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Pulmonary Functions and Work-Related Musculoskeletal Disorders of Road Construction Workers of West Bengal, India

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ABSTRACT

Introduction: Road paving construction workers are exposed to bitumen, asphalt, and other aliphatic amines. They are also exposed to high temperatures and dust during the processing of asphalt production and transport of hot asphalt and bitumen to the working site. Bitumen fumes and asphalt produce respiratory irritations and shortness of breath in asphalt workers. Thus, the purpose of this study was to assess the respiratory impairment of asphalt workers on exposure to bitumen fumes and to assess cardiovascular stress on exposure to high temperatures and heavy workload.

Methods: This cross-sectional study has been made on 32 asphalt workers and 20 control group workers of Kolkata city of West Bengal and its surrounding. Anthropometric parameters, blood pressure, and heart rate were measured by standard procedure. Respiratory parameters were taken by Digital Spirometer (Spirovit SP1) and respiratory symptoms & musculoskeletal problems were recorded by a standard questionnaire.

Results: The study indicated that prolong exposure to bitumen fumes may enhance the risk of lung impairment by reduction of all respiratory parameters ($p< 0.05$-0.001). Smoking habits and the reluctance to use protective gadgets among asphalt workers increase the risk of respiratory distress.22% of workers reported chest tightness, 20% had Chronic Bronchitis and10% suffered from Bronchial asthma. The maximum percentage of Paver operators showed Chest tightness (83.33%), Chronic Bronchitis (100%) and Bronchial asthma(66.66%). Musculoskeletal Disorder(MSD) among Paver operators was maximum(33.3-50%). Odds ratio values of the prevalence of respiratory disorder and MSD with >10years of exposure to bitumen fumes vary from 2-4.5. Exposure to high temperature and heavy workload, mainly among asphalt strippers and paver operators might be the reason for higher heart rate. The awkward working posture might be the cause of musculoskeletal disorders among them.

Conclusion: The use of appropriate respiratory protection and the introduction of modern equipment and technologies can reduce the emission of bitumen fumes to protect the health of asphalt workers.

Key words- Asphalt workers, Musculoskeletal disorders, Pulmonary function, Respiratory impairments,

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INTRODUCTION

Asphalt, an important ingredient of road construction, consists of 4-20 % bitumen mixed with crushed stone. In road paving the bitumen content is usually 4-5 %. The type of bitumen and the size of the gravel vary with the properties requested from the road surface. Filter and/or fibers may also be added to modify the properties of the asphalt and aliphatic amines are used to improve binding between the bitumen and the stone material.[1]

Depending on the type of asphalt paving, temperatures vary from 70°C to 220°C, paving temperatures around 140-150°C are common. Asphalt is produced by heating and drying the gravel and mixing the hot bitumen with it. The asphalt is transported to the paving site by truck and emptied onto the front of the paving machine. The asphalt passes underneath the machine and is spread to the desired width and thickness by the screed.

There is a concern about past and present health risks posed by occupational exposures in the asphalt industry but the evidence for specific exposure - disease association in the industry is equivocal. The primary chemical mixture of interest in the studies of health hazards in the industry is bitumen, a distillation product of crude oil. Bitumen can be combined with coal tar to form a binder for asphalt (binder plus filter of sand and/ or gravel).[2] These are highly carcinogenic at relatively low concentrations.[3,1,4] Additionally, road construction workers are exposed to emissions from the exhaust of passing vehicles. [5] Respiratory effects of exposure to asphalt fume have been evaluated and many researchers have shown a significant reduction in some parameters of pulmonary function as well as upper respiratory tract irritation and shortness of breath in road paving workers .[6,7]

Early reviews suggest that the inhalation of polycyclic aromatic compounds (PCAs), which is one of the ingredients of bitumen may cause lung dysfunction mainly in road construction workers. As there is no report about pulmonary function and musculoskeletal disorders among road paving industry workers of West Bengal, the present study was undertaken to observe the changes in pulmonary function along with different respiratory symptoms and some cardiovascular parameters. The objectives of this study were to assess the pulmonary function of Road construction (Asphalt) workers who were exposed to Bitumen and other polycyclic aromatic hydrocarbons (PAHs), to evaluate the duration of service/ exposure of asphalt and the degree of impairment in pulmonary function and prevalence of work-related musculoskeletal disorders, and to compare the pulmonary function parameters with those of age-matched healthy adults.

METHODS

This cross-sectional study was undertaken during the period from March-May 2018 among road construction/ asphalt workers (n= 32) of Kolkata and North 24 Pargana district of West Bengal to study pulmonary function, respiratory impairment, and some related physical and physiological parameters of those workers. A control group (n=20) was also taken to study the above-mentioned parameters.

All the measurements were taken in different tents at the road construction site between 3 pm to 5 pm and the control group workers were selected at random from college students and other people in our society who perform different sedentary works every day compared to Road construction workers.

Road construction (asphalt) workers were divided according to their pattern of the job into three groups Paver operator (n=6), roller driver (n=13), and asphalt stripper (n= 13).

Study Area - The study area has been divided into 2 sub-areas like the Nagerbazar area and the Dumdum Road of Kolkata and the North 24 Paragana area of West Bengal. The subjects were selected at random by a simple random sampling method among willing workers from different areas.

Inclusion Criteria - The following criteria were considered for subject selection in this study-

i) Only willing workers are included. ii) Age between 14- 45 years. iii) Workers with more than 1 year of experience will be taken. iv) No migrant workers working at least 10 months or more round the year and are not engaged in other occupations.

Exclusion Criteria - i) Workers working below less than 1 year are excluded. ii) History of tuberculosis, emphysema, and diabetes mellitus were excluded. iii) Unwilling workers were excluded. iv) Subjects with clinical abnormalities of the vertebral column and the thorax were excluded.

Sampling Strategy - Measurements were carried out between March-May 2018, to assess exposure to modern asphalt work. A random sample of workers representing different work tasks was asked to participate but participation was voluntary. All the road Asphalt workers had a minimum working experience of one year in their present occupation.

The sample size was calculated by using “PS Power and sample size calculator” version 2.1.30. The details of the sample size calculation are as follows-

1. Type I error probability for a two-sided test =0.05.
2. Power (Probability of correctly rejecting the null hypothesis of equal population means given n pairs

of patients and a type I error probability) = 0.8.
3. Difference in population mean of Forced Vital Capacity (FVC)=0.74
4. Standard deviation of the difference in the response of matched pairs of FVC =0.63

Using the above FVC score, the estimated sample size was 8. Considering a dropout rate of 20%, the sample size was increased to 10 subjects. To be on the safe side we recruited a total of 32 subjects in the experimental group.

Spirometric Study[8]- The pulmonary function tests (PFT) were performed in their workplace by using an automatic Spirometer (Spirovit SP 1 model) according to the guideline recommended by the American thoracic society. The testing procedures are quite simple and non-invasive and harmless to the participants. The Spirometer was calibrated each day before use and a new filter was introduced. The relevant data age, sex, body weight, body height was recorded. The subject was connected to the mouthpiece and was asked to breathe in and out to familiarize himself with the equipment. During the tests, the subjects were adequately encouraged to perform at their optimum level, and also a nose clip was applied. The test was repeated 3 times and the best results were considered for analysis. Following were the pulmonary function parameters studied -

Forced vital capacity (FVC) - volume achieved by the quickest possible exhalation after a maximum inhalation.

Forced Expiratory Volume in 1 sec (FEV_1) - Lung volume in liters, measured after 1 sec forced expiration.

Slow vital capacity (SVC) - Lung volume measured from a complete expiration following a deep inspiration.

FEV_1%- It is the ratio of FEV_1 and SVC.

Mid Expiratory Flow Rate ($FEF_{25-75\%}$) - Flow rate of expired air by 25-75% of the forced vital capacity.

End Expiratory Flow Rate ($FEF_{75-85\%}$) - Flow rate of expired air by 75-85% of the forced vital capacity.

PEFR (Peak Expiratory Flow Rate) - It is the maximum flow that can be sustained for 10 seconds during a forced expiration starting from total lung capacity. It was measured by Wright's peak flow meter.

The subject was instructed to take a deep breath and place the mouthpiece in his/her mouth, between the teeth and with the lips placed tightly around it, and then to blow into the instrument a short, sharp blow. Reading was recorded. The pointer was returned to zero, by pressing the release button. After a couple of practice blue, 3 attempts in succession were taken and three attempts were recorded. It is expressed by lit/min.[9]

All the tests were performed between 3 pm to 5 pm to exclude the bias of circadian rhythm. All the gas volumes were corrected to BTPS (Body temperature, ambient pressure, and saturated with water vapor) automatically by the instrument.

Physical Parameters

Age - was recorded from their ADHAR card.

Body height- was measured by the anthropometric rod.

Body weight- was taken by weighing machine with light clothes without shoes.

Body mass index (BMI) - was calculated using formulae Bodyweight in Kg/ (body height in meter) ^{2},[10].

Cardiovascular Parameters - Selected Cardiovascular parameters were taken in this study-

Blood Pressure - was measured by the auscultatory method with the help of a Sphygmomanometer and a Stethoscope. The subjects were advised to take a rest for half an hour. Then three measurements were taken with a gap of 15 minutes before each one[11]

Heart rate- was taken by the palpatory method. It was measured by placing three fingers side by side on the carotid artery of the subjects.[12]

A questionnaire has been filled up by the investigator. A modified version of the British Occupational Health Research Foundation[13] questionnaire was used for respiratory health as well as a questionnaire related to symptoms of pain in Musculoskeletal structure and skin irritation. These include Smoking habit, Chronic Cough, Shortness of breath during walking Uphill, Feeling of Chest Tightness, Respiratory Discomfort like asthma, Pain in different parts of the body, Skin irritation.

Statistical Analysis- All parameters have been expressed in terms of mean and standard deviation. Percentage prevalence of respiratory and health problems with an odds ratio and 95% confidence intervals has been performed to assess the risk of physiological problems acquired due to exposure in

asphalt workers by the approved SPSS (version 16.0) statistical package.

RESULTS

Table 1: represents the socio-demographic characteristics of Asphalt workers (n= 32) and control group workers (n= 20). It was found that 87.5% of asphalt workers and 65% of control group workers were in the lower age group (14-30 years) and 12.5% of Asphalt workers and 35% of control group workers were from a higher age group (>30 years).

Table 2: represents mean± SD values of different physical parameters and cardiovascular parameters of asphalt workers and control group workers. It was found that age, body weight, BMI, and blood pressure values were significantly (p<0.05-0.001) higher in control group workers in comparison to asphalt workers.

Table 3: represents the mean ± SD values of different pulmonary function parameters of asphalt workers and control group workers. It is observed that FVC, FEV_1, $FEV_{1\%}$, and PEFR values are significantly (p<0.05-0.001) lower in asphalt workers than in the control group.

Table 4: represents age group-wise mean ± SD values of different physical and cardiorespiratory parameters of asphalt workers. No remarkable difference has been found when lower age group (14-30 years) asphalt workers are compared with higher (>30 years) workers except FEV1%.

Table 5: represents the mean ± SD values of physical parameters, heart rate, and blood pressure values of asphalt workers based on years of exposure. Significantly higher heart rate values had been found for workers of >10 years of exposure in comparison to 6-10 years of exposure. No significant difference has been found in other parameters between different levels of years of exposure.

Table 6: represents the mean ± SD values of different pulmonary function parameters based on year of exposure. But no significant difference in pulmonary function parameters has been found between 1-5 years and 6-10 years of exposure, as well as >10 years of exposure except FEV_1.

Table 7: represents the mean ± SD values of pulmonary function parameters of both smokers and nonsmokers Asphalt workers and the control group. Significant (P<0.05 - 0.002) difference has been found for FEV_1, $FEV_{1\%}$, and PEFR between smoker workers and the control group. But in the case of nonsmoker workers, a significant difference in FVC, FEV_1, and PEFR values has been found when compared with the control group.

Table 8: represents the prevalence of respiratory disorder among smokers and nonsmoker Asphalt workers with an odds ratio and 95% confidence interval. It revealed that smoker asphalt workers were 1.84 - 2 times more prone to the prevalence of chest tightness, chronic bronchitis, and bronchial asthma.

Table 9 represents the percentage prevalence of MSD among smoker and nonsmoker Asphalt workers with an Odds Ratio (1.19-9.8) and 95%confidence interval.

Table 10 represents the percentage prevalence of different respiratory problems and other health problems among Asphalt workers according to their duration of exposure. It revealed that the percentage prevalence was high among workers with a longer duration of exposure to bitumen fumes who were more prone to chest tightness, chronic bronchitis, bronchial asthma, abdominal pain and indigestion, skin irritation, and pain in other body parts such as pelvic, shoulder, leg, and hand pain after 6 years of exposure. Odds ratio values focused on the significant association between years of exposure (>10 years) and respiratory disorders and pain(knee, leg, and hand pain), indicating that prolonged exposure to bitumen fumes and dust of asphalt can produce respiratory disorders and musculoskeletal disorders due to awkward posture during work.

Table 11: represents the prevalence of respiratory disorders, pain, and other health-related problems among the lower and higher age group of asphalt workers with an odds ratio and 95% confidence interval. No significant association was found between age and prevalence of respiratory disorders, pain, and other health-related problems.

Table 12: represents the percentage prevalence of respiratory disorders, pain, and other health-related problems among paver operators, asphalt strippers, roller driver categories of asphalt workers. It was found that the paver operators have greater tendencies of respiratory abnormalities such as chest tightness, chronic bronchitis, and bronchial asthma than the other two groups of workers as well as the control group due to their direct exposure to bitumen fumes during their work. Skin irritation and prevalence of pelvic pain, knee pain, and shoulder pain are much higher in asphalt

workers than in the control group. Leg and hand pain is much higher in paver operators than asphalt strippers and roller drivers as well as the control group. Besides, digestive problems and skin irritation is most common in all categories of asphalt workers than in the control group.

The significant association between the prevalence of respiratory disorders and different categories of work has been observed in table 13. Among different categories, paver operators were more vulnerable to respiratory disorders, than asphalt stripper and roller drivers. A significant association has also been found in the case of musculoskeletal disorders among all categories of asphalt workers. The frequency of digestive problems was found more among paver operators and asphalt strippers. The highest prevalence of skin irritation was reported in the case of paver operators.

Fig 1 represents the percentage prevalence of respiratory diseases and other health problems among Asphalt workers. It was found that 22% of workers reported chest tightness, 20% reported chronic bronchitis and 10% had Bronchial asthma-like symptoms.20% of workers suffered from skin irritation due to tar exposure.

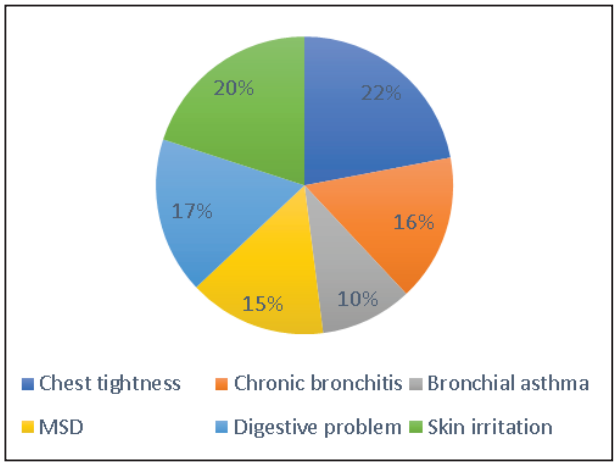

Figure 1: Percentage prevalence of diseases among Road construction workers

Table 1: Socio- Demographic characteristics of Road Construction workers and control group

Characteristics	Road Construction_worker RCW (n=32)	Control group (n=20)
Age Group	14-30 years - 87.5% >30 years - 12.5%	14-30 years - 65% >30 years - 35%
Religion	Hindu - 12.5% Muslim- 87.5%	Hindu - 100% -
Literacy	Literate - 10% Non-literate - 90%	Literate - 80% Non-literate -20%
Working Period	1-5 years - 59.37% 6-10 years - 25% > 10 years - 15.62%	- - -
Smoking Habit	Smoker - 75% Non-Smoker - 25%	Smoker - 70% Non-Smoker - 30%
Daily Working Hour	12 hours - 100%	-
Use of Personal Protective Equipment.	Yes - Nil -	Yes - Nil -

#Percentage values indicate Percentage of total population

Table 2: Mean ± SD values of Physical and Physiological Parameters of Road Construction workers (RCW) and the control group.

Parameters	RCW	Control	t-test
Age (years)	24.19±7.69	30.55±8.67	0.01***
Height (cm)	160.03±5.46	166.23±4.65	7.14079E-05****
Weight (kg)	50± 7.48	60.2±9.26	0.0002****
BMI (kg/m^2)	19.54±2.71	21.76±3.08	0.01***
Systolic Blood Pressure (mm Hg) #	122.12±12.44	129.85±12.02	0.03
Diastolic Blood Pressure (mm Hg). #	70.19±9.14	76.6±7.29	0.007***
heart rate (beats/min) #	78.97±11.42	75.8±10.92	0.32

P<0.01 -***, P<0.001 -****

#Measurements were taken in resting condition before starting work or after taking 1hour of rest

Table 3: Mean SD values of different pulmonary function parameters of Road Construction workers (RCW) and control group.

Parameters	RCW	Control	t-test
SVC(lit)	1.95±0.65	1.84±0.49	0.42
FVC(lit)	1.77±0.76	2.13±0.43	0.03
FEV1(lit)	1.32±0.38	1.60±0.23	0.002****
FEV1%	66.16±17.49	89.26±20.23	0.0002****
$FEF_{25-75\%}$(lit/min)	2.75±0.92	1.39±0.58	0.95
$FEF_{75-85\%}$(lit/min)	1.46±0.65	0.57±0.42	0.28
PEFR(lit/min)	320.94±83.45	407.5±48.76	1.95689E-05****

P<0.001 -****, SVC=Slow vital capacity, FVC= Forced vital capacity, FEV_{1} = Forced Expiratory Volume in 1 sec, $FEF_{25-75\%}$= Mid Expiratory Flow Rate, $FEF_{75-85\%}$= End Expiratory Flow Rate, PEFR= Peak Expiratory Flow Rate.

Table 4: Mean ± SD values of physical parameters, blood pressure, heart rate, and pulmonary function values of the higher and lower age group of Road Construction Workers (RCW).

Parameters	Age groups	
	14-30 years(n=28)	>30 years(n= 4)
Height(cm)	160.03± 5.72	160± 3.56
Weight (kg)	50.07± 7.92	49.5± 3.70
Systolic Blood Pressure (mm Hg)	123.11± 12.89	115.25± 5.56
Diastolic Blood Pressure (mm Hg)	69.78± 9.48	73± 6.53
Heart Rate(beats/min)	78.25± 10.63	84± 17.11
BMI(kg/m^2)	19.56± 2.80	19.40± 2.32
SVC(lit)	2.02± 0.62	1.44± 0.65
FVC(lit)	1.73± 0.58	2.04± 1.70
FEV1(lit)	1.30± 0.38	1.48± 0.33
FEV1%	63.76± 16.84	83.02± 13.32
FEF 25-75%(lit/min)	1.29± 0.78	1.97± 1.66
FEF 75-85%(lit/min)	0.65± 0.49	1.29± 1.33
PEFR(lit/min)	327.14± 81.55	277.5± 96.05

Table 5: Mean ± SD values of Physical and Cardiovascular parameters of Road Construction workers (RCW) based on years of exposure.

Parameters	1-5 years (n=19)	6-10 years (n=8)	>10 years (n=5)	t-test (1-5 with 6-10)	t- test (1-5 with >10)	t-test (6-10 with >10)
Age (years)	21.79±7.38	24.87±4.67	32.2±8.17	0.21	0.04*	0.12
Height (cm)	159.58±5.34	159.62±6.30	162.4±4.98	0.98	0.30	0.40
Weight (kg)	49.58±8.51	51.25±4.46	49.6±8.32	0.51	0.99	0.70
BMI (kg/m^2)	19.48±3.22	20.19±1.35	18.72±2.33	0.42	0.57	0.25
Systolic Blood Pressure (mm Hg)	120.53±11.12	121.75±9.35	128.8±20.53	0.77	0.43	0.50
Diastolic blood Pressure (mm Hg)	69.95±11.53	70.37±4.90	70.8±0.49	0.89	0.77	0.84
Heart rate (beats/ min)	80.05±9.85	71.37±12.23	87±10.53	0.10	0.23	0.03*

P<0.0.5 - *

Table 6: Mean ± SD values of different Pulmonary function parameters of Road Construction workers (RCW) based on exposure.

Parameters	1-5 years (n=19)	6-10 years (n=8)	>10 years (n=5)	t- test(1-5 with 6-10)	t- test (1-5 with>10)	t- test(6-10 with>10)
SVC(lit)	1.97± 0.72	2.06± 0.50	1.72± 0.61	0.70	0.46	0.32
FVC(lit)	1.61± 0.44	1.82± 0.87	2.26± 1.38	0.53	0.36	0.55
FEV1 (lit)	1.37± 0.35	3.10± 0.44	1.50± 0.28	0.16	0.41	0.07
FEV1%	68.11± 17.57	53.5± 12.22	79.36± 12.43	0.02**	0.14	0.005***
FEF25-75% (lit/min)	1.44± 0.76	0.99± 0.73	1.73± 1.60	0.17	0.72	0.38
FEF 75-85% (lit/min)	0.70± 0.47	0.42± 0.31	1.34± 1.22	0.08	0.31	0.17
PEFR(lit/min)	**313.68± 81.25**	**345± 83.49**	**310± 102.47**	**0.39**	**0.94**	**0.54**

P<0.02-**, P<0.01-***

Table 7: Mean ± SD values of Pulmonary function parameters of the smoker and nonsmoker Road Construction workers (RCW) with the control group.

Respiratory Parameters	RCW		control		t-test	
	Smoker (n=24)	Non smoker (n= 14)	Smoker	Non smoker	Smoker t- test	Nonsmoker t- test.
SVC(lit)	1.92± 0.59	2.05± 0.82	1.70± 0.33	2.11± 0.70	0.16	0.90
FVC(lit)	1.85± 0.81	1.53± 0.58	2.09± 0.44	2.22± 0.43	0.23	0.02**
FEV1(lit)	1.35± 0.40	1.26± 0.30	1.57± 0.21	1.67± 0.28	0.03*	0.02**
FEV1%	67.19± 15.48	63.07± 23.52	91.61± 17.44	83.77±26.68	0.0002****	0.16
FEF25-75% (lit/min)	1.44± 0.99	1.18± 0.65	1.34± 0.55	1.49± 0.70	0.70	0.41
FEF 75-85% (lit/min)	0.76± 0.73	0.65± 0.37	0.54± 0.44	0.63± 0.38	0.26	0.96
PEFR (lit/min)	325± 86.68	308.75± 76.98	403.57± 48.93	416.67± 51.64	0.001****	0.009***

P<0.05-*, P<0.02-**, P<0.01-***, P<0.001****

Table 8: Prevalence of different respiratory diseases among smoker and nonsmoker Asphalt workers with odds ratio and 95% confidence interval.

Parameters	Smoker (RCW) (n=24)		Non-smoker (n=8) (RCW)		Odds ratio	Confidence limit (95%)
	n	%	n	%		
Chest tightness	16	66.67	4	50	2	0.39-10.16
Chronic bronchitis	13	54.17	3	37.5	1.97	0.38-10.17
Bronchial asthma	5	20.83	1	12.5	1.84	0.18-18.66

Table 9: Prevalence of Musculoskeletal disorder (MSD) among smoker and nonsmoker Asphalt workers with odds ratio and 95% confidence interval.

Parameters	Smoker (RCW) (n=24)		Non-smoker (n=8) (RCW)		Odds ratio	Confidence limit (95%)
	n	%	n	%		
Pelvic pain	10	41.67	3	37.5	1.19	0.23-6.17
Knee pain	10	41.67	2	25	2.14	0.36-12.89
Shoulder pain	13	54.17	2	25	3.54	0.59-21.24
Leg pain	8	33.33	2	25	1.5	0.24-9.18
Hand pain	8	33.33	1	12.5	1.5	0.36-33.56
Abdominal pain & indigestion	11	45.83	3	37.5	1.41	0.27-7.28
Skin irritation	14	58.33	1	12.5	9.8	1.04-92.70

Table 10: Prevalence of different pulmonary & musculoskeletal disorders among RCW according to their years of exposure with odds ratio and 95% confidence level.

Parameters	1-5 years of exposure (n=19)		6-10 years of exposure (n=8)		>10 years of exposure (n=5)		Odds ratio & CI 95% (1-5) & 6-10 years)		Odds ratio & CI 95% (1-5 &>10 years)		Odds ratio & CI 95% (6-10 &>10 years)	
	No	%	No	%	No	%	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Chest tightness	11	57.89	6	75	3	60	0.46	0.07-2.89	0.92	0.12-6.82	2	0.18-22.06
Chronic bronchitis	8	42.10	6	75	2	40	0.24	0.04-1.53	1.10	0.15-8.12	4.5	0.41-49.63
Bronchial asthma	1	5.26	4	50	1	20	0.05	0.005-0.64	0.22	0.01-4.36	4	0.30-53.47
Pelvic pain	8	42.10	4	50	1	20	0.73	0.14-3.82	2.91	0.27-31.21	4	0.30-53.47
Knee Pain	3	15.79	6	75	3	60	0.06	0.008-0.47	0.12	0.01-1.1	2	0.18-22.06
Shoulder pain	5	26.32	6	75	4	80	0.12	0.02-0.79	0.09	0.008-1.002	0.75	0.05-11.31
Leg pain	2	10.53	6	75	2	40	0.04	0.004-0.34	0.18	0.02-1.78	4.5	0.41-49.63
Head pain	1	5.26	6	75	2	40	0.02	0.001-0.24	0.08	0.006-1.23	4.5	0.41-49.63
Abdominal pain and indigestion	7	36.84	3	37.5	4	80	0.97	0.18-5.36	0.14	0.014-1.58	0.15	0.01-2.05
Skin irritation	9	47.37	2	25	4	80	2.7	0.43-16.94	0.22	0.02-2.40	0.08	0.005-1.26

Table 11: Prevalence of different Pulmonary & musculoskeletal disorders among lower age group and higher age group Road Construction workers (RCW)

Parameters	14-30 years (RCW) (n=28)		>30 years (RCW) (n=4)		Odds ratio	Confidence limit 95%
	N	%	N	%		
Chest tightness	17	60.71	3	75	0.51	0.05-5.60
Chronic bronchitis	13	46.43	3	75	0.29	0.03-3.13
Bronchial asthma	5	17.86	1	25	0.65	0.05-7.64
Pelvic pain	11	39.28	2	50	0.65	0.08-5.29
Knee pain	9	32.14	3	75	0.16	0.01-1.74
Shoulder pain	13	46.43	2	50	0.87	0.11-7.05
leg pain	7	25	3	75	0.11	0.001-1.25
Hand pain	7	25	2	50	0.33	0.04-2.83
Abdominal pain and indigestion	10	35.71	3	75	0.18	0.01-2.02
Skin irritation	12	42.86	2	50	0.75	0.09-6.11

Table 12: Percentage prevalence of different Respiratory & health problems among Road Construction workers (RCW) according to their type of work.

Parameters	Paver operator (n= 6)		Asphalt stripper (n= 13)		Roller driver(n=13)		Control (n=20)	
	total	(%)	total	(%)	total	(%)	total	(%)
Chest tightness	5	83.33	10	76.92	5	38.46	1	5
Chronic bronchitis	6	100	7	53.85	3	23.08	1	5
Bronchial asthma	4	66.66	2	15.38	1	7.69	1	5
Pelvic pain	2	33.33	5	38.46	6	46.15	3	15
Knee pain	3	50	6	46.15	3	23.08	1	5
Shoulder pain	3	50	5	38.46	6	46.15	1	5
Leg pain	3	50	6	46.15	1	7.69	2	10
Hand pain	3	50	5	38.46	1	7.69	1	5
Abdominal pain and indigestion	3	50	5	38.46	6	46.15	4	20
Skin irritation	3	50	4	30.77	8	61.54	4	20

Table 13: Prevalence of respiratory disorders, pain, and other health-related disorders among Road Construction workers (RCW) according to their type of work with odds ratio and 95% confidence interval.

Disorders	Paver operator (PO) (n=6)		Asphalt stripper (AS) (n=13)		Roller driver (RD) (n=13)		Odds ratio & CI(PO&AS)		Odds ratio & 95% CI (PO &RD)		Odds ratio & 95% CI (AS &RD)	
	No	%	No	%	No	%	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Chest tightness	5	83.33	10	76.92	5	38.46	1.5	0.12-18.36	8	0.71-90.00	5.33	0.97-29.39
Chronic bronchitis	5	83.33	7	53.85	3	23.08	4.28	0.38-47.63	16.67	1.36-204.04	3.89	0.72-21.06
Bronchial asthma	4	66.67	2	15.38	1	7.69	11	1.14-106.43	24	1.69-341.00	2.18	0.17-27.056
Pelvic pain	2	33.33	5	38.46	6	46.15	0.8	0.10-6.10	0.58	0.08-4.39	0.73	0.15-3.47
Knee pain	3	50	6	46.15	3	23.08	1.17	0.17-8.09	3.33	0.43-26.04	2.86	0.53-15.47
Shoulder pain	3	50	5	38.46	6	46.15	1.6	0.23-11.27	1.17	0.17-8.09	0.73	0.15-3.47
Leg pain	3	50	6	46.15	1	7.69	1.17	0.17-8.09	12	0.90-160.41	10.28	1.02-103.95
Hand pain	3	50	5	38.46	1	7.69	1.6	0.23-11.27	12	0.90-160.41	7.5	0.73-76.78
Abdominal pain and indigestion	3	50	5	38.46	6	46.15	1.6	0.23-11.27	1.17	0.17-8.09	0.73	0.15-3.47
Skin irritation	3	50	4	30.77	8	61.54	2.25	0.31-16.41	0.62	0.08-4.40	0.28	0.05-1.41

DISCUSSION

Asphalt workers in this study had significantly lower FVC, FEV_1, $FEV_{1\%,}$ and PEFR values than the control group. This result was in agreement with Ulvestad et al.[14]

In the present study, no statistically significant difference in pulmonary function parameters, heart rate, and blood pressure values has been observed in higher and lower age group asphalt workers except $FEV_{1\%.}$ Although diastolic blood pressure and heart rate values insignificantly increase, other pulmonary function parameters (SVC and PEFR) decreased insignificantly. But smoking reduces the pulmonary function parameters (FVC, FEV_1, $FEV_{1\%}$ & PEFR) significantly. No significant difference had been found between different levels of years of exposure on pulmonary function except $FEV_{1\%.}$ The reduced lung function parameters of asphalt workers might be due to maximum exposure to bitumen fumes in the peak season of asphalt paving and repeated daily 8 hours of exposure might be the reason for chronic lung function loss.

An increase in IL6 occurred among asphalt pavers during the season, and this change is assumed to be due to exposure to bitumen fume. IL6 is a pro-inflammatory mediator produced locally in the lung but it may also be produced in muscle and increase during exercise.[15,16]

From the result, it has been observed that Paver operators and asphalt strippers are more prone to respiratory diseases, knee, shoulder, leg, hand pain than the Roller driver. This might be due to the more physically demanding job of asphalt stripper and paver operator than roller driver. The reduction in respiratory time volume (FEV1) among asphalt strippers might be due to constant exposure to dust and fumes of bitumen in comparison to roller drivers. Paver operators also inhale air pollutants in their worksite because they work at the site of mixing of bitumen and stones .[14]

In the present study >10 years of exposure to bitumen, fumes can reduce the respiratory parameters to some extent but Ulvestad et al [14] reported that some degree of respiratory impairment could occur with 10-15 years of exposure to bitumen fumes.

In our study, it has been observed that smoking affects pulmonary function and other physiological problems like blood pressure among asphalt workers. Marine et al [17] reported that smokers have been shown to have an excess yearly decline of lung function parameters of 10 ml than a non-smoker. The excess decline that occurs among the smoker asphalt worker was probably related to work exposure.

Neghab et al [18]studied and reported that asphalt workers exposed to asphalt fumes increased the prevalence of cough and wheezing by 6.9 to 18.1-fold respectively. The observation was in agreement with the present study and it was supported by Randem[1], Burr et al [19]and Maintz et al.[20]

Our study revealed that asphalt workers felt discomfort in the different parts of the body which might be due to constant backward and forward bending posture for prolonged periods during work. This was in agreement with Kivi and Maltila[21]and Gangopadhyay et al. This study reported the highest percentage of paver operators and asphalt strippers suffered from pain in the knee, shoulder, leg, hand, and pelvis. According to Chaffin and Anderson [23]and Leskinen [24]the amount and quality of forwarding bent working posture influence the compressive force on the vertebral disk and erector spine muscle. The forward bent posture of the asphalt stripper and paver operator might be responsible for muscle pain and musculoskeletal disorder in different parts of the body including lower back pain.

CONCLUSION

Exposure during asphalt paving may enhance the risk of lung impairment. Smoking is another factor associated with bitumen fume that might be responsible for further reduction in lung function. Besides the heavy workload of asphalt workers mainly asphalt stripper & paver operators might be associated with higher resting heart rate and systolic blood pressure. The awkward working posture has a strong association with musculoskeletal disorders among asphalt workers.

RECOMMENDATION

If the risk factors of workers engaged in asphalt industries can be removed or minimized the health of workers can be protected and productivity can be increased. So to maintain the health of workers following practices can be recommended-

- Use of appropriate respiratory and dermal protection e.g. masks, goggles, gloves, boots, clothes, etc.
- The application of sophisticated techniques and modern machinery will reduce the hazardous working atmosphere like dust, fumes, and temperature

The present study brings to light the prevalence of respiratory impairments from the pulmonary function of Asphalt workers and their respective causative factors. This study will prove beneficial in identifying the underlying risk factors associated with this occupation and proposed rehabilitation and preventive measures. The result from this study will prove to be a yardstick for improving the work environment, reducing the risk from exposure, and improving the overall health of the workers engaged in this occupation.

Despite an extensive cross-sectional study, there exist some limitations as mentioned below-

i. The study considers both smoking and non-smoking population for the assessment of respiratory impairment. This makes it challenging to assess the individual impact of smoking habits and exposure to bitumen fumes. However, this can be overcome by considering a large non-smoking population, which will be addressed in future works.
ii. The seasonal nature of the occupation forces the workers to engage in secondary occupations like farming, masonry, etc. in the unorganized sector. This makes it even more challenging for the present study to accurately predict the causes of occupational health disorders.

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