Research Article

Effect of organic solvent exposure on lung function tests in male workers in Western Rajasthan

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ABSTRACT

Introduction

Occupational exposure to organic solvents is a significant health concern, in paint workers. Chronic inhalation of these volatile compounds can adversely affect pulmonary function, leading to respiratory impairments. This study aimed to assess the impact of organic solvent exposure on lung function parameters in male workers in Western Rajasthan.

Methods: A cross-sectional study was conducted among male paint workers. A total of [60] participants were recruited, including exposed workers (study group, n=30) and non-exposed workers (control group, n=30). Pulmonary function tests (PFTs), including Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), Forced Expiratory Flow 25–75% (FEF 25-75%), and Peak Expiratory Flow Rate (PEFR), were measured using a spirometer. Data were analyzed using independent t-tests to compare lung function parameters between the groups.

Results: Paint workers exposed to organic solvents exhibited a significant decline in lung function parameters compared to the control group ($p < 0.001$). The most pronounced reductions were observed in FEV1 and FEV1/FVC ratio, indicating obstructive airway changes. Additionally, PEFR and FEF 25-75% were significantly lower in the exposed group.

Conclusion: Prolonged exposure to organic solvents negatively impacts pulmonary function, increasing the risk of developing obstructive and restrictive lung diseases. These findings highlight the need for regular health monitoring, workplace ventilation improvements, and personal protective measures to minimize respiratory hazards among exposed workers in Western Rajasthan.

Keywords: Lung Function Tests, Occupational Health, Spirometry, Obstructive Lung Disease

INTRODUCTION

The most widespread and some of the most dangerous, occupational hazards are created by liquid chemicals, such as solvents. These chemicals may present hazards from the use of the liquid itself, as a vapor of the liquid, or as a mist of the liquid. The vast majority of liquid chemicals found in the industrial workplace are organic compounds. The organic compounds are those that contain carbon. They are found in plant and animal tissues and in materials, such as petroleum and coal, which result from the breakdown of living substances. Lubricants, solvents, fuel, and many insecticides are but a few of the many hundreds of different

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compounds in use, and new ones are constantly being produced. These chemicals are used in the course of most industrial-type jobs, as well as being commonly found in the home. Because of their widespread use and their harmful properties, the organic compounds present significant occupational hazards.[1]

Organic solvents and its effect on lung functions: Vapors of volatile organic solvents (VOCs) could exert an adverse effect in the airways even at low concentrations. Irritation in nose, exacerbating asthma and other adverse respiratory effects are seen in subjects exposed to a mixture of organic solvents.[2] Painters have a mixed exposure, including aerosols from spray painting and grinding, and VOCs from paint emissions. Painters exposed to organic solvents due to the hazardous nature of their intensify exposure to high levels of chemical hazards with resultant health problems. Based on the clinical finding and years of exposure to paints leads to an obstructive pattern of pulmonary disease.[3] This study was conducted to observe long-term effects of solvent exposure on respiratory function in paint workers.

MATERIAL AND METHOD

Study area and population

Male paint workers in western Rajasthan who were exposed to organic solvents and age-matched unexposed control from the general population.

Study type and design: A comparative cross-sectional observational study with age matched controls and paint workers.

Sample size: Each group have 30 subjects (N=30).

Subjects and eligibility: Subjects exposed to the organic solvents (specifically painters) were examined for the respiratory functions.

Inclusion criteria:

1. Male subjects (N = 30) who had been working as painters for more than seven years were included in the study.
2. Male painters with age ranging between 25 - 55 years.
3. Informed consent was taken from each subject.

Exclusion criteria:

1. Workers who have recently undergone thoracoabdominal procedures.
2. Workers with congenital or acquired cardiorespiratory disorders.
3. Workers with tuberculosis, recent respiratory infections, or any manifestations of COVID-19.

Controls: Age-matched unexposed controls (N=30) from the general population were examined for the control values of the respiratory functions.

Proposed Intervention

No active intervention; the study was observational. However, it involves assessment through pulmonary function tests (PFTs).

Data Collection Procedures & Instruments Used:

Lung Function Test (LFT) was assessed in study and control group using COMPUTERIZED SPIROMETER. All tests were carried out at a fixed time of the day (10.00 – 14.00 hours), to minimize diurnal variations. The apparatus was calibrated daily and it was operated within the ambient temperature range of 30-40 degrees centigrade.

1. The subject was required to breathe into a sophisticated transducer connected to a computerized spirometer via a cable. The test was conducted with the subject in a seated position while wearing a soft nose clip. To ensure accuracy, the test was repeated three times after allowing the subject adequate rest.

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2. The tests measured the following parameters:
    - FVC- Forced vital capacity.
    - FEV1- Forced expiratory volume in 1 second.
    - FEV1/FVC
    - FEF25-75%- Forced expiratory flow between 25% and 75% of vital capacity.
    - PEFR- Peak Expiratory Flow rate
3. Data were recorded, and printouts of the reports, including graphical curves, were obtained for further analysis.

Quality Control

- Calibration: The spirometer was calibrated regularly to ensure accuracy.
- Training: Proper training to ensure consistent and accurate measurements.
- Reproducibility: Tests were repeated for each subject to ensure reliability of the measurements.

Confidentiality

- Data Protection: Personal information of subjects was anonymized.
- Consent: Informed consent was obtained, detailing the purpose of the study, procedures, risks, and benefits.
- Storage: Data were securely stored with access limited to authorized personnel only.

Plan of Analysis/Statistical Tools

Likely involves statistical tests to compare lung function parameters between exposed (painters) and unexposed (control) groups.

1. **Descriptive Statistics:** Mean, median, standard deviation for continuous variables; frequency and percentage for categorical variables.
2. **Comparative Analysis:**
    - T-tests: for comparing means of continuous variables between exposed and control groups.
    - Chi-square tests: for comparing categorical variables.
    - Statistical Software: Analysis was conducted using SPSS software.

OBSERVATION AND RESULT

The study assessed anthropometric parameters, lung function test parameters, and the percentage of diagnosed cases in paint workers (Group 1) and a control group.

Table 1: Anthropometric parameters in paints workers Group 1 and Control Group

PARAMETER	Group 1 (n = 30)	Control Group (n = 30)	p-Value
Age (yrs)	38.03±5.88	36.86±6.15	0.45
WEIGHT(kg)	83.68±4.98	84.86±5.85	0.40
HEIGHT(m)	174.83±5.07	175.08±4.92	0.85
BMI(kg/m^2)	27.1±1.35	27.8±1.96	0.11

n: Numbers of subjects; BMI: Body Mass Index; * The data were expressed by mean ±SD;
* statistically significant as $p<0.05$

The comparison of age, weight, height, and BMI between the two groups did not show any statistically significant differences (Table 1). The mean age of the paint workers (38.03±5.88 years) was slightly higher than the control group (36.86±6.15 years), but the difference was not significant (p = 0.45). The weight and height were similar in both groups (p-values of 0.40 and 0.85, respectively), indicating that body size was not a confounding factor in lung function

differences. BMI was slightly lower in paint workers (27.1±1.35 kg/m²) compared to the control group (27.8±1.96 kg/m²), but again, the difference was not significant ($p = 0.11$).
These findings suggest that differences in lung function between the two groups are unlikely to be influenced by anthropometric factors.

Table 2: Comparison of the lung function test parameters in paints workers Group 1 and Control group

PARAMETER	Group 1 (n = 30)	Control Group (n = 30)	p-Value
FVC(liters)	3.56±0.89	4.04±0.42	<0.01 *
FEV1(liters)	2.65±0.82	3.41±0.35	<0.001 **
FEV1/FVC%	74.43±9.54	86.89±4.14	<0.001 **
FEF 25-75%(liters/sec)	2.63±0.97	4.36±1.46	<0.001 **
PEFR(liters/sec)	6.14±0.95	8.32±0.80	<0.001 **

n: Numbers of subjects; FVC forced vital capacity; FEV1 forced expiratory volume in the first seconds; FEF 25-75% forced expiratory flow; PEF: peak expiratory flow rate, * statistically significant as p<0.05, ** statistically highly significant as p < 0.001

A significant reduction in pulmonary function was observed in the paint workers compared to the control group (Table 2): Forced Vital Capacity (FVC): Paint workers had significantly lower FVC (3.56±0.89 L) compared to controls (4.04±0.42 L) ($p < 0.01$). This suggests a reduction in overall lung volume. Forced Expiratory Volume in 1 second (FEV1): The mean FEV1 was markedly lower in paint workers (2.65±0.82 L) than in the control group (3.41±0.35 L), with a highly significant p-value (<0.001). This indicates airflow limitation. FEV1/FVC Ratio: The ratio was significantly lower in paint workers (74.43±9.54%) compared to the control group (86.89±4.14%) ($p < 0.001$). A reduced FEV1/FVC ratio is indicative of obstructive airway disease. Forced Expiratory Flow (FEF 25-75%): A significant decline was observed in paint workers (2.63±0.97 L/sec) compared to controls (4.36±1.46 L/sec) ($p < 0.001$). This measure reflects small airway function, suggesting early airway obstruction in the exposed group. Peak Expiratory Flow Rate (PEFR): The PEFR in paint workers (6.14±0.95 L/sec) was significantly lower than in controls (8.32±0.80 L/sec) ($p < 0.001$), indicating reduced respiratory effort and lung function impairment. These findings suggest that chronic exposure to paint fumes may contribute to reduced pulmonary function, particularly affecting expiratory flow rates.

Table 3: The percentage of diagnosed cases in the two groups: paints workers Group 1 and Control Group

DIAGNOSIS	Group 1	Control Group	p-Value
Normal	6 (20%)	25 (83.3%)	<0.001**
Obstructive	12 (40%)	3 (10%)	
Restrictive	8 (26.7%)	2 (6.7%)	
Combined	4 (13.3%)	0 (0%)	
Total	30	30	

Data were represented as No. (%), Chi-square test used to test the difference between the groups. * statistically significant as p<0.05, ** Statistically highly significant as p < 0.001

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A significant difference was observed in the percentage of normal and abnormal lung function between the two groups (Table3): Normal lung function was found in only 20% of paint workers, compared to 83.3% in the control group ($p < 0.001$). This highlights a clear occupational health concern. Obstructive lung disease was present in 40% of paint workers, compared to only 10% of controls, reinforcing the observation that exposure to paint fumes contributes to airway obstruction. Restrictive lung disease was seen in 26.7% of paint workers, compared to 6.7% of controls, suggesting some level of restrictive lung impairment due to exposure. Combined obstructive and restrictive patterns were observed in 13.3% of paint workers, while no such cases were found in the control group. These results strongly suggest that long-term exposure to paint fumes is associated with a higher prevalence of both obstructive and restrictive lung impairments.

DISCUSSION

The present study evaluated the impact of occupational exposure to paint fumes on pulmonary function by comparing paint workers with a control group. The findings indicate a significant decline in lung function parameters among paint workers, underscoring the detrimental effects of long-term exposure to volatile organic compounds (VOCs) and other airborne pollutants commonly found in paint fumes.

The comparison of age, weight, height, and BMI between the two groups revealed no statistically significant differences, suggesting that body size was not a confounding factor in the observed pulmonary function impairment. Similar findings were reported by Raghuvanshi S et al., who found no significant difference in BMI between exposed and non-exposed individuals in occupational settings, reinforcing that lung function deterioration in paint workers is attributable to chemical exposure rather than anthropometric differences.(4)

The study demonstrated a significant reduction in Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), FEV1/FVC ratio, Forced Expiratory Flow (FEF 25-75%), and Peak Expiratory Flow Rate (PEFR) in paint workers compared to the control group. These findings suggest a combination of restrictive and obstructive lung impairments due to chronic inhalation of toxic fumes. Similar results have been documented in previous studies. Zuskin E et al., reported significantly lower FVC and FEV1 in paint industry workers, attributing these declines to prolonged exposure to isocyanates, toluene, and other volatile organic compounds.(5) Additionally, Gupta S et al., found a significant reduction in FEV1 and PEFR in workers exposed to organic solvents, consistent with the present study's findings that suggest a decline in airway function due to occupational exposure.(6)

The significantly lower FEV1/FVC ratio among paint workers (74.43±9.54%) compared to the control group (86.89±4.14%) ($p < 0.001$) suggests an obstructive lung disease pattern. This aligns with studies by Mandryk J et al.,(7) and Leira HL et al., which reported a high prevalence of occupational asthma and chronic bronchitis among workers exposed to paint fumes.(8) The significantly reduced FEF 25-75% among paint workers (2.63±0.97 L/sec vs. 4.36±1.46 L/sec, $p < 0.001$) further suggests small airway obstruction, a known early marker of obstructive lung disease.(9,10)

A striking finding of the study was the significantly higher prevalence of abnormal lung function among paint workers. Only 20% of paint workers exhibited normal lung function compared to 83.3% in the control group, with obstructive lung disease present in 40% of paint

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workers versus only 10% in controls. The prevalence of restrictive lung disease was also notably higher in paint workers (26.7% vs. 6.7%).

These findings are supported by previous research. Murgia N et al., found that paint workers exposed to isocyanates had a higher incidence of chronic obstructive pulmonary disease (COPD) and restrictive lung diseases compared to unexposed individuals.(11) Similarly, a study by Al-Neaimi YI et al., reported that long-term exposure to paint fumes was associated with a higher prevalence of both obstructive and restrictive lung impairments, highlighting the significant occupational health risks involved.(12)

The findings of this study highlight the occupational health risks associated with chronic exposure to paint fumes. Studies such as those by Fishwick D et al.,(13) and Tungu AM et al., advocate for workplace interventions and stricter regulations to reduce the impact of hazardous chemical exposure in industrial settings.(14) Furthermore, awareness campaigns and occupational health training programs could play a pivotal role in reducing exposure-related risks.

CONCLUSION

This study provides compelling evidence that long-term exposure to paint fumes significantly impairs pulmonary function, predominantly through obstructive and restrictive airway diseases. The results are consistent with previous research, reinforcing the need for enhanced occupational health policies to safeguard the respiratory health of paint workers. Future studies should focus on longitudinal assessments to better understand the long-term implications and effectiveness of protective measures in minimizing respiratory risks in this workforce.

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