Peak Expiratory Flow Rate, Blood Oxygen Saturation, and Pulse Rate among the Mine Tailing Community

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Abstract

Background: Chronic inhalation of dust impairs lung function and may cause respiratory symptoms. Very little attention has been paid to the health of community exposed to dust raised by mine tailing which is deposited for many years without precautionary measures. Therefore, a study of peak expiratory flow rate (PEFR), oxygen saturation (SPO_2), and their control groups in Kolar Gold Fields and Kolar was carried out. **Materials and Methods:** Ventilatory function tests were done using 400 exposed community participants with the unexposed of same from Kolar who stayed in the mine tailing town for >3 years and aged 18–60 years. Their weight and height were taken and matched with controls who were not exposed to any known air pollutant. The percentage of SPO_2 of both the participants and their control population was determined using a pulse oximeter. **Results:** Respirable dust level in the test sites was 1.492 ± 0.336 mg/m^3 and it was significant with the control sites, which was 0.531 ± 0.783 mg/m^3 with $P < 0.05$. There was highly significant difference in the mean values of SPO_2, pulse rate, and PEFR between the test and control participants with $P < 0.001$. **Conclusion:** There is an increase in air pollution by increase in particulate matter <2.5 in the gold mining township, and the residents here had decreased PEFR, decreased SPO_2, and increased pulse rate. This proves that the mine tailing community people without precautionary measures may predispose to respiratory symptoms.

Keywords: Mine tailing, oxygen saturation, peak expiratory flow rate, respirable dust

Introduction

Ambient air pollution is one of the prime contributors to cardiorespiratory morbidity contributing to more than 2.9 million deaths globally per year.[1]

Developing world in its quest for economical mobility has adopted the latest technologies for industrialization; however, their protective guidelines are not so stringent. According to the World Economic Forum Report 2016, India is the eighth largest polluter in the world. The health burden associated with it is, however, rarely quantified.[2] In India, mining, specifically gold mining, has played a significant role in the development and sustenance of the country's economy, with both positive and negative consequences.[3]

Among the negative impacts, environmental pollution is of significance especially that of gold mining. Underground mining involves dumping of leftover materials after the process of separating the valuable fraction from the uneconomic fraction of the ore in the environment forming mine dumps often called mine tailings, an important source of windblown substances leading to increased concentration of dust in air and particulate matter (PM).[4]

PM is a mixture of suspended solid and liquid particles from different sources and varying in size, mass, and chemical composition and often divided into PM 10, PM 2.5, and PM <2.5, depending on the aerodynamic diameter in microns. Of this, PM 2.5 and less is considered most dangerous because of its ability to penetrate the respiratory and even the cardiovascular system affecting the health of mining residents in the buffer zone as well as the inhabitants of this region.[5] There are guidelines in place for the protection of the health of miners but that of the community is found wanting.[6]

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Pulmonary function tests permit a precise and reproducible assessment of the functional state of the respiratory system.[7]

Among them, peak expiratory flow rate (PEFR) still remains one of the useful and simple parameters in assessing the lung function status in the general population. Pollution-related hypoxia and pulse rate changes have been reported by a few.[8,9] Pulse oximeter is a simple, noninvisible, and reliable tool that detects pulsatile signal in an extremity such as finger or toe that deduces the oxygen saturation (SPO_2) and pulse rate. Kolar Gold Fields (KGF), a gold mining town, was established in 1894 by the British. Mining continued till 2001 when the mines closed because of nonviability. However, the community continues to live here among the 32 million ton of mine tailings that have been deposited over the area forming small hillocks. These mine tailings are a constant source of environmental pollution, especially air pollution. With increasing recognition of air pollution as an invisible silent killer of noncommunicable disease, it was important to assess the effect of the environment on the cardiorespiratory health of the long-time residents of the mine tailing. Therefore, the aim of this study was to compare the PEFR, SPO_2, and pulse rate in the mine tailing community (exposed) with nonmine tailing community (unexposed).

Materials and Methods

Sample size estimation

Considering the prevalence for the chronic bronchitis of 50% in the adults with an allowable error of 5% and confidence interval of 95%, the sample size was 384 using the formula $n=Z^2$ P(1-P)/ d^2. With the response rate of 10% required, a sample of 400 was studied. The institutional ethical clearance was obtained before the start of the study. Area of the study (exposed) was KGF which was divided into four main areas, Champion reef, Ooragum, Coromandel, and Marrikuppum, based on the presence of mine tailings. Enrollment of the participants took place from June 2017 to August 2017. All those consenting from the community aged between 18 years and 60 years of both genders with a minimum residence of 3 years were recruited for the study. Similar guidelines were followed to recruit unexposed participants from Kolar, a town 10 km away from the mine tailings with similar socioeconomic and demographic parameters. Participants suffering from neuromuscular disorders and kyphoscoliosis were excluded from the study Figure 1 shows subject recruitment and parameters assessed.

Baseline anthropometric parameters such as height and weight were measured, and body mass index (BMI) was calculated using Quelet's index by dividing weight (kg) with the square of height (m^2). The subjects were requested to avoid excercise for 24hours prior to spirometry. Before starting the lung function tests, the participants were asked to loosen their tight clothing. The study was conducted at the same time for all the days to rule out diurnal variation.

Spirometry was performed using spirotech (model name: CMSP-01 Clarity Medical Pvt. Ltd., Mohali, Punjab, Haryana, India). After demonstrating the procedure to the participants, the participants were asked to take deep inspiration from the external air followed by forceful expiration into the mouthpiece in a 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. The nasal clip was applied to prevent expiration through the nose. The participants were asked to repeat the procedure three times, and the best PEFR value was taken and expressed as L/s with correction for body temperature at the ambient pressure, saturated with water vapor.[10]

Blood SpO_2 and pulse rate were recorded using pulse oximeter (Romsons imported and marketed by Rennex Medical, New Delhi, India). Pulse oximeter uses a light sensor containing two sources of light (red and infrared) that are absorbed by hemoglobin and transmitted through tissues to a photo detector. The amount of light transmitted through the tissue is then converted to a digital value representing the percentage of hemoglobin saturation. Hence, the sensor device is placed around the pulsating arteriolar bed of finger (e.g., left or right index), and the SpO_2 and pulse rate were also recorded.[8] The variables, such as PEFR and SpO_2, were tabulated and the data were analyzed using appropriate statistical software (SPSS-20, IBM, Armonk. New York, USA).

The respirable dust was collected using respirable dust sampler Side Kick Ex 51 having 37-mm filter cassette holder which holds polyvinyl chloride filter of 37-mm diameter, having a pore size of 5.0 µm. Precalibration of Side Kick 51Ex personal respirable dust sampler was carried out using DRYCAL DCLITE BIOS calibrator in National Institute of Miners Health Laboratory. The respirable dust sampler Side Kick E × 51 when used as an area dust sampler has a correlation factor of 1.13 with gravimetric dust sampler mine research establishment (MRE) 113A dust samples. Hence, the dust concentration result obtained for area respirable dust samples, using Side Kick Ex 51, is divided by 1.13 to get the equivalent MRE respirable dust concentration in mg/m^3 in case of area samples. For area dust sampling, Side Kick 51Ex was placed in the periphery of 5–15 m of the dust generating source in the mine. After sampling for 8 h, the Side Kick 51Ex was rechecked for its constant flow rate of 2.2 l/m with the help of rotameter. The constant flow rate of 2.2 l/min was also noted in the datasheet. The collected samples were carefully preserved and taken to the laboratory for further analysis by weighing the filters and calculating the dust concentration.[11]

Results

The Statistical Package for the Social Sciences (SPSS) version 20.0 (IBM,Armonk. New York, USA) was used for the statistical analysis.

Data is represented as a mean ± standard deviation in Table 1. Independent *t*-test was applied to compare age, BMI and

Table 1: Baseline characteristics of the participants (*n*=400)

Variables	Mean±SD		*P*
	Exposed (KGF)	Unexposed (Kolar)	
Age (years)	42.23±10.47	41.67±11.43	0.466
BMI (kg/m²)	25.38±5.46	25.29±5.29	0.784
Duration of stay (years)	39.91±12.2	38.36±11.2	0.062

Independent *t*-test was applied to compare above parameters between the groups. KGF: Kolar Gold Fields, SD: Standard deviation, BMI: Body mass index

Table 2: Dust levels (mg/m³) in the mine tailing and nonmine tailing area obtained by Gravimetric Dust Sampler (MRE 113A)

Parameter	KGF Mine tailing	Kolar Nonmine tailing	*P*
Respirable dust concentration mg/m³, mean±SD	1.4924±0.7830	0.5316±0.3364	0.006

Independent *t*-test to compare the dust concentration. KGF: Kolar Gold Fields, SD: Standard deviation, MRE: Mine research establishment

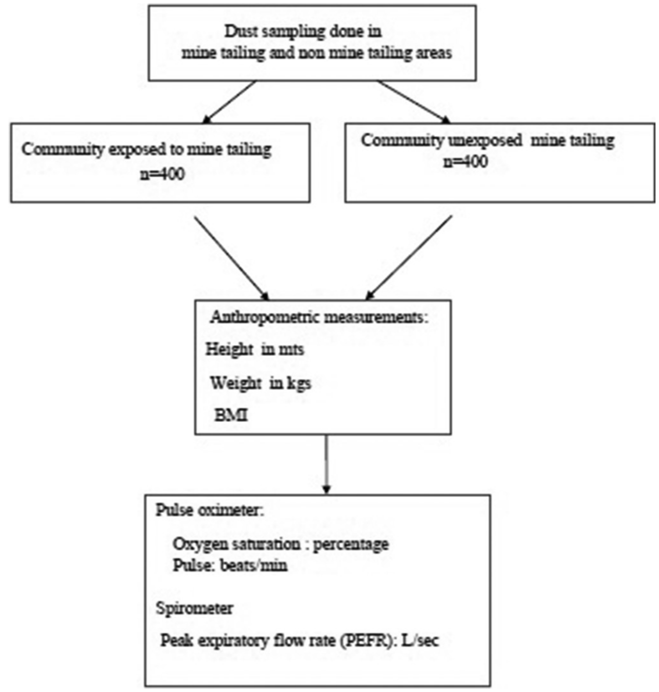

Figure 1: Methodology

duration of stay, which did not show any significant difference, indicating that the data was matched. The respirable dust concentrations are represented in Table 2. The comparison of pulse rate, PEFR and SpO_2 were compared between exposed and unexposed which are depicted in [Figures 2-4] respectively.

Discussion

Gold mining is especially notorious as a source for environmental pollution, and the mine tailings become the source of pollutants. KGF was first established in the 1880 and has a well-established township of the same name. Families of the employees resided here and continue to do so even two decades after its closure. Although the earliest silicosis case was reported as early as 1933 in the underground workers, there are hardly any data regarding the respiratory status of the residents of the township. Increase air pollution has been documented by Krishna and Gejji in 2001 from the 32 tons of mine tailings around the area in the form of hillocks and the families live in proximity of these tailings.[12]

An attempt is made here to study the effect of mine tailings on air pollution and on the cardiorespiratory status of the residents of this area. On analysis of atmospheric air for PM in the mining town, PM 2.5 levels were significantly higher when compared to unexposed area although it was within the permissible limits of 3 mg/m³.[13]

This was despite no active mining since 2001 when the mines closed showing that the mine tailings continue to be a source of air pollution. Of the lung function tests, PEFR has been selected as a simple screening measurement. The exposed resident participants recorded significant lower PEFR values when compared to those from the unexposed group as showed in Figure 3 in spite of the PM values being with permissible limit. This may be because the majority of the exposed group participants were born here averaging 39 years, having a lifetime exposure. Peak flow rate mainly reflects the caliber of the bronchi and larger bronchioles which are subject to reflex bronchoconstriction due to airway obstruction and increased airway resistance leading to decrease PEFR. Our study correlates with the findings of Gupta *et al*., whose reports show that reduction in PEFR is due to exposure of individual to various kinds of dusts.[14]

Air pollutants irritate the respiratory passages, increase inflammation of bronchial walls, and increase secretion of mucus. This leads to narrowing of respiratory passages and increase in respiratory resistance.[15]

The significant increase in respirable particulate dust concentration in KGF (Table 2) when compared to unexposed area would decrease PEFR in residents of KGF. Epidemiological studies have linked PM quantity and cardiorespiratory morbidity. Two of the parameters studied here are SPO_2 and pulse rate using pulse oximeter. Although the values recorded are within normal limits, there is a significant decrease in SPO_2 and increase in pulse rate in the exposed group as compared to the unexposed group as shown in Figures 2 and 4. Although the underlying mechanism is not well established, a plausible explanation for decrease in SPO_2 is that the increase in air pollutants results in oxidative species, leading to oxidative stress leading to lung damage and inflammation causing decrease in pulmonary function and hypoxia. Studies have shown link between air pollution and pulse rate, and it has been documented as early as 1985 that air pollution increases

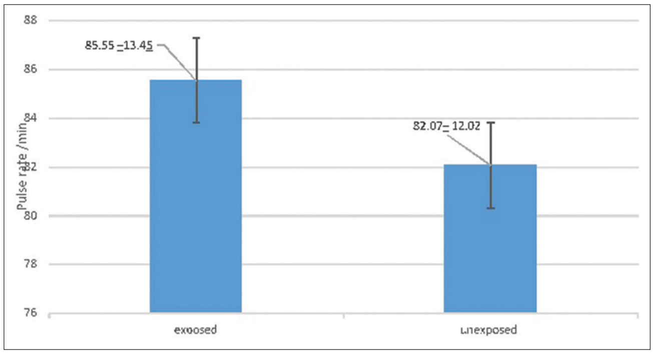

Figure 2: Comparison of the mean pulse rate between the exposed and unexposed mine tailing community

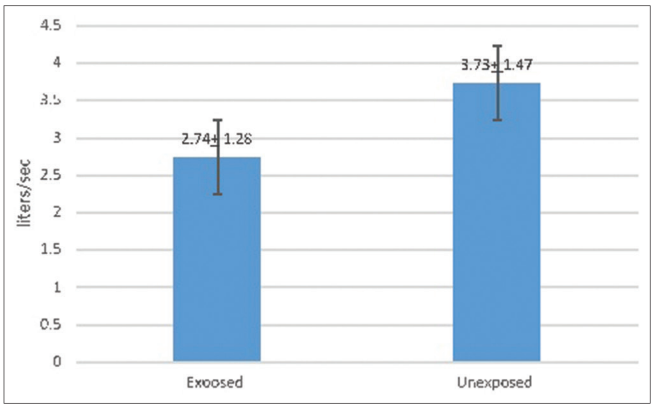

Figure 3: Comparison of the mean peak expiratory flow rate between the exposed and unexposed mine tailing community

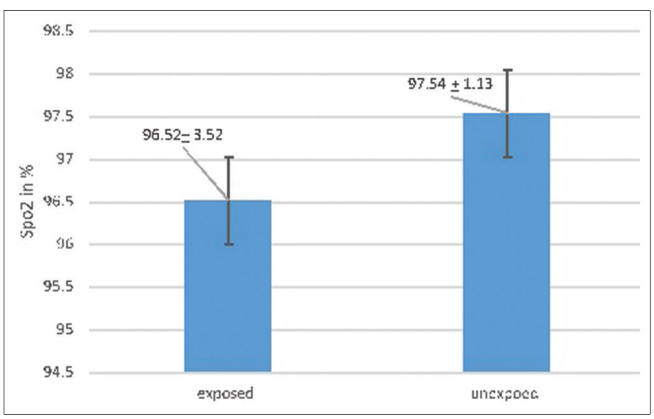

Figure 4: Comparison of the mean oxygen saturation (SpO_2%) between the exposed and unexposed mine tailing community

the plasma viscosity by increasing the pulse rate.[9] Another factor may be due to alteration in autonomic function due to inflammation arising both in respiratory and cardiovascular system. Moreover, there seem to be no definite threshold levels of PM concentration beyond which it affects the cardiorespiratory system with even increased incidence of cardiorespiratory morbidity in countries with stringent guidelines.[16]

Conclusion

There is increase in air pollution by increase in PM <2.5 in the gold mining township, and the residents here who were exposed this environment have decreased PEFR, decreased SPO_2, and increased pulse rate.

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Conflicts of interest

There are no conflicts of interest.

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