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Assessment of Respiratory Health Issues Among Stone Carvers of Rajasthan, India

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Abstract: Workers in the stone carving sector are subject to risks from airborne particle inhalation. The research investigated ventilatory functions and analyzed the occurrence of respiratory symptoms among stone carving employees in Rajasthan, India. A total of 121 stone carving workers (83 exposed group and 38 controls) were interviewed with the help of a structured questionnaire. A Contec (SP-10) spirometer was used to assess FVC, FEV1, and the ratio of FEV1/FVC. Respiratory issues appeared more prevalent among stone dust-exposed workers, and smoking habits and resistance to wearing masks were the prime reason for developing respiratory problems among stone carvers.

Keywords: lung function; spirometry; stone carving; respiratory health

1. Introduction

Occupational pulmonary health issues are a prime health concern in developing nations like India. Specific occupations like mining, quarrying, stone carving, stone sculpting, etc., are at risk of occupational pulmonary health problems[1]. Continuous exposure to a dusty working environment leads to pneumoconiosis[2]. Common materials such as silica, asbestos, and coal generate inhalable dust particles within the range of 0.5 microns to 5 microns[3]. Sustained exposure to such dusty particles may result in the deposition of fine dust in the workers' lungs, which may also cause the occurrence of pulmonary issues among the concerned population[4].

Stone carving is an eternal commercial exercise in the areas affiliated with raw materials such as limestone, sandstone, and marble[5]. Stone carving involves three significant operations (i.e., rough cutting, fine cutting, and polishing[6], as stone processing is a kind of handicraft work involving various activities such as cutting the stone and grinding and carving it into a presumed shape. Handicraft occupations like stone carving, wood turning, etc., are prone to various health issues concerning respiratory[7] or musculoskeletal disorders[8]. Industries where everyday operations are carried out manually in a dusty work environment are more likely to experience respiratory illnesses and job-related musculoskeletal problems[9]. Stones have a substantial amount of free silica, and the stone working processes make discharge a significant amount of silica dust in the workplace environment[10]. The highest amount of dust is released during the grinding process[11], and uncontrolled dust production may lead to numerous environmental implications[12]. The national environmental policy is liable to control environmental pollution[13]. Stone workers are susceptible to varying risks, such as airborne dust, and such exposure affects a considerable threat to their health and safety[14].

India has poor preventive measures against inhaling dust because of lacking resources and attention at stone-working sites. Exposure to airborne dust may lead to probable health problems among stone workers, including pulmonary, cutaneous, and visual inflammation and damage[15]. The air quality of the workstations is also affected by the design and availability of the ventilation system[16]. Hence, extended exposure to silica dust may evolve extensive respiratory function disorders among the workers[17] that would not be reversed[18]. Silica dust accumulation in the lung region is a prime measure engaged in occupational lung diseases[19]. Multiple factors like the type of dust, duration of exposure, density, and the amount of dust particles within the working area affect the deposition of silica dust in airways[20].

The Indian carving crafts are often renowned for their uniqueness and quality[21]. Stone carving workshops belong to the unorganized small-scale industrial sector. These workshops are home-based industrial units that involve 10-20 carving workers at a single working site. Such workers are often migrant-type, needing more employment records or health and social security benefits[22]. The usual respiratory issues among stone carving workers were not noticeable in recent literature. Further, there needs to be more literature regarding the work environment and the workplace safety and health of the informal sector of developing nations[23]. Hence, there is a necessity to take on the respiratory problems of stone carvers to investigate the occurrence of respiratory disorders during stone carving. The present study hypothesized that constant exposure to stone dust is directly related to pulmonary symptoms and unusual respiratory functions. Hence, the current research represented pulmonary symptoms and unusual respiratory functions resulting from extended exposure to stone dust among the stone carvers of Jaipur, India.

2. Materials and Methods

2.1 Participant selection

This study was conducted in the rural region of Jaipur, Rajasthan. The study population consisted of eighty-three stone carvers and thirty-eight administrative workers. A random sampling approach was employed to select 121 participants from 19 stone carving units since the size of the individual samples was modest. The study population was divided into two groups depending on the nature of their work. Stone carvers are manufacturing workers involved in various fabrication activities such as rough cutting, fine cutting, finishing, and polishing. Hence, these stone carvers were considered an "exposure group." Simultaneously, workers concerned with office work were considered a "control group." Adults (above eighteen years) who had been involved in the stone carving activities for at least a year were included in the investigation. At least one year of work experience was considered to ensure that the workers have enough exposure to stone dust. Stone carving workers under the age of 18 and those experiencing spirometry objections (i.e., history of Covid-19, recent surgery, cardiovascular diseases, pneumothorax issues, etc.) were not included in the research. Stone carvers who satisfied the consideration criteria and provided written consent were selected sequentially from the carving units based on their size to get involved in the study.

2.2 Data collection

A modified questionnaire and a portable Spirometer (Model: Contec SP-10) were used to gather data. The systematic use of quantitative and trustworthy health and research data gathering in a respiratory study reflects the growth of research in diverse settings[24]. A modified American Thoracic Society Division of Lung Disease questionnaire[25] was utilized to gather data on the research participants' sociodemographic traits and respiratory complaints. The questionnaire was translated into the local language (i.e., Hindi) and laid out by the researchers to the study subjects. Cough, phlegm, wheezing, breathlessness, chest illness, sputum, and stuffy nose were pulmonary symptoms of interest. The environmental conditions were assessed while preparing for Spirometry, and the environmental factors were within acceptable levels. The spirometer was calibrated daily prior to the first subject blowing into it and again after the eighth subject or upon completion of four hours of regular use. A legitimate, verified, accurate 3L calibration syringe was used throughout the whole calibration process. According to ATS/ERS (2005) guidelines, the research participant was required to perform at least three satisfactory forced expiratory motions during the spirometry test. The best value of forced vital capacity (FVC) and the forced expiratory volume in one second (FEV1) were used for further investigation.

2.2 Data analysis

Statistical analysis of collected information is done with IBM SPSS version 25. Initially, univariate analysis was performed on each variable to analyze their distributions and determine if they lie within acceptable limits. Further, in order to summarize categorical data (i.e., gender, marital status, education level, work experience, wearing mask during work, smoking habit), proportions were utilized, whereas mean values and standard deviations were employed for analyzing continuous variables (i.e., worker's age, weight, stature). The key outcome variables of spirometry test were FEV1, FVC, the ratio of FEV1/FVC, and pulmonary symptoms. The ratio of FEV1/FVC <70% was used to determine airflow obstruction. Hence, the concern ratio includes the results of both assessments and is expressed in percentages or decimals. This value indicates how proficiently the airways are functioning. The FEV1/FVC ratio of most healthy adults falls in the 70 to 80 percent range. The independent variables were socio-demographic parameters and period of stone dust exposure, whereas smoking habits and wearing a mask during work were the dependent attributes. The independent-samples t-test was utilized for comparing the means of the spirometry outcomes (i.e., FVC, FEV1, the ratio of FEV1/FVC), whereas the chi-square test was applied to determine the occurrence of pulmonary symptoms along with the association of factors with pulmonary symptoms of stone carvers. The significance criterion was determined at a $p < 0.05$.

3. Results

3.1 Personal and socio-demographic attributes of workers

One hundred twenty-one stone carving workers, including 83 site workers and 38 administrative personnel, were investigated. Table 1 represents the personal and socio-demographic attributes of participating workers. The exposed groups' mean age of 33.4 ± 7.9 years was substantially younger than the controls' mean age of 41.1 ± 8.8 years at a significance level of $p < 0.01$, and a more significant percentage of the control group was married ($p < 0.05$). Other demographic factors were almost identical between the two groups. A majority of male workers were observed among both categories. A more significant percentage of the exposure and control groups, 43 (51.8%) and 16 (42.1%), had worked in the stone carving occupation for one to five years. Mask-wearing was observed among 38 (45.7%) site employees and 23 (60.5%) office workers. In both categories, more than 60% of responders were nonsmokers.

Table 1. Personal and socio-demographic attributes of workers.

Characteristics	Exposed group n (%)	Control group n (%)	P-value
Mean age of workers; year (SD)	33.4 (7.9)	41.1 (8.8)	< 0.01
Mean weight of workers; kg (SD)	61.06 (5.2)	62.76 (6.5)	0.12
Mean stature of workers; m (SD)	1.69 (0.1)	1.70 (0.1)	0.62
Gender			
Male	64 (77.1)	33 (86.8)	0.21
Female	19 (22.9)	5 (13.2)	
Marital status			
Married	60 (72.2)	34 (89.4)	0.03
Un-married	23 (27.8)	4 (10.6)	
Education level			
Primary	24 (28.9)	7 (18.4)	0.17
Secondary	46 (55.4)	20 (52.7)	
Graduation	13 (15.7)	11 (28.9)	
Working experience (years)			
1 to 5	43 (51.8)	16 (42.1)	0.61
6 to 10	22 (26.5)	12 (31.6)	
> 10	18 (21.7)	10 (26.3)	
Wearing mask during work			
Yes	38 (45.7)	23 (60.5)	0.13
No	45 (54.3)	15 (39.5)	
Smoking habit			
Yes	31 (37.3)	12 (31.5)	0.53
No	52(62.7)	26 (68.5)	

3.2 Occurrence of respiratory symptoms among the stone carvers

Table 2 shows the occurrence of respiratory symptoms among the stone carvers. The exposed group had substantially more cough symptoms (63.8%) than the controls (18.4%) at a significance level of $p < 0.01$. Likewise, the prevalence of phlegm was higher among the exposed group (57.8%) as contrasted to the controls (15.7%) at $p < 0.01$. Furthermore, chest illness was found to be more in the exposed group (48.2%) as compared to the controls (26.3%) at a significance level of $p < 0.05$. The prevalence of wheezing was higher among the exposure group, while the occurrence of breathlessness, sputum, and stuffy nose was higher among the controls. However, these variations lacked statistical significance.

Table 2. Occurrence of pulmonary symptoms among the stone carvers

Respiratory symptoms	Exposed group n (%)	Controls n (%)	P-value
Cough			
Yes	53 (63.8)	7 (18.4)	< 0.01
No	30 (36.2)	31 (81.6)	
Phlegm			
Yes	48 (57.8)	6 (15.7)	< 0.01
No	35 (42.2)	32 (84.3)	
Wheezing			
Yes	9 (10.8)	4 (10.5)	0.95
No	74 (89.2)	34 (89.5)	
Breathlessness			
Yes	4 (4.8)	2 (5.2)	0.91
No	79 (95.2)	36 (94.8)	
Chest illness			
Yes	40 (48.2)	10 (26.3)	0.02
No	43 (51.8)	28 (73.7)	
Sputum			
Yes	14 (16.8)	8 (21.1)	0.58
No	69 (83.2)	30 (78.9)	
Stuffy nose			
Yes	22 (26.5)	11 (28.9)	0.78
No	61 (73.5)	27 (71.1)	

3.3 Lung functions measures of study population

Table 3 displays the spirometry outcomes of participating workers. When the exposure group was compared to the control group, the mean (SD) values of FEV1 and FVC were considerably lower in the exposure group: 2.72L (0.61) v/s 3.20L (0.72) at $p < 0.01$ and 3.36L (0.83) versus 3.72L (0.75) at significance level $p < 0.05$. Likewise, the two groups had a statistically significant difference in respiratory measurements (at $p < 0.05$), regardless of whether they wore masks at work or not. Moreover, compared to non-smokers, the mean (SD) values of FEV1 and FVC were lower in smokers ($p <$

0.01).

Table 3. Mean (SD) values of spirometry outcomes of the stone carvers.

Variables	Exposed group	Control group	P-value	Wearing mask during work		P-value	Smoking habit		P-value
				Yes	No		Yes	No	
FEV1 (L)	2.72 (0.61)	3.20 (0.72)	< 0.01	3.22 (0.54)	2.96 (0.61)	0.01	2.73 (0.65)	3.27 (0.71)	< 0.01
FVC (L)	3.36 (0.83)	3.72 (0.75)	0.02	3.58 (0.81)	3.27 (0.84)	0.04	3.23 (0.63)	3.98 (0.56)	< 0.01
FEV1/FVC	0.81 (0.08)	0.86 (0.07)	0.62	0.89 (0.06)	0.91 (0.09)	0.53	0.84 (0.08)	0.82 (0.06)	0.48

3.4 Association of factors with pulmonary symptoms of stone carvers

Table 4 shows the factors related to respiratory issues among participants. Respiratory symptoms such as cough, phlegm, and chest illness were higher among participants with more than ten years of working experience. In contrast, the respiratory symptoms of wheezing, breathlessness, and sputum were more in the work experience category of (6-10) years. Further, the signs of a stuffy nose were higher among workers with working experience between one to five years. Symptoms of cough were significantly associated with wearing a mask during work at a significance level of $p < 0.01$. A higher occurrence of cough and sputum was found among the carvers who were not habitual in wearing masks during work. Cough and chest illness were significantly associated with the smoking habit (at $p < 0.01$), while the rest were higher among the non-smokers.

Table 4. Factors allied with pulmonary symptoms of stone carvers

Parameters	Cough	Phlegm	Wheezing	Breathlessness	Chest illness	Sputum	Stuffy nose
Working experience (years)							
1 to 5	16 (26.7)	12 (22.2)	3 (23.1)	1 (16.7)	13 (26.0)	6 (27.3)	13 (39.4)
6 to 10	20 (33.3)	18 (33.3)	6 (46.1)	3 (50.0)	16 (32.0)	9 (40.9)	11 (33.3)
> 10	24 (40.0)	24 (44.5)	4 (30.8)	2 (33.3)	21 (42.0)	7 (31.8)	9 (27.3)
P value	< 0.01	< 0.01	0.13	0.26	< 0.01	0.08	0.45
Wearing mask during work							
Yes	18 (30.0)	30 (55.6)	7 (53.9)	4 (66.7)	27 (54.0)	9 (40.9)	18 (54.5)
No	42 (70.0)	24 (44.4)	6 (46.1)	2 (33.3)	23 (46.0)	13 (59.1)	15 (45.5)
P value	< 0.01	0.31	0.79	0.41	0.51	0.32	0.57
Smoking habit							
Yes	39 (65.0)	23 (42.6)	3 (23.1)	1 (16.7)	29 (58.0)	6 (27.3)	13 (39.4)
No	21 (35.0)	31 (57.4)	10 (76.9)	5 (83.3)	21 (42.0)	16 (72.7)	20 (60.6)
P value	< 0.01	0.14	0.32	0.32	< 0.01	0.37	0.58

4. Discussions

This research showed that stone workers who worked in the field were much more likely to have respiratory issues than those who worked in the office. It is reasonable to assume that stone carving employees are exposed to more significant amounts of stone dust. Our results indicated a higher occurrence of cough, phlegm, and chest illness among the stone carving workers. In the same way, an Indian study by Ahmad[26] found that mine workers in Rajasthan were more likely to have chest infections and coughs. Yingratanasuk et al.[22] stated a higher occurrence of cough and phlegm among stone carvers in Thailand. Similarly, Nwibo et al.[27] noted that Nigerian stone workers had a greater incidence of respiratory problems such as cough and chest infections. Additionally, a study in Zambia[28] found that cough and phlegm were more common, although research among Brazilian stone workers[29] showed that cough was more prevalent.

The average FEV1 and FVC values of site employees were substantially lower than those of administrative workers. The Indian study of stone quarry workers[30] also reported lower values of FVC among the exposure group. Likewise, the study of Gupta et al.[31] mentioned the declining ventilatory functions among stone quarry workers. Since we have not gathered dust samples from the working site and office environments for this investigation, respirable dust will likely be more significant at the stone carving site than at the office. Further, our research also highlighted the lower values of lung functions among the stone workers who usually did not wear masks during manufacturing activities. Again, these findings are aligned with the study of Thongtip et al.[32], which stated that avoidance of masks at stone workstations would result in declined spirometry volume of concerned workers. The stone carvers who smoked cigarettes had considerably lower mean values of FEV1 and FVC. These results are comparable with the results of Nigerian[27] and Indian study on stone workers[28], which found that smokers' respiratory functions were impaired compared to those of non-smokers. Somade et al. mentioned that lung function measures of Indian stone crushing workers were inversely linked with exposure duration[33]. Thus, continuous exposure to stone dust combined with the failure to utilize personal protected equipment (PPE) will result in a decline in pulmonary function parameters.

In this research, stone carvers who had worked in the stone carving units for over ten years had a greater frequency of respiratory symptoms such as cough, phlegm, and chest illness. Although the relationship was statistically significant, it contrasted with Indian research that found that stone quarry employees exposed for more than 15 years were likelier to develop silicosis and other respiratory issues[15]. The occurrence of cough was higher among the stone carvers who were not wearing masks during their carving work, and this relationship was significantly associated at a significance level of $p < 0.01$. A cross-sectional study of stone carvers in Spain[34] also reports such an association. Cough and chest illness were significantly associated with smokers at $p < 0.01$. Similarly, a Brazilian study reported that respiratory symptoms such as cough and chest illness were mainly associated with smoking[29]. Likewise, an Indian study by Arumugam et al. reported that smoking and longer work years in the quarries were associated with airflow blockage among quarry employees[35]. Hence, the present study investigated that continuous exposure to stone dust, smoking habit, and avoiding masks during work was related to respiratory issues.

One of its limitations is that this research depended on data collected from the study population to evaluate respiratory symptoms. In addition, dust sampling would have enabled quantification and comparison of the accumulation of inhalable stone dust in both the stone carving site and office domains.

5. Conclusion

The current research revealed that respiratory issues appeared more prevalent among stone dust-exposed workers. Moreover, the study also stated that smoking habits and resistance to wearing masks were the prime reason for developing respiratory problems. The findings of this research will be used as an advocacy tool to convince government officials of the need for legislation mandating stone carving proprietors to provide their employees with PPEs such as respirators and facemasks. In future, a portable dust sampler can be used to determine dust concentration level at respective stone carving sites. It is also recommended to enforce the usage of PPEs and to routinely assess the lung health of stone carving employees.

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References

1) World Health Organization. “Occupational Health: A Manual for Primary Health Care Workers”, *World Health Organization* (2002), Regional Office for the EasternMediterranean.https://apps.who.int/iris/handle/10665/116326. (Accessed March 29, 2023).
2) K. P. Vlahovich, and A. Sood, “A 2019 update on occupational lung diseases: a narrative review,” *Pulmonary Therapy*, **7** 75-87 (2021). doi: 10.6084/m9.figshare.13313066.
3) S. V. Priya, R. Rajalingam, V. Vallabhaneni, and J. Varghese, “A cross-sectional study of lung functions and respiratory morbidity in stone sculptors in rural areas of Kanchipuram District,” *Indian Journal of Respiratory Care*, **11**(3) 261-266 (2022). doi: 10.4103/ijrc.ijrc_73_22.
4) N. Ophir, A. B. Shai, R. Korenstein, M. R. Kramer, and E. Fireman, “Functional, inflammatory and interstitial impairment due to artificial stone dust ultrafine particles exposure,” *Occupational and Environmental Medicine*, **76**(12) 875-879 (2019). doi: 10.1136/oemed-2019-105711.
5) N. Wu, C. Xue, S. Yu, and Q. Ye, “Artificial stone-associated silicosis in China: a prospective comparison with natural stone-associated silicosis,” *Respirology*, **25**(5) 518-524 (2020). doi: 10.1111/resp.13744.
6) P. Mukhopadhyay, and S. Srivastava, “Evaluating ergonomic risk factors in non-regulated stone carving units of Jaipur,” *Work*, **35**(1) 87-99 (2010). doi: 10.3233/WOR-2010-0960.

7) Y. Mishra, A. K. Singh, M. L. Meena, and G. S. Dangayach, "Assessment of Respiratory Health of Wood and Stone Occupation Workers: A Review," *Ergonomics for Design and Innovation: Humanizing Work and Work Environment: Proceedings of HWWE* 2021, 419-428 (2022). doi: 10.1007/978-3-030-94277-9_36.
8) L. K. Sharma, M. K. Sain, M. L. Meena, and G. S. Dangayach, "An Investigation of Ergonomic Risk for Work-Related Musculoskeletal Disorders with Hand-Held Drilling," *Evergreen*, **10**(1) 36-42 (2023). doi: 10.5109/6781034.
9) U. Gurnani, S. K. Singh, M. K. Sain, and M. L. Meena, "Musculoskeletal health problems and their association with risk factors among manual dairy farm workers," *Evergreen*, **9**(4) 950-961 (2022). doi: 10.5109/6622881.
10) R. R. Tiwari, N. G. Sathwara, and H. N. Saiyed, "Serum copper levels among quartz stone crushing workers: a cross sectional study," *Indian journal of physiology and pharmacology*, **48**(3) 337-342 (2004).https://ijpp.com/IJPP%20archives/2004_48_3/337-342.pdf.
11) J. Patel, and M. Robbins, "The agate industry and silicosis in Khambhat, India," *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, **21**(1) 117-139 (2011). doi: 10.2190/NS.21.1.l.
12) A. T. Rivai, K. Yonezu, and K. Watanabe, "Mineralogy and Geochemistry of Host Rocks and Orebodies at the Anjing Hitam Prospect (Dairi, North Sumatra, Indonesia) and Their Environmental Implications," *Evergreen*, **6**(1) 18-28 (2019). doi: 10.5109/2320997.
13) S. Dwiki, "Development of environmental policy in Indonesia regarding mining industry in comparison with the United States and Australia: The lesson that can be learned," *Evergreen*, **5**(2) 50-57 (2018). doi: 10.5109/1936217.
14) A. R. Isara, V. Y. Adam, A. Q. Aigbokhaode, and I. O. Alenoghena, "Respiratory symptoms and ventilatory functions among quarry workers in Edo state, Nigeria", *Pan African Medical Journal*, **23**(1) (2016). doi: 10.11604/pamj.2016.23.212.7640.
15) S. K. Singh, G. R. Chowdhary, V. D. Chhangani, and G. Purohit, "Quantification of reduction in forced vital capacity of sand stone quarry workers," *International Journal of Environmental Research and Public Health*, **4**(4) 296-300 (2007). doi: 10.3390/ijerph200704040005.
16) F. Savanti, E. Setyowati, and G. Hardiman, "The Impact of Ventilation on Indoor Air Quality and Air Change Rate," *Evergreen*, **9**(1) 219-225 (2022). doi: 10.5109/4774237.
17) G. P. Theriault, J. M. Peters, and L. J. Fine, "Pulmonary function in granite shed workers of Vermont," *Archives of Environmental Health: An International Journal*, **28**(1) 18-22 (1974). doi: 10.1080/00039896.1974.10666426
18) P. Malmberg, H. Hedenström, and B. M. Sundblad, "Changes in lung function of granite crushers exposed to moderately high silica concentrations: a 12 year follow up," *Occupational and Environmental Medicine*, **50**(8) 726-731 (1993). doi: 10.1136/oem.50.8.726.
19) K. Silanun, N. Chaiear, and W. Rechaipichitkul, "Prevalence of silicosis in stone carving workers being exposed to inorganic dust at Sikhiu District Nakhonratchasima Province, Thailand; Preliminary results," *Journal of the Medical Association of Thailand*, **100**(5) 598 (2017). http://jmatonline.com/index.php/jmat/article/view/8063.
20) Y. A. Mengesha, and A. Bekele, "Relative chronic effects of different occupational dusts on respiratory indices and health of workers in three Ethiopian factories," *American journal of industrial medicine*, **34**(4) 373-380 (1998). doi: 10.1002/(SICI)1097-0274(199810)34:4<373::AID-AJIM11>3.0.CO;2-%23.
21) S. Sahu, S. Moitra, S. Maity, A. K. Pandit, and B. Roy, 'A comparative ergonomics postural assessment of potters and sculptors in the unorganized sector in West Bengal, India," *International Journal of Occupational Safety and Ergonomics*, **19**(3) 455-462 (2013). doi: 10.1080/10803548.2013.11077001.
22) T. Yingratanasuk, N. Seixas, S. Barnhart, and D. Brodkin, "Respiratory health and silica exposure of stone carvers in Thailand," *International journal of occupational and environmental health*, **8**(4) 301-308 (2002). doi: 10.1179/107735202800338722.
23) I. L. O., "Small and Medium-Sized Enterprises and Decent and Productive Employment Creation – International Labour Conference," *104th Session. –Report IV: Geneva* (2015). http://www. ilo. org/wcmsp5/groups/public/---ed_norm/---relconf/documents/meetingdocument/wcms_358294.pdf (Accessed April 2, 2023).
24) S. F. Z. Bakri, A. Hariri, and M. Ismail, "Malay Version of the ATS-DLD-78A Questionnaire for Detecting Respiratory Symptoms in Welders: Translation and Cross-Cultural Validation," *Evergreen*, **10**(2) 676-687 (2023). doi:10.5109/6792814
25) B. G. Ferris, "Epidemiology standardization project (American Thoracic Society). Recommended respiratory disease questionnaires for use with adult and children in epidemiological research," *Am Rev Respir Dis*, **118** 7-53 (1978). https://cir.nii.ac.jp/crid/1570291226427889536
26) A. Ahmad, "A study of miners, demographics and health status in Jodhpur district of Rajasthan, India,

" *International Journal of Development Studies Research*, **3**(1) 113-121 (2014). https://www.researchgate.net/profile/Dr-Mohammad-Wani/publication/325660105_2_THE_JOURNAL_OF_DEVELOPMENT_STUDIES_RESEARCH/links/5b1bc4c10f7e9b68b42ae113/2-THE-JOURNAL-OF-DEVELOPMENT-STUDIES-RESEARCH.pdf#page=119

27) A. N. Nwibo, E. I. Ugwuja, N. O. Nwambeke, O. F. Emelumdu, and L. U. Ogbonnaya, "Pulmonary Problems among Quarry Workers of Stone Crushing Industrial Site at Umuoghara, Ebonyi State, Nigeria," The International Journal of Occupational and Environmental Medicine, 3(4) 178-185 (2012). https://pesquisa.bvsalud.org/portal/resource/pt/emr-156233.
28) E. Muneku, and S. Naidoo, "Dust exposure, respiratory symptoms and disease among informal quarry workers in Lusaka Province, Zambia," *Occupational Health Southern Africa*, **21**(6) 12-16 (2015). doi: 10.10520/EJC180728.
29) V. C. D. S. Antao, G. A. Pinheiro, J. Kavakama, and M. Terra‐Filho, "High prevalence of silicosis among stone carvers in Brazil," *American journal of industrial medicine*, **45**(2) 194-201 (2004). doi: 10.1002/ajim.10331.
30) M. L. Mathur, and A. K. Dixit, "A study of forced vital capacity and its predictors among the sand stone quarry workers," I*ndian journal of physiology and pharmacology*, **43** 347-354 (1999). https://www.ijpp.com/IJPP%20archives/1999_43_3/347-354.pdf.
31) P. Gupta, M. Chaswal, and S. Saxena, "Ventilatory functions in stone quarry workers of Rajasthan," *Indian journal of physiology and pharmacology*, **43** 496-500 (1999). https://www.ijpp.com/IJPP%20archives/1999_43_4/496-500.pdf
32) S. Thongtip, P. Siviroj, A. Deesomchok, T. Prapamontol, A. Wisetborisut, and S. Khacha-Ananda, "Effects of high silica exposure on respiratory disorders among stone-mortar workers in Northern Thailand," *Southeast Asian Journal of Tropical Medicine and Public Health*, **50**(2) 401-410 (2019).
33) P. M. Somade, S. N. Patil, A. R. Chopade, and P. A. Patil, "Assessment of Pulmonary Functions in Stone Crusher Workers in Western Maharashtra," *Journal of Pharmaceutical Sciences and Research,* **11**(12) 3721-3724 (2019).
34) M. Requena-Mullor, R. Alarcon-Rodríguez, T. Parron-Carreno, J. J. Martinez-Lopez, D. Lozano-Paniagua, and A. F. Hernández, "Association between crystalline silica dust exposure and silicosis development in artificial stone workers,". *International Journal of Environmental Research and Public Health*, **18**(11) 5625 (2021). doi: 10.3390/ijerph18115625.
35) E. Arumugam, P. Rajkumar, B. Dhanaraj, E. Govindasamy, N. Jaganathasamy, M. Mathiyazhakan, V. N. Mariappan, S. Shanmugam, C. Durairajan, S. Rajadurai, V. Joshua, and Y. Jayaraman, "Determining pulmonary function and the associated risk factors among stone quarry workers in a suburban area of Chennai, Tamil Nadu, India," *Lung India: Official Organ of Indian Chest Society*, **38**(6) 558 (2021). doi: 10.4103/lungindia.lungindia_63_21