Available online at **www.ijmrhs.com**

ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2018, 7(7): 127-131

Adverse Respiratory Health and Decline in Lung Functions among Workers of Riyadh Metro Railway Tunnel

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ABSTRACT

Objective: *Railway tunnel workers are exposed to excavated dust, gaseous fumes, oil vapours, etc. at their work site which may cause adverse respiratory health and decline in lung functions among these workers if safe occupational practices are insufficient. The aim of this study is the assessment of respiratory health and lung function among the tunnel workers of Riyadh metro railway tunnel.* ***Methods:*** *This is a cross-sectional study to monitor the respiratory health and lung functions among workers of Riyadh metro railway tunnel. Total of 87 tunnel workers were recruited for this study who were exposed with excavated dust during their work practices at the under-construction site of a metro railway tunnel. These tunnel workers were compared with 53 control subjects of same socio-economic status and were not occupationally exposed to dust before. Self-reported respiratory symptoms were obtained through the questionnaire-based survey. Spirometry was conducted for the lung function tests FEV1 (Forced expiratory volume in 1 second) and FVC (Forced vital capacity) of both exposed and control subjects.* ***Results:*** *Most of the symptoms reported by tunnel workers were shortness of breath (25.28%) and coughing that produces phlegm (25.28%). Both the lung function parameters viz. FEV1 and FVC were found to be significantly decreased among tunnel workers ($p<0.01$) as compared to control subjects. Significant negative correlation ($p<0.01$) was found between dust exposure period and FEV1 and FEV1/FVC.* ***Conclusion:*** *In conclusion, we found adverse respiratory health and decreased lung functions among tunnel workers which were also correlated with the exposure period.*

Keywords: Respiratory health, Lung functions, Railway tunnel workers

INTRODUCTION

Respiratory health and lung function are very much affected by the exposure of dust and chemical aerosols among tunnel construction workers. Tunnel construction workers suffer from respiratory diseases [1]. During the construction of tunnels, a large amount of soil and sand dust are released in the process of excavation. Earlier studies found that tunnel workers are exposed to both particulate and gaseous air contaminants [2,3]. Increased risk of long-term and short-term lung function decline and chronic obstructive pulmonary disease (COPD) among tunnel workers were documented in some earlier studies [4,5]. Workers in tunnel construction and mining get exposed to dust during drilling and blasting operations. During drilling operations, exposure to oil mist and oil vapour may occur. During tunnel construction, more effective drilling equipment may produce more oil mist per time unit. Occupational asthma and pulmonary fibrosis may be caused by exposure to oil mist [6,7]. Due to exposure to nitrogen dioxide (NO_2) during tunnel construction, decreased lung function has also been reported [8]. Poor ventilation, microclimate, and air pollutants are the main features of the environment in the tunnels of an underground railway which may lead to various respiratory disorders [9].

Riyadh is the capital city of Saudi Arabia in which metro railway is under construction and most of the railway track is underground for which tunnel is being constructed in the city. This is a cross-sectional study for the assessment of

respiratory health and lung function among the tunnel workers of Riyadh metro railway tunnel who are exposed to excavated dust, gaseous fumes, oil vapors, etc.

MATERIALS AND METHODS

Study Design and Population

This is a cross-sectional study which was conducted among tunnel workers of Riyadh metro railway tunnel for their respiratory health and lung function examination conducted in the year 2016. Total of 87 tunnel workers were recruited for this study who were exposed with excavated dust during their work practices at the under-construction site of a metro railway tunnel. These dust exposed workers were compared with 53 control subjects of the same socio-economic status and were not occupationally exposed to dust before. All the workers were foreign nationals working as expatriates. These workers originally came from developing countries like Bangladesh, Pakistan, Philippines, Syria, etc. The workers were engaged in their work at the construction site from 7:00 AM to 4:00 PM daily except Fridays. These workers voluntarily participated in this study and their informed written consent was obtained. This study was approved by the institutional ethical committee.

Questionnaire

A self-administered questionnaire was used for getting information related to socio-demographic characteristics, education, smoking habits. Other information on the occupational work practices during their job and self-reported respiratory symptoms were also obtained through this questionnaire. The questions related to occupational safety like the use of personal protective equipment (PPE) at workplace, the importance of PPE during occupational practices, awareness about the adverse respiratory health effects of dust exposure and exposure (hours) of dust per day were asked from the workers. Self-reported respiratory symptoms like shortness of breath, dry coughing: coughing that produces phlegm, wheezing, chest pain, etc. were asked from workers.

Occupational Information

The tunnel workers were doing their job for 10 hours daily, 6 days a week at the construction site of the Riyadh metro railway tunnel. During their job, they get the exposure of excavated dust due to the several digging activities. The workers were engaged in the activities of drilling, blasting, loading, etc. by which they get the exposure of dust into their mouth and nose which eventually moves to upper and lower respiratory tract causing some acute and chronic respiratory symptoms. However, most of the workers used masks during their work practices, but even then they get the excavated dust exposure because of its small size and its continuous persistence in an environment of the work site.

Spirometry

Spirometry for the lung function tests FEV1 (Forced expiratory volume in 1 second), PEFR (Peak expiratory flow rate) and FVC (Forced vital capacity) for pulmonary impairment of each subject (tunnel workers and control) were performed using a spirometer (PIKO-1, UK under the recommendation of the American Thoracic Society standards). The purpose of the lung function test was to evaluate pulmonary impairments among study subjects. The volunteer performed the lung function test in the sitting position three times allowing for sufficient rest between repetitions. The best values for PEFR, FEV1, and FVC from three tests for each subject were recorded. Results were interpreted with the predicted values of lung function parameters calculated by the reference equation for the Indian population [10].

Statistical Analysis

Descriptive statistics have been generated for the demographic parameters in the control group and tunnel workers. Frequencies and percentages have been shown for all the categorical parameters. Student's t-test has been used to compare the mean values of the continuous variables (demographic parameters and spirometry parameters) between the control and exposed group. Chi-square test has been incorporated for comparison of the categorical outcomes (respiratory symptoms). Linear regression analysis was done considering daily dust exposure as an independent variable and FEV1, PEFR and FEV1/FVC as the dependent variables respectively. The criterion for significance was set at $p<0.05$. All the statistical analysis has been performed using IBM SPSS Statistics version 20.

RESULTS

General Information about Tunnel Workers

Table 1 represents physical and occupational characteristic of tunnel workers. The mean and range of the variables viz. age, height, weight, BMI are exhibited. The average occupational experience of tunnel was found to be 5.71 ± 7.31 years which ranged from 1 to 37 years. The mean of dust exposure period (hours per day) was found to be 7.46 ± 3.48 which ranged from 1 to 15 hours. Table 2 represents demographic characteristic and smoking habits of tunnel workers. The frequency distribution of nationality, educational status and smoking habits are shown in this table. Most of the workers were originally from Pakistan (49.42%), most of them were illiterate (19.54%) and non-smokers (57.47%).

Table 1 Physical and occupational characteristic of construction workers

Variables	Mean ± SD (N=87)	Observed range
Age (years)	31.34 ± 8.74	21-58
Height (cm)	167.81 ± 8.42	151-188
Weight (Kg)	73.74 ± 12.87	53-114
BMI (Kg/m^2)	26.14 ± 3.85	18.82-39.81
Occupational experience (years)	5.71 ± 7.31	1-37
Exposure period (hours per day)	7.46 ± 3.48	1-15

Table 2 Demographic characteristic and smoking habits of construction workers

Variables	No. of workers N (%) (N=87)
Nationality	
Egypt	10 (11.49%)
Bangladesh	3 (3.44%)
India	21 (24.13%)
Pakistan	43 (49.42%)
Lebanon	2 (2.29%)
Philippines	4 (4.49%)
Sri Lanka	2 (2.29%)
Syria	2 (2.29%)
Educational status	
Illiterate	17 (19.54%)
Elementary	12 (13.79%)
Primary	16 (18.39%)
Secondary	5 (5.74%)
High School	13 (14.94%)
Intermediate	15 (17.24%)
Graduate	9 (10.34%)
Smoking habit	
Smokers	37 (42.52%)
Non-smokers	50 (57.47%)

Respiratory Health Symptoms and Lung Functions

Table 3 represents frequency of respiratory health symptoms among tunnel workers. The self-reported symptoms found among tunnel workers were shortness of breath during the job, coughing that produces phlegm (thick sputum), coughing during sleep that wakes up, wheezing during the job. Most of the symptoms reported were shortness of breath (25.28%) and coughing that produces phlegm (25.28%). Table 4 shows the results of lung function tests of tunnel workers. The lung function parameters viz. FEV1, FVC, FEV1/FVC of both workers and controls were obtained by spirometry. All these lung function parameters were found to be significantly decreased among workers ($p<0.01$) as compared to control subjects.

Table 3 Frequency of respiratory health symptoms among construction workers

Respiratory health symptoms	No. of workers N (%) (N=87)
Shortness of breath	22 (25.28%)
Shortness of breath during the job	16 (18.39%)
Coughing that produces phlegm (thick sputum)	22 (25.28%)
Coughing during sleeping that wakes up	8 (9.19%)
Wheezing	11 (12.64%)
Wheezing during the job	7 (8.04%)

Table 4 Lung function tests of construction workers

Lung function parameters	Controls Mean ± SD (N=53)	Dust exposed workers Mean ± SD (N=87)	Significance
FEV1	2.47 ± 0.54	1.68 ± 0.80*	p<0.01
FVC	2.52 ± 0.47	1.38 ± 0.87*	p<0.01
FEV1/FVC	1.74 ± 0.21	1.21 ± 0.89*	p<0.01

Correlation of lung function tests with dust exposure

Table 5 represents the correlation of lung function tests with daily dust exposure (hours per day) among tunnel workers. Significant negative correlation was found between dust exposure period and FEV1 and FEV1/FVC. However, there was no significant correlation found between FVC and exposure period.

Table 5 Correlation of lung function tests with daily dust exposure among construction workers

Correlation of lung function parameters with daily dust exposure (hours per day)	R-value	Significance
FVC	0.18	p=0.16 (not significant)
FEV1	-0.28	p<0.05
FEV1/FVC	-0.45	p<0.001

DISCUSSION

In this study, we found respiratory health symptoms and significant decline in lung function parameters among workers of Riyadh metro railway tunnel. These respiratory symptoms and decline in lung function were associated with exposure of excavated dust, gaseous fumes, oil vapours, etc. at work site. Previous studies found significantly lower values of FEV1, and PEFR in the tunnel workers in comparison to controls [1,3]. Galea, et al., in 2015 found that decline in lung functions were attributed to exposure to many harmful substances like respirable dust, respirable crystalline silica and diesel engine exhaust emissions at work sites of tunnel workers [11-13].

In this study, we found that the decrease in lung functions viz. FEV1 and FEV1/FVC among tunnel workers were significantly correlated with the duration of exposure (hours per day). Our finding shows agreement with earlier similar kind of studies. A study by Bakke, et al., in 2001 reported that the short-term lung function changes in tunnel construction workers and found a significant decrease in forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) among railway workers in comparison to a reference group over few days of exposure [2]. Another study showed a significant decrease in lung function parameters after 1 year of exposure to dusts and gases among tunnel workers [5]. Ulvestad, et al., had found that, with cumulative long term exposure to dust, there was a significant decrease in lung functions among tunnel workers over a period of 8 years of follow up [4]. In regard to respiratory symptoms, this study found that the tunnel workers reported significantly higher occurrence of respiratory symptoms particularly shortness of breath and productive cough. A previous study found similar results in which tunnel workers reported a higher prevalence of cough during the day, shortness of breath on exercise, and chest tightness and wheezing compared to the reference groups [1]. Longitudinal studies suggested that exposure to respirable dust is the most important risk factor for respiratory symptoms [4]. In our study, some of the tunnel workers were illiterate and most of the tunnel workers are very less educated which is attributed to their unawareness for the importance of using masks, respirators and other PPE during their work site of under-construction railway tunnel. The awareness for the toxic effects of respirable excavated dust, gaseous fumes, oil vapours, etc. and their exposure could help them in following safe work practices to minimize the exposure and thereby reducing the associated respiratory illnesses.

CONCLUSION

In conclusion this study found a significant decrease in lung functions parameters among tunnel workers among workers of Riyadh metro railway tunnel. Significant correlation was found between dust exposure period and lung function parameters. Shortness of breath and productive cough were the most frequent symptoms reported by workers. The assessment of exposure to hazardous materials was estimated indirectly by using the duration of work as an estimate of exposure but not by work place sampling which is the limitation of this study. Future research is recommended to measure the respirable dusts in the work place by means of fixed monitoring stations as well as by personal monitors and investigate their relationship with the lung function parameters and respiratory symptoms.

DECLARATIONS

Acknowledgment

The authors acknowledge medical students of Al Imam Mohammad Ibn Saud Islamic University who participated in the survey for this study. Authors also acknowledge Dr. S.A. Rizwan, Public Health Specialist, Saudi Board of Community Medicine, Riyadh, Saudi Arabia, for his valuable effort regarding statistical analysis in this article.

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