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Poor Lung Function of Industrial Workers of Bhutan: a retrospective study

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ABSTRACT

Introduction: Occupational lung diseases are some of the common causes of lung function impairment. Spirometry is a gold standard to determine lung function and, to diagnose obstructive and restrictive lung diseases. Therefore, this study aimed to determine the prevalence of abnormal lung function among employees of different industries of Bhutan. **Methods:** This retrospective study was carried out by retrieving all the spirometry findings and demographic variables of employees of different industries of Bhutan from the Spirometry Software of Respiratory Laboratory at the Center for Research in Respiratory and Neuroscience (CRRN), Khesar Gyalpo University of Medical Sciences of Bhutan (KGUSMB) . All these retrieved data were saved in Microsoft Excel and simple descriptive statistics were used to analyze the data and were expressed in numbers, percentages, mean and standard deviation. **Results:** Spirometry and demographic results of 3508 industrial employees were obtained. The mean age was 33.8 years and mean BMI was 24.95 Kg/m2. Non-smokers comprised 79.9% (2804) of the total industrial employees. Abnormal forced expiratory volume between 25% and 75% of vital capacity ($FEF_{25\%-75\%}$), a marker of small airway disease, constituted 24.1% (846) of the total industrial employees. Furthermore, 1.1% (39) had abnormal forced vital capacity (FVC), 1.3% (46) presented abnormal forced expiratory volume in 1 second (FEV_1) and 1.5% (53) showed reduced FEV_1/FVC. **Conclusions:** Small airway impairment is common among industrial workers of Bhutan indicating presence of high prevalence of occupational lung diseases in its early stage which may potentially become clinically apparent after long latency.

Keywords: Occupation, Lung function, Industrial employees, Bhutan.

INTRODUCTION

Globally, chronic respiratory diseases (CRDs) are some of the commonest causes of morbidity and mortality, especially in South Asia Super-region[1]. Occupational exposure is among the top seven associated risk factors with the CRDs[1]. Bhutan is no exception, as its prevalence of non-communicable diseases (including chronic respiratory diseases) is in increasing trend with occupational risk factors noted to be among its top ten risk factors[2,3].

Occupational exposure to different types of chemicals is inherent to almost all types of industrial work. Occupational lung diseases (OLDs) are defined as 'occupational, or work-related, lung conditions that have been caused or made worse by the materials a person is exposed to within the workplace'[4]. The most common OLDs are pneumoconiosis, COPD, occupational asthma, and bronchiolitis obliterans[5]. 15% of asthma and COPD has been estimated to be caused by occupational exposure to mineral dusts, metal fumes, organic dusts, and chemical gases or vapours[6]. Thus, occupational lung diseases can either present as restrictive lung disease or obstructive lung disease or mixed type in pulmonary function test through spirometry[7].

Spirometry is a physiological test that measures the maximum volume of air that an individual can inspire and expire with maximum effort[8]. Several pulmonary function studies carried out through spirometry on industrial workers of different types of industries around the world show significant reduction in mean values of forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), FEV_1/FVC and forced expiratory flow between 25% and 75% of FVC ($FEF_{25\%-75\%}$) among the exposed groups compared to the control groups[9]. Almost all of these studies also show significant negative association between the mean values of spirometry indices and duration of employment[9]. However, only very few studies report prevalence of abnormal pulmonary variables, restrictive and obstructive patterns of spirometry findings. Furthermore, till date, no spirometry study

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has been conducted on industrial workers of Bhutan. Therefore, this study aims to study the prevalence of abnormal FVC, FEV_1, FEV_1/FVC and $FEF_{25\%-75\%}$ along with different spirometry patterns among industrial workers of different industries of Bhutan.

METHODS

All the spirometry test results (FVC, FEV_1, FEV_1/FVC, $FEF_{25\%-75\%}$) and demographic findings (age, gender, weight, height, BMI, smoking history and occupation) of employees of different industries of Bhutan, from September 2017 to October 2019, were retrieved from the spirometry software (RMS Helios 401) of CRRN, KGUMSB and saved in the Microsoft Excel. This spirometry test for the industrial employees was performed by the CRRN as a part of an annual health screening mandated by the Occupational Safety Regulation of Ministry of Labour and Human Settlement, and Occupational Health and Chemical Safety Program, Ministry of Health. A total of 3508 employees had undergone spirometry. These employees were then segregated into cement, metal, mining, polymers, wood, and carbide and ceramics industries, arts and crafts, hydropower plant (HPP) and refined cooking oil factory (RCOF). SPSS version 21.0 was used to find out the descriptive statistics of demographic and spirometry variables. They were expressed in numbers, percentages, mean and standard deviations. The study was approved by the Research Ethics Board of Health (REBH), Ministry of Health, Bhutan with the reference number: Ref. No. REBH/Approval/2021/025.

Table 1. Operational Definitions

Normal FVC, FEV_1, and $FEF_{25\%-75\%}$	measured value is ≥ 80% of predicted value[10,11]
Abnormal FVC, FEV_1, $FEF_{25\% - 75\%}$	measured value is < 80% of predicted value[10,11]
Normal FEV_1/FVC	measured value ≥ 0.7[12]
Restrictive pattern	abnormal FVC
Obstructive pattern	abnormal FEV_1 and/or FEV_1/FVC
Small airway disease	Presence of abnormal $FEF_{25\%-75\%}$ as it measures the average flow rate during middle 50% of FVC indicating the patency of the small airways[13]

RESULTS

Demographic Characteristics

Out of 3508 employees, 2750 (78.4%) were male and 758 (21.6%) were female. 2387 (68%) were below 40 years. 51 (1.5%) of them were 60 and above. Overall mean age was 35.77 years. 2804 (79.9%) were non-smoker as shown in Table 2.

Industrial Material and Occupation

Employees from production process workers, administration and electrical engineering departments constituted 15.6% (547), 11.3% (397) and 8.4% (296), respectively, of the total employees as shown in Table 3.

Pulmonary Function Test Findings

From 3508 employees, 846 (24.1%) had abnormal $FEF_{25\%-75\%}$. From these 846 employees, 24.4%, 23.5%, 25.0%, 25.7%, 26.1%, 27.8%, 22.4%, and 21.3% were from cement, metal, mining, polymers, wood, C & C, HPP and RCOF, respectively. From industrial employees of Polymers, 2.1% had abnormal FEV_1, FVC and FEV_1/FVC. Among C & C employees, 2.3% had abnormal FEV_1 and 2.6% had abnormal FEV_1/FVC as shown in Table 4.

Table 2. Demographic characteristics of industrial employees from September 2017 to October 2019, Bhutan

Age Group (in years)	*n* (%)	Gender	*n* (%)	Anthropometric	μ (SD)
18 – 29	1093 (31.2)	Female	758 (21.6)	Height*	161.37 (7.7)
30 – 39	1294 (36.9)	Male	2750 (78.4)	Weight†	64.96 (11.4)
		Smoking			
40 – 49	704 (20.1)	**History**		BMI‡	24.95 (3.8)
50 – 59	366 (10.4)	Yes	594 (16.9)		
60 – 69	44 (1.3)	No	2804 (79.9)		
70 above	7 (0.2)	Ex-smoker	110 (3.1)		
Mean Age (SD) = 35.77 (10.06)					

*n: number; %: percentage; μ(SD): mean (standard deviation); *: in cm; †: in Kg; ‡: in Kg/m2*

Table 3. Distribution of occupations among Industrial Workers, from September 2017 to October 2019, Bhutan

Occupation	*n* (%)	Occupation	*n* (%)	Occupation	*n* (%)
Administration	397(11.3)	Helper	94(2.7)	Printing	14(0.4)
Blaster	10(0.3)	House Keeping	58(1.7)	PPW*	547(15.6)
CC†	59(1.7)	LTCQ‡	158(4.5)	Rigger	16(0.5)
Casting	19(0.5)	Loader	15 (0.4)	Security Personal	187(5.3)
CE§	77(2.2)	Loom Operator	29(0.8)	Stitcher	16(0.5)
CDC‖	27(0.8)	Masson	11(0.3)	Store keeper	58(1.7)
DWB¶	41(1.2)	ME**	228(6.5)	SF††	172(4.9)
Driver	167(4.8)	Metal Workers	20(0.6)	Technician	40(1.1)
EE‡‡	296(8.4)	Mill attendant	11(0.3)	WF§§	65(1.9)
Engraving	94(2.7)	Mine workers	2(0.1)	Painter	4(0.1)
Fire Personals	24(0.7)	Mine Workers	62(1.8)	PEMO‖‖	238(6.8)
Fitter	55(1.6)	Packaging	68(1.9)	Plumber	10(0.3)
Food handlers	18(0.5)	FFW¶¶	15(0.4)	FST***	86(2.5)

n: number; %: percentage;
**Production Process Workers;*
†Carpenter/Craft;
‡Lab Technicians/Chemists/Quality Control;
§Civil Engineering; ‖ Cutting/Driller/Crashing;
¶Dispatcher/Weight Bridge;
***Mechanical Engineer; ††Supervisor/Forman;*
‡‡Electrical Engineering; §§Welder/Fabrication;
‖‖Plant/Equipment/Machine Operator; ¶¶ Forestry/Field Worker;
****Furnace/Stoker/Tapper;*

Table 4. Abnormal Spirometry Results of Industrial Employees, from September 2017 to October 2019, Bhutan

Industry		Abnormal FVC	Abnormal FEV1	Abnormal FEV1/FVC	Abnormal FEF25%-75%
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Cement	750(21.4)	5(0.7)	6(0.8)	12(1.6)	183(24.4)
Metal	1049(29.9)	15(1.4)	19(1.8)	21(2)	247(23.5)
Mining	320(9.1)	3(0.9)	3(0.9)	5(1.6)	80(25.0)
Polymers	187(5.3)	4(2.1)	4(2.1)	4(2.1)	48(25.7)
Wood	329(9.4)	3(0.9)	4(1.2)	4(1.2)	86(26.1)
C & C*	266(7.6)	2(0.8)	6(2.3)	7(2.6)	74(27.8)
Arts and Crafts	41(1.2)	0(0)	0(0)	0(0)	5(12.2)
HPP†	519(14.8)	6(1.2)	4(0.8)	1(0.2)	116(22.4)
RCOF‡	47(1.3)	1 (2.1)	0 (0)	0 (0)	10 (21.3)
N(%)	3508(100)	39 (1.1)	46 (1.3)	53 (1.5)	846 (24.1)

n: number in respective industry;
N: total number; %: percentage;
**Carbide & Ceramics;*
†Hydropower Plant;
‡Refined Cooking Oil Factory

DISCUSSION

The prevalence of $FEF_{25\%-75\%}$ was high in almost all the industries. This finding suggests that there is a high prevalence of small airway disease among all industrial workers involved in the study. This indicates the majority of industrial workers of almost all the industries of Bhutan have early stage or preclinical occupational lung diseases. In our study, almost all industries showed low prevalence of abnormal FVC, FEV_1, and FEV_1/FVC. This indicates there is low prevalence of obstructive or restrictive lung diseases as a result of occupational exposures in almost all industries. Industrial work related to polymers, cement, metal, wood, mining, C & C, HPP, and KCOF. has higher prevalence of abnormal lung function either in FEV_1, FVC, and FEV_1/FVC. This suggests cement dust, chemical fumes, silica dust, ceramic dust and wood dust are important factors to be considered for OLDs. Overall, we observed prevalence of abnormal FVC, FEV_1, FEV_1/FVC and $FEF_{25\%-75\%}$ among industrial workers of all industries to be within the range of 0 – 2.1%, 0 – 2.3%, 0 – 2.6% and 12.2 – 30.1%, respectively. In a spirometry study carried by Keramydas et al[14] out on indoor and out construction workers observed 3.7%, 4.9%, 7.4%, 11% had abnormal FVC, FEV_1, FEV_1/FVC and $FEF_{25\%-75\%}$, respectively. These values are more or less comparable to general observation made in our study, as silica dust exposure is inherent to almost all types of industries[15].

In our study we observed 0.7%, 0.8% and 1.6% of employees of cement industry to have of abnormal FVC, FEV_1, and FEV_1/FVC, respectively. These findings are in contrary to 58.5%, 48.9%, 40.4% of abnormal FVC, FEV_1, FEV_1/FVC, respectively found in cement production employees observed in a study carried out in Iran[16]. This difference in FVC, FEV_1, FEV_1/FVC findings might be due to difference in population studied. Our study was based on screening almost all the employees of cement factories without considering the exposure status whereas the spirometry study in Iran was performed exclusively on cement production workers involved in ore crushing, kiln and packing of cement. These occupations of cement production were found to have high level respirable cement dust[16]. In addition, it might be due to lower mean age (35.8 years) of our study compared to the mean age (41.7 years) of this referred study. In addition, in our study only 16.9% of study population were smokers, whereas the study subjects of this referred study were all active smokers.

In our study, 2% of metal industry employees had we obstructive lung disease (abnormal FEV_1/FVC) and 1.4% had of them had restrictive lung disease (abnormal FVC). These findings were lower than those observed prevalence of 20% and 10% of obstructive lung and restrictive lung diseases, respectively, in the previous study[17]. The lower prevalence in our study might be mainly due to the large study population involving both exposed and unexposed workers compared to merely 60 employees exposed heavily to metal fumes and toxic gases released during metal work despite having very comparable the mean age between our study and this referred previous study.

With regard to the polymers industry, 2.1% of the employees had abnormal FVC, FEV_1 and FEV_1/FVC. This is just the contrary to the 20% prevalence of abnormal FVC found in the previous study[18], despite having lower mean age (32.2 years) than ours. This disparity might be because of the difference in study population, as explained earlier. Rest of the spirometry parameters could not be compared as their prevalence were not studied in it. In addition, to the best of our knowledge there were no other studies mentioning such findings. Such differences with regard to the prevalence of FVC, FEV_1 and FEV_1/FVC was also noted among the employees of wood industry compared to the findings of Hosseini et al[19]. This difference in findings may owe to two factors- first: the mean age of this referred study (46.4 years) is high much higher than ours, and second: study population difference as explained earlier.

In a study carried out by Keramydas et al[14], noted 11% of construction workers to have abnormal $FEF_{25\%-75\%}$. However, in this study, all industries (except Dharma Arts) showed prevalence of abnormal $FEF_{25\%-75\%}$ above 20%. This dissimilarity could be due to difference in study population as ours included employees of all types of industries with different types occupational exposures apart from silica exposure. Whereas, this referred study had principally focused on studying the effect of silica dust on construction workers.

Occupational exposure to dust (organic or inorganic), fumes, vapours and gases are inherent to almost all types of industrial work which eventually causes OLDs. Although OLDs are common yet due to its long latency, they are often overlooked and underreported in the clinical setting[20,21]. Detection of the early stage of OLDs are indispensable to either prevent from developing OLDs or its progression to severe and irreversible forms[22]. Spirometry is a non-invasive, inexpensive, widely available, and easily reproducible test to detect lung function status and to diagnose respiratory disorders[23]. Some of the commonly used spirometry indices are FVC, FEV_1, FEV_1/FVC and $FEF_{25\%-75\%}$[24]. $FEF_{25\%-75\%}$ is considered to be the marker of small airway disease, despite its limitations[25,26]. Small airway disease is the early-stage lung function impairment found in many chronic respiratory diseases[27,28].

LIMITATIONS

Given the design of this study we retrieved the spirometry findings of all the industrial employees (including those working in administration) without considering if the employees had direct or indirect occupational exposure.

CONCLUSIONS

The prevalence of abnormal $FEF_{25\%-75\%}$ (24.5%) was very high indicating presence of small airway disease among industrial employees; suggestive of presence of early or subclinical stage of occupational lung diseases in large number of Bhutanese industrial employees. However, the prevalence of abnormal FVC (1.1%), FEV_1(1.3%) and FEV_1/FVC (1.5%) among industrial

employees was low. This suggests, currently, only small number of industrial employees has overt occupational obstructive and restrictive lung diseases as majority of them were young and non-smokers.

RECOMMENDATIONS

As occupational lung diseases become clinically apparent after decade(s) of latency. Hence, it is crucial for the Ministry of Health in collaboration with Ministry of Labour and Human Resources to come up with the programs to promote preventive measures, early diagnosis, timely and appropriate management of occupational lung diseases so as to prevent irreversible and severe pulmonary complications. In addition, future prospective analytical spirometry study would provide us better understanding of lung function and their confounding factors among industrial employees.

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AUTHORS CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

P: Concept, design, data collection and analysis, manuscript writing and review.

SCR: Design, data analysis, manuscript writing and review

KD: Concept, design, data collection and analysis

CW: Concept, design, data collection and analysis

Author agree to be accountable for all respects of the work in ensuring that questions related to the accuracy and integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

None

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