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Original research article

A STUDY OF PULMONARY FUNCTION TEST IN WORKERS OF SUGAR FACTORY, PRAVARANAGAR, MAHARASHTRA

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ABSTRACT

Context: Repeated exposure to dusty environment in an industry causes airway diseases which may affect pulmonary function over a period of time. **Aims:** 1) To study the pulmonary function test parameters in workers of sub-departments in sugar factory 2) To find out the prevalence of Obstructive, Restrictive and Mixed type of pulmonary impairment and their correlation with duration of exposure to occupational environment. **Study Design:** An observational study was conducted on 294 permanent sugar factory workers at Urban Health Centre, Pravaranagar. **Materials and Method:** The pulmonary function viz. (FVC, FEV1, FEV1/FVC %, FEF25-75%) was recorded by a portable computerized RMS-Spirometer. Spirometric studies were performed in various sub-departments in sugar factory including 60 matching controls. To evaluate the effect of occupational exposure, the workers were divided into three categories i.e. those exposed for 11-20 yrs, 21-30 yrs and ≥ 31 yrs to the dust. **Results:** The overall prevalence of pulmonary impairment was found to be 31.97%. The highest prevalence was found in Bagasse workers (40.48%) followed by Manufacturing dept. (38.24%). Amongst the type of pulmonary impairment bronchial obstruction was predominant (18.03%). FEV1/FVC was found significant in Bagasse workers and Manufacturing dept. workers. Amongst the occupational exposure sub-groups, ≥ 31 yrs exposed workers were maximally affected by obstructive type (21.43%), Restrictive type (14.29%) & Mixed type (3.17%) of pulmonary impairment. **Conclusions:** The study demonstrated a significant association between pulmonary function abnormalities and certain sub-occupations in the sugar factory. The majority of the workers with pulmonary impairment had ≥ 31 yrs of occupational exposure.

Keywords: Pulmonary function test, Bagassosis, Pulmonary impairment, Spirometry

INTRODUCTION

Maharashtra is one of the largest sugar producers state in India. Sugarcane processing involves many workers in different sub-departments of sugar factory¹. "Bagassosis" is a respiratory disease caused by inhalation of bagasse dust, which is commonly described under the heading of

hypersensitivity pneumonitis² and is also known as a variant of farmers' lung^{3,4}. The organic dust contains high concentrations of bioaerosols, such as bacteria, actinomycetes, and fungi of plant and animal origin. The concentration and pathogenicity of these bioaerosols depend on source materials,

method of their storage, technology of processing materials and their disposal⁵. One such organic dust is Bagasse. Bagasse is a byproduct of sugar cane crushing, size range from 0.5–3 microns are called as respirable dust, to which sugar factory workers are exposed by virtue of their occupation⁶.⁷. Vishwanathan et al⁸ and Nair and Das⁹ from India in 1970 reported reduced FVC, TLC, PEF, and MVV in bagassosis patients. Since 1970 very few pulmonary function studies were reported in this field until recently in 2008 a study by Patil S N¹⁰ from western Maharashtra reported decrease in FVC, FEV1, PEF and MVV in occupationally exposed groups to bagasse as compared to non exposed group. However, this study was conducted during the operational period of a sugar factory. Pandit T and Singh A et al⁸ identified 93 fungal types from sugar factory which are responsible for respiratory symptoms and pulmonary abnormalities in workers. They observed 40% of the symptomatic workers reported improvement in their symptoms when away from work. Hence, the present study is conducted on workers during the non-operational period of a sugar factory.

MATERIALS & MEHTODS

This observational study was carried out in Padmshri Dr. Vitthalrao Vikhe Patil Sahkari Sakhar Karkhana, Pravaranagar, internationally renowned as the first in Asia, started on co-operative basis with the involvement of the local farmers, during the period from August 2011 to October 2011. The permission to carry out the study was sought from the management of Sugar factory, Pravaranagar and ethical clearance was obtained from the institutional ethical committee of Pravara Institute of Medical Sciences (Deemed University) before the commencement of the study. Informed consent was taken from each subject in the study.

Selection of subjects

The study sample comprised of male permanent workers employed in the sugar factory, Pravaranagar. There were 349 permanent

employees, out of which 331 could be interviewed and examined but only 294 were included in this study. The smokers (37 in number) were not included in this study to avoid bias while finding pulmonary impairment purely based on occupational exposure to dust. 18 permanent workers could not be examined due to various reasons but they did not differ much in age or duration of service.

A control group of 60 non-smoking subjects (office workers those who are unexposed to sugar factory occupational environment) were selected, having similar age group and socioeconomic status of the sugar factory area.

Inclusion criteria: 1) Age of workers between 20-60 years 2) Only male workers

Exclusion criteria: 1) Those have cardiovascular illness in present or past 2) Those having kyphoscoliosis deformity 3) Those predispose to allergic asthma 4) Workers addicted to smoking.

As the subjects are industrial labour, there was a habit of slight intake of alcohol and tobacco chewing which does not affect or alter the pulmonary function tests. This habit was present in some workers of sub-departments as well as in controls which nullifies the effect in this study.

Recording occupational and personal histories of exposed workers

A complete history of the workers was recorded with respect to duration of occupational exposure and nature of occupation, respiratory symptoms, smoking habits and socio-economic status on a pre-structured proforma¹².

Pulmonary Function Testing

The anthropometric measurement (standing height, weight etc.) was recorded. The whole maneuver was explained to the subject and they were encouraged to practice this maneuver before doing the pulmonary function test. The spirometric functions were recorded in the sitting position using an electronic computerized portable RMS-Spirometer¹³ according to the guidelines recommended by the American Thoracic Society¹⁴. Each individual performed spirometry thrice to

produce the best result. All the pulmonary function tests were carried out at a fixed time of the day i.e. 9:30 am to 12:30 pm. The RMS- Spirometer used was precalibrated each day prior to use. The room temperature was recorded between 34-36⁰C during the period of study.

Spirometric studies were performed in workers engaged in Engineering dept. (N=96), Manufacturing dept. (N=102), Bagasse workers (N=42) and Godown workers (N=54).

The following respiratory parameters were studied:

1. Forced vital capacity (FVC)

2. Forced expiratory volume in 1 Sec (FEV1.0)

3. FEV1/FVC % ratio

4. Peak expiratory flow rate (PEFR)

5. FEF 25-75%

The criteria for pulmonary impairment were defined on the basis of the American Thoracic Society (ATS) guidelines¹⁴. FEV1/FVC percent values >85% predicted were considered normal and values less than <85% indicated bronchial obstruction. The pulmonary impairments were classified as per Miller's prediction quadrant¹⁵.

RESULTS

Table: 1. Anthropometric measurements of workers in different departments of sugar factory

SUB-GROUPS (N)	AGE (Yrs)	HEIGHT (Cm)	WEIGHT (Kg)
Engineering dept. (N=96)	48.98 ± 5.83	165.77 ± 6.50	62.32 ± 10.29
Manufacturing dept. (N=102)	50.22 ± 5.22	165.72 ± 6.77	63.91 ± 10.65
Bagasse Workers (N=42)	50.15 ± 5.61	167.27 ± 6.82	65.60 ± 9.14
Godown Workers (N=54)	50.27 ± 5.96	165.90 ± 6.73	63.16 ± 10.37
Controls (N=60)	50.04 ± 6.52	167.94 ± 6.40	65.82 ± 8.83
N = Total number of subjects.		Values are means ± S.D.	

By applying 'Z' test for difference between two mean values in Control & Study groups respectively; there is no significant difference in age, height and weight of workers i.e. P>0.05

Table: 2. Mean values & standard deviation of pulmonary function test parameters in workers of different departments in Sugar factory.

Sub-Groups (N)	FVC (L)	FEV ₁ (L)	FEV1/FVC (%)	PEFR (L)	FEF25-75% (L)
Engineering dept (N=96)	2.85±0.52*	2.42±0.48*	85.62±11.14	5.42±1.51*	2.99±0.98
Manufacturing dept N=102)	2.98±0.58	2.45±0.53*	83.67±12.32*	5.41±1.71*	2.98±0.97
Bagasse Workers (N=42)	3.01±0.45	2.38±0.39*	82.56±13.71*	5.26±1.52*	2.92±0.85
Godown Workers (N=54)	2.94±0.47	2.49±0.49	85.51±11.41	5.58±1.67	3.06±1.04
Controls (N=60)	3.04±0.48	2.62±0.46	87.49±9.69	6.08±1.57	3.09±0.94
N = Total number of subjects in each dept.		Values are means ± S.D.			

By applying 'Z' test for difference between mean values of pulmonary function test parameters,

* 'significant' difference between two mean values in control & study group respectively. i.e. p<0.05

PFT values in sub-occupational group:

There is statistically significant difference found with respect to mean values of FVC in workers of engineering dept. as compared to controls. There was significant reduction in FEV1 in Bagasse

workers, Manufacturing dept. and Engineering dept. workers as compared to controls, indicated the prevalence of obstructive type of pulmonary impairment. (Table-2) The above findings of a

reduction of FEV1 are further supported by a reduction in their ratios FEV1/FVC which is found to be significantly reduced in Bagasse workers and Manufacturing dept. workers. The PEF were

reduced in Bagasse workers, Manufacturing dept., and engineering dept. workers, thereby showed the maximum effect on peripheral airway obstruction.

Table: 3. Pulmonary impairment in relation to occupational exposure in workers of different departments in sugar factory.

Sub-groups (N)	Obstructive		Restrictive		Mixed		Total	
	n	%	N	%	n	%	N	%
Engineering Dept. (N=96)	14	14.58	11	11.46	2	2.08	27	28.12
Manufacturing Dept. (N=102)	23	22.55	13	12.75	3	2.94	39	38.24
Bagasse Workers (N=42)	11	26.19	4	9.52	2	4.76	17	40.48
Godown Workers (N=54)	5	9.26	6	11.11	0	0	11	20.37
Total Workers (294)	53	18.03	34	11.56	7	2.38	94	31.97
Controls (N=60)	3	5	5	8.33	0	0	8	13.33

N = Total number of subjects, n = Number of subjects with pulmonary impairment
% = Percent of subjects with pulmonary impairment

Pulmonary impairment in sub-occupational groups:

The overall prevalence of pulmonary impairment was (31.97%) compared to (13.33%) in controls. The highest prevalence of pulmonary impairment was found in Bagasse workers (40.48%) followed by Manufacturing dept. (38.24%), Engineering dept. (28.12%) and Godown workers (20.37%). (Table-3) Among various sub-groups bronchial obstruction (18.03%) was the predominant pulmonary impairment than the restrictive (11.56%) and the mixed type (2.38%). The

obstructive type of pulmonary impairment was found highest in Bagasse workers (26.19%) followed by Manufacturing dept. (22.55%) and Engineering dept. (14.58%) as compared to controls (5%).

In a restrictive type of pulmonary impairment the prevalence is highest in Manufacturing dept. (12.75%) followed by Engineering dept. (11.46%) and Godown workers (11.11%) as compared to controls (8.33%). Mixed type of pulmonary impairment showed the least number of cases 7 (2.38%).

Table 4: Pulmonary impairment in relation to duration of occupational exposure

Duration of Exposure	Obstructive		Restrictive		Mixed		Total	
	n	%	n	%	n	%	n	%
11-20 Years (N=58)	8	13.79	5	8.62	0	0	13	22.41
21-30 Years (N=110)	18	16.36	11	10.00	3	2.73	32	29.09
≥ 30 Years (N=126)	27	21.43	18	14.29	4	3.17	49	38.89
Total Workers (294)	53	18.03	34	11.56	7	2.38	94	31.97

N = Total number of subjects, n = Number of subjects with pulmonary impairment
% = Percent of subjects with pulmonary impairment

Pulmonary impairment according to duration of occupational exposure:

The highest prevalence of pulmonary impairment was found in ≥ 31 yrs exposed workers (38.89%) Followed by 21-30 yrs exposed workers (29.09%) and least in 11-20 yrs exposed workers (22.41%).

(Table-4) The obstructive type of pulmonary impairment showed the maximum number of cases 53 (18.03%) followed by restrictive type 34 (11.56%) and mixed type 7 (2.38%).

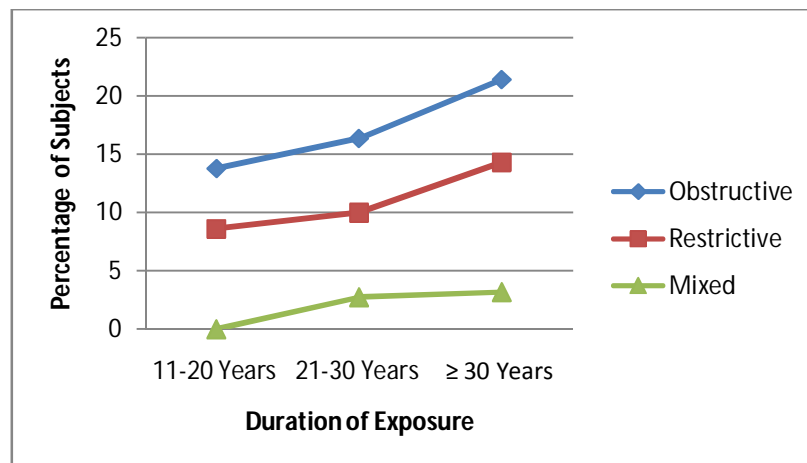


Fig:1. Pulmonary impairment in relation to duration of occupational exposure

DISCUSSION

Sugar processing industry involves different sub-occupations, which are performed in distinct processing units necessary in the manufacturing of sugar. In view of the industrial health scenario in the sugar factory, lung spirometric studies were conducted on workers in various departments namely engineering dept., Manufacturing dept., Bagasse workers and Godown workers.

In the present study, Significant reduction of FEV_{1.0} in Bagasse workers, Manufacturing dept. and Engineering dept. workers as compared with controls, indicated obstructive type of pulmonary abnormalities (Table-2). Reduced FEV₁ has earlier been reported by Bohadana et al¹⁶ showed that workers exposed to sugar dust in the sugar cube manufacture workstation had significantly lower forced expiratory volume in 1s (FEV₁) than the non-exposed ones. Goyal R.C. et al¹⁷ also observed the decrease in FEV₁ in workers actively involved in various plant operations of sugar factory. A possible mechanism could be mobilization of neutrophils into the airways and the subsequent release of tissue irritating substances, either

directly from neutrophils via platelets or by secretion of prostaglandins from macrophages¹⁸. There is decreased diffusion capacity of the alveolar capillary membrane due to the destruction of alveoli caused by inflammatory responses leading to decreased O₂ saturation in the blood^{19,20}. Hypoxia due to decreased O₂ saturation leads to release of leukotriens and chemokines from eosinophils resulting in broncho-constriction²¹. Hypoxia along with associated hyperapnea gives rise to decrease in PACO₂, resulting in further constriction of bronchial muscles²². The lymphocytic infiltration caused by inflammatory response may result in thickening of the walls of the bronchioles resulting in obstruction of the lumen by granulation tissue²³.

In this study, the reduction of FEV₁ is further supported by a reduction in their ratios FEV₁/FVC, which is found to be significantly reduced in Manufacturing dept. and Bagasse workers where the exposure to organic dust is maximized. The Peak Expiratory Flow Rate (PEFR) was reduced in all the exposed workers in sub-occupational groups

(Table-2) being higher in Bagasse workers followed by Manufacturing dept., and Engineering dept. workers, thereby showed the maximum effect on peripheral airway obstruction. A highly significant decrease in PEFr was also reported from western Maharashtra by Patil S.N.¹⁰. PEFr is an index of expiratory airway resistance and is more effort dependent²⁴. The reduction in PEFr may involve the same mechanism already explained for obstructive lesion. In addition, the inflammatory reaction releases proteins from eosinophils which might be responsible for the hyper responsiveness of airways²⁵.

All sub-groups of sugar factory workers suffered with various profiles of obstructive (18.03%), restrictive (11.56%) and mixed type (2.38%) of pulmonary impairments totaling 31.97% Vs 13.33% in controls (Table-3). However, bronchial obstruction was the predominant pulmonary abnormality in sub-occupational groups, especially Bagasse workers (26.19%) and Manufacturing dept. workers (22.55%). A Spirometric study by Gehad Abo et al²⁶ in workers chronically exposed to bagasse during the manufacture of particle-boards showed prevalence of Obstructive ventilatory defects in about 28.5% of the studied workers followed by Restrictive defects affecting about 19.6% of the workers, while combined defect affected about 6% of the studied group. The results in the present study may be due to the differential nature of occupational exposure e.g. Bagasse workers and Manufacturing dept. workers are coming in direct contact with the Bagasse and fine sugar dust than the Engineering dept. and godown workers.

There is an increasing number of cases in each obstructive, restrictive and mixed type of pulmonary impairment from 11-20 yrs exposed worker category to ≥ 31 yrs exposed category, which means there is a direct correlation between the duration of exposure to dust and the pulmonary abnormalities in sugar factory workers. There are no systematic studies related to industrial dust exposure and pulmonary hazards in key processing

units of sugar factory thereby, making it difficult for comparison with the present data.

In conclusion, the study demonstrated a significant association between pulmonary function abnormalities and certain occupations in the sugar factory, thereby suggesting that occupational exposure to Bagasse and certain chemicals used in sugarcane processing lead to pulmonary impairment particularly of the obstructive type followed by restrictive and mixed type. The majority of the workers with pulmonary impairment had ≥ 31 yrs of occupational exposure. A direct correlation was observed between duration of occupational exposure to the organic dust (Bagasse) and increase in pulmonary impairment in sugar factory workers.

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