

Comparative Assessment of Lung Function using Peak Expiratory Flow Rate (PEFR) Between Automobile Painters and Non- Painters within Mechanic Garages In Farin-Gada, Jos, Plateau State, Nigeria.

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Abstract: The study evaluated the lung function of both automobile painters and non-painters using peak expiratory flow rate (PEFR). Sixty subjects were randomly selected and divided into two groups of 30 in each group, the first being the test group and the second the control group, with ages ranging from 18-55 years. Groups were matched for age, height and chest circumference. After being interviewed for respiratory signs and duration of exposure, PEFR was determined using a Mini Wright peak flow meter for each subject in both groups

Pulmonary function marker (PEFR) of the automobile painters showed significant decrease compared with the control group. Also, there was a significant decrease ($P < 0.05$) less value in PEFR of painters exposed for >20 years as compared to those exposed for <20 years. Exposure to automobile spray paints significantly decreased lung function. Also, duration of exposure has an inverse relationship with PEFR Value

Keywords: automobile painters and non-painters, lung function, PEFR.

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I. Introduction

Automobile painters repaint automobiles truck and buses that have been repaired and older vehicles that have lost their luster. Automobile painters are exposed to solvents and other volatile components during spray painting. Car spray painters are exposed to lots of component contained in paints. They are commonly exposed by inhalation of solvents and other volatile component which is common during spray painting (Alexanderson et al., 1987).

The evidences of airborne particulate matter (pm) and its public health impacts is consistent in showing adverse health effects of exposures that are currently experienced by urban population in both developed and developing countries. The range of health effects is broad, but is predominantly to the respiratory and cardiovascular system. All palliation is affected, but susceptibility to the population may vary with health or age. The risk for various outcomes has shown evidence to suggest a threshold below which no adverse effects would be anticipated (Alexanderson et al., 1987).

Exposure to airborne chemicals is very common in several different industrial branches including the automobile workshops (auto body shops). Dust, particles, different gases and moisture are almost always present. It has been shown that depending on size, particles can reach different part of the human airways. Small particles are able to penetrate all the way down to the alveolar region, where residence time is long due to lower gas velocity in these parts of the air ways (Dahlin, 2007).

During painting, multiple thin layers of the different paints are applied. When base metal is exposed, these areas are first covered with a primer. Once the vehicle is ready for final painting several base coats are applied, the paint is allowed to sit a short while (10-20 minutes) then the colour paint is applied, again in several thin coats. Lastly the clear top coat is sprayed on until a uniform gloss is achieved. The vehicle is then allowed to sit overnight in a heated booth for 1-2 hours to allow the paint to dry (McCammon, 1996).

High volume, low pressure (HVLP) spray guns are used to reduce the amount of paint over-spray. However, most of the painters still use conventional spray gun to some degree, especially when applying the clear coats of paints.

The paints are composed of base coat, a reducer (thinner) and hardener. The percentage and make-up of each component varies depending on the type of paint, i.e. a base coat, a colour coat, or a top (clean) coat. The paint contain hexamethylene-1-6- diisocyanate(HDI) polymer and very small amounts of the monomers (<0.006%). All of the various components contain solvent (McCammon, 1996).

The unique feature common in all diisocyanates is that they consist of two N=C=O (isocyanate) functional group attached to an aromatic or aliphatic parent compound. Because of the highly unsaturated nature of the isocyanate functional group, the diisocyanates readily react with compounds containing active hydrogen atoms (nucleophiles). Thus the diisocyanates readily react with water (humidity), alcohols, amines etc. Thus, the diisocyanates also react with themselves to form either dimers or trimer. Many material safety data sheet (MSDS) use isocyanate-related terms interchangeably (Christopher and Roegner, 2000).

Diisocyanates are usually referred to by their specific acronym, e.g TDI for 2,4 and 2,6-toluene diisocyanates. HDI for 1,6hexamethylenediisocyanate, MDI for 4,4- diphenylmethanediisocyanates, NDI for 1,5-naphthalene diisocyanate etc. Commercial grade TDI is an 80: 20 mixture of the 2,4-and 2,6- isomers of TDI, respectively (McCammon, 1996).

Painters in automobile shops (auto body shops) are exposed to many hazardous chemical particular diisocyanates used as hardener of two part paint system and present in high concentration in the final clear coat. Thinners (reducers) are mixed with anti-rust, primer and other types of paints for ease of application. And it is the source of volatile organic compound such as xylene and toluene. Toluene is used as a solvent for paints. The toxicological mode of action of toluene is narcosis. At low concentration it produces skin irritation and at high level it affect blood cells, the liver, the kidney and the central nervous system (through which it causes headaches, nausea, and impaired co-ordination) (Hoyu, 2006).

Benzene has been used as a thinner and diluents of paints, inks and lacquer. It has been in commercial use for a century and its toxic effects have been suspected for almost as long. The toxicological mode of action of benzene is narcosis affecting the central nervous system. At high concentration, inhalation of air containing approximately 64gm/m³ of benzene can be fatal within a few within minutes and one tenth of that level can cause acute poisoning within an hour. Exposure causes skin irritation, fluid accumulation in the lungs, which may eventually lead to respiratory failure and death. At low concentration, benzene can cause blood abnormalities, lower white cell count and bone marrow damages. Xylene is used as clearer, solvent and lacquer. As in the case of toluene and benzene, the xylene act as narcotics on the central nervous system, causing headache impaired co-ordination, edema and nausea at higher concentration and skin irritation, anaemia, blood cell damage and decrease in blood platelets at lower chronic exposure levels (Hoyu, 2006).

During spray painting in automobile body repair shops, workers are exposed to all of the paint components which are atomized. The dose of exposure is worsened by poor ventilation and the reluctance of the painters to use personal protective devices. Acute intoxication can occur mainly as a result of inhalation of solvents, especially in confined spaces with inadequate ventilation. Irritation of the eye (with possible permanent damage to vision) and the respiratory tract occur by various paint components in particular toluene and methylene diisocyanates (Eolts, 1998).

Auto body shop operations can produce emission of toxic air pollutants, including metals and diisocyanates. Paints can release some toxic air pollutant and volatile organic compounds (VOC). Chemicals in these substances can react in the air to form ground level ozone (Smog), which has been linked to a number of respiratory effects. Lead chromium and cadmium are metals that form particle pollution during sanding and welding. Breathing particle pollution can cause respiratory problem and other harmful health effect. Diisocyanates are toxic air pollutants emitted during painting operation. These compounds are a leading cause of occupational asthma.

The routes of exposure to isocyanates are mainly through inhalation and skin exposure. Inhaling even small amounts of isocyanates may sensitize a person and they may develop asthma like reaction and symptoms like wheezing dyspnea, bronchial constriction (Mappetal; 1985, Moscatoet al., 1991). Sensitization may occur within days of exposure or take months or years to develop. It is well known once sensitized, a person is likely to experience symptom upon repeated exposure even in very small concentrations. Direct skin contact with isocyanate-containing products may cause rashes, blistering and reddening of the skin. Repeated contact may cause contact dermatitis and sensitization. Some recent research has suggested that isocyanate exposure through the skin is very significant. Therefore, skin contact should be avoided. Isocyanates are powerful irritants to the mucous membranes of the eye and gastro intestinal tract. Exposure of isocyanates to the eye can result in eye irritation, temporary blurred vision and cornea damage (Dillon, 2000).

The peak flow rate (PFR), also called peak expiratory flow rate (PEFR) is a person's maximum speed of expiration as measured with a peak flow meter. Peak expiratory flow rate is measured with a peak flow meter, a small handheld device used to monitor a person's ability to breath out air. It measures the airflow through the bronchi and thus the degree of obstruction in the airways. Peak flow readings are higher when patient are well and lower when the airways are constricted. From change in recorded values, patients and doctors may

determine lung functionality, severity of asthma symptoms and treatment options. First measure of precaution would be to check patient for signs and symptoms of asthmatic hypervolemia. This would indicate whether or not to even continue with the peak flow meter procedure. Measurement of PEFR requires training to correctly use a meter and the normal expected value depends on a patient's sex, age and height. It is classically induced in obstructive lung disorders such as asthma (Nunn, and Gregg, 1989).

Due to the wide range of "normal" values and high degree of variability, Peak flow is not a recommended test to identify asthma. However, it can be useful in some circumstances. A small portion of people with asthma may benefit from regular peak flow monitoring. When monitoring is recommended, it is usually done in addition to reviewing asthma and frequency of regular medication use. When peak flow is being monitored regularly, the results may be recorded on a peak flow chart. It is important to use the same peak flow meter every time (Martin and Miller, 2004).

The highest of three readings is used as the recorded values of the peak expiratory flow rate. It may be plotted out on graph paper charts together with a record of symptoms or using peak flow charting software.

Peak flow readings are often classified into 3 zones of measurement according to the American lung association, green(80-100%), yellow (50-79%), red(< 50%). An asthma management plan can be developed based on the green red zones (Nunn, and Gregg, 1989).

In normal adult, the peak expiratory flow is 400litres/minute. The peak expiratory flow rate measure maximum flow over 10 milliseconds at the beginning of expiration and is expressed in litre per minute (L/min).factors that might affect PEFR are anthropometry (height and weight), age and sex, nutritional status and the environment (smoking, pollutants).

Car spray painter are exposed to isocyanates (Alexanderson et al., 1987), which are group of low molecular weight aromatic aliphatic compounds containing the highly reactive isocyanate group (-NCO) (Schauertreet al;1985). Inhalation and dermal exposure can occur during the manufacture and use of these compounds (Schauertreet al; 1985).

Association between isocyanate exposure, sensitization and respiratory disease have received little attention (Prank etal; 2007) despite their extensive use during spray painting. Isocyanates are used as cross-linking agent in polyurethane products, such as foams varieties, and paints. Therefore, workers and individuals in close proximity to spray application of polyurethane are likely to be exposed. In acute toxicity all workers (painters) will develop eye, nose and throat irritation with coughing and labored breathing. More severe exposure may result in hypersensitivity pneumonitis and pulmonary edema. Dermal contact will result in dermatitis and eczema (Gad, 2005).chronic inhalation can cause immune disorder as well as nasal and lung lesions. Chronic inhalation exposure to isocyanates in paint workers has been linked to pulmonary effects that are characterized by dyspnea, wheezing, and bronchial constriction (Mappet al; 1985, Mostcatoet al; 1991).

Occupational asthma is a disease characterized by variable airflow limitation and/or airway hyper-responsiveness due to causes and conditions attributable to a particular occupational environment and not to stimuli encountered outside the work place (Bernstein et al; 1999). It is a potentially fetal condition, and death from isocyanates induced asthma has been reported (Lee and Koh, 2008). Nevertheless, it may present with varying degree of respiratory compromise accompanied by rhino-conjunctivitis the ocular and nasal discharge, pruritis and sneezing. Mild cases present with episodic dry cough, chest tightness, and increased breathing effort, whereas severely affected patients suffer from wheezing cough, and dyspnea on exertion (Maloet al; 1997).

No human information is available for the reproductive or developmental toxicity of isocyanates; however, some effects (decreased placental and fetal weight) were noted in experimental animals studies (Kapp, 2005). There is inadequate evidence for the carcinogenicity of isocyanates in humans; however there is sufficient evidence for the carcinogenicity of toluene diisocyanates in experimental animals (Bilban, 2004).

There is evidence of work-related asthma (WRA) among spray painters using isocyanate-based aerosol paint. According to the European Community Respiratory Health Survey (ECRHS) classification, spray painting is considered an occupation with a high risk of respiratory impairment and asthma (Kogevinaset al.1996). All isocyanates are hazardous substances and require care in handling. The greatest risks are from inhaling vapours, fine droplets (aerosols) and dust containing isocyanates, as they irritate the linings of the nose, throat, lungs and eyes (Work Safe Western Australia Commission, 2000).The properties of chemicals, the amount and duration of exposure, as well as unique individual factors may increase the chances of developing isocyanate induced asthma (Dilion, 2000).

Acute exposure to an isocyanate usually occurs with a single exposure to a high concentration dose of the chemical. The exposure is usually of short duration. The exposure could result, for example, from an unexpected or accidental spill of the liquid chemical, or from the release of high concentrations of isocyanate vapour form. Exposure to high concentrations of isocyanate vapour or mist causes irritation to the eyes, nose and throat. Symptoms include itchy, watery eyes, a sensation of burning in the eyes, a runny nose, sneezing, hoarseness, coughing, chest tightness, fever, fatigue. Symptoms may not appear for 6 to 10 hours

following exposure and usually clear up within 12 to 24 hours. Often, because symptoms are delayed, workers don't connect these symptoms with workplace exposure to the chemical. Chronic exposure to isocyanate at low concentrations over a long period of time will affect the lungs and skins as in acute exposures, but the symptoms and signs may be different (Work Safe Alberta, 2006).

In this study we hypothesized that automobile spray has no effect on the peak expiratory flow rate of automobile painters in Farin-gada, Jos, Plateau state, Nigeria.

The study was designed to measure and compare the peak expiratory flow rate (PEFR) among automobile painters and non-painters.

II. Materials/Method

LOCATION AND DURATION OF THE STUDY

The study was carried-out in Jos, using Automobile spray painters and non-painters from the Farin-gada area of Jos.

MATERIALS USED

Cotton wool, Methylated spirit, Mini wright peak flow meter (Vitalograph, Ennis, Ireland), Portable bathroom scale (Hana B.R., 9012), Measuring tape Wall mounted measuring tape (Stadiometer).

DATA COLLECTION METHOD

The study population included 60 male subjects consist of 2 groups (i.e. the test group and the control group). The test group included 30 automobile painters, and the control group included 30 non-painters (their ages ranging from 18-55). Groups were matched for age, height and chest circumference.

QUESTIONNAIRE

Prior to any measurement, each subject was interviewed using a questionnaire which included, personal data, respiratory signs and symptoms, duration of exposure, occupation and the whole time the spent in this profession. This questionnaire was specifically designed for this study.

INCLUSION CRITERIA

The criteria satisfied were (a) availability and capacity to cooperate for the duration of the study (b) Automobile painters with at least 1 year of working period were used as test subjects (c) they were all non-smokers.

EXCLUSION CRITERIA

Inability or unwillingness to take part in the study, history of respiratory disorders including asthma, and history of major cardiopulmonary disease, cigarette smoking.

ANTHROPOMETRY

The subjects were subjected to anthropometry using the standard procedures and instruments. The ages of the subjects were recorded in years. Standing height (stature) was measured without shoes in centimeters with a standard stadiometer. Weights were measured without shoes in kilograms with a pair of bathroom scale (HANA BR – 9012) which has been calibrated and chest circumference was measured in centimeters with a measuring tape at the level of the nipple.

DETERMINATION OF PEAK EXPIRATORY FLOW RATE (PEFR)

A mini wright peak flow meter (Vitalograph, Ennis, Ireland) was used. Briefly, the mouth piece of the peak flow meter was constantly disinfected with methylated spirit before each use by the subject. The subjects took maximal inspiration and then give out a maximal exhalation. The PEFR was read directly from the meter scale of the peak flow meter. Each subject made three maneuvers and the highest value was recorded.

STATISTICAL ANALYSIS

Graph pad prism version 5.02 was used to analyze data obtained and these were expressed as mean± standard deviation. The difference between means was compared using unpaired t-test "p" value <0.05 is taken as significant.

III. Results

In the present study it was observed that there was no significant difference in the mean physical parameters like age, weight, height, and chest circumference by calculating mean and standard deviation in automobile painters and non-painters (table 1).

Table I: Physical Characteristics of Automobile Painters and Non-painters

Characteristics	Automobile painters	Non-painters	p. value
Age (years)	31.90±11.76	31.07±10.38	0.7428
Height (m)	1.703±0.1032	1.687±0.05448	0.4557
Weight (kg)	68.70±75.62	66.13±9.220	0.9985
Chest circumference (cm)	83.43±5.507	84.57±7.338	0.4988

Data Present as mean ± SD

Table II illustrates the mean and standard deviation (SD) of PEFR of Automobile Painters and non-painters. It showed a statistically significant association between painters and non-painters by applying unpaired t-test of significance ($p < 0.001$).

Table II: Peak Expiratory Flow Rate (PEFR) among Automobile Painters and Non-painters

PEFR	Automobile painters	Non-painters
	326.7±88.57***	518.0±104.2

$P < 0.0001$ highly significant

The total number of Automobile painter were 30(100%); 20(66.7%) of them were exposed for >20 years while 10(33.3%) were exposed for <20 years.

Table III: Peak expiratory flow rate, frequency and Percentage of painters Exposed according to years.

Duration (years)	PEFR (L/minute)	Frequency	Percentage
<20	358.5±77.82	20	66.7%
>20	263.0±74.82	10	33.3%

$P < 0.05$

There was a significant p value of 0.0034 in PEFR between painters exposed for >20 years and those exposed for <20 years. (Table III).

IV. Discussion

Automobile painters are at a risk of developing respiratory problems. This is mainly due to the effect of isocyanates, present in the car paint. Inhaling even small amounts of isocyanates may sensitize a person and they may develop asthma-like reaction and symptoms like wheezing, dyspnea, bronchial constriction (Mappet *al.*, 1985, Moscatoet *al.*; 1991). Sensitization may occur within days of exposure or take months.

The mechanism of induced sensitization remains uncertain but the high reaction of the NCO functional group is believed to be the key in the process. Isocyanates are electrophilic (electron accepting) and bind to carrier proteins, via the reaction of the NCO group with nucleophiles (electron supplier) such as SH₂, NH₂, and OH groups present in these proteins. Several peptides in airway epithelial cells, serum and skin have been observed to bind glutathione, albumin and Keratin (Raulf-Heimsoth, 1998).

During the last few decades, lung function tests evolved from tools for physiologic study to clinical investigations in assessing respiratory status. They also became a part of routine health examination in respiratory, occupational, sport, medicine and in public health screening.

Asthma is a heterogenous inflammatory disorder characterized by variable air flow limitation and/or airway hyper-responsiveness, reversible airway obstruction, wheezing and shortness of breath.

Tests have been designed to indicate the extent of the narrowing of the airways. A simple but important test is to measure peak expiratory flow rate (PEFR). Peak expiratory flow rate (PEFR) is a person's maximum speed of expiration as measured with a peak flow meter. It measures the airway flow through the bronchi and thus the degree of obstruction in the airways. Narrowing of the airways reduces the ability to move air in and out of the lungs. The narrower the tubes, the lower the PEFR (Diner *et al.*, 2000).

In the present case-control study, 60 subjects were randomly selected to study the effect of automobile paints on lung function by using peak expiratory (PEFR) measurement. The result showed that there was no significant difference in the mean of all the measured physical parameters of painters as compared to control (non-painters),(Table I). Most of the automobile painters in this study, were exposed for a duration of <20 years (66.7%) of the total population (100%).

In the present study, the pulmonary function marker (PEFR) of the automobile painters showed significant decrease compared with control group by applying unpaired t-test of significance ($p < 0.0001$). Indicating airway obstruction. These changes in pulmonary function may be attributed to the ignorance of workers to comply with standard protective measures that should be followed in this situation. It is also important to point out the fact that such respiratory effect result from blood born toxic effects of the

chemicals, and the possible effects of other inhalational pollutants in the busy working environment may have had an added impact on the result of the pulmonary function test (PFT).

Also the result showed a statistical significance ($P < 0.05$) less value in PEFR of painter exposed for greater than >20 years as compared to those exposed for <20 years.

The findings in this study is in concordance with the work of Vandenasplaset *al.*, 1993,1991; Ould-Kediet *al.*, 2007 and Schweigert *al.*, 2002, Mappet *al.*, 1985, Moscatoet *al.*, 1991, who observed a reduced PEFR in automobile painters than non-painters.

The determination in lung function reported in the present study might be explained better according to the type of solvents used at the work places, which is unfortunately not estimated due to technical limitations. In these respect many researchers indicate that exposure to low toluene diisocyanate concentration is associated with minimal respiratory damage but epithelial barrier permeability causing some changes in the pulmonary function (Vandenasplaset *al.*, 1999) and nearly 36.4% of the automobile garage workers had some form of pulmonary function in part, obstructive and/or restrictive (Chattopadhyay,2007).

V. Conclusion

It can be concluded that exposure to automobile spray paint significantly decrease PEFR in painters as compared to non-painters in Farin-gada area of Jos, Plateau state ,Nigeria. Also there is an inverse relationship between duration of exposure and the PEFR value. That is, PEFR decreased as the duration of exposure increased.

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