An Exploration of the Pulmonary Fitness of Construction Workers in Delhi NCR in the light of the BOCWA Act

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ABSTRACT

The construction sector is one of the most important sources of employment for labour in India. The workers in the construction sector are exposed to high concentrations of particulate matter at their place of work. This increases their susceptibility to various respiratory diseases, particularly Chronic Obstructive Pulmonary Distress (COPD) and Acute Respiratory Distress Syndrome (ARDS). This study is based on a sample of 30 migrant construction workers who have been in the construction labour force in the Delhi- National Capital Region for a minimum of three years. The study reports comparative pulmonary fitness and haematological parameters of the workers in the construction sector versus other sectors. The pulmonary function test parameters like FVC (forced vital capacity), FEV1 (forced expiratory volume in one sec), FEV1/FVC, and PEF (Peak Expiratory Flow) were performed in both test and control groups using a spirometer. Our results show that the pulmonary fitness indicators like FVC, FEV1 and PEF are significantly impaired in construction workers as compared to those of the control group. Based on Independent t-test using SPSS Statistics, we observed significant differences (p< 0.05) in FEV1 and FVC between both groups. The study thus confirms that labourers exposed to poor air quality at the construction site are susceptible to respiratory diseases, particularly ARDS. All of this reflects the poor enforcement of the adequate safety measures well enlisted in social legislations like the BOCWA (Building and Other Construction Workers Act).

Key Words: ARDS, BOCWA, FEV1/FVC, migrant construction labour.

INTRODUCTION

With the second largest labour force in the world, a larger share of the employment in India is in the unorganised sector. As per the estimates of the Periodic Labour Force Survey of 2017-18, of the total employment of 471.3 million, 380.7 million (i.e., 80.8%) work in the unorganised sector 1. On the basis of the various rounds of National Sample Survey Reports on Employment and Unemployment, it is estimated that construction accounts for the next important avenue of employment other than agriculture and trade, hotels etc. Of the total employment of 471.4 million, construction sector accounts for 49.9 million in 2011-12 2. Indeed, construction sector accounts for a large source of employment for labour in the unorganised sector in India.

The construction industry is one of the trades in which exposure levels of air pollutants still frequently exceed the occupational exposure limit norms 3. The
pollution level, particularly due to particulate matter in the working environment, is an important factor that can affect respiratory health among workers. Construction activities generate high concentration of various types and sizes of dust particles and these can lead to significant respiratory distress. Fine dust particles of cement, sand, silica and asbestos initially cause mucous hypersecretion, lung irritation and trigger an inflammatory reaction. Healing of this inflammation causes fibrosis that can lead to defective oxygen diffusion and impaired lung function\(^4\), consequently leading to chronic obstructive lung disease, restrictive lung disease and an increased susceptibility to respiratory infections. It is estimated that 42\% of Chronic Obstructive Pulmonary Disease (COPD) and a gradual loss of lung function is attributable to environmental risk factors such as occupational exposures to dust, chemicals and particulate matter\(^5\).

Also, a cross sectional study among workers with 16-20 years of exposure to construction based pollutants in Gujarat, India the prevalence of respiratory symptoms was found to be high with 60\% having attacks of wheezing, 50\% workers complaining of cough, 45.1\% complaining of phlegm and 40\% having shortness of breath. Similarly, poor respiratory health has been reported in another study in southern India\(^6\).

Given the exposure of construction workers to various airborne particulate matter and their health being deleteriously affected by the same, there have been labour legislations in this regard in India. There are regulations for all workers on wages and payments, on conditions of work and safety and on social security. An important lacuna in the Indian labour regulatory regime is that not all workers are covered by these regulations\(^7\). The regulations by definition cover only certain enterprises in certain locations and with a minimum threshold in terms of number of workers. Thus, a large part of the informal sector with small enterprises is beyond the labour regulatory framework. In addition to regulations across industry and given the limited coverage of these, certain special industry specific worker protection legislations have been enacted in India. One such law is the Building and Other Construction workers Act, 1996 (BOCWA). The BOCWA is specifically designed and aimed at protecting workers in the construction sector who are largely migrants from across the country. Based on the Act, a small surcharge of 1\% has been levied on the value of new construction with which a corpus has been created with intent of providing for the welfare of the workers in the sector. There have been efforts from the part of the governments and trade unions to enlist the workers in the construction sector in the BOCWA, though yet all workers in the sector are not registered. The Act specifically emphasises that the employer provides for protective devices such as close fitting body-ware, goggles, helmets, shoes, gloves and respiratory mask\(^8\). Despite the insistence of the Act on these lines, the workers have extremely low levels of protection, exposing them to pulmonary vulnerabilities and disorders, adding to the larger global disease burden.

According to the World Health Organization, nearly one-third of the world disease burden may be attributed to environmental risk factors. Among the diseases mediated through environmental risks, incidence of lower respiratory infection is the second largest\(^9\). Considering the proportion of construction labour force in India, their contribution to this larger disease burden cannot be ignored. Despite the importance and the rapid growth of construction industry in India, there are very few studies focusing on the pulmonary function status of the construction workers\(^10\).

This study was undertaken to ascertain a comparative analysis of the pulmonary fitness of the workers in the construction sector in comparison to their counterparts in other sectors. In urban areas like Delhi NCR, most of the construction labour force, who are exposed to
occupational air pollutants, are migrant workers who suffer not only from poor nutrition particularly with respect to the consumption of micronutrients, but also reside in ill-ventilated and crowded urban slums with poor sanitation conditions. Finally, lack of safety equipment amidst construction labour further compounds the problems faced by these migrant workers.

The results of this study provide strong evidence as to why it is all the more important for the employers to take preventive measures to maintain the health of their workers, as well as for the governments to design steps in such a manner that the same is enforced. Even when legislations are in place, which require the employers to provide for safety measures, this is found to be wanting. Periodic and regular testing among workers can help detect pulmonary distress in its earlier stages. If some corrective and preventive measures can be initiated at an early stage, this is sure to be beneficial.

**MATERIALS AND METHODS**

**Study design, study population**

The study was conducted in Delhi - NCR, India. A sample of construction workers in our study is drawn from the three urban clusters namely Rangpuri Pahadi, Bhavar Singh Camp and Kidwai Nagar Construction site. The respondents were screened using an elaborate questionnaire. Workers in the age group of 20 to 60 years, who were working in the sector for more than three years were included in the study. Workers having a history of respiratory symptoms or any known lung disease such as asthma, bronchitis, and tuberculosis were excluded from the study. The control group consists of age-matched normal healthy migrant workers employed in other work sectors. Thus, there are two groups of workers in the study: one consisting of the migrant construction workers exposed to occupational air pollutants (n=30), and, the other, migrant workers like indoor security and housekeeping staff whose exposure to similar pollutants is relatively low (n=16).

**Spirometry test:**

Lung function tests were performed using UNI-EM Spiromin 15.0.5 that measures the amount of air that we inhale and exhale and how quickly we exhale according to standard guidelines. Parameters such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), the percentage of FEV1 to FVC (FEV1/FVC), Peak Expiratory Flow Rate (PEFR) and Forced Expiratory Flow (FEF 25-75%) were all assessed using the spirometer. Before performing spirometry, the equipment was calibrated at the beginning of every session. Prior to the test, each participant was given a detailed briefing on lung function tests, this included instructions and a demonstration. Lung function tests were conducted on respondents who cleared the initial screening through a questionnaire after collection of a detailed health history and anthropometric data (height, weight and age). The motivation of the study and its usefulness was explained to each of the respondents participating in the tests prior to the start of the tests and a written consent was obtained. Spirometry was performed while the workers were in a seated position. The tests were repeated three times on each respondent and adequate rest was given between tests to obtain the best measurement. The software in this spirometer allows the calculation of the predicted values based on age, sex, weight and height of the respondent. There are three basic patterns to recognize: (i) Normal in which FEV1 and FVC are above 80% predicted and FEV1/FVC ratio is above 0.7, (ii) Obstructive disease wherein FEV1 is below 80% predicted, FVC can be normal or reduced - usually to a lesser degree than FEV1 and FEV1/FVC ratio is below 0.7 and (iii) Restrictive disease where FEV1 is normal or mildly reduced, FVC is below 80% predicted and FEV1/FVC ratio is above 0.7).
Anthropometric Analysis:
The height and weight of each participant worker was measured. This data was then used to calculate the BMI (Body Mass Index) of the individual.

\[
BMI = \frac{\text{Weight (in kg)}}{\text{Square of the Height in metres}}
\]

Mid Arm position was determined as half the length from shoulder joint to elbow. The mid arm circumference was measured by a standard measuring tape. The mid arm skin fold was measured using a standard skin fold calliper.

The mid arm circumference and triceps skin fold measurements were used to calculate the percentage body fat, MAMC (Mid Arm Muscle Circumference), MAA (Mid Arm Area) and MAFA (Mid Arm Fat Area) using the Heymsfield equation\(^\text{13}\).

Haematological Analysis:
About 5ml of blood samples were drawn from each respondent to performing Haematological analysis. One ml of blood was taken into a 1.5ml micro-centrifuge tube (MCT) and was centrifuged at 5000 rpm for 10 minutes. The pellet obtained gives the Packed Cell Volume (PCV) which is reported as heamatocrit percentage.0.5 ml of the blood was separated out into another MCT for RBC count and haemoglobin estimation. In a microcentrifuge tube, 5 µl of blood was mixed with 995 µl of RBC diluting fluid (1:200). The sample is loaded onto a haemocytometer and the RBCs are counted.

\[
\text{RBC Count} = \frac{\text{No of cells counted} \times \text{Dilution factor}}{\text{No of squares counted} \times \text{Volume of square}}
\]

Haemoglobin was estimated using the Drabkins’ method\(^\text{14}\); haemoglobin and all its derivatives present in whole blood convert to Methaemoglobin under an alkaline pH which reacts with Potassium Ferricyanide to give a red coloured compound (Cyanmethaemoglobin) which can be spectrophotometrically read at 540 nm. Haematological indices were calculated using the following formulae.

Mean Corpuscular Volume (MCV) = Haematocrit (%) x 10/ RBC count (femtoliters)

Mean corpuscular Haemoglobin (MCH) = Hb (g/L) x 10 / RBC count (picograms)

Mean Cell Haemoglobin concentration (MCHC) = Hb (g/L) x 100 / Haematocrit(%) (g/dl)

Statistical Analysis:
Independent t-test was used to compare the lung function parameters between the exposed and non-exposed group, with level of statistical significance set at p<0.05 for all comparisons. SPSS statistical software for Windows (Version 21.0; IBM Corp.; Armonk, NY, USA) was used as the analysis tool. The results are presented as mean ± SE and percentage difference. Unpaired t test was used for group-wise comparisons.

RESULTS AND DISCUSSION
All respondents involved in this study were given a consent form to express their willingness to partake in the study. Table 1 shows the anthropometric data of the workers included in this study. The mean age of workers at the construction site (test group) and control group was 37.7 years and 33.5 years respectively. Mean weight and height of construction workers were 57.97 kg and 163.37 cm respectively while for the control group they were 55.75 kg and 167.77 cm respectively.

The age, height, weight and smoking habits are the factors that contribute to respiratory health effects. The independent t-test done to compare between exposed group and non-exposed group of workers shows that there was no statistically significant difference of age, weight and height with p value more than 0.05. The mean for the smoking status of migrant construction labour (6/30) was similar to the
non-construction control group (3/16). Other anthropometric data like BMI, % body fat and Mean Arm Muscle Area (MAMA) also did not show any significant difference between the test and control groups. In other words, statistical comparisons of the matching variables (age, height and weight, BMI, % body Fat) show inherently similar values for the two groups and hence statistical confirmation of this fact is not discussed.

Studies have shown that BMI<18.5 kg/m² is associated with low dietary intake, and, therefore, has been accepted as the indicator for food insecurity. Other studies have also shown that an adequate BMI with average % fat (adult active Male 11-16% and females 14-18%) and LBM (Lean Body Mass) are indicative of no dietary calorie or protein deprivation. The anthropometric data in this study shows that both the groups under study have similar metabolic status and are not subject to deprivation in food and major calorie or protein intake.

Table 1: Anthropometric data of migrant construction labour and migrant labour of other sectors

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI</th>
<th>% fat</th>
<th>MAMA (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Mean ± S.E.(Test) (n=30)</td>
<td>163.38 ± 0.727</td>
<td>57.97 ± 2.075</td>
<td>21.41</td>
<td>16.34</td>
<td>51.64 ± 3.295</td>
</tr>
<tr>
<td>Sample Mean ± S.E.(Control)(n=16)</td>
<td>167.77 ± 0.827</td>
<td>55.75 ± 1.075</td>
<td>20.41</td>
<td>15.34</td>
<td>50.66 ± 2.95</td>
</tr>
</tbody>
</table>

Table 2 summarizes the comparison of lung function parameters in construction workers and their matched control group. Prolonged exposure to construction related air pollutants in the test group comprising of migrant construction labour showed a significant reduction in percent predicted values and mean values of FVC, FEV1, PEFR and FEF 25-75% when compared with their matched controls (p<0.01). However, these workers did not show a statistically significant reduction in FEV1/FVC relative to controls even though the actual values of FEV1 and FVC were lower. When interpreted according to the American Thoracic Society guidelines, the impairment in lung function recorded in migrant construction site workers can be described more as acute respiratory distress syndrome (ARDS), with a lower incidence of chronic obstructive pulmonary disease (COPD).

Table 2: Lung function data in migrant construction workers with exposure to pollutants(n=30) compared to the control groups(n=16). Unpaired test *(p<0.01)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FVC(L)</th>
<th>FEV1(L)</th>
<th>FEV1/FVC</th>
<th>FEF 25-75%</th>
<th>PEF(L/S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means±/ S.E.(Test)(n=30)</td>
<td>*2.15±0.145</td>
<td>*1.77±0.132</td>
<td>0.823</td>
<td>2.66±0.757</td>
<td>*4.62±0.298</td>
</tr>
<tr>
<td>Means±/ S.E.(Control)(n=16)</td>
<td>4.14±0.077</td>
<td>3.67±0.057</td>
<td>0.886</td>
<td>4.00±0.034</td>
<td>7.27±0.217</td>
</tr>
</tbody>
</table>

Haematological parameters were also assessed in the migrant construction workers. Table 3 summarizes the haematological indices like Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Volume (MCV) along with other parameters like total haemoglobin, total RBC count and haematocrit values. When compared to accepted reference values, all workers showed low haemoglobin values and the haematological indices which indicates that they suffered from hypochromic normocytic anaemia. Erythrocytosis and macrocytosis, both are shown to be triggered by hypoxemia, particularly in patients with respiratory dysfunctions like ARDS. In the current study however though the MCV levels do not indicate macrocytosis, the total RBC count is on the higher side of the
reference range. Hypoxia caused by impaired pulmonary function coupled with a possible iron deficiency due to poor nutrition could however account for the hypochromic but normocytic anaemia. Further in these individuals, hypoxemia and poor pulmonary function could precipitate severe health issues resulting in absenteeism from work causing loss of pay ultimately leading to poor food intake and micronutrient deficiencies.

Table 3: Haematological Indices of construction labour

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Blood Hb (g/dL)</th>
<th>Total RBC count (10^6 cell/cm³)</th>
<th>HCT/PCV (%)</th>
<th>MCV (fl)</th>
<th>MCH (pg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Range</td>
<td>Males: 13 - 17 g/dl; Females: 11.5 - 15.5</td>
<td>Males: (4.4 - 5.8)10^6 cells/cm³; Females: (3.8 - 5.2)10^6 cells/cm³</td>
<td>Males: 37 - 51%; Females: 35 - 46%</td>
<td>82.98 FL</td>
<td>27.33 pg</td>
</tr>
<tr>
<td>Mean +/- S.E. (Test)</td>
<td>11.89 +/- 0.789</td>
<td>5.75 +/- 0.546</td>
<td>44.607 +/- 2.001</td>
<td>91.434 +/- 8.908</td>
<td>22.872 +/- 1.701</td>
</tr>
</tbody>
</table>

CONCLUSION

This study explores the pulmonary fitness among construction workers in NCR region of Delhi. The sample of migrant workers surveyed in the construction sector show poor pulmonary fitness. About 60% show moderate obstruction and 20% show severe obstruction, while greater than 90% show decrease in FVC and FEV1 values indicating a high incidence of ARDS. Comparatively, the sample of migrant workers in the non-construction sector (control group) shows a better pulmonary fitness. It appears that exposure to specific construction related air pollutants like bitumen fumes, tar fumes, silica crystals and vehicular exhausts have severely compromised the pulmonary fitness of construction workers. Though the anthropometric data of the construction workers do no indicate calorie or protein deficiency, the haematological parameters indicate micronutrient deficiencies that could contribute to hypoxemia, which could further add to pulmonary dysfunction.

The hazardous working conditions of workers in the construction sector in our country need to be addressed. The pulmonary fitness among construction workers is far from desirable, despite benevolent social legislation in the form of the BOCWA Act which has been in place in India for some time now. Our study shows that regulation such as the BOCWA is ineffective is protecting the health of workers in the construction sector in Delhi. We suggest that the Act be followed both in letter and spirit. The government should initiate measures in consonance with the trade unions towards enlisting all workers in the construction sector under BOCWA. The funds which have accrued to the BOCWA bodies in different states, thanks to the boom in the construction sector in the first decade of the century and levy on the same, has to be judiciously used towards catering to the health care facilities of the labour. The body in co-ordination with civil society groups and trade unions should conscientize and enforce the employers to assure that the workers are provided with protective equipment and assured of safety measures at the workplace. This coupled with early detection of pulmonary dysfunctions among labour would through Employee State Insurance (ESI) hospitals would secure the Indian construction labour force and would go a long way in reducing our contribution to the global disease burden. Though there have been number of studies which highlight the plight of the construction workers in the light of the BOCWA, ours is possibly the first study of its kind which draws attention to the same in the light of the biochemical and physiological parameters.

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**REFERENCES**


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