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RESEARCH ARTICLE

Effect of Traffic-Related Air Pollution on Lung Function in Taxi Drivers: A Cross Sectional Study

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Abstract

Background: Traffic related air pollution increases the risk of getting and/or exacerbating many respiratory diseases due to the presence of fine particulate matter and contaminants in traffic fuels. The effect of air pollution on respiratory symptoms and bronchial obstruction in highly exposed populations, such as taxi drivers, has not been investigated yet.

Methods: We conducted a cross sectional analytic study that included 120 employees and 200 taxi drivers recruited from the 4 main taxi stations in the Greater Beirut area. Fifty taxi drivers were recruited randomly from each taxi station as well as 30 employees working in stores near every station. We assessed their respiratory symptoms by using a modified version of a standardized questionnaire. Pulmonary function tests were performed using an ambulatory validated spirometer (COPD6, Vitalograph).

Results: A strong correlation was found between traffic related air pollution and the severity of airway obstruction and respiratory symptoms. Smoking and non-smoking taxi drivers had the lowest FEV1/FVC ratios, 0.78 and 0.81 compared to 0.84 and 0.86 for smoking and non-smoking employees respectively. They had also the lowest FEV1 (79.55%) closely followed by non-smoking taxi drivers (80.32%), then employee smokers and non-smokers (83.88% and 91.64%). Furthermore, smoking and non-smoking taxi drivers were found to be the most symptomatic with a highest reported mean symptoms score (46.1 and 31.1) followed by smoking and non-smoking employees (23.7 and 17.4 respectively). These findings were statistically significant (p value 0.006). Finally, our study also showed a strong association between the duration of time working in the taxi station and a significant decrease in FEV1/FVC, as well as FEV1 (p value < 0.001).

Conclusion: The duration of exposure to traffic related air pollution was significantly associated with a reduction in lung function and an increase in mean respiratory symptoms score among all highly exposed subjects included in our study population especially smoking and non-smoking taxi drivers. Consequently, this study offers strong evidence that the longer exposure to traffic air pollution (second hand smoke exposure) is a major public health threat. Therefore, urbanization should take into consideration this major respiratory health issue and many measures should be taken to decrease this risk.

Keywords

Air pollution, Taxi drivers, Store employees, Lung function

Abbreviation

FEV1: Forced Expiratory Volume during the First Second; FVC: Forced Vital Capacity; PM: Particulate Matter; BAL: Bronchoalveolar Lavage; CVD: Cardiovascular Diseases; GI: Gastrointestinal

Introduction

Road transport is a major source of air pollution. Particulate matter, which is a major component of air pollution, triggers an inflammatory reaction in lung tissues and bronchial epithelium. It has been associated with an increase in inflammatory cytokines in BAL of exposed subjects [1]. Moreover, fine particulate matter PM 2, 5 micron enters the alveoli via inhalation and passes through into the systemic circulation causing a progressive inflammatory reaction, leading to cardiopulmonary diseases [2].

COPD, one of these pulmonary diseases, is characterized by a persistent limitation of airflow that is usually progressive and associated with an enhanced pro-

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Table 1: Baseline characteristics.

Variable	Average	Median
Age (years)	43.59	43
Duration of working in the taxi station (years)	9.879	9
Major comorbidities	CVD -Diabetes -GI	
Smoking -Pack/Year	13.04	

gressive inflammatory reaction to noxious particles and gases. COPD is known to be a major cause of morbidity and mortality worldwide; however, its prevalence varies among countries [3]. A recent epidemiologic study done in Lebanon found that the prevalence of COPD is 9.7% [4]. Although smoking remains the most common cause of COPD, many other risk factors have also been involved. Several epidemiological studies have not only shown that air pollution increases the risk of exacerbations in those with preexisting lung disease [5], but also that the prevalence of chronic bronchitis is higher in highly polluted areas [6,7]. Moreover, substantial studies have shown that air pollution in urbanized areas increases respiratory symptoms and decreases lung function in highly exposed subjects [8-12]. Lebanon is an urbanized country with high levels of pollution [13,14]. The adverse effects of traffic related air pollution on respiratory symptoms and lung function in specifically highly exposed populations, such as taxi drivers, have not yet been investigated in Lebanon.

Method

Study design

Cross sectional analytic study.

Study population

The study population included all the taxi drivers working at the main taxi-stations located at the 4 focal entries to Beirut, as well as the employees working in the stores found at those same locations. Accordingly: 200 taxi drivers; 50 taxi drivers from each station, with 120 employees; 30 from each station.

It is important to highlight that due to the absence of subways and tramways, the main means of public transport in Lebanon, especially Beirut, are taxis and busses.

Data collection

After obtaining oral, informed consent, a modified version of a standardized questionnaire [15] was administered by objective investigators to every participant.

FEV1 and FEV1/FVC ratio and delta FEV1 were measured for each participant in the study using an ambulatory spirometer (COPD6, Vitalograph) [16].

The symptoms score has been calculated for each participant according to the types and severity of cough, wheezing and dyspnea. Dry cough and productive cough were scored as 1 and 2 points respectively. Cough during the day, at night, and both day and night, were scored as 1, 2, and 3 points. Wheezing during the day and at night was scored 1 and 2 points respectively. For dyspnea, scores were calculated according to MRC scale [17]: During strenuous exercise 1 point, rising on a mound 2 points, walking less than people of the same age 3 points, after 100 meters 4 points and when changing clothes 5 points. Consequently, the symptoms score ranged from 1 to 12.

Statistical analysis

Data was collected and entered using the SPSS software for statistical analysis (version 19.0; SPSS Inc. Chicago, IL, USA) such as ANOVA and Chi-square test. ANOVA was used to test if there was a statistically significant difference between continuous means. Chi-square was used to test if there was a statistically significant association between two categorical variables; p value less than 0.05 was considered as statistically significant.

Descriptive results

Concerning age and duration in the station, their respective averages and medians were close, 43.59 and 43 years for age with 9.87 and 9 years for the duration in the station, meaning our patients characteristics data displayed a normal distribution. The three major comorbidities reported by our study population were CVD, Diabetes, and GI (Table 1).

Distribution of study population according to the underlying diseases

The majority of taxi drivers (43 drivers) reported diabetes and other diseases, while the majority of employees (20 employees) reported cardiovascular diseases (CVD). We also noted that among taxi drivers: 118 were healthy, 20 had CVD, 10 were diabetic and 9 had other diseases. Concerning employees: 78 were healthy, 13 were diabetic with other diseases, 6 were diabetic and 3 had other diseases (Table 2).

The majority of both groups (70% taxi drivers and 75% employees) were cigarette smokers. More employees (25%) than taxi drivers (17%) smoked water pipes. Out of 200 taxi drivers, 64 (32%) had COPD with FEV1/FVC < 0.7 compared to 30 (25%) of employees. Almost all taxi drivers and employees had an FEV1 not reversible to bronchodilators (less than 15%), which excluded asthma as a confounder diagnosis in our study population.

This table showed that more taxi drivers than employees reported cough (32.5% *vs.* 25%), especially productive cough (12.5% *vs.* 7.5%). Moreover, more taxi drivers than employees reported "night time" and "day and night" wheezing (6.5% *vs.* 4%). Finally, more taxi drivers than employees reported dyspnea (36.5% *vs.* 27.5%), especially severe dyspnea (8% *vs.* 6%) (Table 3).

Table 2: Distribution of study population according to smoking, FEV1, Delta FEV1and FEV1/FVC.

Smokers		Taxi Drivers (n = 200) (%)	Employees (n = 120 (%)
	No	60 (30)	30 (25)
	Yes	140 (70)	90 (75)
Smoking- pack-years	< 20	152 (76)	86 (72)
	20-39	34 (17)	24 (20)
	40-60	8 (4)	10 (8)
	> 60	6 (3)	0 (0)
Smoking waterpipe	No	165 (82.5)	90 (75)
	Yes	35 (17.5)	30 (25)
FEV1(% of predicted)	> 80	100 (50)	82 (68)
	71-80	56 (28)	14 (12)
	51-70	40 (20)	18 (15)
	30-50	4 (2)	6 (5)
	< 30	0 (0)	0 (0)
Delta FEV1 (%)	0-15	198 (99)	118 (98)
	> 15	2 (1)	2 (2)
Post bronchodilator FEV1/FVC ratio	< 0.7	64 (32)	32 (27)
	> 0.7	136 (68)	88 (73)

Analytical results

According to One-Way Anova, the difference of symptoms score average among the 4 groups (smoking and non-smoking taxi drivers, smoking and non-smoking employees) was statistically significant (p = 0.006). Taxi drivers had higher symptoms scores than employees. Among taxi drivers, smokers were the most symptomatic, they had the highest symptoms score (46.5), followed by non-smoking taxi drivers (31.1), then smoking employees (23.7%) (Table 4).

Moreover, the difference of FEV1/FVC average among the 4 groups was statistically significant. Although the average of FEV1/FVC was superior to 0.7 across the 4 groups, smoking taxi drivers had the lowest FEV1/FVC ratio (0.78).

Furthermore, the difference of the FEV1 average among the 4 groups was also statistically significant. Smoker taxi drivers also had the lowest FEV1 average (79.55%), closely followed by non-smoker taxi drivers (80.32%), then smoker employees (83.88%).

Using the Chi-square test we found that the association between FEV1 and duration of working in the taxi station was statistically significant (p = 0.001).

The majority as 99 (mentioned in red 1 + 14 + 19 + 8 + 41 + 16), of those with the longest duration of working in the taxi station (11 to 15 years and > 15 years) had the lowest FEV1 level (< 30% and 30-49%), while the majority as 148 (mentioned in blue, 100 + 48) of those with the shortest duration of working in the taxi station (< 5

Table 3: Distribution of study population according to symptoms.

Respiratory Symptoms (points)		Taxi drivers n = 200 (%)	Employees n = 120 (%)
Cough	NO	135 (67.5)	90 (75)
	YES	65 (32.5)	30 (25)
	Day time (1 point)	47 (23.5)	18 (15)
	Nighttime (2 points)	5 (2.5)	5 (4)
	Day and night (3 points)	13 (6.5)	7 (6)
	Productive for > 2 y (2points)	25 (12.5)	9 (7.5)
Wheezing	No	180 (90)	110 (91)
	Yes	20 (10)	10 (9)
	Day time (1point)	7 (3.5)	6 (5)
	Nighttime (2 points)	9 (4.5)	2 (2)
	Day and night (3 points)	4 (2)	2 (2)
Dyspnea	Yes	73 (36.5)	33 (27.5)
	Dyspnea during:		
	Strenuous exercise (1 point)	26 (13)	11 (9)
	Walking up a slight hill (2 points)	22 (11)	7 (6)
	Walking less than people of the same age (3points)	9 (4.5)	8 (6.5)
	Walking 100 meters (4 points)	14 (7)	7 (6)
	Changing clothes (5 points)	2 (1)	-

Table 4: Analytic results.

	Study population				
Spirometry Test	**Taxi drivers' smokers**	**Taxi drivers non-smoker**	**Employees smokers**	**Employees non-smokers**	**P-Value**
Participants/n	140	60	90	30	
FEV1 (%) average*	79.55	80.32	83.88	91.64	< 0.05
FEV1/FVC average*	0.78	0.81	0.84	0.86	< 0.05
Mean symptoms score*	46.5	31.1	23.7	17.4	0.006

Table 5: Lung function and the duration of occupational exposure across the study population (in years).

		Duration of occupation across study population					
Spirometry test	**Percentage of predicted**	**< 5**	**5 to 10**	**11 to 15**	**> 15**	**Total**	**P-Value**
FEV1	< 30%	0	0	1	8	9	
	30-49%	1	2	14	41	58	
	50-79%	14	20	19	16	64	
	> 80%	100	48	30	6	184	
	Total	115	70	64	71	320	0.001
FEV1/FVC	< 0.7	5	7	25	59	96	
	> 0.7	110	63	39	12	224	
	Total	115	70	64	71	320	0.001

Using chi- square, we found that FEV1 and FEV1/FVC correlated well with the duration of occupation. Those with higher duration of occupation > 15 years had lower FEV1 and FEV1/FVC (< 50% and < 0.7 respectively; p-value < 0.001) (mentioned in red). While those with lower working duration had higher FEV1 and FEV1/FVC (> 80% and > 0.7 respectively; P-value 0.001) (mentioned in blue).

years) had the highest FEV1 level (> 80%).

Similarly, using the Chi-square test, we found that the association between FEV1/FVC ratio and duration of working in the taxi station was statistically significant ($p < 0.001$).

The majority as 84 (25 + 59) of those with the longest duration of working in the taxi station (11-15 years and > 15 years) had the lowest FEV1/FVC ratio (< 0.7), while those with the shortest duration of working in the station (< 5 years) had the highest FEV1/FVC ratio (> 0.7) (Table 5).

Discussion

Many international studies have found that outdoor air pollution, especially traffic-related air pollution is a major risk factor for high morbidity and mortality from lung diseases despite the presence of active or passive smoking [18-21]. Beirut, which is the capital of Lebanon, like many "metropoles" is characterized by continuous heavy traffic jams. Moreover, according to recent studies active and passive smoking are highly prevalent across all socioeconomic levels of the Lebanese population [22,23]. Consequently, the Lebanese people living in urban areas, especially in Beirut, are highly exposed to environmental outdoor air pollution including traffic as well as tobacco smoking.

Indeed, in our study, we found that more smoking and non-smoking taxi drivers (32%) had FEV1/FVC < 0.7 than employees (25%). This finding can be explained by the fact that taxi drivers, spend most of their working time heavily exposed to traffic air pollution from diesel exhaust particles compared to employees who mainly stayed in their shops.

Moreover, since Lebanon and especially the Greater Beirut area was recently found to have an unacceptable high air pollution level exceeding international standards [13,14], our study findings showed that taxi drivers reported significantly more severe respiratory symptoms, more cough especially productive ones, wheezing especially at night, and more severe dyspnea compared to employees (Table 2). Furthermore, taxi drivers who smoked had the highest mean symptoms score (46.5) among the 4 groups of our study population (Table 3), followed by non-smoking taxi drivers (31.1), then, smoking employees (23.7). Thus, even non-smoking taxi drivers obtained worse symptoms scores than smoker employees. This startling find is consistent with many other cross-sectional study results which also showed higher prevalence of chronic bronchitis symptoms in non-smoker subjects living in highly polluted areas [5,6].

Nonetheless, in our study, smoking and non-smoking taxi drivers were much more exposed to the deleterious effects of outdoor air pollution on lung health than were shop employees, since taxi drivers are stuck in traffic jams throughout their day due to the nature of their jobs.

Concerning spirometry findings, the difference of FEV1/FVC's and FEV1's averages among the 4 groups of our study population (smoker taxi drivers, non-smoker taxi drivers, smoker employees and non smoker employees) was found to be statistically significant according to one-way Anova (Table 3). Smoker taxi drivers had the lowest FEV1/FVC ratio and FEV1 among the 4 groups closely followed by non-smoker taxi drivers then smoker and non-smoker employees. This significant result confirms further the strong relation between exposure to outdoor air pollution and decreased PFT's, knowing that smoking, age, male gender, and lower socioeconomic status are also predictors of COPD [24]. Nevertheless, decreased lung function among subjects highly exposed to air pollution has been also reported in previous studies. Bayda, et al. found a significantly decreased lung function and an increase in respiratory symptoms among non-smoker inhabitants of urban areas highly exposed to air pollution compared to those who live in rural areas [8]. Indeed, Lindgren A and his colleagues [7] also showed increased prevalence of COPD diagnosis (decrease FEV1/FVC < 0.7) among inhabitants of highly polluted areas. Similarly, Borlee, et al. conducted a cross sectional study to assess the effects of exposure to air pollution on lung function [25]. Their study showed spatial and temporal negative effects of outdoor air pollution on lung function among residents living near livestock farms. Moreover, Kan H and colleagues showed a decreased FEV1 and FVC among women highly exposed to traffic roads [26].

Finally, our study also showed a strong and significant association between FEV1, FEV1/FVC and the duration of working in the taxi station. Those who had the longest working duration had the lowest FEV1 and FEV1/FVC ratio across all our four groups (p value < 0.001), while taxi drivers who had the shortest duration had the highest FEV1 and FEV1/FVC ratio. The importance of the duration of exposure to traffic related air pollution was illustrated as well by a prospective cohort study that was conducted by Andersen ZJ, et al. which showed that long term exposure (over 35 years) to traffic related air pollution may contribute to the development of COPD with probably increased predisposition among asthmatic and diabetic patients [27].

Conclusion

After the thorough analysis of our results, it was evident that these findings were alarming from a clinical and public health perspective. Subsequently, our study was the first to show that in highly-exposed subjects, especially taxi drivers, smoking or non-smoking, there is a strong association between both the presence and duration of the exposure to traffic polluted air and a significant decrease in lung functions as well as an increase in the severity of respiratory symptoms.

These study findings are as important as they are valid since our study was designed to avoid any selection and classification bias. Our study population included all taxi drivers and employees, smokers or not, who were present at the time of recruitment. Furthermore, the diagnosis of chronic bronchitis was made according to a standardized questionnaire [14] and the confirmation of COPD diagnosis was done according to a validated ambulatory spirometer [15] administered to both taxi drivers and employees at the same time of the day and with the same environmental conditions.

These study results aim to increase the awareness of policy-makers regarding air pollution as an important additional risk factor of COPD and to establish a sound health intervention for the management and prevention of this disease.

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Authors Contribution

Loubna Tayara and Fida Charif contributed equally in writing, reviewing and correcting the manuscript.

Ali Hajj Diab and Ali Toufaily did the data collection and reviewed statistical data analysis and reviewed the manuscript.

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