https://journalofcomprehensivehealth.co.in/

ScientificScholar® Knowledge is power
Publisher of Scientific Journals

Journal of Comprehensive Health

Original Article

Health Status of the Coal Mine Workers in an Open-cast Mine of Eastern India

Asim Saha[1], Somnath Sen[2], Kalyan Bhowmik[2], Anirban Das[2], Jai Sen Mahankuda[2], Tilak Kanti Dasgupta[2]

[1]Occupational Medicine Division, Centre for Non Communicable Disease, [2]ICMR-Centre for Ageing and Mental Health, Kolkata, West Bengal, India.

***Corresponding author:**
Asim Saha,
ICMR-Centre for Ageing and Mental Health, Indian Council of Medical Research, Block DP 1, Sector V, Salt Lake, Kolkata, West Bengal, India.

asimsaha2311@yahoo.co.in

Received: 02 January 2024
Accepted: 01 February 2024
Published: 08 March 2024

DOI
10.25259/JCH_1_2024

Quick Response Code:

ABSTRACT

Background: Coal mining in India has a long history of nearly 200 years. Coal mining can also increase the risk of coal workers' pneumoconiosis, asthma, and chronic obstructive pulmonary diseases such as emphysema and chronic bronchitis.

Objectives: This study was conducted with the objective of knowing the health effects of coal mining workers.

Material and Methods: A cross-sectional study was conducted in an open-cast mine in Eastern India. Two hundred and fifty coal mine workers were included in the study. A questionnaire survey followed by a health examination of the study subjects was carried out. Workers actively involved in mining activity were included in this study.

Results: The most common symptom complained by study subjects was musculoskeletal pain (16.8%). As far as the pulmonary function status of study subjects is concerned, about 7% of subjects had a restrictive type of abnormality. Obstructive type of abnormality was also present in a similar number of subjects.

Conclusion: The current study has shown a higher prevalence of musculoskeletal pain than the national prevalence. Morbidity is more than the normal population. Health education was imparted among workers regarding chronic diseases and their risk factors.

Keywords: Coal miners, Musculoskeletal pain, Pulmonary function, Open-cast mine, Forced vital capacity, Forced expiratory volume in the first second

INTRODUCTION WITH OBJECTIVES

The four major coal types ranked in order of increasing heat value are lignite, subbituminous, bituminous, and anthracite. The inorganic portion of coal can range from a few percent to >50% (by weight) and is composed of phyllosilicates (kaolinite, illite, etc.), quartz, carbonates, sulfides, sulfates, and other minerals. Apart from dust exposure, confrontation with metals during work is a hazard in coal mining. Aluminum and iron are the main metals in coal. Arsenic, nickel, zinc, cadmium, cobalt, and copper are trace metals that represent only a very small fraction of the mineral matter.[1]

Coal mining in India has a long history of commercial exploitation covering nearly 220 years, starting in 1774 in the Raniganj Coalfield along the Western bank of river Damodar. However, for about a century, the growth of coal mining in India remained sluggish. Later on, from 1853, it again gained momentum through introduction of steam locomotives industries. As of 2011, India had 285 billion tonnes of resources. In 2010–11, the production of coal was 532.69

million tonnes. The production of lignite was 37.73 million tonnes in 2010–11. In 2011, India ranked third in world coal production.[2]

Coal remains a major energy resource worldwide. However, coal mining causes environmental problems such as acid mine drainage, whereas the inhaled coal particles at the workplace may lead to the development of coal workers' pneumoconiosis (CWP).[3,4] Typically, coal workers' pneumoconiosis takes many years to develop and be manifested that requires surveillance for a long duration. Further, once initiated, the disease is progressive in nature, often leading to lung function impairment, disability, and premature death.

Apart from CWP, coal mining can also increase the risk of developing asthma and chronic obstructive pulmonary disease, such as emphysema and chronic bronchitis.[5-7] It is suggested that coal dust stimulates the recruitment of neutrophils to the lungs, and both these neutrophils and resident alveolar macrophages show evidence of activation, secreting free radicals and proteolytic enzymes, and plausible mediators of tissue injury in emphysema.[8-10]

Extensive mining, including coal mining, is undertaken in different parts of India. Nowadays, as far as coal mining is concerned, more and more open-cast mines are emerging in contrast to older underground mines. This shift is friendly to workers' health. However, considering the environmental–occupational hazards inherently involved, regular and periodic monitoring of environmental conditions and the health status of the workers is always necessary. Under this background, the present study was undertaken with the aim of studying the coal mining as well as coal dust-related health effects in the open-cast mining workers.

MATERIAL AND METHODS

An occupational health study was conducted involving different mining areas of the concerned mining project during 2019–2020. This cross-sectional study was undertaken among the exposed workers mainly from active mining and crushing activity. A representative sample of workers working in such occupations is included in this study. Initially, the aim of the study was explained to the workers; informed consent was obtained after which they were enrolled for this study. Every individual subject was interviewed with a pre-designed questionnaire to collect information in relation to the personal, occupational, and morbidity details of the workers. Informed consent was obtained from each study participant. This study covered about 250 participants from the mining project. These workers were randomly selected from the total exposed workforce (workers in active mining and crushing activity). This was followed by clinical examination and spirometry of each subject.

Comprehensive anthropometric characteristics of the subjects were measured. The nutritional status of the workers was also estimated by standard anthropometry[11] and body composition using standard anthropometric equations.[12-14] The subjects were classified for their nutritional status based on body mass index.[15]

Environmental monitoring

The monitoring was carried out after a preliminary walk-through survey in all the sites of the coal mining areas and shop floor, where the open-crust mining, crushing, and loading processes were performed. The static respirable dust sampling in the above sections was conducted with SKC personal sampling pumps Model 224-PCXR8 (SKC, Pittsburgh, USA), followed by NIOSH 0600 analysis. The pumps had previously been charged and calibrated before sampling. The personal sampling pumps were equipped with 37 mm aluminum cyclone filter heads, were loaded with glass paper filters (0.8 µm pore size), and were kept in sites during the working shift. The respirable dust was sampled for 8 h. At the end of each shift, the pumps were removed, and the filters were analyzed by the gravity metric method. A total of 30 respirable samples were collected from three units. Dust concentrations were calculated for each of the samples, and the mean dust concentrations were also estimated.

Pulmonary function test (PFT)

Lung function tests were carried out in all subjects. Forced vital capacity (FVC) and peak expiratory flow rate (PEFR) were recorded by Spirovit SP-1 (Schiller Health Care Ltd., Switzerland) and Wright's Peak Flow Meter, respectively. Three successive recordings of FVC and PEFR were made in standing posture, and the nose clip was used. The best of the three performances were considered for calculation purposes. The different flow volumes such as forced expiratory volume in the first second (FEV_1) and FEV_1%, were calculated from the same tracings. All volumes obtained were expressed in body temperature on atmospheric pressure of air saturated with water vapor.[16] Body height and body weight were measured in bare feet on a standard scale. Pulmonary function test values were predicted from the standard prediction equation.[17] The instrument was calibrated every day before starting the experiment. The respondents were defined as current smokers if they were smoking at the time of the survey and had smoked more than 100 cigarettes in their lifetime; as former smokers if they no longer smoked but had smoked more than 100 cigarettes in their lifetime; and as never smokers if they had never smoked or had smoked fewer than 100 cigarettes in their lifetime.[18] The study was approved by the Institutional Ethics Committee of Regional Occupational Health Centre (Eastern) and informed consent was obtained from each participant.

Statistical analysis

Initially, a descriptive analysis was done. Central tendency and dispersion of the continuous dataset were presented in terms of mean, median and standard deviation (SD), and interquartile range (IQR)., Inferential statistics was performed by unpaired Student's *t*-test by comparing two mean values of two independent groups. The statistical analysis was performed by Epi Info software.

RESULTS

This study covered 250 workers. Although the majority of subjects were actively involved in mining activity, about 32% of subjects of this study were enrolled by allied staff to have a complete and comprehensive understanding of the occupational health condition. However, these allied workers were spending all of their duty time in the same work atmosphere as active mining workers. Moreover, they included coal-carrying heavy truck drivers as well as crusher employees who had ample exposure to coal dust during their jobs.

The mean age of the workers was 29.68 ± 7.10 years. Most of the workers were between the 25- and 34-year age groups. The mean age of allied staff was slightly lower than that of miners. About 80% of workers were married. As far as education is concerned, the majority (66%) had a middle school education. Only about 8% of subjects had a graduate level or higher education. The mean height of the study subjects was 163.94 ± 5.79 cm, and the mean weight was 61.23 ± 10.63 kg. The mean height was slightly higher in allied staff, whereas the mean weight was considerably higher. This may be the result of a sedentary lifestyle and relative lack of exercise. So far, as personal habits are concerned, about 76% of subjects were nonsmokers and about 24% were smokers. Tobacco chewing habit was present in 58% of subjects, and occasional alcohol intake history was found in about 37% of workers. The mean job experience was 5.53 ± 5.02 years. About 62% of workers had job experience of <5 years and about 38% of workers had experience of more than five years. The mean job experience was a little lower in the allied employee group than the miner's group.

The most common symptom complained by study subjects was musculoskeletal pain (16.8%) [Figure 1]. Other complaints were cough, difficulty in breathing, chest pain, and soreness of mouth. Some subjects also experienced headaches, sleep disturbances, weakness, and tremors in their fingers. The mean systolic and diastolic blood pressure of study subjects was 124.84 ± 14.78 and 77.28 ± 11.27 mm of mercury, respectively. About 10% of subjects had systolic blood pressure >140 as well as diastolic blood pressure >90 mm of mercury. About 5% of workers had only higher systolic blood pressure, and 4% had only higher diastolic blood pressure [Table 1].

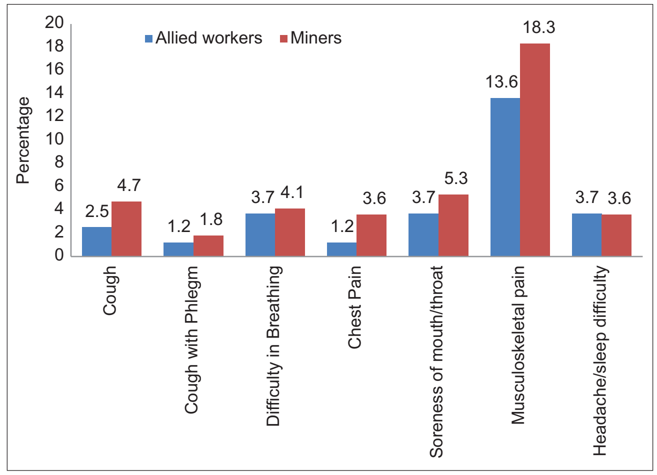

Figure 1: Distribution of symptoms of the study participants.

Table 1: Distribution of blood pressure and pulmonary function tests among study participants.

Variables	Allied workers No. (%)	Miners No. (%)	Total No. (%)
Blood Pressure (mm Hg)			
>140 and <90	5 (2.0)	7 (2.8)	12 (4.8)
<140 and >90	4 (1.6)	6 (2.4)	10 (4.0)
<140 and <90	63 (25.2)	137 (54.8)	200 (80.0)
>140 and >90	8 (3.2)	16 (6.4)	24 (9.6)
FVC/PFVC			
<80%	2 (0.8)	15 (6.0)	17 (6.8)
≥80%	79 (31.6)	154 (61.6)	233 (93.2)
FEV_1%			
<70%	3 (1.2)	14 (5.6)	17 (6.8)
70–79.99%	16 (6.4)	28 (11.2)	44 (17.6)
≥80%	62 (24.8)	127 (50.8)	189 (75.6)

FVC: Forced vital capacity, PFVC: Predicted forced vital capacity, FEV_1: Forced expiratory volume in the first second

As far as the pulmonary function status of study subjects is concerned, about 7% of subjects had a restrictive type of abnormality (FVC/PFVC <80%). Obstructive type of abnormality was also present in a similar number of subjects. A good number of subjects (17.6%) had $FEV_{1\%}$ values between 70% and 80%. The mean FVC values were significantly lower among the subjects who were 45 years or more of age. The difference was more prominent among the miners in comparison to the supervisory staff. Such a significant difference in FVC values was not observed when compared between higher and lower job experience groups. A significant difference was also observed when compared in relation to the smoking habits of the subjects. A similar trend was not observed in the case of FEV_1 values. No significant difference was observed between subjects of <45 years and the rest of the workers. This trend was similar in miners and supervisory staff. No significant difference in FEV1 values was observed when compared in relation to the job experience and smoking habits of the study subjects. The mean PEFR values were significantly lower among the subjects aged 45 years or above. The difference was more prominent among the miners in comparison to the supervisory staff. Such a significant difference in PEFR values was not observed when compared between higher and lower job experience groups. No significant difference was observed when compared to the smoking habits of the subjects [Table 2].

A total of 30 personal samplers were placed in three different working areas of the open-cast mine. Concentrations (mean ± SD) of respirable dust in the mining section were 3.8 ± 1.1 mg/m^3, 2.5 ± 0.21 mg/m^3 in the crusher section, and 2.0 ± 0.4 mg/m^3 in the loading section. The levels were found to be relatively higher in the mining section than in the other process units [Table 3].

DISCUSSION

The most common symptom complained about by study subjects in this present study was musculoskeletal pain (16.8%). A report published by Sharma *et al*. indicated the prevalence of musculoskeletal disorders among general people to be 7.08% in Delhi, 9.53% in Jodhpur, and 11.52% in Dibrugarh.[19]

Among the miners, the higher prevalence may be due to workload. Other complaints were cough, difficulty in breathing, chest pain, and soreness of mouth. Some subjects also experienced headaches, sleep disturbances, weakness, and tremors in their fingers. Among the miners, 6.4% were hypertensive in our study, which is almost similar to the findings of the study conducted by Rajashekar *et al*., where 6.38% of the miners were hypertensive.[19] As far as the pulmonary function status of the study subjects is concerned, about 7% of subjects had the restrictive type of abnormality (FVC/PFVC <80%) in our study. Obstructive type of abnormality was also present in a similar number of subjects. A good number of subjects (17.6%) had FEV$_{1\%}$ values between 70% and 80%.

The mean FVC values were significantly lower among the subjects aged 45 years or above. Such a significant difference in FVC values was not observed when compared between higher and lower job experience, but a significant difference was observed when compared to the smoking habit of the subjects. This result is similar to the findings of two other studies carried out in Southern India[20] and Western part of India.[21] Similar trend was not observed in the case of FEV1 values. The mean PEFR values were significantly lower among the subjects aged 45 years or above. Such a significant difference in PEFR values was not observed when compared between higher and lower job experience groups. In this respect, our study results are in contrast with the findings of Gupta *et al*.,[22] which showed a reduction in PEFR due to dust exposure.

CONCLUSION

Our study depicts the working conditions and morbidities of workers working in surface mining operations. On the basis of the findings, considering the environmental and occupational hazards involved, our study recommends regular and periodic

Table 2: FVC, FEV$_1$, and PEFR according to study variables among study participants.

Study variables	FVC (L)			FEV$_1$ (L)			PEFR (L/min)		
	Allied workers	Miners	Total	Allied workers	Miners	Total	Allied workers	Miners	Total
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Age group (in years)									
<45	3.72±0.56	3.6±0.55	3.64±0.56	3.13±0.46	3.06±0.46	3.09±0.46	490±58.33	486±57.36	487±57.61
≥45	3.11±0.09	3.28±0.48	3.24±0.43	2.56±0. 42	2.84±0.51	2.81±0.48	420±56.57	445±50.43	440±49.44
Students *t*-test (*P*-value)	2.34 (0.13)	2.61 (0.11)	4.89 (0.03)	1.47 (0.23)	1.51 (0.22)	2.77 (0.09)	2.84 (0.09)	3.87 (0.05)	6.52 (0.01)
Duration of exposure (years)									
<5	3.66±0.53	3.61±0.61	3.63±0.58	3.09±0.45	3.03±0.49	3.06±0.47	491±56.95	485±49.45	487±52.62
≥5	3.85±0.68	3.55±0.48	3.60±0.53	3.25±0.53	3.08±0.44	3.11±0.46	479±67.05	483±65.94	482±65.80
Students *t*-test (*P*-value)	1.49 (0.23)	0.61 (0.44)	0.21 (0.65)	1.49 (0.23)	0.45 (0.51)	0.77 (0.38)	0.59 (0.45)	0.04 (0.85)	0.47 (0.49)
Smoking habit									
Current smoker	3.61±0.49	3.56±0.55	3.58±0.53	3.07±0.46	3.04±0.46	3.05±0.46	485±62.15	487±60.22	486±60.72
Never smoker	4.04±0.69	3.64±0.57	3.75±0.63	3.33±0.46	3.10±0.49	3.16±0.49	502±44.19	476±49.10	483±48.84
Students *t*-test (*P*-value)	8.28 (0.005)	0.68 (0.412)	4.7 (0.04)	4.11 (0.05)	0.44 (0.46)	2.70 (0.10)	1.06 (0.31)	1.11 (0.29)	0.12 (0.73)

FVC: Forced vital capacity, FEV$_1$: Forced expiratory volume in the first second, PEER: Peak expiratory flow rate, SD: Standard deviation

Table 3: Respirable dust concentrations (mg/m^3) at different sections of coal mining area.

Section	No.	Range	Mean±SD	Median (IQR)
Mining	15	2.3–5.9	3.8±1.1	3.5 (3.14–4.04)
Crusher	8	2.1–2.7	2.5±0.21	2.5 (2.42–2.70)
Loading	7	1.7–2.8	2.0±0.4	1.9 (1.72–2.03)
Total	30	1.7–5.9	3.1±1.1	2.74 (2.33–3.48)

SD: Standard deviation, IQR: Interquartile range

monitoring of environmental conditions and the health status of the workers involved in all such activities.

Ethical approval

The research/study approved by the Institutional Review Board at ICMR-ROHC(E), number ROHC(E)/ETHIC/A/04 DATED 14.11.2019, dated 14/11/2019.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Finkelman RB. Modes of Occurrence of Environmentally-Sensitive Trace Elements in Coal. In: Swaine DJ, Goodarzi F, editors. Environmental Aspects of Trace Elements. Boston: Kluwer Academic Publishers; 1995. p. 24-50.
2. Indian Bureau of Mines, Government of India. Coal and Lignite - Indian Minerals Year Book - 2011; 2012. Available from: https://ibm.gov.in/writereaddata/files/07092014130735IMYB-2012-Prelim_2012.pdf [Last accessed on 2013 Dec 26].
3. Castranova V, Vallyathan V. Silicosis and Coal Workers' Pneumoconiosis. Environ Health Perspect 2000;108(suppl 4):675-84.
4. Demchak J, Skousen J, McDonald LM. Longevity of Acid Discharges from Underground Mines Located Above the Regional Water Table. J Environ Qual 2004;33:656-68.
5. Attfield MD, Kuempel ED. Pneumoconiosis, Coalmine Dust and the PFR. Ann Occup Hyg 2003;47:525-9.
6. Ruckley VA, Gauld SJ, Chapman JS, Davis JM, Douglas AN, Fernie JM, *et al*. Emphysema and Dust Exposure in a Group of Coal Workers. Am Rev Respir Dis 1984;129:528-32.
7. Soutar CA, Hurley JF, Miller BG, Cowie HA, Buchanan D. Dust Concentrations and Respiratory Risks in Coalminers: Key Risk Estimates from the British Pneumoconiosis Field Research. Occup Environ Med 2004;61:477-81.
8. Rom WN. Basic Mechanisms Leading to Focal Emphysema in Coal Workers' Pneumoconiosis. Environ Res 1990;53:16-28.
9. Rom WN. Relationship of Inflammatory Cell Cytokines to Disease Severity in Individuals with Occupational Inorganic Dust Exposure. Am J Ind Med 1991;19:15-27.
10. Brown GM, Donaldson K. Inflammatory Responses in Lungs of Rats Inhaling Coalmine Dust: Enhanced Proteolysis of Fibronectin by Bronchoalveolar Leukocytes. Br J Ind Med 1989;46:866-72.
11. Weiner JS, Lourie JA. Practical Human Biology. New York: Academic Press; 1981.
12. Heyward VH, Stolarczyk LM. Applied Body Composition Assessment. London: Human Kinetic Publication; 1996.
13. Siri WE. The Gross Composition of the Body. In: Lawrence JH, Tobias CA, editors. Advances in Biological and Medical Physics. New York: Academic Press; 1956.
14. Durnin JV, Rahaman MM. The Assessment of the Amount of Fat in the Human Body from Measurements of Skinfold Thickness. Br J Nutr 1967;21:681-9.
15. WHO. Physical Status: The Use and Interpretation of Anthropometry. World Health Organization Technical Report Series No. 854. Geneva: WHO; 1995.
16. Chattopadhayay BP, Alam J. Spirometric Function of Ventilatory Function of Non-smokers and Different Graded of Smokers of Calcutta. Ind J Environ Protec 1996;14:274-9.
17. Chatterjee S, Saha D, Chatterjee BP. Pulmonary Function Studies in Healthy Non-smoking Men of Calcutta. Ann Human Biol 1988;15:365-79.
18. Saha I, Paul B, Dey TK. An Epidemiological Study of Smoking among Adult Males in a Rural Area of Hooghly District, West Bengal, India. J Smok Cessat 2008;3:47-9.
19. Rajashekar S, Sharma P. Morbidity among Mine Workers: A Cross Sectional Study in Chitradurga, Karnataka, India. Int J Community Med Public Health 2017;4:378-84.
20. Mistry A, Tyagi R, Kagathara J, Vaidya L, Dholakiya U, Shah C. Comparative Study of Pulmonary Function Tests in Smokers and Non-Smokers. GCSMC J Med Sci 2014;3:22-7.
21. Malathi MR, Rajkumar D, Desigan GE, Balumahendran K. A Study of Pulmonary Function Tests among Smokers in Rural Areas. IOSR J Dent Med Sci 2017;16:76-9.
22. Gupta P, Chaswal M, Saxena S. Ventilatory Functions in Stone Quarry Workers of Rajasthan. Indian J Physiol Pharmacol 1999;43:496-500.

How to cite this article: Saha A, Sen S, Bhowmik K, Das A, Mahankuda J, Dasgupta TK. Health Status of the Coal Mine Workers in an Open-cast Mine of Eastern India. J Compr Health. 2024;12:34-8. doi: 10.25259/JCH_1_20234