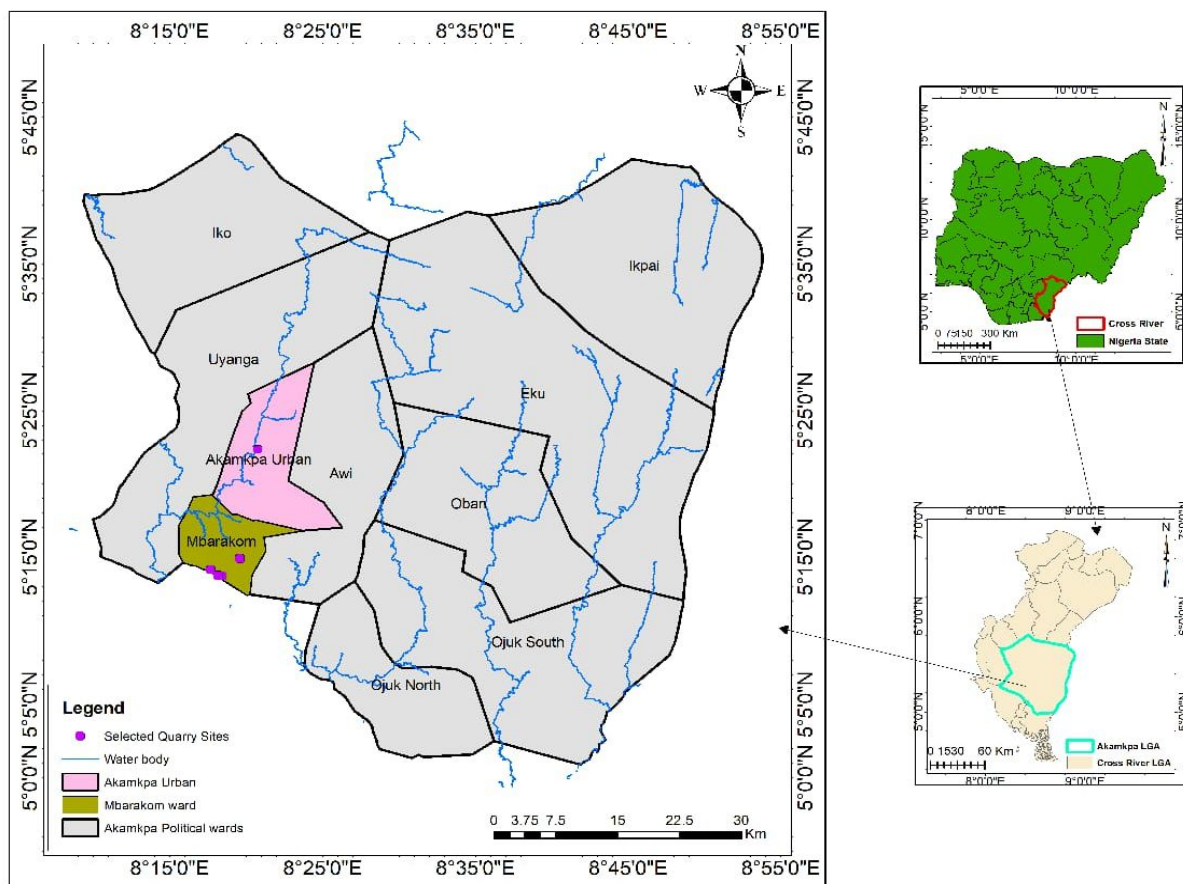


FIG. 1: Akamkpa Local Government Area and quarry sites

Source: Department of Geography and Environmental Science GIS Unit, University of Calabar

Results

Table 5, presents the occupational categories, job roles, exposure intensity, and duration of exposure to quarry dust among the 359 quarry workers surveyed. The findings show that drillers/blasters accounted for 68 workers, representing 18.9 percent of the workforce, with 45 workers exposed for 5 to 8 hours daily and 18 workers exposed for more than 8 hours. Crusher operators constituted 61 workers (17.0 percent), of

Table 5: Occupational Categories, Exposure Intensity and Duration of Exposure to Quarry Dust Quarry Workers among Quarry Workers

Occupational Category	Job Role	Exposure Intensity	< 5 hrs/day	5 to 8 hrs/day	> 8 hrs/day	Mean Working Days/Week	Mean Months/Year	Total
Drillers/ Blasters	Rock drilling and blasting	Very High	5	45	18	6.0	11	68
Crusher Operators	Stone crushing operations	Very High	8	39	14	6.0	11	61
Loaders/ Haulage Workers	Loading and transportation	High	12	42	9	6.0	11	63
Excavator Operators	Excavation activities	Moderate	14	29	7	5.0	10	50
Sorters/ Packers	Material sorting and packaging	Moderate	16	31	5	5.0	10	52
Maintenance Personnel	Equipment servicing	Low	13	19	3	5.0	10	35
Administrative Staff	Office duties	Very Low	12	12	0	5.0	10	24

Source: Fieldwork, 2024

which 39 worked for 5 to 8 hours, and 14 worked for more than 8 hours daily. Similarly, loaders and haulage workers accounted for 63 workers (17.5 percent), with 42 exposed for 5 to 8 hours and 9 exposed for more than 8 hours per day. These occupational groups were classified as having high to very high exposure intensity because of their direct involvement in dust-generating activities such as drilling, blasting, crushing, loading, and transportation of quarry materials.

Table 5 also shows that excavator operators (50 workers, 13.9 percent) and sorters/packers (52 workers, 14.5 percent) experience moderate exposure, with most spending 5 to 8 hours daily at the site. Maintenance personnel accounted for 35 workers (9.7 percent), while administrative staff recorded the lowest exposure with 24 workers (6.7 percent) due to minimal direct involvement in quarry activities. Overall, workers operate about 5 to 6 days per week and 10 to 11 months per year, indicating sustained exposure, especially among operational staff, and increased risk of quarry dust inhalation and related health effects.

Table 6 presents the daily, weekly, monthly, annual, and 10-year cumulative exposure patterns of quarry workers based on time of day. The results show that 238 workers, representing 66.3 percent, are

exposed mainly in the morning, 79 workers (22.0 percent) in the afternoon, and 42 workers (11.7 percent) in the evening. On average, workers are exposed for 4.9 hours in the morning, 2.3 hours in the afternoon, and 0.8 hours in the evening, giving a total daily exposure of 8.0 hours. The pattern also indicates that workers are active about 6 days per week, with exposure extending across 48 weeks per year for morning and afternoon shifts and 40 weeks for evening shifts. This translates into 1,411 annual exposure hours in the morning, 662 hours in the afternoon, and 192 hours in the evening, giving a total of 2,265 hours per year. Over a 10-year period, cumulative exposure rises significantly to 14,110 hours in the morning, 6,620 hours in the afternoon, and 1,920 hours in the evening. The exposure risk rating shows that morning periods carry a very high risk, followed by a high risk in the afternoon and a moderate risk in the evening, indicating that most workers experience prolonged exposure during the most active and dust-intensive periods of quarry operations.

Table 6: Daily, Weekly, Monthly and Annual Exposure Pattern of Quarry Workers by Time of Day

Exposure Variable	Morning	Afternoon	Evening	Total
Workers exposed daily	238 (66.3%)	79 (22.0%)	42 (11.7%)	359 (100%)
Average hours exposed per day	4.9	2.3	0.8	8.0
Average working days per week	6	6	4	16
Average exposure weeks per year	48	48	40	136
Average exposure months per year	11	11	10	32
Estimated annual exposure hours	1,411	662	192	2,265
Estimated cumulative exposure (10 years)	14,110	6,620	1,920	22,650
Exposure risk rating	Very High	High	Moderate	Overall High

Source: Fieldwork, 2024.

Table 7 shows a clear pattern linking longer exposure to quarry dust with increasing disease burden among quarry workers. Workers with less than 2 years of exposure recorded the lowest total cases (54), with relatively mild conditions such as catarrh (25) and cough (8). This gradually increased among those exposed for 2 to 4 years (87 cases) and 5 to 7 years (120 cases), where respiratory conditions like catarrh (48), cough (17), and nasal infection (13) became more common alongside emerging chronic bronchitis (7). The highest burden was observed among workers with 8 to 10 years of exposure, who recorded 153 total cases, with elevated occurrences of catarrh (55), nasal infection (21), chronic bronchitis (12), and eye irritation (13). The results indicate that longer duration of exposure is strongly associated with higher frequency and severity of respiratory and related health conditions, confirming a cumulative health effect of quarry dust on workers.

Table 8 presents a composite exposure burden index showing how increasing intensity and duration of quarry dust exposure relate to worsening health outcomes among workers. Workers in the low exposure category, who spend less than 5 hours daily and have 1 to 3 years of exposure, recorded the lowest cumulative exposure (below 8,000 hours over 10 years) and mainly experienced mild conditions such as catarrh and eye irritation. Those in the moderate exposure group, with 5 to 8 hours daily and 4 to 7 years of exposure, recorded higher cumulative exposure (8,000 to 16,000 hours) and showed more frequent respiratory conditions such as cough, catarrh, and sinusitis.

Table 7: Duration of Exposure and Disease Burden among Quarry Workers

Exposure Duration (Years)	Cough	Catarrh	Sinusitis	Nasal Infection	Chronic Bronchitis	Skin Disorders	Hearing Impairment	Eye Irritation	Acute Malaria	Total
Less than 2 years	8	25	3	4	1	3	1	5	4	54
2 to 4 years	12	39	6	8	4	5	2	8	3	87
5 to 7 years	17	48	9	13	7	9	3	10	4	120
8 to 10 years	23	55	11	21	12	11	4	13	3	153

Source: Fieldwork, 2024

Table 8: Composite Exposure Burden Index and Health Outcome among Quarry Workers

Exposure Category	Mean Daily Hours	Mean Days/Week	Mean Years of Exposure	Estimated Cumulative Exposure Hours (10 Years)	Dominant Diseases	Disease Burden Rating
Low Exposure	<5	4 to 5	1 to 3	<8,000	Catarrh, Eye Irritation	Low
Moderate Exposure	5 to 8	5 to 6	4 to 7	8,000 to 16,000	Cough, Catarrh, Sinusitis	Moderate
High Exposure	>8	6 to 7	8 to 10	>16,000	Catarrh, Nasal Infection, Chronic Bronchitis	High
Very High Exposure (Drillers/Crushers)	>8	6 to 7	8 to 10	>20,000	Chronic Respiratory Disorders, Hearing Impairment, Nasal Infection	Very High

Source: Fieldwork, 2024

In contrast, workers in the high exposure category, who spend more than 8 hours daily and have 8 to 10 years of exposure, recorded cumulative exposure above 16,000 hours and suffered more severe conditions, including nasal infection and chronic bronchitis. The most severe burden was observed among drillers and crusher operators classified under very high exposure, with cumulative exposure exceeding 20,000 hours over 10 years. This group experienced chronic respiratory disorders, hearing impairment, and persistent nasal infections. Overall, the table demonstrates a clear dose–response relationship between exposure intensity and disease burden, indicating that higher cumulative exposure significantly worsens occupational health outcomes among quarry workers.

Discussion

The findings from the composite exposure patterns show that quarry workers in Akamkpa Local Government Area experience sustained and high-intensity exposure to quarry dust across different occupational roles and time periods. A large proportion of workers fall within the moderate to very high exposure categories, with daily exposure often ranging between 5 and more than 8 hours, alongside 5 to 6 working days per week and up to 10 to 11 months per year. The breakdown by occupational category further shows that drillers, blasters, and crusher operators experience the highest exposure intensity due to their direct involvement in core production activities, while administrative staff and maintenance personnel experience comparatively lower exposure. The cumulative exposure analysis over a 10-year period further highlights the severity of the situation, with workers in high-risk roles accumulating over 16,000 to more than 20,000 hours of dust exposure. This pattern reflects a consistent occupational environment where prolonged and repeated exposure is the norm rather than the exception, increasing the likelihood of long-term health complications among workers.

The health outcome pattern strongly aligns with the exposure gradient, showing a clear dose–response relationship between exposure intensity and disease burden. Workers in the low exposure category mainly reported mild conditions such as catarrh and eye irritation, while those in the moderate category exhibited more frequent respiratory symptoms, including cough, sinusitis, and catarrh. In contrast, workers in the high and very high exposure categories recorded more severe and chronic conditions such as nasal infections, chronic bronchitis, hearing impairment, and persistent respiratory disorders. The increasing prevalence and severity of diseases with higher cumulative exposure hours confirm the progressive impact of quarry dust on workers' health over time. This trend suggests that occupational exposure in quarry environments is not only immediate but also cumulative, with long-term exposure significantly worsening health outcomes.

Conclusion

This study concludes that quarry workers in Akamkpa Local Government Area are consistently exposed to quarry dust for long and repeated periods, with most workers spending between 5 and more than 8 hours daily in active quarry operations. Exposure is particularly high among core production workers such as drillers, blasters, and crusher operators, who also accumulate very high cumulative exposure levels over a 10-year period. The results further show that exposure is not only sustained throughout the working day but also concentrated during peak operational hours in the morning and afternoon, when dust levels are highest.

The findings confirm a clear dose–response relationship between exposure duration and disease burden. Respiratory conditions such as catarrh, cough, and nasal infection are common across all exposure groups, while more severe conditions, including chronic bronchitis, hearing impairment, and persistent respiratory disorders, increase with higher cumulative exposure. This pattern demonstrates that prolonged exposure to quarry dust significantly worsens workers' health over time, making occupational dust exposure a serious public health concern in the study area.

Recommendations

1. Quarry operators should enforce strict use of personal protective equipment, such as nose masks and respirators, for all workers.
2. Dust control measures such as water sprinkling, enclosure of crushers, and regular site dampening should be implemented consistently.
3. Routine medical screening and respiratory health monitoring should be introduced for early detection of occupational diseases.
4. Working hours in high-dust zones should be reduced through shift rotations to limit cumulative exposure.

5. Occupational health and safety training should be conducted regularly to improve workers' awareness and compliance.
6. Regulatory agencies should strengthen the inspection and enforcement of environmental and safety standards in quarry sites.
7. Employers should redesign workflows to reduce worker presence in high dust-generating areas during peak production periods.

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