Epidemiological Evaluation of Temporal Disparity in Pulmonary Functions amongst Coke Oven Employees in Bokaro Steel Plant

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ABSTRACT

Chronic exposure to high concentration of coal dust, in acute hot and humid working environment at Coke Oven (CO) Battery in Bokaro Steel Plant leads to significant temporal changes in pulmonary functions amongst the employees. Periodic health check-up (PHC) records of majority of the employees, clearly indicates the causal relationship of temporal reduction in all parameters of Spirometry specifically in FVC, FEV_1, PEF, $FEF_{25-75\%}$ and FMFT. On the contrary, in spite of working in the same environment over a period of time, a significant number of Coke Oven workers' pulmonary records indicate 'No' or negligible changes ($p<0.01$). To understand such disparity, a planned study was designed.

Initially, 634 Coke Oven employees' pulmonary data were retrieved based on their presence in the master roll both in 1992 and 2012. Considering FVC as a key indicator of dust related dysfunction, 20 lowest FVC% (Group -I) as well as 20 highest FVC% (Group 2) data were selected from the retrieved data. The mean age (years), height (centimeters) and BMI (kg/m^2) of Group -I were correlated with Group .2 and no significant difference were observed between the two groups ($p> 0.1$). Surprisingly, high significant differences were observed both in FVC% [(56.4±7.91 in Gr.1) and (97.3±4.81 in Gr.2)] & FEV1% [(48.35±13.20 in Gr.1) and (95.25± 4.34 in Gr.2)] between the two groups ($p<0.001$) in spite of their same occupational exposure to dust & smokes. No significant associations were observed between temporal disparity in PFT and alcoholism, nutritional status and other socio-cultural parameters.

Till date, author does not have any logical explanation regarding temporal irreversibility of pulmonary functions amongst a significant group of employees, who are equally exposed to severe dust hazards over a specific time period. Individual susceptibility or personal body resistance in a normally distributed population may not be simple answer of such differences. Advanced physiological research in this respect may open up new vistas in occupational health scenario in future.

Key words: Pulmonary Function, Temporal irreversibility, Coke Oven, Steel Plant

INTRODUCTION

Bokaro Steel Plant (BSL), a large integrated steel industry with capacity to produce five million tons of steel, has eight large Coke Oven (CO) Batteries with 552 ovens, producing approximately 13 tons of coke daily after charging 22 tons of coal per oven. Coke is used in Blast Furnace (BF) both as a reducing agent and as a source of thermal energy. It involves reduction of ore to liquid metal in the blast furnace and refining in converter to form steel. When coal is heated at 1,000°C to 1,400°C in absence of air, a series of physical and chemical changes take place with the evolution of gases and vapours. While tars and light oils like

benzene, xylene, toluene, and solvent naphthas are distilled out at Bye Product Plant (BPP), the solid residue left behind is the ultimate coke. The CO emissions are therefore complex mixtures of dusts, vapors, and gases that typically include polycyclic aromatic hydrocarbons (PAHs), formaldehyde, acrolein, aliphatic aldehydes, ammonia, carbon monoxide, nitrogen oxides, phenol, cadmium, arsenic, mercury and other potent pollutants which have already been identified by several researchers as potential occupational health hazards at CO & BPP [1, 2]. Nearly two thousand employees are exposed to such hazardous work environment during several moderate to heavy operations at BSL. For obvious reasons, all the employees of CO & BPP are evaluated medically once in a year to study the effects of various pollutants on employees' health and efficiency. Detailed pulmonary evaluation (Spirometry) is the prime test for Periodic health check-up (PHC) which is also a statutory requirement as per Indian Factory Act. PHC records of majority of the employees clearly indicate temporal reduction in all parameters of Spirometry specifically in Forced Vital Capacity (FVC), Forced expiratory volume in one second (FEV_1), Peak expiratory flow (PEF), Forced expiratory flow in 25 -75% ($FEF_{25-75\%}$) and Forced mid flow time (FMFT)[3, 4]. On the contrary, it has been noticed that in spite of working in the same environment over a period of time, a significant number of Coke Oven workers' pulmonary records indicate 'No' or negligible changes ($p<0.01$). Such disparity can initiate a debate on absolute causal relationship between pulmonary dysfunction and exposure to coke oven pollutants over a period of time. A systemic planned research study regarding the root cause of such disparity can open new vistas in the area of preventive pulmonary physiology, benefits of which can be measured in terms of health and wellbeing of coke oven employees.

METHOD

Out of 2525 Coke Oven employees' temporal data of pulmonary functions, data of 634 employees were retrieved based on their presence in the master roll both in 1992 and 2012. Out of 634, based on the following criteria 122 employees' pulmonary data were screened out:

- Non-smoker and Non-alcoholic
- No history of Cardio-pulmonary disorders before joining
- No parental history of lung disorders
- Not doing any form of physical exercise
- Residing only at Company's accommodation

Considering FVC as a key indicator of dust related dysfunction[4], 20 lowest FVC% (Group - I) as well as 20 highest FVC% (Group- II) data were selected from the retrieved data. The mean age (years), height (centimeters) and BMI (kg/m^2) of Group - I was correlated with Group - II. Pulmonary data in percent for Forced Vital Capacity (FVC), Forced expiratory volume in one second (FEV_1), Peak expiratory flow (PEF), Forced expiratory flow in 25 -

75% ($FEF_{25-75\%}$) and Forced mid flow time (FMFT), Nutritional Status, Racial variation and Dust mask usage for both the group were statistically correlated.

RESULTS

Table 1: Physical Parameters for both the group (mean & SD)

Group	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)
I	53.6±6.32	164.75±4.41	65.35±10.56	22.99±2.94
II	54.9±5.32	164.25±4.62	66.15±11.76	23.24±2.68
Difference	p>0.10	p>0.10	p>0.10	p>0.10

Table 2: Pulmonary Functions for both the group (mean & SD)

Group	FVC%	FEV_1 %	PEF%	FEF_{25-75}%	FMFT%
I	56.4 ±7.91	48.35±13.20	59.65±13.99	66.32±11.23	44.73±12.44
II	97.30±4.81	95.25±4.34	90.25±13.51	78.57±10.70	93.46±13.62
Difference	P<0.001	P<0.001	P<0.001	P<0.01	P<0.001

Table 3: Dust mask usage for both the group

Group	Regular user (%)	Occasional user (%)	Rare user (%)
I	55.00	30.00	15.00
II	65.00	25.00	10.00

DICUSSIONS

Table 1 depicted that there is no significant age difference between the two groups along with their physical parameters like height, weight and BMI. It is evident that any differences in observed pulmonary functions between the two groups is not influenced due to their age or any physical parameters likely to influence pulmonary functions amongst CO employees[5].

Previous studies indicate that addictions like smoking and alcohol, past history of cardio-pulmonary disorders, parental history of lung disorders, exercise and yoga and quality of civic life have significant effect on lung kinetics as well as on pulmonary function parameters for coke oven workers [2, 5, 6]. To avoid the effect of all such factors on present research, care has been taken before selecting the groups so that any differences in observed pulmonary functions between the two groups is not influenced by those factors.

As previous studies interpreted that dynamics of pulmonary function amongst steel workers significantly varies with proper implementation of industrial hygiene programme as well as efficient use of personal protective equipment at work [7], present study cross matched dust mask usage for both the groups (Table 3). No significant difference in using dust mask between the groups has been observed. This observation clearly indicates that any differences in observed pulmonary functions between the two groups are not influenced by their usage pattern of dust mask at work.

Available research findings clearly indicate that Coke oven employees are at an increased risk of impaired lung function from chronic exposure to several pollutants [8, 9]. A significant decline

in lung function, consistent with slight airway obstruction, has been reported in CO workers. Exposure to dusts in CO workers has also been strongly associated with reductions in forced vital capacity (FVC), FEV_1, and FEV_1/FVC%. Significant decreases in FEV_1 and FVC have been associated with increases in occupational exposures to gases and fumes [9]. Combined occupational exposures to dusts, gases and fumes have been reported to reduce peak expiratory flow rate (PEF)[9]. Studies also indicate that temporal decrease in forced mid flow time (FMFT) amongst CO employees has strong association with chronic obstructive pulmonary disease (COPD) [8]. The reports of previous studies therefore highlight the causal relationship of changed FVC, FEV_1, $FEF_{25-75\%}$, FMFT and PEF with temporal exposure of CO pollutants in Steel industry [10]. In present study, the pulmonary functions for Group I in Table–2 supports the previous studies on causal relationship with temporal decrease of all the above parameters with increasing risk of chronic airflow limitations [11] even after twenty years of working at Coke Oven [12]. On the contrary It is evident from the table–2 that the pulmonary functions for Group II are significantly differ from Group I with little or negligible changes over a period of twenty years of working in the same environment where group I works. It is interesting to note that after twenty years of exposure of pollutants, the mean FVC%, FEV_1% and PEF% are more than 90% of normal average in Group II. It clearly indicates that some important physical or physiological safety factors are responsible in preventing decrease of pulmonary function amongst a significant number of CO employees in spite of their occupational exposure of several CO pollutants. A well executed occupational hygiene programme along with proper use of dust mask may be the additional but not the absolute factor for controlling pulmonary disorder amongst CO employees.

Analysis of detailed biochemical, hormonal, genetic and other advanced physiological factors for both the group are beyond the scope of present research in an industrial setup. The author believes that there must be some hidden physiological factor(s) which help in preventing pulmonary dysfunctions amongst a significant numbers of CO employees whose age, body composition, socio-economic status, dietary habit, addictions, life style, dust mask usage, type of occupation and period of exposure to CO pollutants are not different from those employees whose pulmonary functions decrease significantly over a period of time.

CONCLUSION

The above results and discussion therefore indicates the followings:

i) Pulmonary functions of several Coke Oven employees do not change significantly over a period of twenty years.

ii) Level and period for occupational exposure of pollutants are not the absolute factors for pulmonary dysfunction for those employees in Coke Oven.

iii) Age, body composition, socio-economic status, dietary habit, addictions and life style status have little contribution in changing pulmonary functions amongst those employees whose pulmonary status remained significantly unaltered after a period of time in CO.

iv) Well executed occupational hygiene programme along with proper use of dust mask may not the absolute factors for controlling pulmonary disorder amongst CO employees.

v) Individual susceptibility or personal body resistance in a normally distributed population may not be simple answer for identifying the key factors.

vi) There must be some hidden physiological factors which help in preventing pulmonary dysfunctions amongst a significant numbers of CO employees

vii) Analysis of detailed biochemical, hormonal, genetic and other advanced physiological factors may identify the hidden factor for unaltered pulmonary status in any polluted environment.

viii) Advanced physiological research in this respect may open up new vistas in occupational health scenario in future.

REFERENCES

1. Lebowitz MD (1981). Epidemiological recognition of occupational pulmonary diseases. Clin Chest Med, **2:** 305-316.
2. Wang ML, McCabe L, Hankison JL, et al. (1996). Longitudinal and cross-sectional analyses of lung function in steelworkers. Am J Respir Crit Care Med, **153:**1907-1913.
3. Nemery B, Van Leemputten R, Goemaere E, et al. (1985). Lung function measurements over 21 days shift work in steelworkers from a sand casting department. Br J Ind Med, **42 :** 601-611.
4. Sobaszek A, Edme JL, et al. (1998). Respiratory symptoms and pulmonary function among stainless steel welders. J Occup Environ Med , **40:** 223-229.
5. Pham QT, Mastrangelo G, Chau N, et al.(1979). Five year longitudinal comparison of respiratory symptoms and function in steelworkers and unexposed workers. Bulletin, Europeen de Physiopathologie Respiratoire, **15 :**469-480.
6. Gomes.J, et al. (2001). Dust exposure and impairment of lung function at a small iron foundry in a rapidly developing country. Occ Env Med, **58:**656- 662.
7. Christensen et al. (2008). A prospective study of decline in lung function in relation to welding emissions. J Occup. Medicine and Toxicology, **3:**63-6.
8. Boschetto P, Quintavalle S, et al. (2006). Chronic obstructive pulmonary disease (COPD) and occupational exposures. J Occup Med Toxicology, **1:**11.:11
9. Xu X, Christiani DC, Dockery DW, et.al. (1992). Exposure-response relations between occupational exposures and chronic respiratory illness: a community based study. Am Rev Respir Dis, **146:**413-418.
10. Armstrong BG, (1998). Effect of measurement error on epidemiological studies of environmental and occupational exposures. Occup Env Med, **55:**651-656.
11. Townsend M C, Eschenbacher, W. et al (2011). Spirometry in the Occupational Health Setting-2011:Update. J Occup Environ Med, **53:** 5: 569-584.
12. Post WK, Heederik D, Kromhout H, Kromhout D (1994). Occupational exposures estimated by a population specific job exposure matrix and 25 year incidence rate of chronic nonspecific lung disease (CNSLD): The Zutphen Study. Eur Respir J, **7:**1048-1055.