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ORIGINAL ARTICLE

A COMPARATIVE STUDY OF MORBID CONDITIONS AMONGST OPENCAST AND UNDERGROUND COAL MINERS

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ABSTRACT: OBJECTIVE: To study prevalence and pattern of morbid conditions and to compare these amongst opencast and underground coal miners. **METHODS:** A cross sectional study was carried out at one of the coal mines having both opencast and underground mines in central India. By systemic stratified random sampling, 204 study subjects each from opencast and underground mines were selected. **RESULTS:** Prevalence of morbid conditions was found significantly ($p < 0.05$) more in underground miners (65.7%) as compared to opencast miners (54.4%). A significant linear trend was observed between length of service and prevalent morbid conditions in both the groups ($p<0.001$). Prevalence of morbidities was significantly ($p<0.001$) more in underground miners as compared to opencast miners, especially chronic respiratory morbid conditions (21.6% versus 7.8%) and musculoskeletal conditions (28.9% versus 12.2%). Mean values of forced vital capacity and forced expiratory volume of underground miners were significantly ($p<0.001$) lower than in opencast miners (FVC 2.80 ± 0.55 liters versus 2.98 ±0.53 liters; FEV 2.9 ±0.21 liters versus 3.01 ±0.36 liters). Multivariate analysis revealed significant role of miner's age, place of work, past history of underground mining exposure, length of service and smoking habit in reduction of FVC and FEV. **CONCLUSION:** Underground miners carry more risk of developing morbidities. Chronic respiratory diseases, musculoskeletal problems, skin diseases and backache are more prevalent in underground miners than in opencast miners. Miner's age, place of work, past history of underground mining exposure, length of service and smoking habit significantly affect FVC and FEV.

KEYWORDS: Coal miners, opencast and underground mines, musculoskeletal conditions.

INTRODUCTION: Coal is primarily used as a solid fuel to produce electricity and heat through combustion. World coal consumption was about 6.75 billion short tons in 2006[1] and is expected to increase 48% to 9.98 billion short tons by 2030.[2]

India is currently the third largest hard coal producer in the world after China and USA.[3] Coal supply constitutes nearly 53% of India's primary energy consumption.[4]

Earlier pattern of morbidities was largely occupied by respiratory morbidity but advances in technology resulted in improvement of the working conditions. Previously known morbidities are on decreasing trend but now other morbidities like skin infections, locomotor problems are on the increase.

Limited medical literature is available regarding morbidities among coal miners other than respiratory morbidities. Against this background, the current study was undertaken to compare prevalent morbid conditions amongst underground and opencast coalminers.

MATERIALS AND METHODS: A cross sectional study was carried out at one of the coal mines in central India. This colliery was selected on the grounds of operational feasibility and also because it has both the underground and opencast mines.

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Only those workers who were engaged in coal extraction process were recruited and other administrative staff was excluded from the study. Stratified random sampling technique was used to proportionately include different categories of workers like loaders, khalasi and drillers. A sample size of 204 subjects in each group was considered sufficient to estimate a difference in prevalence of morbidities in two groups with a relative precision of 10% with a 95% confidence interval.

Detailed history of subjects was recorded in a pretested proforma followed by a thorough clinical examination. Student's 't' test was used to compare the means of two independent groups of underground and opencast coal miners. Chi-square tests and multiple logistic regression analyses were performed to study associations between categorical out come and a set of independent predictor variables by STATA (version 10,2009) software.

RESULTS: Mean (±SD) age of the study subjects in underground mine was 46.7 (± 2.4) years as compared to 46.9 (± 1.9) years in open cast mine workers. Eighty three (40.7%) study subjects in the underground mine and 65 (31.9%) study subjects in opencast mine were in the age group of 45–49 years. Out of 204 subjects in underground mine, 132 (64.7%) study subjects were tobacco chewers and 69 (33.8%) were smokers. Among the opencast mines, 147 (72.1%) study subjects were tobacco chewers and 78 (38.2%) were smokers. In underground mine 116 (56.9%) subjects had length of service more than 20 years as compared to 79 (38.7%) subjects from open cast mine.

Out of 204 study subjects in each group, 134 (65.7%) study subjects of underground mine and 111 (54.4%) study subjects of opencast mine had one or morbidity (Table 1). The association of working in underground mine and morbidity was found to be statistically significant {$\chi^2 = 5.40$, df = 1, $P < 0.05$, OR = 1.6, 95% CI (1.05 – 2.44)}. Mean numbers of morbid conditions per study subject was found to be 1.98 ± 0.73 for underground miners versus 1.60 ± 0.53 for open cast miners (Fig 1).
Out of 116 underground workers who had morbidities, 89 (76.72%) subjects had put up more than 20 years of length of service whereas 43 (54.4%) out of 79 open cast mine subjects belonged to this category (Table 2).This difference was found to be statistically significant ($p<0.001$). Further, the risk of suffering from morbid conditions increased significantly with increase in length of service in both underground ($p<0.001$) and opencast ($p<0.001$) study subjects.

A total number of 44 (21.56%) chronic respiratory morbid conditions were found in underground study subjects as against 16 (7.84%) in open cast study subjects and these percentages differed significantly ($P<0.001$) across the groups. When the prevalence of chronic musculoskeletal conditions in underground study subjects (28.92%) was compared to open cast study subjects (12.25%), it was found to be highly significant ($p<0.001$). Although prevalence of skin morbidities in underground study subjects (9.8%) was higher compared to opencast mine subjects (5.9%), the difference was not found statistically significant (Table 3).

Twenty five (56.9%) study subjects from underground mine and five (31.25%) study subjects from opencast mine in whom respiratory morbid conditions were present have had length of service more than 20 years (Table 4).

Mean value of forced vital capacity in underground study subjects was 2.80 ± 0.55(liters) as compared to 2.98 ± 0.53(liters) in opencast study subject and this difference found to be significant ($p<0.001$). Significant differences ($p<0.001$) were also observed in mean forced expiratory volume (25%-75%) 2.90 ± 0.21(liters) in underground mine study subjects versus 3.01 ± 0.36 (liters) of opencast mine study subjects (Table 5).

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Multiple logistic regression analysis was used to estimate independent and joint effects of several factors like age, sex, place of origin, place of work, smoking habit, length of exposure, respiratory infection etc. on Forced Vital Capacity and Force Expiratory Volume with the help of a mathematical model. Those variables found significantly contributing in the full model were later selected for the final reduced model and adjusted risk was estimates were obtained.

Subject's age, place of work, past history of underground work, smoking habit and length of exposure had significant effect on forced vital capacity outcome independently. Similarly subject's workplace, past history of underground mine, smoking habit and length of service (exposure) were found to have significant effect on the outcome of FVC & FEV in combination (Tables 6 & 7).

DISCUSSION: In the present study it was observed that loco motor disorder and skin disorder were commonly prevalent in the underground and opencast miners.

A significant dose and duration response type of association was found between presence of morbidities and length of service, with miners' risk of having morbidities increasing with duration of services. Similar findings were reported by Camels P et al (1998) [5]. They found significant relation between the evaluation of occupational strain and functional independence, locomotion impairment of the low back and the length of time spent working at the coal face. Zagorski J, Swiadro J (1979)[6], have observed that the morbidity among underground workers with considerably loaded spine is 1/3 higher and they begin to complain about it 5 years earlier than surface workers.

In the present study the prevalence of backache was found to be 23.03% in underground study subjects and 7.35% in opencast study subjects. Our findings are somewhat similar to Chauhan (1987)[7] who reported a 19.71% prevalence of backache in underground miners and 17.2% in open cast miners.

The present study revealed a prevalence of mild anemia to the tune of 38.23% in underground study subjects and 31.27% in opencast study subjects. Golay MS also reported 42% prevalent of anemia in undergroung coal miners.[8] Guha et al (1971)[9] investigated abnormal hemoglobin in coal miners and their families and observed decreased hemoglobin level as compared to standard values.

Fishers SW (1944)[10] studied 759921 coalmine workers and found 0.04% prevalence of dermatitis. Carta P et al (1996)[11] studied role of dust exposure on incidence of respiratory symptoms and decline of lung function in young coal miners In logistic models, dust exposure was significant predictor of the onset of respiratory symptoms and decline in lung function. Also Jain B.L. (1981)[12] reported that coalface work is associated with 8% impairment of maximum expiratory airflow, probably due to dust exposure.

Multivariate analyses in the present study also revealed that smoking habit, place of work, duration of underground work and length of service were the strong predictors of decreased lung function among the coal miners.

CONCLUSIONS: Backache was more prevalent in the study subjects of underground mine as compare to those of opencast mine. Respiratory problems were also more common in underground miners as compared to opencast miners. Morbidity status was found to be independently associated their duration of service. Forced vital capacity and forced expiratory volume among the coal miners were found to be jointly affected by age, work place, past history of underground mine, smoking habit and length of service.

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Study subjects by category	Morbidity present		Morbidity absent		Total
	Number	Percent	Number	Percent	
Underground mine	134	65.6	70	34.4	204
Opencast mine	111	54.4	93	45.6	204

Table 1: Distribution of study subjects by their morbidity status

Length of service (Years)	Study subjects in Underground mine		Study subjects in opencast mine	
	Sample number	Morbid study subject (Percentage)	Sample number	Morbid study subject (Percentage)
5-10	08	1(12.5)	06	3(50)
11-15	12	6(50)	44	29(65.9)
16-20	68	38(55.9)	75	36(48)
> 20	116	89(76.72)	79	43(54.43)
Total	**204**	**134(65.7)**	**204**	**111(54.4)**

Table 2: Relationship between morbidity & length of service of study subjects in underground and opencast mine

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Morbid conditions	Study subjects in Underground mine (n=204)		Study subjects in Opencast mine (n=204)		OR	95% CI	Chi square	p value
	Number	percentage	Number	percentage				
Chronic respiratory conditions	44	21.56	16	7.84	3.23	1.69-6.23	15.23	0.001
Musculoskeletal condition	59	28.92	25	12.55	2.91	1.69-5.05	19.33	0.001
Skin condition	20	5.8	12	5.88	1.74	0.78-8.91	2.17	0.14

Table 3: Frequency distribution of chronic morbid conditions in study subjects in underground and opencast mine

Length of service in years	Study subjects in Underground mine		Study subjects in Opencast mine	
	Numbers	Percentage	Number	Percentage
5-10	00	00	01	6.2
11-15	02	4.5	03	18.8
16-20	17	38.6	07	43.8
> 20	25	56.9	05	31.22
Total	**44**	**100.00**	**16**	**100.00**

Table 4: Distribution of respiratory morbidities as per length of service of study subjects

Parameter		Study subjects in Underground mine (n=204)	Study subjects in opencast mine(n=204)	p value
FVC	Mean	2.80	2.98	0.001
	SD	0.55	0.53	
FEV	Mean	2.90	3.01	0.001
	SD	0.21	0.36	

Table 5: Comparison of Forced vital capacity (FVC) and Forced expiratory volume (FEV)in study subjects in underground and opencast mines

Variables	Odds ratio	95% Confidence. Interval	P value
Age	1.59	1.24 - 2.03	0.001
Work place	3.93	2.16 - 7.15	0.001
Past history of underground work	7.92	2.61 - 23.99	0.001
Smoking Habit	17.67	9.41 - 33.18	0.001
Length of service	1.82	1.32 - 2.52	0.001

Table 6: Results of Multiple logistic regression analysis(Final Model) for FVC

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Variables	Odds ratio	95% Confidence interval	P value
Work place	3.92	2.35 -6.52	0.001
Past history of underground work	3.92	1.50 - 10.23	0.005
Smoking Habit	6.37	3.85 -10.54	0.001
Length of service	1.82	1.38 - 2.40	0.001

Table 7: Results of Multiple logistic regression analysis (Final Model) for FEV

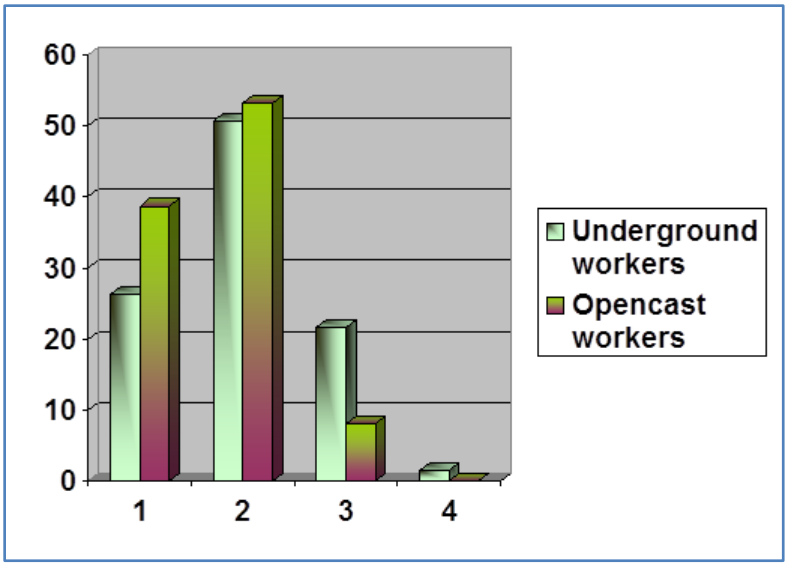

Figure 1: Frequency distribution of morbid conditions in study subjects

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