Original Article

Pulmonary Functions and Respiratory Symptoms of the Women Exposed to Mine Tailings

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Abstract

Introduction: Impact of mining on environmental degradation affecting water, soil, and air is established. With the recognition that air pollution is the most important cause for noncommunicable cause for mortality and women as a gender at higher susceptibility to lung dysfunction, it was necessary to make a start to understand the detrimental effect of mine tailing on ambient air pollution almost two decades after closure and its effect on the vulnerable women residents. **Materials and Methods:** After institutional ethical clearance and informed consent, 258 females between the age of 18 and 60 years living in the gold mining town for over 3 years were selected. Respiratory symptoms were assessed using the American Thoracic Society questionnaire and lung functions of forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), peak expiratory flow rate (PEFR), and FEV1/FVC% using computerized spirometer. Dust samples were analyzed for particulate matter concentration (PM) by gravimetric method. **Results:** The average PM concentration in the mining area was 1.491±0.737 mg/m. Of the respiratory symptoms, complaints of cough were 34%, breathlessness 31%, phlegm 30%, and asthma 20%. FVC, FEV1, and PEFR were 1.3157 ± 0.487 L/s, 1.2500 ± 0.4850 L/s, and 2.611 ± 1.185 L/s, respectively. FEV/FEV1 was 93.650 ± 9.2733%. **Conclusion:** Mine tailing contributed to ambient air pollution, which has significantly decreased lung functions in the local women residents and produced the restrictive type of lung abnormality.

Keywords: Lung functions, Mine tailings, particulate matter, women

Introduction

Mining in India is an important developmental activity and has a manifold impact on population dynamics, development, and environment.[1] One of the worst negative impacts of mining is its contribution to environmental degradation. Mining towns are often a well-established township with good roads, housing, schools, and hospitals. Its impact on environment and health effects are often overlooked by the residents or community. Long-term impact on soil, water, and air quality and their effects on humans, though known are rarely studied.

Men and women are differentially exposed or vulnerable to determinants of health.[2] The most vulnerable groups, especially women, the elderly and children, often live in poorer socioeconomic conditions and have poorer literacy skills compared with their urban counterparts.[3] Living in mine tailing communities exposes disadvantaged groups to health problems related to contamination of air, water, food, soil, and river beds with toxic chemical and metallic discharges[4] The WHO recognizes ambient air pollution as the most important cause for noncommunicable cause for mortality. Women are at a higher susceptibility with already increased exposure to household air pollution (HAP).[5] Women employed in the mines or collinies are exposed to toxic and hazardous substances due to poor safety, lack of control, and monitoring measures, and as a result, and they are susceptible to risks from several occupational illnesses.[6]

Most of the rural/tribal women due to mining-induced exploitation suffer from the social and particularly ill effects of mining-related hazards, pollution, poor waste disposal,

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denial of access to natural resources (water, forest, agriculture, land), incomplete rehabilitation, poor housing facilities, mine disasters, lack of livelihood, accidents, this sentence is repeated, chemical spillage, and closure.[7,8]

However, there has not been any documentation of lung functions among the women residents of the mine tailing town during the active phase of mining in the area or after closure. This study was designed to make a start to understand the detrimental effect of mine tailing on ambient air pollution almost two decades after closure and its effect on the vulnerable women residents.

Materials and Methods

This is part of a larger study for which institutional ethical clearance was procured before the start of the study. Ethical clearance has also been obtained for a part presentation of the data collected. It is a cross-sectional study. Data were collected during June, July, and August of 2017. Public announcement and pamphlets were distributed regarding health camps to be held in four preselected areas in the mine tailing town from the 15 mine tailing hillocks present over the area. Twelve air samples were collected in total from the four areas using personalized samplers-SidekickEx. 51 SKC U.S. A and respirable dust–particulate matter (PM) concentration was analyzed using the gravimetric method by the office of National Health of Miners Health.

After informed written consent, 258 females between the ages of 18 and 60 years, living in the gold mining town for over 3 years were selected. Those who were directly involved in the working of the mines, suffered from neuromuscular disorders or had abnormalities of spine were excluded from the study. Demographic details such as name, age, marital status, and duration of stay in this area were noted by face-to-face interview. The American Thoracic Society (ATS) Division of Lung Disease questionnaire-78A was used to record the presence of the respiratory symptoms of cough, breathlessness, phlegm, and asthma.

To record the pulmonary function tests, all volunteers were asked to come the next day after a light breakfast and to avoid exercise until the tests were done. Stadiometer was used to record the height in meters to the nearest centimeter. Weight was recorded to the nearest half kilogram. Body Mass Index was calculated using Quetelet's Index, weight in kilograms divided by height in meters squared. Pulmonary function tests were performed using a computerized spirometer (Spirotech manufactured by Clarity Pvt. Ltd. Mohali, Punjab, India). The procedure was demonstrated to the subjects. Nose clip was applied to prevent breathing through the nose. They were asked to take deep inspiration from the external air, followed by forceful expiration into the mouthpiece in the standing posture. It was ensured that the mouthpiece was inserted without any leakage of air or obstruction by the lips or teeth, and forced expiration continued to completion without a pause to maximum capacity. The procedure was repeated three times, and the best one was taken. All the lung volumes and capacities obtained were expressed with correction for Body Temperature at the Ambient Pressure, Saturated with Water Vapour.[9]

The pulmonary function determinants were forced vital capacity (FVC) the maximum amount of air forcefully expired after maximum inspiration expressed in liters, forced expiratory volume in 1 s (FEV1) is the percentage of FVC expired in the 1st s expressed in liters, their ratio (FEV1/FVC) expressed in %, and peak expiratory flow rate (PEFR) expressed in liters per second. Percent predicted values were based on the standardized equations of the European Respiratory Society 1993, with a correction factor of 0.9 for the Asian population.[10] For normal lung function tests, predicted percentage of >80% for FVC and FEV1 and FEV1/FVC ratio of >0.7 were considered cutoff values.[11] Obstructive lung function was defined as having FEV1 <80% of predicted and FEV1/FVC <70%, and restrictive lung function was defined as having FVC < 80% of predicted and FEV1/FVC >70%.[12]

Table 1: The Spirometry parameters of the predicted and observed values of the women of the mining area

Pulmonary function test	Predicted	Observed	*P*
FVC (L)	2.224±0.3466	1.3157±0.487	0.001
FEV1 (L)	1.8255±0.654	1.2500±0.4850	0.001
PFER L/S	5.90±0.9393	2.611±1.185	0.001
FEV1/FVC %	79.0931±3.2280	93.650±9.2733	0.001

P<0.001=Statistically highly significant. FVC: Forced vital capacity, FEV1: Forced expiratory volume in 1 s, FEV1/FVC: Forced expiratory volume in 1 s/forced vital capacity, PEFR: Peak expiratory flow rate, SD: Standard deviation

Results

The respirable dust concentration in the mine tailing was 1.491 ± 0.737 mg/m^3. The demographic details showed that the total women in the study group comprised 258 with a duration of stay was 39.87 ± 12.2 years. Among them, 171 (65%) were Hindus 55 (23%) were Christians, and the rest 31 (21%) were Muslims. Their marital status showed that 235 (91.4%) were married and 17 (6.6%), 5 (2%) were single and widow, respectively.

Then educational status was found that 21% had completed their graduation and rest were 26%, 40%, and 13% had completed primary, secondary, and were illiterate, respectively. Regarding the respiratory symptoms among the women using ATS questionnaire, it was observed that 34%, 30%, 39%, and 20% said yes, they had a cough, phlegm, breathlessness, and asthma when enquired.

In the present study, the predicted and observed values of different pulmonary parameters have been evaluated in the women in the mine tailing region, showing a statistically significant value of $P < 0.001$, which is represented in Table 1.

Discussion

Women as a gender differ from male counterparts mentally and physically, including the respiratory system. Studies have shown considerable sex differences in the respiratory system and their response to environmental factors. Although this has been recognized, they do not get the same preference in research. However, there have been an increased number of publications on the effect of biogas fuel-HAP on lung functions in females considering they spend more time in cooking.

The WHO brought out a report in 2012, highlighting the burden of household and ambient air pollution, especially on the more vulnerable female population? Most studies have been done on women are on HAP associated with fuel usage. HAP was not assessed in our study. On the effect of air pollution on respiratory symptoms or lung function, it either occupational hazard studies on the population and presented as a whole and not presented separately on women. However, we have tried to incorporate a few studies for comparison.

Here, we are making an attempt to discuss the effects of ambient air pollution on women. All women in the study have been staying in this area of mine tailing for an average of 35 years exposing themselves to the crushed material from the mines consisting of toxic wastes and PM.[13]

The PM concentration recorded here averaged 149 ±0.737 mg/m^3 well above the notification of "Central air pollution for National Ambient Air Quality" where PM10 is 60–100 μg m^3 even 17 years after the closure of mines, highlighting the long-lasting detrimental effects of mining on ambient air.[14] Since the other air pollutants had not been recorded, it is not possible to calculate the air quality index of the area, however taking into the PM value alone, it may not be wrong to say that this rural area would fall in the category of moderately polluted. PM reports from active mining in Gwalior and its impact on ambient air on the mining and near the residential area were found to be 601.6–753 μg/m^3 and 311.7–361.96 μg/m^3 respectively both being way above the notified values emphasizing the fact that this population may have been exposed to high levels in the early years of their lives.[15] However, there has been little data regarding the same during active mining in this mining area, although higher values have been recorded since the closure of mines.

Respiratory symptoms are the most common presentation to a clinician. Symptoms of cough, phlegm, and breathlessness are important indicators of respiratory morbidity. In this study, the cough was the most common respiratory symptom, with 34% of women having complaints of the same, followed by breathlessness in 31%, expectorant of phlegm in 30%, and 20% giving the history of asthma. In women who were exposed to PM10 levels to almost nine times above the safe values for the past 2 years of the study, the prevalence of chronic cough of 5.6%, chronic phlegm of 2.4%, wheeze of 2.6%, and dyspnea of 14.2%.[16]

This difference may be due to the different questionnaires used or by the fact that almost all the women in our study where exposed to high levels of PM through their lifetime. In the different studies done in India, the prevalence of chronic bronchitis was 2.7%–4.15%, where they have used different questionnaires and were associated with household pollution and not environmental pollution. In a study done in Ghana, on residents of the gold mining area, air quality was affected by gold mines and resulted in increased respiratory complaints with a prevalence of 21.2% in chronic bronchitis and 31.3% in breathlessness.[17] Among elderly living in proximity to the mine tailings, there was a significantly higher prevalence of respiratory symptoms compared to the unexposed population.[18] In both these studies, the prevalence was of the population studied, both genders included.

Women have smaller lung volumes for comparable weight and height in men; airway resistance is lower and PEFR comparable.[19] The effect of ambient air pollution from mine tailing on the lung functions women in this area is shown in Table 1 where we been able to demonstrate a significant decrease in observed values FVC, FEV1 and PEFR when compared to predicted values. FVC and FEV1 decline with age as a part of the normal aging process, but an enhanced or accelerated decline occurs in lung disorders when working in dusty work areas or exposure to air pollutants.[20] Residents in the gold mining area in Ghana recorded a significant decrease in pulmonary function parameters.[17] The FEV1/FVC ratio, another important parameter in lung functions to categorize the type of abnormal function, was found to be significantly higher in the women exposed to mine tailing. This point to the restrictive type of lung abnormality. A similar finding has been seen in adult women exposed to increased air pollutants and biogas.[21]

This may be explained by the fact that the PM deposited in alveoli, produces inflammation, and parenchymal scarring. This would explain the decrease in FVC too.

Although this is a cross-sectional study where direct effect and cause cannot be established, it seems plausible that the environmental air pollution would be a major contributing factor to the increased respiratory symptoms and abnormal lung function parameters, especially with the majority of women living here their entire life. The indoor air pollutants had not been assessed in our study.

Air pollution index (AQI) had not been calculated as other air pollutants have not been assessed. The respirable suspended particulate matter recorded was 149.1 μg/m^3 that is above the 100 μg/m^3 notified as safe by the central pollution board and would come under the category of moderate pollution in AQI.

Conclusion

This study has been able to demonstrate that mining can be a major environmental disaster with mine tailing contributing to ambient air pollution years after its closure, which has significantly decreased the lung function on the women.

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Conflicts of interest
There are no conflicts of interest.

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