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The Impact of Automobile Painting Profession on Selected Respiratory Parameters: a Study from Palestine

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ABSTRACT

An increasing rate of respiratory problems among workers in automobile painting workshops in West Bank (Tulkarm and Nablus cities) has been noted in the last period. However, to date, no studies have been published about the effects of this profession on respiratory health in Palestine. This study aims to determine the impact of automobile painting profession on respiratory health. This case-control study was conducted. Forced spirometry was used to measure the forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), the FEV1/FVC ratios and prevalence of restrictive and obstructive lung patterns. Twenty two workers (cases) and 45 controls were studied. The case and control groups have similar demographic characteristics. According to the type of lung status, 82% of the workers showed abnormal respiratory parameters (68% restrictive vs. 14% obstructive). In comparison, 42 % of non-workers showed abnormal respiratory parameters (40% restrictive vs. 2% obstructive) while others showed normal pattern. In this study, we concluded that working in automobile painting workshops might result in respiratory problems (Obstructive and Restrictive diseases).

1. Introduction

A primary concern of human respiratory system health is the interruption of this cycle by chemicals or foreign bodies from the atmosphere which may impair the total function of the lungs. Restrictive lung diseases are mainly characterized by reduced total lung capacity (TLC) and the loss of lung compliance [1] while obstructive lung diseases [2] are characterized by the obstruction of the airways and the inability to exhale properly. However, some lung diseases display both obstructive and restrictive characteristics [3]. In some occupations, workers are constantly exposed to inorganic dusts, gases, fumes and other harmful substances, leading to anatomical and physiological changes in the respiratory system causing many acute occupational lung diseases from which are occupational asthma and pneumoconiosis [2].

Thousands of chemical compounds are used in the manufacturing of paint products, like pigments, extenders, binders, additives, and solvents (toluene, xylene, ketones, alcohols, esters, and glycol ethers). Paint manufacture workers are potentially exposed to the chemicals found in paint products although the patterns and levels of exposure to individual agents may differ from those of painters[4]. A previous study has reported that heavy and prolonged exposure to paint solvents leads to neuropsychological ill health [5].

The most common cause of occupational asthma are isocyanates and related chemicals [6]. Isocyanates are a family of highly reactive, low molecular weight chemicals. They are widely used in the manufacture of flexible and rigid foams, fibers, coatings such as paints and are increasingly used in the automobile industry, isocyanate is a power irritant to the mucus membranes of the eye and the gastrointestinal and respiratory tract. Direct skin contact also can cause marked inflammation [7].

Isocyanate is known to induce Asthma by specific sensitization. The mechanism of this specific type of sensitivity is unclear. The specificity of the responses as well as the patterns of early, late and dual asthmatic responses are similar to those of allergen-induced asthma and suggest an immunologic mechanism. The studies show that the conjugation of isocyanate and human serum albumin stimulate the lymphocyte from sensitized individuals cause severe asthma with continuous exposure. With the increasing use of isocyanates and related chemicals in industry, asthma induced by sensitization to these chemicals is likely to become an increasing problem [7] .

N-methyl-2-pyrrolidone (NMP) is an important organic solvent for varnishes in industry. NMP has been previously shown to be a developmental toxicant in rodents. NMP is miscible with both water and organic solvents, making it a powerful polar solvent for many industrial applications. Its primary use is as a solvent for varnishes, paints, and coating materials in the chemical and automobile industries. Two specific metabolites, 5-hydroxy-N-methyl-2-pyrrolidone (5-HNMP) and 2-hydroxy-N-methyl-succinimide (2-HMSI). All workers employed in the spraying department of the automobile plant were exposed to NMP [8]. A considerable amount of literature has been published on painting and its effects on the human health. A study concerned about respiratory health effects related to occupational spray painting and welding concluded that welders and painters in this plant appeared to have increased risk of respiratory health effects compared with assembly workers[9]. The purpose of another study was to determine the prevalence rates of acute and chronic neurologic symptoms among paint workers and the association of such symptoms with the severity of exposure to mixtures of solvents, after modeling by multiple logistic regression, they concluded that exposure to a medium level of mixtures of solvents may produce acute and chronic central neurological symptoms[10]. Also, in Korea a study investigated the neurobehavioral effects in workers occupationally exposed to organic solvents in using WHO neurobehavioral core test battery (NCTB) [11] . Solvents in car paints are a recognised source of occupational toxicity. In particular, they can cause DNA damage and occupational rhinobronchitis [12].

Researchers have not treated the topic of painting in much detail, especially with the abnormal increasing in the respiratory health status problems worldwide. Here in Palestine, far too little attention has been paid to solve this occupational environmental problem. So, this study was undertaken to determine the effect of working in automobile painting workshops on the respiratory system of workers in Palestine (Tulkarm and Nablus cities).

2. **Experimental detail**

2.1. Study Design

This study is a case-control study that included a group of automobile painting workers in Tulkarm and Nablus cities (cases) in addition to a control group which consisted of non-workers in automobile painting. The study was conducted during August 2014.

2.2 Study population

The study included 67 subjects (22 cases vs. 45 controls) by a ratio of roughly 2/1. All cases were males with ages ranged from 16 to 59 years (mean = 32.5).Their duration of working ranged from few months to 20 years (mean = 11.1 years). The height and the weight of the two groups were entered directly into the spirometer for direct calculation. The case and control groups have similar socio-demographic characteristics.

2.3. Data collection

Collecting data from the subjects was done by two steps, the first was taking history (questionnaire) and the other was the spirometer testing.

2.3.1 History taking

Questionnaire was used to collect data about the subjects. Data included age, sex, height, weight and important health conditions such as asthma, chronic lung diseases, diabetes and hypertension. Subjects were also asked about current drug use and smoking. These information were recorded in the questionnaire and in the spirometer

before testing each subject. Cases were also asked more about occupational issues such as work duration and the use of any kind of airway protection method.

2.3.2 The spirometry

Different resparotory parameters such as FEV1, FVC and FEV1/FVC ratio were recorded using spirometry. The subjects were seated during the test and a nose clipper was used to prevent air leakage from the nose. The procedures were carefully explained to each subject and then the tests were carried out. Forced spirometry test was measured with exhalation of at least six seconds, then the subject take a rest for several seconds then repeat the measurement until the spirometer reaches three acceptable measurements. The procedure performance was according to international guidelines of office spirometry [13,14]. Spirometer calibration was done daily to ensure the quality of the test. Calibration check was done by connecting three liters syringe to transducer with the adapter supplied and empty by pushing the handle fully in.

2.4. The statistical data analysis was carried out using statistical package for social sciences (SPSS Statistics V.17.0, SPSS Ink, Chicago, Illinois, USA). Features that were used in analysis and description of study population include: cross tabulation, frequencies and percentages, mean and chi-square measurements. A p-value less than 0.05 was considered significant.

3. Results and discussion

3.1. Lung status

The relation between working in automobile painting workshops and the type of lung status is shown in table 1. Eighty-two percent of the workers showed abnormal lung function, 68.18% had restrictive lung pattern, 13.64% had obstructive lung pattern and 18.18% workers were normal. In comparison, 57.8 % of non-workers were normal and 42.2 % showed lung diseases, 40% had restrictive lung pattern and 2.2% had obstructive lung pattern.

Table (1) : The relation between working in automobile painting workshops and the type of lung status

		Normal	Restrictive	Obstructive	Total
Worker	Count	4	15	3	22
	%	18.18%	68.18%	13.64%	100%
Non –worker	Count	26	18	1	45
	%	57.8%	40%	2.2%	100%
Total	Count	30	33	4	67
	%	44.7%	49.25%	5.97%	100%
P= 0.005					

3.2. FEV1

The effect of working in automobile painting workshops on the forced expiratory volume in the first second (FEV1) values is shown in table 2. Among the 22 cases 14 subjects (63.6%) had decreased FEV1 value, 8 workers (36.3%) had normal FEV1 value and 1 worker (2.2%) had increased FEV1 values. In comparison with the control groups, only 4 subjects (8.9%) had decreased FEV1 values and 41 subjects (91.1%) had normal FEV1 values , the results show that the decrease in FEV1 values between workers in Automobile painting workshops was significant in comparison to non-worker group (P-value = 0.001).

Table (2) : The relation between working in automobile painting workshops and the FEV1 changes					
		Decrease	Normal	Increase	Total
Worker	Count	14	8	1	22
	%	63.6%	36.3%	2.2%	100%
Non –worker	Count	4	41	0	45
	%	8.8%	91%	0%	100%
Total	Count	18	49	1	67
	%	26.87%	73.1%	1.49%	100%
P = 0.001					

3.3. FVC

The effect of working in automobile painting workshops on FVC is shown in table 3.Among 22 cases, 15 workers (68.2%) had decreased FVC values, and 7 workers (31.8%) had normal FVC values. In comparison with workers group only 15 of the non-workers group (33.3%) had decreased FVC values and 2% had increased FVC values, 29 workers (64.4%) had non- decreased FVC values and 1 worker (2.2%) had an increased FVC values. The results show that the decrease in FVC values among workers in Automobile painting workshops in comparison with the non-workers was significant (P-value =0.007).

Table (3) : The relation between working in automobile painting workshops and the FVC changes					
		Decrease	Normal	Increase	Total
Worker	Count	15	7	0	22
	%	68.2%	31.8%	0%	100%
Non –worker	Count	15	29	1	45
	%	33.3%	64.4%	2.2%	100%
Total	Count	30	36	1	67
	%	44.77%	53.73%	1.49%	100%
P = 0.007					

3.4. FEV1/FVC ratio

The effect of working in automobile painting workshops on FEV1/FVC ratio is shown in table 4. Among 22 cases (workers), 9% of them had decreased ratio, 63.6% had normal ratio and 27.3% with increased ratio.In comparison with controls, no one of the control group had decreased ratio but 75.5% had normal ratio and 24.2% had increased ratio. The results shows that the association between working in automobile painting workshops and FEV1/FVC ratio is not significant (P = 0.1).

Table (4) : The relation between working in automobile painting workshops and the FEV1/ FVC ratio					
		Decrease	Normal	Increase	Total
Worker	Count	2	14	6	22
	%	9%	63.6%	27.3%	100%
Non –worker	Count	0	34	11	45
	%	0%	75.5%	24.2%	100%
Total	Count	2	48	17	67
	%	3%	71.64%	25.3%	100%
P = 0.1					

4. Discussion

Working in automobile painting workshops in Palestine is one of jobs that lack documented scientific information about its nature, and its impact on the workers health. Moreover, the majority of the workers do not use any protection methods to protect their lungs from the chemical (especially hydrocarbons and Volatile Organic Compounds (VOCs)) in the working field. Occupational lung diseases are now taking more attention internationally in order to reduce the negative impact on the workers health. Regarding the relation between the lung impairment patterns and working in the automobile painting workshops, the results of the study show that there is a significant relation between them. This means that there are significantly more subjects with restrictive and obstructive lung disease among automobile painting workshops workers than in non-workers. Also the severity of the restrictive lung disease itself is more severe among workers than in non-workers as the results show. Our results are compatible with other studies demonstrating that isocyanate-exposed automobile-paint workers showed a significant reduction in FEV1/FVC ratio suggestive of obstructive lung pattern (15). In addition, the results during data analysis showed that among the workers, during mixing process of hydrocarbons and Volatile Organic Compounds (VOCs) and other chemical workers were more susceptible to inhale toxicants and so their results were more severe than other workers. Going back to the objectives of this study, one of them aims to study the prevalence of restrictive lung diseases among automobile painting workshops, which is 15 workers representing 68.18% of all the workers. And it can be significantly compared to the prevalence of restrictive lung disease among non-workers, as there are 18 subjects who represent 40% of the non-workers. The common pathogenesis of occupational lung diseases, may explain these results. This is by the inhalation of the hydrocarbons and Volatile Organic Compounds (VOCs) by the lung, that result in inflammatory reaction around it, which will result in lung fibrosis. Lung fibrosis is a cause of restrictive pulmonary disease. A previous study suggested that lung exposure inhaled toxicants from different sources in the environment may lead to acute and chronic pulmonary or even systemic inflammation; these toxicants induce the recruitment and activation of macrophages, activation of mitogen-activated protein kinases, inhibition of protein synthesis, and production of interleukin-1 beta (16). Also, the exposure to the hydrocarbons and Volatile Organic Compounds (VOCs) will result in localized emphysema in some conditions and this will result in an obstructive lung diseases. In some studies, the relation between hydrocarbons and Volatile Organic Compounds (VOCs) exposure in working fields and the progression to chronic obstructive lung disease in some of the cases was confirmed in most of the occupational lung diseases (17). These results are supported by the findings of a previous study that demonestraed a correlation between the reduction in exposure to airborne isocyanate and a reduction in asthma (18). This may explain why the workers in this study have more impaired patterns than the non-workers but still need more pathological and histological evidence to confirm that. The

results also show an association between working in automobile painting workshops and FVC. The comparison between the cases and the control group shows that the workers have lower FVC values, which are about twice lower in the cases than in the control group. These results are compatible with the restrictive pattern that some of the workers have as proved in this study results. The value of FVC is decreased in restrictive lung diseases due to decreased compliance associated with the presence of fibrotic changes and even fibrosis; this means that the lungs become smaller and stiffer than normal, leading to a decrease in the FVC value. There is also a significant association between working in automobile painting workshops and FEV1. The comparison between the cases and the control group shows that the percentage of workers who have decreased FEV1 values, its roughly double the percentage the cases than in the control group. The value of FEV1 is reduced in obstructive pattern while it is reduced or normal in restrictive patterns. These results are also compatible with the fact that there is a significant relation between the exposure to hydrocarbons and Volatile Organic Compounds (VOCs) during paints manufacturing ,and restrictive and even obstructive lung diseases that a significant number of the workers have that was proven in this study as shown above. The results show also that the FEV1/FVC ratio had significant association with working in automobile painting workshops .These results can be explained by many facts. The first explanation is that this result is compatible with the concept that the FEV1/FVC in restrictive disease pattern is normal or increased according to the severity of the condition. Going back to the results of this study; both FVC and FEV1, which are the component of the FEV1/FVC ratio, are decreased significantly among workers in automobile painting workshops in comparison to non workers. The FEV1/FVC ratio is increased in some subjects, and this can be explained by the more significant decrease in FVC in comparison to FEV1 in some subjects. This is compatible with the scientific fact that in restrictive pattern, FVC and FEV1 usually decreasing but in variable degree, resulting in normal or increased FEV1/FVC ratio. In the other hand, the obstructive pattern affects mainly FEV1 by decreasing it, but also may also affect FVC by increasingits value.This result can be explained by the progressive pathological events that happen with increase exposure to the chemicals in occupational lung diseases, such as what happen after exposure to hydrocarbons and Volatile Organic Compounds (VOCs). Lung fibrosis will be more and more significant with each increase in the amount of toxicants which accumulates in the lung by the time . This will end finally by progressive massive fibrosis in some patients, which give a restrictive pattern to the lung function and other lung complications including emphysema and COPD. So, workers who are exposed less to chemicals and toxicants will have lower amount of lung fibrosis, and lower restrictive lung pattern than those who exposed to more chemicals and toxicants with time. These results highlight the necessity of health and safety measurements implication in this field in Palestine compared to other countries (19).

Conclusions

Working in automobile painting workshops may lead to a decrease in both FVC and FEV1 values, while normal FEV1/FVC ratio. These readings reflect the negative effect of paints exposure on the lung function, evident by increased severity of restrictive lung disease compared to control group. An inverse relation between the duration of working and lung function was found. These negative effects of paints exposure detected in this study necessitate intervention and implementation of protective measures to prevent the occurrence and progression of health problems among the workers. It also necessitates the conduction of studies on pathological changes that result from exposure to paints in order to have an explanation of the spirometrical changes found in this study.

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