Chettinad Health City Medical Journal
Volume 13, Issue 2 - 2024, Pg. No. 26-34
Peer Reviewed & Open Access Journal

Research Article

Hazards, Practices and Health Outcomes of Stone Quarry Workers of Mahendragarh, Haryana: A Socio-Demographic Analysis

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DOI: https://doi.org/10.24321/2278.2044.202425

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How to cite this article:
Saha A R, Ajeet, Mathur N. Hazards, Practices and Health Outcomes of Stone Quarry Workers of Mahendragarh, Haryana: A Socio-Demographic Analysis. Chettinad Health City Med J. 2024;13(2):26-34.

Date of Submission: 2023-12-20
Date of Acceptance: 2024-04-20

A B S T R A C T

Introduction: Unhealthy work conditions and the absence of legislative protection in the stone quarrying activity carried out in the urban and semi-urban areas of developing countries have a high incidence of respiratory and pulmonary diseases.

Method: The current research was conducted among 229 male workers in the middle age group with around ten years of experience in stone quarrying at 5 units of Nangal Chaudhary tehsil of the Mahendragarh district of the Haryana state in northern India.

Result: A binary logit regression model has shown the expected vulnerability and negative health outcomes of such workers, explained majorly by the type and duration of exposure to dust, lack of protective devices, and inadequate health facilities.

Conclusion: The results provide major insights into the broader discourses on pollution and health with a micro-focus on the stone quarry sector. This indicates the need for immediate and serious policy attention to a sector generally overlooked.

Keywords: Stone Quarrying, Health Outcome, Pulmonary Disease, Respiratory Disease, Work Condition

Introduction

Diseases which are caused due to the adverse environment at the workplace are called occupational diseases.[1] The general consensus is that industrialised nations and industrialised activities are the primary sources of occupational health problems. However, in developing countries like India, millions of people are engaged in labour that may cause occupational hazards, such as, stone grinding, mining, and quarrying etc.[2] Among these, stone quarrying activities have drawn special attention of researchers due to the high incidence of pulmonary diseases. The following industries expose workers to silica dust: agate, slate, sandstone quarrying, ceramic and pottery manufacturing, and many more.[3] Dust inhalation has been correlated with several respiratory diseases and the stone carving industry has been the most affected with high incidence of disease as well as deaths.[4] There is unquestionably a rise in occupational lung disorders with a progressive tendency toward industrialisation.[5] However, informal sector activities like the ones mentioned above have been long neglected, both in labour studies as well as health analyses. Studies have shown that the presence of high levels of silica in stone-crushing workplaces may cause silicosis within six months only.[6] Thus, the possible correlation

between stone-crushing activity and occupational diseases may be of major significance in understanding the scope and lack of well-being of workers in this sector.

The terms mining and quarrying are generally clubbed together indicating secondary activities. However, mining operations are carried out under the ground at great depth whereas quarrying is carried out at ground level in an exposed condition. Quarrying is the practice of removing stones from naturally occurring rock beds using one of three different techniques: blasting, machine quarrying, or hand tools. The hand tools method is used in the case of soft stones or for smaller works, involving excavating, heating and wedging. In machine quarrying, a groove is cut around the rock and horizontal holes are drilled beneath the block to separate it from its bed. The process is carried out on the site using channelling machines. Larger blocks of stones, such as marbles, limestone etc. can be obtained using this method. The blasting method is based on the use of explosives to separate stones from parent hard rock or stone that does not contain any cracks or fissures. Once a hole has been made in the rock, explosives are placed inside and blasted to produce small stones that are utilised as aggregate in concrete projects, ballast for railroad projects, etc. Higher levels of PM10 are released from quarry sites during drilling, blasting, and loading operations. On the other hand, a higher percentage of finer dust (PM2.5) is produced when vehicles crush and re-suspension roadside dust. Dust particles within the size range of 0.5 to 3 microns are retained in the lungs and continue to exert their effect even after cessation of exposure.[7] This gives rise to high and frequent exposures to Respirable Crystalline Silica (RCS) resulting in diseases that affect the lungs and other parts of the respiratory system, such as lung disorder, and pulmonary and respiratory diseases. Dust inhalation in quarrying has been identified as an etiological factor that may manifest in the form of pneumoconiosis, silicosis, grain fever syndrome, occupational asthma, farmer's lung, chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, pneumonia, and lung cancer. Several studies have shown a high incidence of respiratory symptoms for occupational lung disease like silicosis in the stone quarrying units, among male workers in the age group of 30–45 years[4] with around 10 year-long history of exposure to dust.[8] Moreover, common habits like smoking increase the risk of airflow obstruction and cause a higher incidence of chest diseases among workers.[9]

Occupational hazards associated with quarrying have drawn the attention of medical experts and the need for preventive measures against dust inhalation has become imminent. In developing societies like India, there is a definite lack of resources at the stone-crushing sites and awareness among both the workers and owners. Researchers have identified laxity in rules and regulations by concerned agencies for environmentally sustainable mining and for the prevention of diseases like silicosis.[1] In general, there are insufficient and subpar preventive measures against dust particle inhalation, such as face masks, gloves, and personal protective equipment. This makes workers more susceptible to respiratory diseases.[10] The occupational history of the stone crushers is also very important in explaining the poor health outcomes as these diseases leave long-term impacts and can have very short gestation periods.[11] Since diseases like silicosis are not curable, it is important to have awareness and preventive measures for its effective control.[12]

The current study is an examination of the hazards, measures and health outcomes of the workers in one of the most prominent stone-crushing areas in India, namely the Mahendragarh district of the state of Haryana. While most of the previous studies have been carried out from medical perspectives, the current research promises to bring in the socio-demographic variables and thus provide new dimensions to the enquiry. The study aims to analyse the incidence of respiratory and pulmonary diseases of the workers in terms of (a) working conditions, use of preventive measures, employment type and occupational history, (b) socio-demographic features, such as education, gender, age, religion, caste etc. (c) migration status, living conditions and personal hygiene, and finally (d) access to health care facilities and patterns of availing medical care. The results of the study may give insights into the neglected health concerns associated with stone quarrying activities and provide directions towards health care policies and precautions for the workers.

Material and Methods

Study Area

The Aravalli range, which stretches 692 kilometres from Gujarat, Rajasthan, Haryana, and Delhi, is one of the oldest mountain ranges on Earth. It was formed about two billion years ago when the tectonic Indian Plate pushed up against the Eurasian Plate. Although these ranges are not continuous, it is broken further by mining and construction activities. Illegal mining, uncontrolled building, excessive livestock grazing, and the planting of non-adaptable trees and plant species have all contributed to the degradation of the Aravalli.[13] Of the 22 districts of Haryana, the Aravalli is present in Nuh, Faridabad, Gurugram, Mahendragarh and Rewari, which have all seen fast development and building activity and are now, or were until recently, severely mined. Together with the districts of Rewari and Gurgaon, Mahendragarh district (Figure 1) forms the southernmost point of the state of Haryana. The district of Mahendragarh is located between latitudes 27° 47' 50" N and 28° 28' 00" N and longitudes 75° 54' 00" E and 76° 22' 11" E. Its 1899 square kilometres of land are divided into 32.98 square kilometres of urban area and 1866.02 square kilometres of rural area.[14]

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202425

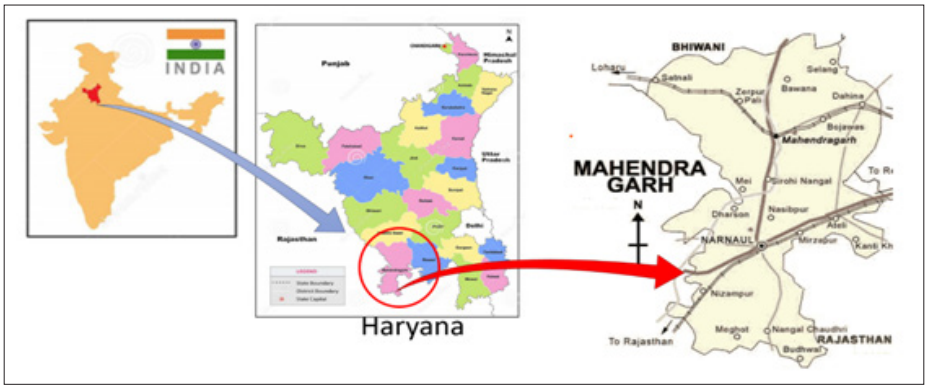

Figure 1.Location of Mahendragarh District

Administratively, Mahendragarh district is divided into 5 tehsils, Narnaul, Nangal Chowdhary, Kanina, Mahendragarh, and Ateli. Narnaul city is the administrative headquarters of the district. The district comprises 370 villages and 5 towns with a population of 9,21,680 with 4,86,553 males and 4,35,127 females.[15] Physically, the district is made up of low, desolate hills and plains that are broken up by these features. It abounds in sand dunes and barren low hills of the great Aravalli Range which provide a wide range of commercially exploitable minerals.[14] Mahendragarh district has rich mineral deposits including important minerals like dolomite, barite, quartz, quartzite, road metal and masonry stone, limestone, calcite, iron ore, slate stone, granite, felspar, bajri/ sand, etc. This has resulted in quarrying being a major economic activity in the district with more than 150 stone crushing units currently in operation. Nangal Chaudhary, Mahendragarh and Narnaul tehsils house the stone quarries with 107 stone crushers in Nangal Chaudhary, 34 in Mahendragarh and 21 in Narnaul operating under clusters. The study has been conducted mostly in the 5 units of Nangal Chaudhary area. The units and the stone crushers (numbers in brackets) are Jainpur (12) in unit 1; Begopur (24), Dholera (15) in unit 2; Gangutana (19), Bakhrija (17) in unit 3; Khatoli Ahir (13), Berundla (3), Khatoli Jat (1) in unit 4 and Panchnota (2), Bayal (1) in unit 5.

There has been a significant rise in air-borne diseases in Mahendragarh between 2011 and 2019 according to the state pollution control board[16] that submitted the report to the National Green Tribunal (Figure 2). The assessment of the air quality in the region of stone crushers in the district reveals that the total pollution generated is over the assimilative capacity of the region and is resulting in a high incidence of respiratory and pulmonary diseases.

Against the backdrop of the rising aggregate trend of occupational diseases, the present study aims to add a disaggregated scrutiny of the stone quarry sector by identifying the explanatory factors and gaps in practices.

Sample

The sample consisted of people working in stone crushing units presenting with respiratory symptoms for occupational lung disease, silicosis etc. A primary survey consisting of 36 questions was conducted among 229 workers at stone quarrying sites. All participants of the survey were informed of the purpose and they gave consent for the same. The sample consisted of predominantly young male (87.33%) workers aged less than 40 years (76.41%). They mostly belonged to the Hindu religion (95.75%) with Scheduled Caste as the dominant community (51.52%), followed by Other Backward Castes (34.06%). Despite the caste-based socio-economic backwardness, a major segment of the respondents reported to have completed secondary/ higher secondary education. Although some workers had migrated from Uttar Pradesh and Bihar, the workers were generally local (79.03%) (Table 1).

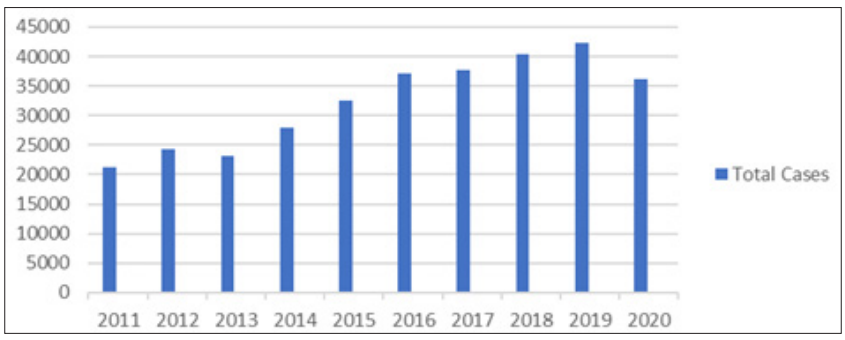

Figure 2.Record of Airborne Diseases in Mahendragarh District

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202425

Table 1.Sample Specification with Percentage Contribution

Sample Specification		Percentage (%)
Gender	Male	87.33
	Female	12.67
Age (years)	< 40	76.41
	≥ 40	23.59
Education level	Secondary level	36.20
	Primary level	30.60
	Illiterate	17.90
Marital status	Married	69.43
	Unmarried	30.57
Religion	Hindu	95.75
	Non-Hindu	4.25
Caste	Scheduled caste	51.52
	Other backward castes	34.06
	General	13.97
	Others	4.75
Migration status	Local	79.03
	Migrated	20.97

Methodology

This study was conducted during January–March 2022. Ethical clearance was obtained before the commencement of the study. A questionnaire-based sample survey was conducted for the collection of primary data. Since the study aims to determine some of the key factors which may explain the occurrence of air-borne diseases among stone quarry workers, the first exercise was to identify possible correlations between different variables using crosstabulation. The chosen variables range from occupational history, and nature of employment to social indicators like educational skill level, and health indicators like duration of symptoms and diagnosis etc. These categorical variables have been examined for associations using Pearson's chi-square test. Subsequently, a binary logit regression model has been used to identify the explanatory variables behind the incidence of respiratory and pulmonary diseases that are expected outcomes of air pollution through dust generated during the stone quarrying activity. The dependent variable in the model is categorised into two, namely, having any respiratory and/ or pulmonary disease or not, while all the predictor variables are categorised into two or more. The presence of disease has been identified through symptoms like breathlessness, prolonged dry cough, phlegm, sudden fever, swollen legs, blue lips, weight loss, chest pain, fatigue and tiredness. While some respondents have reported none, most of them reported multiple symptoms. The predictor variables were designed in terms of (a) the nature, duration and conditions of work, availability of preventive devices like face masks and water for wetting tools, history of past occupational engagement, (b) living conditions, such as types of houses, ventilation systems, access to water, toilet, clean fuel, geographical conditions like a sandy desert and/ or vegetation etc., (c) personal medical history, family history of respiratory and pulmonary diseases, smoking habits, a record of medical tests that may be indicative of such diseases, access and availing rate of health care facilities, and (d) basic socio-demographic indicators like age, gender, income etc.

Results and Discussion

Cross-Tabulation Results on Correlation Among Variables

The field survey analysed several aspects of the socio-economic and health conditions of the workers engaged in stone quarrying. Nearly 17.9% of the total respondents were illiterate, 15.2% could sign their names, 29.6% had primary education, and 36.2% had secondary education (Table 2). Among those who were employed with regular wages, a substantial proportion had secondary education. On the other hand, most of the respondents who worked for daily wages had primary education only. However, education did not seem to have a significant impact on the nature of employment except for those who were illiterate.

Table 2.Classification of Nature of Employment based on Education (in %)

Variable	Value	Nature of Employment (in %)			Total
		Contractual	Daily Wager	Regular Salaried	
Education	Illiterate	18.9	18.2	0.0	17.9
	Can sign	14.0	16.4	30.0	15.2
	Primary	29.9	34.5	20.0	29.6
	Secondary	37.2	30.9	50.0	36.2
Total		100.0	100.0	100.0	100.0

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202425

While traditional health concerns like communicable diseases and malnutrition have been emphasised in the country's health policy, areas often neglected are occupational safety, hazards and morbidity. The latter tend to have a greater impact on workers in low-resource settings than those in developed countries. Due to a lack of education, these workers are often unaware of the hazards that their work entails. In the case of the stone quarrying industry, prolonged exposure/ inhalation of dust leads to respiratory illnesses. As the current study examines the hazards, measures and health outcomes of the workers, a cross-tabulation was carried out between the variables, namely, engagement in stone quarrying and duration of symptoms like breathlessness, prolonged dry cough, phlegm, sudden fever, etc.

Table 3.Engagement in Stone Quarrying and Duration of Symptoms

Variable	Value	Duration of Symptoms			Total (%)
		Less than a year	1-3 years	More than 3 years	
Engagement in stone quarrying	Less than 3 years	69.6	19.6	10.9	100.0
	Between 3-10 years	75.4	24.6	0.0	100.0
Count		N = 170	N = 54	N = 5	N = 229

χ^2 = 20.454, Significant, p = 0.000, p < 0.01

Table 3 depicts a significant relationship between the time spent in stone quarrying and the duration of symptoms. As the engagement in stone quarrying tends to increase, the duration of symptoms also rises. In other words, working in the stone quarrying industry has a direct impact on the health of the respondents. The survey revealed that roughly 70% of the respondents who had been engaged in stone quarrying for less than three years and 75.4% of the respondents who had been engaged in stone quarrying for 3–10 years, had developed symptoms of the disease in the last one year.

Regression Results

Overall, 58.1% of respondents did not have symptoms associated with pulmonary disease including silicosis. This shows that the remaining 41.9% of respondents may have symptoms associated with pulmonary disease including silicosis. Based on the survey of 229 workers in the stone quarrying industry, an attempt has been made to identify the probability of various socio-economic factors influencing the health of these workers. This has been done using binomial logistic regression. In order to see the distinct influence of variables related to work and variables related to the health of the individual, two regression models were used.

Variables Related to Work - Model I

In the first model (Table 4), those who did not suffer from any disease were represented as 1, and all those with a disease were represented as 0. The variables that affect the probability of suffering from respiratory disease are the nature of the previous job, time period of engagement in stone quarrying, ventilation at the place of work and the use of a face mask. All the predictor variables except working hours per day were categorical variables.

Prevalence of respiratory disease = F (nature of the previous job, time period of engagement in stone quarrying, ventilation at place of work, use of a face mask, working hours per day)

Table 4.Description of Variables Used in the Binary Logit Model for Variables Related to Work (Model I)

Variable	Code Description
Dependent Variable (Y)	
Workers suffering from disease	If the respondent suffers from disease = 0
	If the respondent does not suffer from disease = 1
Independent Variables (X_i)	
Previous job (X_1)	Quarrying/ mining = 1, Construction = 2, Excavation = 3, Plaster or dry wall installation = 4, None = 5, Multiple Jobs = 0
Engagement in stone quarrying (X_2)	Between 3 and 10 years = 1, Less than 3 years = 0
Ventilation (X_3)	Well-ventilated = 1, Ill-ventilated = 0
Face mask (X_4)	Yes = 1, No = 0
Working hours per day	Continuous variable

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202425

Table 5.Regression Result of Binomial Logit Model for Variables Related to Work (Model 1)

Variable	Coefficient	Wald	p Value
Constant	-7.836 (0.000)***	3.630	0.057
Previous job (1) - quarrying	0.591 (1.805)	0.983	0.321
Previous job (2) - construction	-1.477 (0.228)*	7.522	0.006
Previous job (3) - excavation	18.462 (104237691.5)	0.000	0.999
Previous job (4) - plaster	21.296 (1772660941)	0.000	0.998
Previous job (5) - none	-1.169 (0.311)**	4.247	0.039
Engagement in stone quarrying (1) - between 3 and 10 years	-1.920 (0.147)*	9.366	0.002
Ventilation (1) - well-ventilated	-0.552 (0.576)	0.933	0.334
Face mask (1) - yes	1.750 (5.756)*	7.829	0.005
Working hours per day	0.863 (2.371)**	4.372	0.037
Cox & Snell R square	0.369	-	-
Nagelkerke R square	0.496	-	-
Omnibus tests (chi-square)	105.345*	-	0.000
Hosmer and Lemeshow test (chi-square)	9.897	-	0.129
Observations	229	-	-

Note: Values in the parenthesis are odd ratio coefficients.
*1%, **5% and ***10% level of significance

The chi-square value is significant showing that the independent variables taken together, have a significant effect on the dependent variable. A non-significant coefficient on the Hosmer and Lemeshow test shows that the data fit the model well. The Nagelkerke R square, which shows the explained variation by the model is 0.496.

Table 5 depicts the relationship between the dependent variable and the explanatory variables, with the former being on a logit scale. The estimates show the probability or predict the natural log odds of not suffering from any respiratory disease that is predicted by a one-unit change in any predictor, ceteris paribus.

The table shows that being employed in construction activities in the previous job was a significant factor affecting the probability of suffering from a respiratory disease. Those employed in the construction sector, 'Previous Job (2)' were only 0.228 times more likely to not suffer from a disease than the base category (those who were in multiple jobs previously). Similarly, those who were not employed anywhere, 'Previous Job (5)' were 0.311 times more likely to not suffer from a disease than the base category.

Engagement in stone quarrying for 3–10 years is also a significant factor affecting the probability of being disease-free. Here the reference category is that an individual is engaged in stone quarrying for less than three years. An individual engaged in stone quarrying for 3-10 years is 0.147 times as likely to not suffer from any disease than an individual who has been engaged in stone quarrying for less than three years. Hence, the probability of suffering from an illness increases with a rise in the duration of engagement in the stone quarrying industry.

Face mask is also a significant factor affecting the probability of being disease-free. Those who wore a face mask while at work were 5.76 times more likely to be disease-free than the base category comprising those who did not wear a face mask. Hence, adequate protection at work is a significant factor in reducing occupational hazards.

Ventilation at the place of work did not turn out to be a significant factor in affecting the probability of a worker not suffering from any disease.

The binary logit model shows that the nature of the previous job, engagement in stone quarrying and use of a face mask are statistically significant factors affecting the probability of not suffering from any disease. However, ventilation at the place of work is not a significant factor.

Variables Related to Health - Model 2

The second binary logistic regression model is based on health-related variables (Table 6). The predictor variables were the distance of the nearest health facility, frequency of visiting the health facility, medical history of the individual, medical history of the family and the habits of the respondent.

Table 6.Description of Variables Used in the Binary Logit Model for Variables Related to Health (Model 2)

Variable	Code Description
Dependent variable (Y)	
Workers suffering from disease	If the respondent suffers from disease = 0
	If the respondent does not suffer from disease = 1

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202425

Independent variables (X_i)	
Nearest health facility (X_1)	Within 1 km = 1, within 3 kms = 2, within 5 kms = 0
Frequency to visit health facility (X_2)	Once a month = 1, once in 3–4 months = 2, as and when required = 0
Medical history of individual (X_3)	Heart problem = 1, lung problem = 2, no problem = 0
Medical history of family (X_4)	Yes = 1, no = 0
Habits (X_5)	Yes = 1, no = 0

Table 7.Regression Result of Binomial Logit Model for Variables Related to Health (Model 2)

Variables	Coefficient	Wald	p Value
Constant	-19.998 (0.000)	0.000	0.999
Nearest health facility (1) - within 1 km	21.258 (1707771126)	0.000	0.999
Nearest health facility (2) - within 3 kms	21.325 (1825518273)	0.000	0.999
Frequency to visit health facility (1) - once a month	-1.842 (0.159)*	15.466	0.000
Frequency to visit health facility (2) - once in 3-4 months	-1.449 (0.235)*	16.660	0.000
Medical history of the individual (1) - heart problem	-2.143 (0.117)*	10.037	0.002
Medical history of the individual (2) - lung problem	-1.291 (0.275)**	6.208	0.013
Medical history of the family (1) - yes	0.216 (0.805)	0.332	0.565
Habits (1) - yes	0.244 (1.279)	0.428	0.513
Cox & Snell R square	0.211	-	-
Nagelkerke R square	0.283	-	-
Omnibus tests (chi-square)	54.166	-	0.000
Hosmer and Lemeshow test (chi-square)	53.502	-	0.000
Observations	229	-	-

Note: Values in the parenthesis are odd ratio coefficients
*1% and **5% level of significance

Table 7, depicts the relationship between the dependent variable and the explanatory variables, with the former being on a logit scale. The estimates show the probability or predict the natural log odds of not suffering from any respiratory disease that is predicted by a one-unit change in any predictor, ceteris paribus.

The chi-square value is significant showing that the independent variables taken together, have a significant effect on the dependent variable. The Nagelkerke R square, which shows the explained variation by the model is 0.283.

The frequency of visiting a health facility is a significant factor affecting the probability of not having any disease. The reference category is visiting a health facility as and when required. Those who visited a health facility once a month were only 0.159 times as likely as the base category to be disease-free. Similarly, those who visited a health facility once in 3-4 months were 0.235 times as likely as those who visited a health facility as and when required to not suffer from any disease. It is possible that those who visit a health facility as and when required are healthy individuals who do not need medical check-ups on a regular basis and hence have a higher probability of being disease-free than those who visit medical facilities on a regular basis.

The medical history of the individual is a significant factor affecting the probability of a person suffering from a disease. Those who had a history of heart problems were 0.117 times more likely than the reference category, of those who have no problem to be free of any respiratory disease. Similarly, those who had a medical history of a lung problem were 0.275 times more likely than the base category to be disease-free. Hence, as expected, having a medical history of a heart or lung problem exacerbates the chance of having a respiratory illness.

Having a health facility in the vicinity is not a significant factor affecting the probability of suffering from a respiratory illness. The medical history of the family and the respondent's habits were also not significant factors.

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202425

Concluding Remarks

The results of the current study validate the hypotheses of negative health outcomes and medical vulnerability of the stone quarry workers due to a host of socio-demographic reasons and policy limitations. There is a general lack of resources, poor work conditions and unhealthy working practices in the stone quarry sector, further aggravated by unhealthy living conditions, inadequate access to health care facilities and so on. These factors act collectively in creating the adverse outcomes for health indicators of the stone quarry workers in the sample which may be considered representative of many other parts of India. While the lack of precaution and preventive measures may be perceived as negligence on the part of the employers, the workers are also majorly unaware of such hazards at the workplace. This calls for the immediate attention of policy designers and legislators to frame appropriate rules, regulations and monitoring guidelines. At a time when stone quarrying is a significant and growing activity in the process of urbanisation, the health conditions and occupational hazards of its greatest stakeholders must be considered a priority for the long-term development of this sector as well as for the associated sectors across which the labour force moves.

Acknowledgement

The study was carried out as a master's level dissertation of Mr Ajeet under the supervision of Prof Anindita Roy Saha at the Department of Environmental Studies, University of Delhi, Delhi, India in the year 2022. The data analysis, visualisation and econometric modelling were supervised by Dr Namita Mathur. The authors thank all the respondents for their cooperation, sincere input, and consent.

Source of Funding: None

Conflict of Interest: None

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ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202425