Review

Exposure and Risk Assessment in Environmental and Occupational Health

Md Redowan Rashid *

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Exposure and Risk Assessment in Environmental and Occupational Health

Md Redowan Rashid

Graduate Research Assistant, Department of Civil, Architectural, and Environmental Engineering, North Carolina A&T State University, Greensboro, North Carolina 27411, USA; Email: mrashid@aggies.ncat.edu

Abstract: This analysis examines the wide range of occupational and environmental health risks that affect people in diverse settings. This article emphasizes the importance of conducting exposure and risk assessments to safeguard public health by analyzing various hazards, including arsenic, oil accidents, lead, welding fumes, and mycotoxins. Various methodologies are utilized in these research articles to conduct the study, emphasizing hazard identification, exposure assessment, and risk characterization. The results uncover harmful substances, vulnerable demographics, and occupational duties linked to increased hazards. The report suggests various mitigation strategies, such as targeted interventions, enhanced community efforts, and improved exposure estimates. Notwithstanding the constraints identified in certain studies, the review emphasizes the necessity for continuous investigation to improve assessments of exposure, comprehend the cumulative effects, and examine the wider societal consequences. The significance of sector-specific risk assessments, protective measures, and ongoing monitoring is underscored to ensure mental and physical health protection.

Keywords: Hazard identification; Chemical exposure; Industrial workplaces; public health policies; Vulnerable groups

1. Introduction

Environmental and occupational health is a critical interdisciplinary domain that is committed to the identification, evaluation, and reduction of risks linked to the inhalation of various hazards (Li et al., 2023). The sources of these hazards are diverse, including environmental contaminants and occupational activities; their effects on public health are significant. It is essential to comprehend the characteristics, scope, and repercussions of these exposures to protect the health and safety of communities and individuals.

Environmental and occupational health hazards are present in a diverse range of contexts, including industrial workplaces and natural environments (Oginawati et al., 2023). This paper will examine all these diverse contexts, providing an analysis of the difficulties faced and the approaches utilized to safeguard individuals who are vulnerable.

An examination of various hazards is undertaken in this review paper. These hazards include but are not limited to arsenic and oil spills, lead exposure in the batik industry, welding fumes and dust exposure in automobile and subway manufacturing, mycotoxins in rural agricultural settings, and aggressive silicosis in the artificial stone industry, which poses a severe health risk. By providing an analysis of these diverse obstacles and prospects, this article intends to aid in the overarching objective of guaranteeing a more secure and salubrious setting for every individual.

Objectives

This review seeks to examine the effects of environmental and occupational health risks, such as oil spillage, arsenic exposure, lead pollution, welding fumes, dust inhalation, and severe silicosis, on human health. The analysis is based on reviewing research publications. Furthermore, it highlights the crucial significance of exposure and risk assessment in influencing efficient risk management and

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public health policies, eventually arguing for a more salubrious and secure environment for everyone.

2. Background

Occupational health and safety are an issue of international concern since employees in various sectors are exposed to a wide range of hazardous substances. Chemicals, physical stressors, biological hazards, and psychosocial factors are all classified as agents. Comprehensive risk and exposure assessments are essential for safeguarding the well-being of workers.

To begin with, employees may encounter a diverse range of agents that pose risks to their health, including but not limited to biological hazards, stressful ergonomic conditions, and psychosocial difficulties (Persoons et al., 2014). Risk and exposure evaluations are critical in mitigating occupational injuries and health complications. Additionally, it is worth noting that numerous nations have implemented stringent occupational safety and health policies, which require employers to perform these evaluations to ensure a secure workplace. Noncompliance may lead to significant legal ramifications as well as monetary sanctions. In addition, work-related injuries and ailments impose substantial economic costs on both employees and society (Requena-Mullor et al., 2021). An accurate evaluation can decrease healthcare expenditures, diminish workers' compensation litigation, and alleviate productivity setbacks caused by absenteeism and disability.

Unfortunately, assessment of exposure is crucial in domains such as recreational activities. Children may be exposed to dangerous substances even on playgrounds. Due to their physiological and behavioral characteristics, children are particularly susceptible (Ferguson et al., 2018). On the other hand, playing on the shore is also hazardous. There have been several major accidents, such as the Deepwater Horizon oil disaster. These spills can pose serious health hazards, particularly to youngsters who participate in recreational activities near impacted coastal areas (Black et al., 2016).

Occupational health exposure and risk assessment encompasses various agents and environments. The chemical agents included in these evaluations are solvents, heavy metals, and industrial chemicals that are capable of being absorbed via skin surface, inhaled, or ingested (Oginawati et al., 2023; Khoshakhlagh et al., 2023; Li et al., 2023). Biological agents present hazards of infectious diseases; they include bacteria, viruses, fungi, and other microorganisms. Moreover, employees' health can be adversely affected by physical stressors such as radiation, pollution, vibration, and extreme temperatures (Ferri et al., 2017). Also, workplace design-related ergonomic stressors can lead to musculoskeletal disorders and injuries. Additionally, workplace harassment, tension, and workload are psychosocial factors that can have a significant impact on mental and emotional health. Figure 1 shows the relationship between risk and exposure assessment, risk characterization, and risk management.

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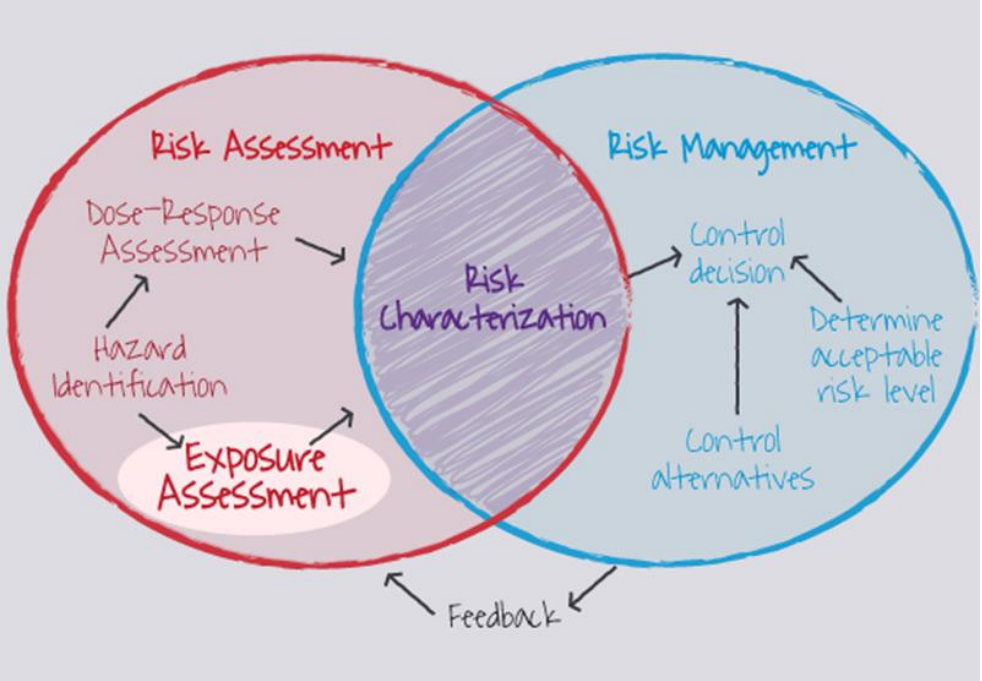

Figure 1. Exposure assessment as a component of risk assessment (Credit: ToxTutor, ORAU, ©).

These assessments have broad applicability across various work environments. Chemical agents, physical stresses, and ergonomic challenges are frequently encountered in the manufacturing sector (Khoshakhlagh et al., 2023; Oginawati et al., 2023). Within the construction industry, employees are exposed to various hazards, including physical stressors, accidents, and exposure to dust and chemicals (Li et al., 2023). In healthcare environments, attention must be paid to biological agents due to the potential for infectious diseases. Pesticides, fertilizers, and biological agents pose hazards in agriculture and farming, which have adverse effects on both laborers and the environment (Ferri et al., 2017; Beamer et al., 2012). The runoff from these agricultural activities contaminates surface water, leading to a decrease in the quality of drinking water. As a result, it becomes necessary to utilize household water treatment methods (Niloy & Chowdhury, 2017; Karim et al., 2018; Chowdhury et al., 2019). Office settings are susceptible to psychosocial stressors, ergonomic challenges, and indoor air quality issues.

In general, the evaluation of exposure and risk is critical for safeguarding the well-being of employees, ensuring compliance with regulations, mitigating financial repercussions, and improving the standing of an organization. These assessments cover an extensive array of agents and have practical applications in diverse occupational environments, rendering them essential for ensuring occupational health and safety on a global scale.

3. Methodology

A range of methodologies were utilized in these papers to evaluate the health hazards linked to distinct occupational and environmental exposures. Although every study possessed its own distinct emphasis, they all exhibited commonalities in their methodologies, including the identification of hazards, assessment of exposure, characterization of dose-response relationships, and assessment of risks associated with chemicals, metals, pesticides, and mycotoxins.

The process of sampling and analysis encompasses the collection of environmental samples, such as air, soil, or biological specimens, followed by the utilization of laboratory techniques, such as chromatography and mass spectrometry, to measure the levels of exposure. Exposure evaluations involve the quantification of concentration levels through several pathways, including oral, cutaneous, inhalation, and nutritional routes. These assessments employ standardized equations to evaluate the potential health risks associated with such exposures. Risk characterization include the

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assessment of both non-cancer and cancer hazards, commonly employing various quantitative measures such as Hazard Quotients (HQs) for non-carcinogenic effects, Cancer Risk (CR) indices for carcinogenic effects, Margin of Exposure (MoE), and reference benchmark dose levels. Statistical analysis methods, such as linear regression and Chi-squared tests, are frequently utilized to investigate correlations, compare different cohorts, and evaluate the impact of diverse variables on health hazards. The inclusion of ethical issues, such as obtaining necessary approvals, securing informed consent, and implementing appropriate participant recruiting strategies, is crucial in these studies to uphold the protection and well-being of individuals involved in the research. The overall methodologies are shown in table 1 below.

Table 1. Overall methodology and analysis.

Assessments	Sector	Exposure Material	Sample Collection	Analysis	Statistics	References
Hazard, Exposure, Dose, Risk	Baseball fields	Arsenic	Soil samples	Concentrations measurement	EPA standardized equations for exposure and dose calculations	Ferguson et al., 2018
Hazard, Exposure	Beach sand	Oil spill chemicals	Air and sand samples	Gas chromatography ion trap mass spectrometry (Organic), inductively coupled plasma mass spectroscopy (Metal)	Point estimates for exposure parameters, Monte Carlo simulation for sensitivity analysis	Black et al., 2016
Dose and Risk	Batik workers	Lead and u-ALA	Blood and Urine samples	X-Ray Fluorescence (lead), spectrophotometry for u-ALA, HiCN colorimetric method for hemoglobin measurement	Hazard Quotients (HQ) for dermal and inhalation routes, Excess Lifetime Cancer Risk (ELCR) for carcinogenic risks	Oginawati et al., 2023

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Exposure	Welding industry	Chromium (Cr), Nickel (Ni), Manganese (Mn)	Urine samples	Inductively coupled plasma mass spectrometry	Not specified	Persoons et al., 2014
Exposure	University Hospital of Bari and "Moscati" in Southern Italy	Carcinogens and pesticides	Blood samples	Univariate and multivariate analyses	Non-parametric methods	Ferri et al., 2017
Exposure, Risk	Salinas Valley	Chlorpyrifos and Diazinon	Pesticide exposure data	CASE model for exposure estimation, PBPK model for dose estimation	Benchmark dose values and relative potency factors (RPFs) for cumulative risk assessment	Beamer et al., 2012
Health Risk	Automobile manufacturing factory	BTEX, Styrene, 2-propanol, 2-butoxyethanol, Vinyl chloride, Metal fumes	Air samples	Measurement vapors by adsorbent tubes and fumes by mixed cellulose esters (MCE) membrane filters	HQ for non-carcinogenic risks, LCR for carcinogenic risks	Khoshakhlagh et al., 2023
Health Risk	Subway Aluminum Alloy Body Workshop	Aluminum dust	Dust samples	Measurement of TSP, PM10, and PM2.5 using specific equipment	HQ for non-carcinogenic risks, CR for carcinogenic risks	Li et al., 2023
Diet and Occupation, Exposure, Risk	MAUCO participants	Mycotoxins	Urine samples, Food questionnaires	LC-MS analysis for mycotoxin quantification	Probable daily intake (PDI) adjusted for creatinine concentration	Foerster et al., 2021

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Health Risk through data mining	Artificial stone industry	Silica dust	Medical records and clinical informati on	Data mining and analysis	Multiple binary logistic regression analysis	Requena-Mullor et al., 2021

By combining these methodologies, health risks associated with environmental and occupational exposures are systematically evaluated, with a particular focus on hazard identification, exposure assessment, and risk characterization.

4. Results and Discussions

The summary of the results from the studies that were evaluated highlights important information about microplastic pollution in different ecosystems and regions of the world. Together, these studies provide an examination of the occupational health hazards present in many industries and exposure scenarios. It emphasizes how the diverse methodologies employed in these articles uncover exposure results, identify the most perilous agents, specify at-risk populations, pinpoint occupational tasks associated with the highest risks, and propose concrete strategies for enhancing exposure assessments and mitigating risks.

Exposure Outcomes

The studies collectively assess exposure outcomes, both non-cancer and cancer risks, in various settings, such as baseball fields, beaches, industrial workplaces, agricultural environments, and foods (Black et al., 2016; Ferguson et al., 2018; Foerster et al., 2021; Oginawati et al., 2023). In each case, the findings help to understand the level of risk associated with different exposures.

Hazardous Agents

The studies identify specific hazardous agents, such as arsenic, organic compounds, pesticides, metals, lead, mycotoxins, crystalline silica dust, and chemical substances in the workplace. These agents are recognized as significant contributors to exposure risks, whether in recreational settings, industrial settings, or through chemical exposure in different occupations. Moreover, they pose non-cancer and cancer risks, emphasizing the wide range of health threats stemming from exposure. Among them mycotoxins and silica dust are identified as highly significant and potentially life-threatening agents (Foerster et al., 2021; Requena-Mullor et al., 2021).

At-Risk Populations

Vulnerable populations, including very young children, workers in specific industrial settings, and individuals with extreme behaviors like high ingestion rates, are consistently identified as being at higher risk of exposure (Black et al., 2016; Ferguson et al., 2018; Khoshakhlagh et al., 2023; Li et al., 2023; Oginawati et al., 2023). Moreover, workers in high-risk industries like artificial stone manufacturing, Batik industry, and the agricultural sector are consistently at risk of exposure to hazardous agents (Requena-Mullor et al., 2021; Oginawati et al., 2023). The studies highlight that individuals with specific occupational backgrounds, dietary habits, and educational levels face varying degrees of risk. Addressing these disparities is essential for developing effective mitigation strategies.

Occupational Tasks

While some studies focus on non-occupational settings like baseball fields and beaches, others address potential hazards in specific occupational tasks, particularly in industrial and agricultural

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work (Beamer et al., 2012; Ferri et al., 2017). Identifying the risks associated with these tasks, as well as the influence of factors like working conditions, is important for developing targeted mitigation strategies. For instance, in the silicosis study, tasks like cutting, particularly in the artificial stone industry, are highlighted as high-risk activities due to exposure to crystalline silica dust (Requena-Mullor et al., 2021). Understanding which occupational tasks lead to the most hazards is crucial for tailoring mitigation strategies to reduce risks effectively.

Mitigation Strategies

All the studies suggest methods for improving exposure estimates, including more precise data collection techniques such as direct observations, soil adherence measurements, surveys, and various biomarkers. Mitigation strategies proposed across the studies emphasize proactive community efforts, regular testing, handwashing, appropriate clothing, and maintaining safe public spaces. Specific strategies, such as using natural colorants in the batik industry, implementing better ventilation and personal protective equipment in GMA welding, and reevaluating the use of pesticides in agriculture, are discussed. These strategies aim to reduce exposure and protect public health. Proper training and education for workers are crucial, particularly for those with lower education levels, as highlighted in the silicosis study. This includes education on hazard awareness, safe practices, and the use of personal protective equipment (PPE). Promoting safer methods, such as wet cutting to reduce dust exposure, is a practical mitigation strategy. The identification of dry cutting as a high-risk activity calls for industry-wide adoption of safer practices.

Limitations

These papers certainly have some shortcomings, even though they offer insightful information. Some studies restrict the applicability of their findings to wider contexts by concentrating on specific chemicals and industries. Some studies have relatively small sample sizes, which may have an impact on how representative the findings are. Table 2 below lists the papers' specific limitations.

Table 2. Limitations of the selected articles.

Limitations	Paper
Lack of precise data on player behavior and exposure patterns	Ferguson et al., 2018
Excluded dispersants due to lack of human toxicological data	Black et al., 2016
Small sample size; Limited focus on lead exposure	Oginawati et al., 2023
Limited industrial hygiene resources; Focus on urinary biomarker levels rather than inherent toxicity of metals.	Persoons et al., 2014
Small sample size and potential instability in estimates	Ferri et al., 2017
Uncertainties in exposure parameters	Beamer et al., 2012
Limited study scope in terms of substances and locations	Khoshakhlagh et al., 2023
Absence of female workers in the research; Uncertainties in exposure parameters	Li et al., 2023
Potential health effects of mycotoxin are not assessed	Foerster et al., 2021
Limited sample size; Variations among studies in age and risk factors	Requena-Mullor et al., 2021

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Collectively, these studies demonstrate the importance of considering the specific behaviors, characteristics, understanding the dynamics of exposure risks, with an emphasis on tailored strategies that consider the specific contexts, agents, tasks, and populations involved. Whether in recreational spaces, workplaces, or communities, these findings emphasize the significance of health and safety measures to protect against exposure to hazardous agents. These studies also highlight the potential long-term health effects of exposures and the importance of ongoing monitoring and risk management. Furthermore, the findings call for more comprehensive assessments, larger sample sizes, and the consideration of combined effects of toxic substances to provide a holistic view of risk landscapes.

Future Work Needed

Improving exposure assessment and comprehending risks are crucial to occupational health research. Future studies should use advanced monitoring methods and new tools to accurately measure chemical and route exposure levels for more thorough exposure evaluations. These assessments must also evaluate the cumulative impact of various exposures, as occupational hazards might interact to provide distinct health risks. Researchers should also examine how occupational tasks, indoor versus outdoor employment, and work surroundings affect exposure levels. Through research across industries and sectors, occupational trends and dangers can be identified. Age and vulnerability must be examined, especially about older workers, teenagers, and children's occupational health concerns. Engineering controls, exposure reduction approaches, and personal protective equipment must be evaluated for efficacy, feasibility, and adherence in real-world work situations. In addition, studies should evaluate the cumulative effects of occupational exposures on long-term health. Since exposure patterns, employment functions, and health outcomes affect men and women differently, gender-specific occupational risks should be considered. Finally, occupational exposure can pollute the environment, impacting workers and their communities. Researchers must comprehend these effects. These guidelines will improve worker safety, public health, and occupational health.

5. Conclusion

This review article offers an in-depth examination of the wide range of environmental and occupational health hazards that affect persons in different settings. It emphasizes how complex occupational exposures are and how important it is to do thorough risk assessments that consider factors outside of the workplace. The study highlights the extensive array of health consequences linked to non-cancerous and cancerous ailments, underscoring the significance of customized risk evaluations that are tailored to individual exposure circumstances. The implementation of protective measures and risk mitigation methods is crucial in safeguarding the physical and mental health of employees. This study emphasizes the need for such measures across different sectors. The necessity for ongoing study and continual monitoring is highlighted by the discovery of sensitive populations, particularly youngsters, and the possible cancer risks linked to occupational exposures. Although there are significant limitations present in these articles, such as limited sample sizes and a narrow emphasis, they provide valuable insights into the field of occupational health. Future research endeavors should aim to enhance the comprehensiveness of exposure evaluations, develop a deeper knowledge of cumulative impacts, and conduct a more thorough investigation into the influence of working conditions and various work environments. Furthermore, it is imperative for studies to investigate the correlation between age and susceptibility, analyze the effectiveness of preventative interventions, evaluate the enduring health consequences, examine gender-specific hazards, and explore the broader environmental and societal ramifications of occupational exposures. By focusing on these domains, scholars and decision-makers have the potential to augment worker safety, increase public health results, and propel the field of occupational health, ultimately fostering the establishment of safer and healthier settings for all persons.

References

Beamer, P. I., Canales, R. A., Ferguson, A. C., Leckie, J. O., & Bradman, A. (2012). Relative pesticide and exposure route contribution to aggregate and cumulative dose in young farmworker children. International journal of environmental research and public health, 9(1), 73-96.

Black, J. C., Welday, J. N., Buckley, B., Ferguson, A., Gurian, P. L., Mena, K. D., ... & Solo-Gabriele, H. M. (2016). Risk assessment for children exposed to beach sands impacted by oil spill chemicals. International journal of environmental research and public health, 13(9), 853.

Chowdhury, O. S., Rashid, R., & Karim, M. R. (2019, January). E. Coli Removal Efficiency and Physical-Chemical Parameter Analysis of Mineral Pot Filters in Bangladesh. In In2nd International Conference on Water and Environmental Engineering (iCWEE-2019), Bangladesh University of Engineering and Technology, Dhaka, Bangladesh, 2019, pp 1-8, ISBN: 978-0-6482681-1-6.

Ferguson, A. C., Black, J. C., Sims, I. B., Welday, J. N., Elmir, S. M., Goff, K. F., ... & Solo-Gabriele, H. M. (2018). Risk assessment for children exposed to arsenic on baseball fields with contaminated fill material. International journal of environmental research and public health, 15(1), 67.

Ferri, G. M., Specchia, G., Mazza, P., Ingravallo, G., Intranuovo, G., Guastadisegno, C. M., ... & Cocco, P. (2017). Risk of lymphoma subtypes by occupational exposure in Southern Italy. Journal of Occupational Medicine and Toxicology, 12(1), 1-10.

Foerster, C., Ríos-Gajardo, G., Gómez, P., Muñoz, K., Cortés, S., Maldonado, C., & Ferreccio, C. (2021). Assessment of mycotoxin exposure in a rural county of Chile by urinary biomarker determination. Toxins, 13(7), 439.

Karim, M.R., Khan, M.A.I., Chowdhury, O.S. and Niloy, R.R. (2018) Assessment of Various Methods to Remove Pathogen from Raw Water to Meet Who Standard for Domestic Consumption. 7th Brunei International Conference on Engineering and Technology 2018 (BICET 2018), Ban-dar Seri Begawan, 12-14 November 2018, 1-4.

Khoshakhlagh, A. H., Yazdanirad, S., Saberi, H. R., & Liao, P. C. (2023). Health risk assessment of exposure to various vapors and fumes in a factory of automobile manufacturing. Heliyon, 9(8).

Li, C., Han, D., Wei, X., Yang, J., & Wu, C. (2023). Health Risk Assessment of Inhalable Dust Exposure during the Welding and Grinding Process of Subway Aluminum Alloy Components. Buildings, 13(10), 2469.

Niloy, M.R.R. and Chowdhury, O.S. (2017) Effectiveness of Household Water Treatment Technologies Based on WHO Guidelines. Master's Thesis, Islamic University of Technology (IUT), Gazipur.

Oginawati, K., Nathanael, R. J., Chazanah, N., Prabandari, D., Basuki, M. F., Oclandhi, B., ... & Tanziha, I. (2023). Occupational lead exposure health risk assessment and heme biosynthesis: A study on batik artisans in yogyakarta, Indonesia. Heliyon, 9(9).

Persoons, R., Arnoux, D., Monssu, T., Culié, O., Roche, G., Duffaud, B., ... & Maitre, A. (2014). Determinants of occupational exposure to metals by gas metal arc welding and risk management measures: A biomonitoring study. Toxicology letters, 231(2), 135-141.

Requena-Mullor, M., Alarcón-Rodríguez, R., Parrón-Carreño, T., Martínez-López, J. J., Lozano-Paniagua, D., & Hernández, A. F. (2021). Association between crystalline silica dust exposure and silicosis development in artificial stone workers. International Journal of Environmental Research and Public Health, 18(11), 5625.