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Survey Based Research Paper

Monitoring of Railway Traffic Pollution and Health Effects on Exposed Population

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ABSTRACT

India's transport system is one of the largest transport systems serving the land mass of 3.3 million square km and a population of over one billion. Indian Railways has one of the largest and busiest rail networks in the world. The present study was undertaken to monitor and study the health effects on exposed population of railway transportation. To determine the impact of railway transportation on lung function of the workers, spirometric analysis was conducted. Significant declines in forced vital capacity (FVC), peak expiratory flow rate (PEFR) and forced expiratory volume in one second (FEV_1) were observed in the exposed population as compared to expected values. This study reveals reduced lung efficiency of exposed group due to excessive exposure to fine dust emitted at workplace environment. Group of coolie is most vulnerable group to respiratory impairment whereas group of RPF shows less effect among all the groups. The impairment in lung efficiency was increased with duration of exposure in the exposed population. It is recommended to use the personal protective equipment like nose mask and installation the dust collector equipments in the affected areas. Also tree plantation is advised on either sides of the tracks. All workplaces of the groups should introduce the dust exhaust system wherever possible. A regular health check up and awareness campaign is necessary to mitigate the problem.

INTRODUCTION

The issue of transportation and the environment is paradoxical in nature. From one side, transportation activities support increasing mobility demands for passengers and freight, and this ranging from urban areas to international trade. On the other side, transport activities have resulted in growing levels of motorization and congestion. As a result, the transportation sector is becoming increasingly linked to environmental problems. The relationships between transport and the environment are multidimensional. The most important impacts of transport on the environment relate to climate change, air quality, noise, water and soil quality as well as loss of biodiversity. Transport systems becomes nuisance to the public when they pass through or near the residential areas (Carpenter 1994). Transport sector encompasses highway vehicles, marine engines, locomotives and aircraft, which are the sources of pollution in the form of gases and particulate matter emissions that affects on air quality causing damage to human health. Ambient air is most polluted in cities, with the increase in the number of motor vehicles caused by economic growth and industrialization, the level of pollution is expected to worsen further in the future (Alam et al. 1999). Long term exposure to air pollution is an important factor in the development of chronic respiratory diseases (Karakatatsani et al. 2003). The effects of air pollution include breathing and respiratory problems, aggravation of existing respiratory and cardiovascular diseases, alteration in the body defence systems against foreign materials, damage to lung tissue, carcinogenesis and premature death (Cotes 1978, NHLBI/WHO 1995).

The particles emitted from the exhaust of more than 10 micron size are held in upper respiratory tract and particles less than 10 micron size (PM_{10}) accumulate in lungs and produce respiratory abnormalities. Hence, PM_{10} are of great concern in air pollution studies (Ingle et al. 2005). Long term exposure to particulate matter for years or decades is associated with elevated cardiovascular problems, infant mortality and morbidity, respiratory symptoms, and effects on lung growth and function of immune system. Short term study show consistent association of exposure to daily concentrations of PM with mortality and morbidity on same day or subsequent days. The major subgroups of the population that appear to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary, cardiovascular disease, influenza, pneumonia and other respiratory diseases and asthma (Kappos et al. 2004, Balmes 1993).

Railway is an important means of transport in India. Indian Railways has one of the largest and busiest rail networks in the world, transporting over 18 million passengers and more than 2 million tonnes of freight daily (Indian Railways Year Book 2007, Rao 2008). The emissions from rail activities are directly related to the construction during the completion of the foundation work, superstructure and track laying, signal and telephone lining, and electrical lining (Banverket & Luleå 2006) before implementation of regular railway activity. Coal generated smoke in steam days was a significant part of atmospheric pollution. Although steam traction is now only of historic interest due to introduction of electric traction, it still has a part to play in the areas where electrification has not been entirely phased in. Steam locomotives emit smoke particulates in the vicinity and contribute sulphur and nitrogen oxides and CO_2 to the wider atmosphere. Diesel locomotives and rail motor units produce the same sort of emissions as do road lorries, including carbon monoxide, nitrogen oxides, hydrocarbon and carbon based particulates. The contribution of electric transport to atmospheric pollution occurs where electricity is generated at fossil fuel burning power stations (Carpenter 1994). The sources of pollution in railway stations are welding fumes and iron particulate emission from rail track due to speed of train. People are exposed to iron oxide, assuming the fine iron abrasion dust is rapidly oxidized, with trace amounts of chromium, copper, zinc, manganese, and quartz. These cases are mostly observed in underground railways (Seaton et al. 2005). Godowns located on or nearby areas of railway stations are also the source of dust emission in railway stations. Varieties of goods carried out through freights are emptied in the godowns for its consecutive journey. Particulate matter generated by these goods is added in the atmosphere during its handling, which acts as a source for ambient air pollution on platform. Renovation activities in the railway station or nearby areas, which include breaking of old constructions and construction of new structures, are the source of dust pollution in railway stations.

The volume and spatial distribution of the emissions, as well as dispersion conditions, affect pollution levels. Several other factors also play a part in determining the exposure of a population. Pollution intake is also determined by the number of people in polluted areas, how long they stay there and what they do (Krzyzanowski, WHO 2005). Time-activity patterns, particularly residence or work near busy stations (or both), and time spent in traffic are critical for population exposure. Population growth and future expansion of urban centers are not considered while planning of rail projects in India. As a result large proportion of population is exposed to railway transportation (Khairnar & Ingle 2009).

Occupational activities, which involve exposure to dust and plant source particulate matter affect the lung capacity and cardio-respiratory fitness of workers (Debray et al. 2002). The impairment in lung efficiency increases with duration of exposure in workers (Wagh et al. 2006). Shopkeepers work at high risk of exposure to the air pollution (Ingle et al. 2005). Shop assistants in an air conditioned environment should be less exposed to traffic fumes and their lung should be better preserved compared to unprotected vendors exposed directly to vehicular pollution (Jones et al. 2008). Travelers are often exposed to levels that are three times the background levels. Groups with high levels of exposure include people who live near transportation activity and people whose jobs require them to spend a long time on the stations. Urban planning and development also strongly shape exposure; they determine not only patterns of residence and mobility but also the availability of public transport.

The present study emphasizes on the health effects, especially pulmonary function test and ventillary impairment, among population exposed to railway transportation in Jalgaon region. The Jalgaon railway shares 350 km from 5,440 km of total railway network in Maharashtra. Bhusawal railway division is the Central Railway's one of the most important headquarters located at 24 km from Jalgaon. The rail route passes through Jalgaon covering approximately 8 km distance through city. The residential colonies are well developed on both sides of railway track. Many vendors are also established their business on both sides of the track.

MATERIALS AND METHODS

Site description: Jalgaon and Bhusawal railway stations were selected for the present study. Jalgaon is a city in western India, to the north of Maharashtra state. Jalgaon is one of the fastest developing cities in north region of the state (Wagh et al. 2003). Jalgaon railway station is a junction for the trains coming from Central and Western Railways. Bhusawal, is located on the bank of Tapi river, and is biggest taluka of Jalgaon district. Bhusawal has very good railway connectivity, and an important divisional headquarters of Indian Central Railway. Workplaces of IWO (Inspection of Works), C&W (Carriage & Wagons), RPF (Railway Police Force) and Operating Department along with workplace of coolie of stations, residential areas and shops located on both sides of railway track passing through the Jalgaon city were selected for the study purpose.

Study population: Working population of IWO, C&W, RPF, Operating Department along with licensed Coolie, Population doing daily up-down from same stations were selected as subjects for the study purpose. Residential people living either sides of track and shopkeepers of shops located around railway activity were also considered as subjects. The control subjects were selected from general population of the Jalgaon city working in Banks or Government offices. It was ensured that these subjects are not exposed to any type of air pollution. Subjects having asthmatic history were rejected from the study. Number of exposed subjects was 50 each, and control subjects 60 respectively.

Screening questionnaires: The data on the health status of the study groups were collected using the standard Respirator Medical Evaluation Questionnaire (OSHA 1998) translated into a local language.

Workplace environment: The work was carried out in March-April. The humidity of workplace environment of railway employees and indoor environment of exposed population varied from 46% to 53.5%, while temperature was in the range of 30.5°C to 40.5°C.

Dust exposure monitoring: The exposure of dust was measured by a portable dust sampler over an 8-h period. The sampling unit contained an air pump powered by an internally sealed lead-acid gel battery. Air was drawn at a flow rate of 0.5 to 3.5 litres per minute, and the dust sampling unit was attached to the body of the object for 8-h per day. The dust (PM_{10}) was collected by filtration of air through glass fibre filter (25 mm diameter). The samples collected were measured by the gravimetric method and expressed as PM_{10} dose in $\mu g/m^3$.

Pulmonary function test: The target groups and control samples were subjected to the Pulmonary function test (Williams 1986, Jeelani 1992, Krelt et al. 1989). The pulmonary function tests were conducted by the instrument Spirometer (Medspiror Recorder & Medicare Systems Chandigarh, India). The Medspiror is based on the volume differential method for flow detection. Forced vital capacity (FVC) is the maximal amount of air that can be exhaled following maximal inspiratory effort (Normal: Male 4.8 L, Female 3.1 L). Forced expiratory volume (FEV_1) is the volume of air exhaled in one second during a forced vital capacity effort and peak expiratory flow rate (PEFR) is the maximum amount of air exhaled with forced effort during the FVC. Before spirometric test of the subjects, their age, height, weight and gender were fed into the spirometer. Spirometer gives two values viz., predicted and actual. The predicted values are based on the age, height, weight and gender whereas the actual values are based on the maximal exhalation followed by maximal inspiration of the subject. The pulmonary function test was conducted by sitting the subject comfortably in a chair for clearance manoeuvre (Badr et al. 2002). Regular sterilization of mouthpieces was done before the use. The subjects were asked for maximum exhalation followed by maximum inspiration. Three such tests were performed and subjects were asked to improve the performance. Best of three performances of FVC, FEV_1 and PEFR were taken into consideration. The equations for prediction were as follows.

$$FVC\ (L) = 0.050H - 0.014A - 4.49$$

$$FEV_1\ (L) = 0.040H - 0.021A - 3.13$$

$$PEFR\ (L/Sec) = 0.071H - 0.035A - 1.82$$

Where, H is height in cm and A is age in years.

The results of spirometry were assessed as per the criteria given in the manual of the Medspiror. The Medspiror software using a set of prediction equations for the adults calculates the expected values (Krelt et al. 1989).

The tests were conducted in the morning hours and ensured that the subjects were not exposed to air pollution at least for 12 hours before the test (Pandey 2001).

Statistical analysis: In the present study, some simple statistical parameters were applied with advanced statistical parameters such as Analysis of Variance (ANOVA) to the collected data. The data were processed for mean, standard deviation and two-way ANOVA (Armitage & Berry 1994). It comprises recording of FVC, FEV_1 and PEFR.

Risk assessment: The data on health status of the study groups were collected by standard questionnaire. The Respirator Medical Evaluation Questionnaire (OSHA 1998, ISO-7708, 1995) was used for collection of the data. The symptoms viz., frequent coughing, shortness of breath and irritation in respiratory tract were considered for risk analysis. The risk (Ito & Thurston 1996, Sengupta 1996) were calculated for the target groups (IWO, C&W, RPF, Operating Department, Coolie, Residential, Shopkeepers and Up-downers) against control group having different exposure to risk factors. The odds ratio, relative risk and attributable risk were calculated by setting a simple 2 × 2 matrix (Gilbert 2004) such that the rows divide the population according to those who had been exposed and those who have not been exposed (control) to the risk factor. According to Hennekens & Buring (1987), odd ratio is nothing but the odds of disease in exposed persons divided by odds of disease in unexposed persons. Attributable risk is, finding the probability of disease for exposing to the particular factor. Sackett et al. (1996) reported that the attributable risk is a measure of excess risk accounted for by exposure to a particular factor. Relative risk is the ratio of two absolute risks. It measures the strength of effect of an exposure on risk (Sackett et al. 1996). The columns were based on the number of individuals who had acquired the symptoms being studied and those who had not in both of the target groups.

RESULTS

Environmental monitoring of exposed and control groups: Table 1 shows the environmental monitoring of each group. The average temperature of IWO, C&W, RPF, operating, Coolie, Up-Down, Residential, Shopkeepers and Control groups during study period were 34°C, 40.5°C, 37.5°C, 31°C, 39.5°C, 39°C, 32.5°C, 33.5°C and 30.5°C respectively, while the relative humidity of the same places was 49.5%, 46 %, 49%, 53%, 49%, 48%, 53.5%, 46.5% and 49.5% respectively. Air monitoring of these places shows PM10 concentration of 366.37, 460.52, 206.76, 182.73, 394.73, 308.02, 174.36 and 293.21 respectively. Each group is classified as indoor, mix and outdoor. IWO and Shopkeepers are the groups working in mix environment whereas Residential, operating and C&W are categorized in indoor environment. Remaining groups i. e., Coolie, R.P.F. and Up-downers groups are categorized in outdoor environment.

Pulmonary status of exposed and control groups: Table 2 shows the physical parameters of the subjects i. e., age, height and weight, which were considered for the spirometric test. The age of subjects selected for the study ranged between 18 and 53 years. Average weight of the subjects was ranged from 24 kg to 116 kg. The average height of the respondents was 152 cm and ranged from 131 to 187cm.

Observed values and percentage of pulmonary function tests show decline in the FVC, FEV_1 and PEFR indices of the exposed population as compared to the control group. Average value of FVC in IWO, C&W, RPF, operating, Coolie, Up-Down, Residential, Shopkeepers and control groups was 76%, 83%, 83%, 77%, 75%, 79%, 73%, 77% and 92% respectively. The average value of FEV_1 in the same groups was 86%, 96%, 92%, 87%, 80%, 85%, 82%, 83% and 101%. Peak Expiratory Flow Rate (PEFR) is the best test of expiratory effort. Its values in the exposed and control groups were 69%, 69%, 79%, 72%, 66%, 76%, 73%, 62% and 84% respectively.

Ventillary impairment in target groups: The ventillary impairment of exposed group is categorized on the basis of air flow obstruction (FVC), restrictive defect (FEV_1) and expiratory flow rate (PEFR) in as given in Table 3. The data show that all the groups have warning signal and fatal asthma. Coolie and IWO workers are more affected groups having 32% and 20% fatal asthma respectively, whereas operating and shopkeepers have 62% and 74% warning signals. All the groups show stable asthma less than 50%. Control group shows 65% stable asthma. Severe restrictive defect is observed in Coolie (10%), Up-downers (2%), Residential (2%) and Shopkeepers (2%). All the groups except C&W shows moderate restrictive defect. Mild restrictive defect is observed in all groups, whereas it is more in IWO (32%), Up-downers (34%) and Residential (36%) groups. Control group shows no severe and moderate effect. Severe air flow obstruction is observed in IWO (2%), Coolie (10%), Up-downers (2%), Residential (8%) and Shopkeepers (4%). Moderate air flow obstruction is observed in each group, whereas mild air obstruction is observed more in Up-downers (60%) group. Control shows no severe and moderate air flow obstruction effects.

Risk assessment of population exposed to workplace environment: Table 4 shows the higher risk for all the groups exposed to the ambient air prevailing at the workplace environment. Relative risk and odd ratio for the symptoms studied were above one in all the exposed groups, which indicates an association between exposure and group. Coolies are on higher risk having relative risk of 2.58, 6.33 and 6.5, whereas odd ratio 3.84, 9.6 and 8.43 for symptoms like frequent coughing, shortness of breath and irritation in respiratory tract respectively. Attributable risk in all the groups shows strong relationship in exposure and groups.

Pulmonary status (as per years of exposure) of exposed and control groups: All the groups were categorized into 5 categories as per their duration of exposure. Test was performed for comparison of individual pulmonary function test of IWO, C&W, RPF, operating, Coolie, UP-Down, Residential, and Shopkeeper against control group. All the groups are categorized according to 0 to 5, 6 to 11, 12 to 16, 17 to 22 and above 22 years of exposure as in Tables 5, 6, 7,8 and 9 respectively, where data show that *p* values in ANOVA are significant $p<0.05$ by multiple comparison tests. The comparison of duration of dust exposure with pulmonary function test of each individual group against control group clearly indicates a relation between dust exposure and pulmonary functions in exposed groups.

DISCUSSION

Temperature of exposed groups was in the range of 30.5°C to 40.5° C. Workplace temperature of Coolie and C&W group is more as they are working on platform (outdoor) and in the carriage and wagons (indoor) respectively. Observed value of PM_{10} concentration of C&W and Coolies was more. Passenger trains, freights containing variety of goods like coal, food items, agriculture products, fertilizers, etc. are carried out from the stations. Particles of these goods sometimes mix with the atmosphere and increase the concentration of particulate matter on the stations. Godowns, which are located on Bhusawal as well as on Jalgaon railway stations, are also the source of dust emission in ambient atmosphere while handling or transferring the goods. Due to speed of trains dust from surroundings is carried out with the flow when trains enter the stations. At the same time the coolies become exposed population to this dust who are waiting for the customers on platform. C&W workers work in carriage and wagons which are standing on platforms, so they are also exposed to heavier concentration of dust. Whenever renovation activity is conducted on Bhusawal station, it contributes to the source of dust pollution on platform. FVC of all the groups has declined as compared to control group, where group of coolie and residential show less FVC i. e., 75% and 73% respectively. It may be due to accumulation

Table1: Environmental monitoring of IWO, C&W, RPF, Operating Department, Coolie, Up-Downers, Residential, Shopkeepers and Control Samples.

Sr No.	Target Groups	PM_{10} dose (μg/m^3)	Average Temperature °C	Relative Humidity, %	Type
1	IWO	366.37±71.11 (316.09-416.6)	34 ± 2.82 (32-36)	49.5 ± 3.53 (47-52)	Mix
2	C&W	460.52 ± 62.02 (416.6-504.38)	40.5 ± 3.53 (38-43)	46 ± 4.24 (43-49)	Indoor
3	RPF	206.76±44.30 (175.43-244.25)	37.5 ± 4.94 (34-41)	49 ± 8.48 (43-55)	Outdoor
4	Operating Deptt.	182.73±87 (121.21-244.25)	31 ± 4.24 (28-34)	53 ± 5.65 (49-57)	Indoor
5	Coolie	394.73 ± 31.01 (372.8-416.6)	39.5 ± 6.36 (35-44)	49 ± 8.48 (43-55)	Outdoor
6	Up-Downers	308.02±8.91 (301.72-314.32)	39 ± 4.24 (36-42)	48 ± 7.07 (43-53)	Outdoor
7	Residential	174.36±73.87 (122.12-226.60)	32.5 ± 4.94 (29-36)	53.5 ± 7.7 (48-59)	Indoor
8	Shopkeepers	293.21 ± 42.5 (263.15-323.27)	33.5 ± 6.36 (29-38)	46.5 ± 7.77 (41-52)	Mix
9	Control	NA	30.5 ± 4.94 (27-34)	49.5 ± 10.6 (42-57)	Indoor

Table 2: Pulmonary status of different exposed and Control groups.

Sr. No.	Parameter		A (n=52)	B (n=50)	C (n=50)	D (n=50)	E (n=50)	F (n=49)	G (n=52)	H (n=50)	I (n=59)
1	Age (yr)		41.16±7.59 (24-52)	40.14 ± 8.52 (24-51)	39.8 ± 9.02 (20-51)	37.32±9.42 (18-51)	37.04 ±9.24 (21-51)	29.6±5.79 (19-46)	33.0 ±10.90 (19-51)	35.88±9.87 (20-51)	40.52±7.27 (27-51)
2	Height (cm)		161.58 ± 7.68 (143-177)	161.94± 8.53 (145-180)	165.26 ± 7.42 (150-179)	166.42 ± 7.65 (153-186)	163.8 ± 5.92 (148-175)	164.2± 9.87 (140-181)	159.89± 9.82 (132-180)	164 ± 9.01 (143-176)	161.83±15.04 (140-181)
3	Weight (kg)		60.06±10.42 (40-86)	63.62±7.95 (45-84)	66.48±12.72 (41-95)	63.18±13.44 (44-116)	58.24±8.68 (44-82)	57.96±7.49 (48-86)	56.21±13.07 (25-82)	60.06±12.89 (35-86)	65.30±8.27 (45-82)
4	FVC (L)	Obs	2.15±0.85	2.43±0.68	2.54±0.81	2.52±0.64	2.27±0.82	2.46±0.63	2.13±0.66	2.44±0.86	7.53±35.82
		%	76	83	83	77	75	79	73	77	92
5	FEV_1 (L)	Obs	2.0±0.66	2.32±0.58	2.28±0.62	2.33±0.60	2.02±0.80	2.21±0.55	1.97±0.58	2.17±0.74	2.54±0.51
		%	86	96	92	87	80	85	82	83	101
6	PEFR (L/s)	Obs	5.46±1.70	5.56±1.62	6.08±1.72	6.13±1.79	5.44±1.99	8.03±13.35	7.36±1.90	5.18±1.70	6.78±1.48
		%	69	69	79	72	66	76	73	62	84
7	FEV_1/FVC (%)	Obs	92.0±2.10	93.80±8.48	91.79±12.13	92.02±16.02	5.44±1.99	93.60±14.43	91.92±10.79	88.59±16.63	89.54±12.54
		%	107	114	114	113	106	112	111	107	111

A = IWO, B = C&W, C = RPF, D = Operating Department, E = Coolie, F = UP-Downers, G = Residential, H = Shopkeeper, I = Control

Table 3: Ventillary impairment in target groups.

Sr. No.	Lung status	A	B	C	D	E	F	G	H	I
1	**Air flow obstruction**									
	Normal (FVC > 80 %)	34	46	52	44	42	32	34	42	91.5
	Mild (FVC 60 - 80 %)	36	46	40	40	30	60	42	36	8.4
	Moderate (FVC 40 - 60 %)	28	8	8	16	18	6	20	16	0
	Severe (FVC < 40 %)	2	0	0	0	10	2	8	4	0
2	**Restrictive defect**									
	Normal (FEV_1 > 80 %)	52	86	70	62	54	56	42	56	93.3
	Mild (FEV_1 60 - 80 %)	32	14	28	28	20	34	36	28	6.7
	Moderate (FEV_1 40 - 60 %)	16	0	2	10	16	6	14	12	0
	Severe (FEV_1 < 40 %)	0	0	0	0	10	2	2	2	0
3	**Asthma symptoms**									
	Stable asthma (PEFR > 80 %)	30	28	42	28	26	38	38	12	64.04
	Warning signal (PEFR 50 - 80 %)	50	54	52	62	42	52	50	74	32.2
	Fatal asthma (PEFR < 50 %)	20	18	6	10	32	10	16	14	5.08

A = IWO, B = C&W, C = RPF, D = Operating Department, E = Coolie, F = Up-Downers, G = Residential, H = Shopkeeper, I = Control

of dust particles in the lung airways of both the groups as these groups are more exposed to the dust due to workplace environment of platform and residential group which is located on either sides of track. FEV_1 of all the groups shows decline compared to the control group but coolies are more affected. PEFR is the parameter which is adversely affected in shopkeepers and coolie i. e., 62% and 66% respectively among all the exposed groups. RPF is the group which is least affected in all the groups with respect to FVC, FEV_1 and PEFR parameters. It may be due to their workplace exposure of dust which is very less in all the groups. The healthy physical condition of RPF group is also responsible for fewer

Table 4: Risk assessment of population exposed to workplace environment.

Sr. No.	Target Group	Risk Assessment								
		Frequent coughing			Shortness of Breathe			Irritation in respiratory tract		
		Relative risk	Attributable risk	Odd Ratio	Relative risk	Attributable risk	Odd Ratio	Relative risk	Attributable risk	Odd Ratio
1	IWO	1.88	0.15	2.3	3	0.12	3.44	3	0.28	3.27
2	C&W	2	0.17	2.52	3.16	0.13	3.67	4.25	0.23	4.92
3	RPF	1.35	0.06	1.46	2	0.06	2.14	2.75	0.07	2.97
4	Operating Deptt.	1.47	0.08	1.63	2.16	0.07	2.34	2.25	0.05	2.37
5	Coolie	2.58	0.27	3.84	6.33	0.32	9.6	6.5	0.22	8.43
6	Up-Downers	1.05	0.01	1.07	2.16	0.07	2.34	2.75	0.07	2.97
7	Residential	1.05	0.01	1.07	2	0.06	2.14	2	0.04	2.09
8	Shopkeepers	1.88	0.15	2.3	4	0.18	4.95	4.75	0.15	5.63

[a] Relative risk and odds ratio above 1.0 indicates an association between exposure and risk.
[b] An attributable risk of 0.0 suggests no relationship, and above it strong relationship.

Table 5: Pulmonary status of different exposed and Control groups (0 to 5 yrs exposure).

Sr. No.	T.G.	0 to 5 yrs Exposure								
		FVC (L)		FEV_1 (L)		PEFR (L/s)		FEV_1/FVC (%)		
		Obs	%	Obs	%	Obs	%	Obs	%	p-value
1	A (n=8)	2.05 ± 0.65	68.10 ±29.00	1.97 ± 0.73	76.35 ±32.27	5.93 ± 1.79	71.70 ± 22.19	94.29 ± 14.83	107.63 ±14.52	<0.0001
2	B (n=11)	2.98 ± 0.84	99.00 ±27.74	2.56 ± 0.66	100.78 ±26.44	5.08 ± 1.5	61.72 ±16.67	88.91± 11.85	103.27 ±12.02	<0.0001
3	C (n=8)	2.43 ± 0.68	81.27 ± 16.67	2.35 ± 0.71	93.62 ± 20.06	6.22 ± 1.85	79.64 ±13.28	96.24 ± 8.55	114.83 ± 9.54	<0.0001
4	D (n=12)	2.72 ± 0.74	74.11± 16.47	2.49 ± 0.77	79.55 ± 18.11	6.23 ± 1.84	67.49 ±18.24	85.63 ± 29.71	100.25 ± 20.83	<0.0001
5	E (n=12)	2.52 ± 0.92	78.01 ± 27.37	2.52 ± 0.80	86.89 ± 28.53	6.73 ± 1.92	76.65 ±23.45	89.99 ± 14.90	102.59 ± 13.73	<0.0001
6	F (n=39)	2.53 ± 0.63	79.31 ± 20.74	2.25 ± 0.55	84.26 ± 18.12	8.71 ± 15.04	85.14 ±19.08	93.68 ± 15.99	112.98 ± 10.31	<0.0001
7	G (n=11)	2.18 ± 0.69	74.65 ± 18.66	1.90 ± 0.59	78.18 ± 21.55	4.56 ± 1.80	59.76 ±18.93	90.48 ±18.35	109.23 ± 23.25	<0.0001
8	H (n=18)	2.88 ± 0.77	80.44 ± 19.43	2.68 ± 0.63	87.29 ± 19.82	6.15 ± 1.02	66.12 ±10.77	94.10 ± 5.69	109.21 ± 6.40	<0.0001
9	I (n=10)	3.37 ± 0.53	101.3 ± 8059	2.84 ± 0.69	103.64 ± 16.31	6.82 ± 1.28	81.28 ±15.26	84.798 ± 17.4	103.54 ±14.13	<0.0001

Overall difference is based on two-way ANOVA. Test was performed for comparison of individual pulmonary function test of IWO, C&W, RPF, Operating Deptt., Coolie, Up-Downers, Residential, Shopkeeper against Control group, where p values in ANOVA are significant p<0.05 by multiple comparison tests. A = IWO, B = C&W, C = RPF, D = Operating Deptt., E = Coolie, F = Up-Downers, G = Residential, H = Shopkeeper, I = Control

Table 6: Pulmonary status of different exposed and Control groups (6 to 11 yrs exposure).

Sr. No.	T.G.	6 to 11 years exposure								
		FVC (L)		FEV_1 (L)		PEFR (L/s)		FEV_1/FVC (%)		p-value
		Obs	%	Obs	%	Obs	%	Obs	%	
1	A (n=11)	1.66 ±0.49	64.34 ± 23.45	1.88 ±0.84	81.38 ± 36.94	4.41 ± 1.79	59.59 ± 20.44	93.77 ± 10.30	112.94 ± 29.74	<0.0001
2	B (n=7)	2.32±1.01	82.85 ± 26.62	2.74±0.81	103 ± 35.22	5.38 ± 2.06	65.85 ± 23.38	95.89 ± 7.27	115.40 ± 7.364	<0.0001
3	C (n=5)	3.20±0.70	101.26 ± 13.28	2.58±0.55	98.47 ± 19.56	5.66 ± 1.37	68.68 ± 11.9	79.84 ± 20.42	98.81 ± 25.2	<0.0001
4	D (n=9)	2.37±0.63	73.60 ± 19.6	2.26±0.59	84.32 ± 21.66	6.38 ± 2.00	76.77 ± 20.32	96.08 ± 7.73	115.71 ± 10.80	<0.0001
5	E (n=4)	2.28±0.44	76.25 ± 13.22	1.91±0.68	83.05 ± 31.88	4.49 ± 2.47	55.56 ± 24.28	91.33 ± 6.73	112.71 ± 10.34	<0.0001
6	F (n=10)	2.34±0.61	76.25 ± 9.02	2.17±0.49	84.76 ± 13.76	6.01 ± 2.21	76.17 ± 27.75	93.93 ± 6.86	112.35 ± 8.99	<0.0001
7	G (n=7)	2.08±0.50	69.33 ± 17.65	1.99±0.51	78.03 ± 21.39	5.10 ± 1.73	71.83 ± 30.50	95.63 ± 5.88	112.29 ± 8.24	<0.0001
8	H (n=10)	2.42±0.56	77.81 ± 14.92	2.23±0.44	88.49 ± 14.61	5.74 ± 1.54	70.25 ± 14.05	92.94 ± 5.68	114.26 ± 8.52	<0.0001
9	I (n=15)	2.81±0.56	92.13 ± 8.37	2.68±0.51	107.2 ± 9.12	6.49 ± 1.59	81.12 ± 13.10	95.09 ± 9.85	115.83 ± 11.15	<0.0001

Overall difference is based on two-way ANOVA. Test was performed for comparison of individual pulmonary function test of IWO, C&W, RPF, Operating Deptt., Coolie, Up-Downers, Residential, Shopkeeper against Control group, where p values in ANOVA are significant p<0.05 by multiple comparison tests. A = IWO, B = C&W, C = RPF, D = Operating Deptt., E = Coolie, F = Up-Downers, G = Residential, H = Shopkeeper, I = Control

effects. Stable asthma in less than 50% is observed in each group, whereas fatal asthmatic condition is observed in coolie (32%) and IWO (20%). This is due to the less PEFR values. Ventillary impairment data show that severe restrictive defects and severe air flow obstruction are high in coolie followed by up-down, residential, IWO and shopkeepers. All the groups except C&W show moderate restrictive defect as well as moderate air flow obstruction due to the decline in FVC and FEV_1 values. All the groups are subject to risk. Coolies are on high relative risk due to the workplace expo-

Table 7:Pulmonary status of different exposed and Control groups (12 to 16 yrs exposure).

Sr. No.	T.G.	12 to 16 Years of exposure								
		FVC (L)		FEV_1 (L)		PEFR (L/s)		FEV_1/FVC (%)		p-value
		Obs	%	Obs	%	Obs	%	Obs	%	
1	A (n=12)	2.21 ± 0.80	78.09 ± 23.81	1.82 ±0.69	84.25 ± 21.01	4.74 ± 1.54	62.53 ± 22.33	89.70 ± 13.43	108.30 ± 16.65	<0.0001
2	B (n=8)	2.35 ± 0.73	84.83 ± 17.28	2.06±0.71	94.93 ± 16.86	5.35 ± 2.11	71.04 ± 22.32	91.69 ± 9.54	114.22 ± 10.16	<0.0001
3	C (n=6)	2.23 ± 1.05	88.49 ± 24.66	1.81±0.44	89.16 ± 10.10	4.34 ± 0.85	64.67 ± 5.66	87.07 ± 15.66	108.12 ± 21.25	<0.0001
4	D (n=8)	2.89 ± 0.49	41.40 ± 20.98	2.62±0.42	97.03 ± 20.5	6.22 ± 1.17	74.49 ± 11.0	91.26 ± 8.90	109.26 ± 9.48	<0.0001
5	E (n=10)	2.16 ± 0.89	77.41 ± 21.47	2.24±0.88	93.72 ± 26.50	6.07 ± 1.99	75.68 ± 26.90	90.29 ± 12.73	107.7 ± 17.53	<0.0001
6	F (n=0)	-	-	-	-	-	-	-	-	-
7	G (n=9)	1.80 ± 0.77	74.07 ± 19.78	1.70±0.65	86.73 ± 20.23	4.21 ± 0.91	65.67 ± 13.36	95.58 ± 6.58	118.79 ± 10.42	<0.0001
8	H (n=13)	2.28 ± 0.94	44.35 ± 25.02	1.90±0.64	83.33 ± 18.79	4.49 ± 1.81	59.23 ± 18.38	84.11 ± 20.10	104.74 ± 27.70	<0.0001
9	I (n=13)	2082 ± 0.28	89.80 ± 9.30	2.59±0.39	101 ± 9.10	6.67 ± 1.61	81.94 ± 17.93	93.37 ± 8.78	116.04 ± 0.95	<0.0001

Overall difference is based on two-way ANOVA. Test was performed for comparison of individual pulmonary function test of IWO, C&W, RPF, Operating Deptt., Coolie, Up-Downers, Residential, Shopkeeper against Control group, where p values in ANOVA are significant $p<0.05$ by multiple comparison tests. A = IWO, B = C&W, C = RPF, D = Operating Deptt., E = Coolie, F = Up-Downers, G = Residential, H = Shopkeeper, I = Control

Table 8: Pulmonary status of different exposed and Control groups (17 to21 yrs exposure).

Sr. No.	T.G.	17 to 21 Years of exposure								
		FVC (L)		FEV_1 (L)		PEFR (L/s)		FEV_1/FVC (%)		p-value
		Obs	%	Obs	%	Obs	%	Obs	%	
1	A (n=9)	2.84 ± 1.38	99.77 ± 45.15	2.40±0.52	102.44 ± 23.53	6.29 ± 1.42	77 ± 14.39	87.75 ± 14.50	106.4 ± 19.16	<0.0001
2	B (n=8)	2.38 ± 0.22	84.87 ± 18.48	2.18±0.23	95.62 ± 16.35	5.94 ± 0.97	75 ± 12.76	95.44 ± 5.50	117.25 ± 7.36	<0.0001
3	C (n=19)	2.56 ± 0.87	82.15 ± 20.15	2.30±0.65	90.89 ± 17.77	6.64 ± 1.74	89.52 ± 26.10	91.98 ± 11.31	112.52 ± 13.76	<0.0001
4	D (n=5)	2.54 ± 0.27	77.6 ± 12.09	2.33±0.32	87.4 ± 14.63	7.09 ± 2.06	82.8 ± 24.13	92.4 ± 13.24	112.6 ± 15.22	<0.0001
5	E (n=16)	2.41 ± 0.62	81.25 ± 19.43	1.96±0.59	80.12 ± 24.45	5.00 ± 1.55	63.56 ± 20.8	85.06 ± 23.05	101.8 ± 27.98	<0.0001
6	F (n=0)	-	-	-	-	-	-	-	-	-
7	G (n=19)	1.96 ± 0.69	67.15 ± 18.32	1.81±0.62	76.67 ± 18.63	5.34 ± 2.46	84.81 ± 35.59	94.26 ± 9.74	109.78 ± 23.90	<0.0001
8	H (n=5)	2.03 ± 0.72	67.8 ± 17.96	1.74±0.52	73.58 ± 19.09	4.50 ± 0.76	58.58 ± 8.50	81.25 ± 28.90	101.6 ± 36.92	<0.0001
9	I (n=12)	2.67 ± 10.56	88.75 ± 10.29	2.28±0.36	96.08 ± 14.65	7.06 ± 1.43	89.08 ± 11.41	87.09 ± 13.26	109 ± 17.21	<0.0001

Overall difference is based on two-way ANOVA. Test was performed for comparison of individual pulmonary function test of IWO, C&W, RPF, Operating Deptt., Coolie, Up-Downers, Residential, Shopkeeper against Control group, where p values in ANOVA are significant $p<0.05$ by multiple comparison tests. A = IWO, B = C&W, C = RPF, D = Operating Deptt., E = Coolie, F = Up-Downers, G = Residential, H = Shopkeeper, I = Control

Table 9: Pulmonary status of different exposed and Control groups (above 22 yrs of exposure).

Sr. No.	T.G.	Above 22 Years of exposure								
		FVC (L)		FEV_1 (L)		PEFR (L/s)		FEV_1/FVC (%)		p-value
		Obs	%	Obs	%	Obs	%	Obs	%	
1	A (n=12)	2.14±0.31	70.91 ± 8.4	2.05±0.35	86.5 ± 14.7	6.19±1.10	76.91 ± 14.	95.89 ± 7.1	113.5 ± 31.	<0.0001
2	B (n=16)	2.16±0.23	72.5 ± 9.71	2.17±0.27	88 ± 8.07	5.88±1.54	72.37 ± 17.53	96.48 ± 5.68	120.93 ± 7.03	<0.0001
3	C (n=12)	2.45±0.67	77.25 ± 18.84	2.33±0.56	93.66 ± 19.02	6.14±1.66	75.16 ± 17.53	95.87 ± 5.16	124.75 ± 11.37	<0.0001
4	D (n=16)	2.25±0.65	74.64 ± 17.34	2.11±0.58	88.3 ± 18.32	5.58±1.85	69.81 ± 21.36	94.76 ± 4.97	119.25 ± 7.63	<0.0001
5	E (n=8)	1.72±0.96	57.5 ± 29.46	1.17±0.41	53.75 ± 19.99	4.09±1.69	55.12 ± 23.87	88.11 ± 27.66	112.87 ± 35.84	<0.0001
6	F (n=0)	-	-	-	-	-	-	-	-	-
7	G (n=6)	1.52±0.40	63.33 ± 19.89	1.49±0.37	80.16 ± 21.12	4.68±1.34	72 ± 17.58	98.58 ± 1.67	127.5 ± 7.529	<0.0001
8	H (n=4)	1.52±0.92	65.75 ± 31.98	1.15±0.71	65.45 ± 38.16	2.58±1.45	42.11 ± 22.01	76.73 ± 29.95	98 ± 37.76	<0.0001
9	I (n=9)	2.75±0.19	92.33 ± 7.58	2.29±0.39	98.33 ± 14.94	7.02±1.56	87.88 ± 98.94	83.4 ± 11.43	107 ± 17.33	<0.0001

Overall difference is based on two-way ANOVA. Test was performed for comparison of individual pulmonary function test of IWO, C&W, RPF, Operating Deptt., Coolie, Up-Downers, Residential, Shopkeeper against Control group, where p values in ANOVA are significant $p<0.05$ by multiple comparison tests. A = IWO, B = C&W, C = RPF, D = Operating Deptt., E = Coolie, F = Up-Downers, G = Residential, H = Shopkeeper, I = Control sure and unhealthy work conditions. Statistical analysis of all the groups shows significant relationship between dust exposure and decline in pulmonary function.

CONCLUSION AND RECOMMENDATIONS

Unhealthy work conditions were observed in all the groups during the survey. These conditions affect health of the exposed population. Most of the exposed population was unaware about the effects of the dust pollution. Group of coolie is most vulnerable group to respiratory impairment whereas group of RPF shows fewer effects. In the control group, FVC, FEV_1 and PEFR were close to the expected values, which show better lung efficiency in unexposed population. The study concludes that all exposed population to the railway transportation is vulnerable to respiratory impairment. It is recommended that equipments like dust collectors must be kept on railway platform for collection and separation of dust particles. Tree plantation must be done on either sides of track which will restrict dust exposure of shopkeepers as and residential people. IWO, C&W and coolie workers must use the mask at workplace area. All work places of the groups should introduce the dust exhaust system wherever possible. Group of operating, up-down and RPF must use mask whenever they are exposed to dust on platform. Campaign should be organized in context of public awareness about dust and effects of air pollution.

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