CARBON MONOXIDE AND RESPIRATORY SYMPTOMS IN YOUNG ADULT PASSIVE SMOKERS: A PILOT STUDY COMPARING WATERPIPE TO CIGARETTE

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Abstract

Objectives: Studies have correlated second hand smoke (SHS) with many diseases, especially respiratory effects. The goal of this study was to measure the impact of SHS on the respiratory symptoms and exhaled carbon monoxide. **Material and Methods:** The study population consisted of 50 young workers in restaurants serving waterpipes, 48 university students who sit frequently in the university cafeteria where cigarette smoking is allowed and 49 university students spending time in places where smoking is not allowed. Subjects completed questionnaires on socio-demographic characteristics, respiratory symptoms and exposure to SHS. Exhaled carbon monoxide levels were measured. ANOVA and Chi-square tests were used when applicable as well as linear and logistic regression analysis. **Results:** Exposure to cigarette smoke in university (adjusted odds ratio (ORa) = 6.06) and occupational exposure to waterpipe smoke (ORa = 7.08) were predictors of chronic cough. Being married (ORa = 6.40), living near a heavy traffic road (ORa = 9.49) or near a local power generator (ORa = 7.54) appeared responsible for chronic sputum production. Moreover, predictors of chronic allergies were: being male (ORa = 7.81), living near a local power generator (ORa = 5.52) and having a family history of chronic respiratory diseases (ORa = 17.01). Carbon monoxide levels were augmented by the number of weekly hours of occupational exposure to waterpipe smoke (β = 1.46) and the number of daily hours of exposure to cigarette smoke (β = 1.14). **Conclusions:** In summary, young non-smoker subjects demonstrated more chronic cough and elevated carbon monoxide levels when exposed to SHS while the effect of waterpipe was even more evident.

Keywords:
Second hand smoke, Carbon monoxide level, Respiratory health, Waterpipe smoke, Cigarette smoke

INTRODUCTION

The World Health Organization estimates that 700 million people are exposed to Second Hand Smoke (SHS) worldwide [1]. SHS is formed by the side stream smoke emitted from the smoldering of cigarettes and other tobacco products between puffs and from the mainstream smoke exhaled by smokers [1]. SHS is now well-known to be a major menace to public health due to its acknowledged harmful health effects [2–7]. Passive smoking also increases severity and risk of asthma and respiratory symptoms [8–10], as well as a significant impairment of lung function [11,12].

Nowadays, in Lebanon, as in many other countries, waterpipe smoking constitutes a trend; waterpipe active smoking seems to cause several respiratory symptoms and chronic diseases, such as chronic bronchitis, chronic obstructive pulmonary disease, and others [13–15]. However, few studies were carried out to evaluate the effect of its associated SHS: the observed indoor air pollution by various harmful elements during a waterpipe session is substantial, and the exposure is likely to constitute a serious health hazard [16]. Studies performed in the laboratory [17] and among real life smokers [18] showed that chemical toxicants contained in waterpipe mainstream are numerous, while particularly carbon monoxide seems to be a good marker of exposure when measured in exhaled air [19]. It remains to be established whether the same is true about the side stream exposure (passive smoking) and its adverse health effects.

The aim of the present study was to measure the effect of SHS on respiratory symptoms and exhaled carbon monoxide (ECO) levels by comparing the selected respiratory indices in subjects exposed to cigarette and waterpipe second-hand smoke and those recorded in non-smokers.

MATERIAL AND METHODS

Type of the study

This is a cross-sectional descriptive pilot study comparing the effects of waterpipe and cigarette passive smoking exposure, performed over 3 groups of individuals: non-smokers exposed to second-hand (SH) waterpipe smoke, non-smokers exposed to SH cigarette smoke, and non-smokers who were not exposed to any type of smoke.

Study population

A total of 147 non active smokers from Beirut were included in the study; they were selected by empirical sampling. Fifty of them are workers in restaurants that serve waterpipes, 48 are university students who stay frequently in the university restaurant where cigarette smoking is allowed, and 49 are university students who frequently attend the university restaurant where smoking is not allowed.

The participants were between 18 and 35 years, non-asthmatic, and non active smokers (neither current nor previous smoking was allowed). Asthma was defined as a positive answer to the question: "has the doctor ever told you that you had asthma?", while active smoking was defined as a positive answer to the question: "have you ever smoked cigarette or waterpipe (more than one trial)?". A positive answer to any of these 2 questions was an exclusion criterion.

The study was carried out in the workplace (for the group or restaurant workers) and the cafeterias (for university students). After explaining the objectives of the study, a face-to-face interview was carried out using a standardized questionnaire to eligible individuals. The questionnaire was divided into several parts: socio-demographic characteristics (age, sex, marital status, and education), respiratory health questions (regarding chronic respiratory diseases / chronic bronchitis defined as "morning productive cough for more than 3 months a year for more than 2 years?" [20], as well as respiratory symptoms outside flu periods, such as chronic cough, chronic sputum production, chronic wheezing and upper respiratory tract allergy types), assessment of present passive smoking exposure duration (for both cigarette and waterpipe smoking, we asked about current estimated duration of exposure in hours per day and per week, respectively), and evaluation

of other known potential source of carbon monoxide such as living near local power plants and biomass fuel use for cooking and house heating [21].

Carbon monoxide measurement

Measurements of the expired-air carbon monoxide (CO) levels were also performed in all individuals to improve exposure evaluation precision, using a calibrated CO-tester (CO – Tester-NG, F.I.M); ECO was reported in terms of parts per million (ppm), after taking into account the local environmental carbon monoxide concentration during calibration.

Statistical analysis

Data entry and analysis were performed using SPSS statistical software, version 20.0. The level of significance was set at 0.05 (rejection of the null hypothesis at $p < 0.05$). Differences in the baseline characteristics between the exposure groups were evaluated using Pearson Chi-square test to compare percentages of nominal variables between groups, and ANOVA to compare means of the continuous variables: in fact, ANOVA could be used because the sample size was > 30 in every subgroup of comparison, and because sample sizes were almost equal [22]. For identification of groups differing significantly, *post hoc* test with Bonferroni correction was used. These tests were then used to study the differences of current and previous sources of exposure to carbon monoxide as well as personal and family disease history and respiratory symptoms between the groups.

To study the predictors of carbon monoxide levels, a multiple linear regression was carried out, with carbon monoxide, in ppm, as the dependent variable. Independent variables were all variables that could influence the CO in exhaled air in addition to socio-demographic variables: number of weekly hours of occupational exposure to waterpipe smoke, biomass fuel use for home heating, house close to a heavy traffic road, house close to a local power

generator, home exposure to tobacco smoke, number of daily hours of exposure to cigarette smoke in the university, in addition to education, sex, age, marital status, and body mass index.

We ensured the linearity of the relationship (using residual plots as function of predicted values), the normality of distribution of residuals (using the residuals histogram along with density of normal distribution and Kolmogorov-Smirnov test), and the non-colinearity of variables that were kept so that the model could be accepted (Variance Inflation Factors were used to check colinearity of variables).

We then carried out stepwise logistic regression using likelihood ratio test to determine the best predictors of respiratory symptoms. The following definitions of the dependant variables for respiratory symptoms were used: chronic cough, chronic sputum production and chronic allergy. Because of the relatively low sample size, we used a forward stepwise selection procedure. After ensuring the adequacy of the models using the Hosmer-Lemeshow test, adjusted odds ratios (ORa) were calculated with 95% confidence intervals (CIs). Independent variables initially introduced in the models were the followings: exposure to cigarette smoke at university, occupational exposure to waterpipe smoke, age, sex, marital status, education, house close to a heavy traffic road, house close to a local power generator, biomass fuel use for house heating, family history of chronic respiratory disease, home exposure to tobacco smoke, chronic respiratory disease during childhood, parental smoking during childhood and fetal life, and body mass index. They were only introduced when absence of collinearity was ensured using the Variance Inflation Factors.

RESULTS

Socio-demographic characteristics distribution

In Table 1, exposure distribution is reported according to socio-demographic characteristics. There were significant differences between all subgroups: The non-exposed

subjects and the ones exposed to cigarette smoke were mainly women (83.7% and 58.3% respectively), whereas only men were exposed to waterpipe smoke. Moreover, the subjects exposed to waterpipe smoke were significantly older than the others: their mean age was 30.02±2.92, and 74% of them were between the age 29 and 34. Non-exposed subjects as well as the ones exposed to cigarette smoke were mainly between the age of 18 and 22 (89.8% and 97.9% respectively), none was older than 29, and they were all single university students, whereas the ones exposed to waterpipe smoke were evenly distributed between married and single, and mainly had a secondary education level or less (82%).

Exposure to carbon monoxide

The examination of the current and previous sources of exposure to CO (Table 2) showed that restaurant workers exposed to waterpipe smoke were the least exposed to tobacco smoke at home (38%), having the lowest number of smokers at home (0.66±0.96) and the lowest daily hours of exposure to smoke at home (0.94±1.58). They also had the lowest exposure rate to maternal smoke during childhood (26%) leaving the ones exposed to cigarette smoke with the highest rate of 52.1%. Moreover, the subjects non-exposed to smoke appeared to have the highest exposure rate to a local power generator (42.9%). None of the participants used solid fuels for cooking.

On the other hand, the restaurant workers exposed to waterpipe smoke had the highest weekly hours of exposure to smoke at work (61.08±9.31), characterized as exposure to waterpipe in cafés. There was a significant difference between the groups in ECO: with the workers exposed to waterpipe smoke having the highest level (26.84±8.17 parts per million), followed by the students exposed to cigarette smoke (12.25±2.96 parts per million) and finally the non-exposed students (3.76±1.70 parts per million).

Respiratory diseases and symptoms

When examining respiratory diseases and symptoms (Table 3), the workers exposed to waterpipe smoke and students

Table 1. Comparison of socio-demographic characteristics

Characteristic	Non-exposed (N = 49)	Exposed to waterpipe smoke (N = 50)	Exposed to cigarette smoke (N = 48)	p
Sex [n (%)]				< 0.001
male	8 (16.3)	50 (100)	20 (41.7)	
female	41 (83.7)	0	28 (58.3)	
Age (years), M±SD	20.14±1.41	30.02±2.92*	19.69±1.22	< 0.001
18–22 [n (%)]	44 (89.8)	1 (2.0)	47 (97.9)	
23–28 [n (%)]	5 (10.2)	12 (24.0)	1 (2.1)	
29–34 [n (%)]	0	37 (74.0)	0	
Marital status [n (%)]				< 0.001
married	0	25 (50)	0	
non-married	49 (100)	25 (50)	48 (100)	
Education [n (%)]				< 0.001
secondary or less	0	41 (82.0)	0	
university student	49 (100)	9 (18.0)	48 (100)	

* Difference significant between exposed to waterpipe and non exposed to smoke, and between exposed to waterpipe and cigarette; difference non-significant between non-exposed and exposed to cigarette smoke.

Table 2. Current and previous sources of exposure to carbon monoxide

Characteristic	Non-exposed (N = 49)	Exposed to waterpipe smoke (N = 48)	Exposed to cigarette smoke (N = 50)	p
Exposed to tobacco smoke at home [n (%)]	31 (63.3)	19 (38.0)	29 (60.4)	0.022
Smokers at home (n), M±SD	1.27±1.10	0.66±0.96*	1.29±1.20	0.006
Exposure to smoke, M±SD				
at home (h/day)	2.72±3.52	0.94±1.58*	2.07±3.13	0.009
at work/university (h/week)	0	61.08±9.31*	3.42±2.47	< 0.001
to waterpipe smoke in restaurants/cafés (h/week)	3.71±4.65	61.08±9.31*	3.04±9.10	< 0.001
Home close (< 100 m) [n (%)]				
to a heavy traffic road	17 (34.0)	19 (38.0)	20 (41.7)	0.779
to a heavy traffic road (ever in the past)	23 (46.9)	18 (36.0)	25 (52.1)	0.261
to a local power generator (ever in the past)	21 (42.9)	9 (18.0)	9 (18.0)	0.007
Biomass use for heating	28 (57.1)	38 (76.0)	28 (58.3)	0.091
Parents smoking during individual's fetal life [n (%)]				
mother	9 (18.4)	12 (24.0)	5 (10.4)	0.093
father	19 (38.8)	15 (30.0)	19 (39.6)	0.410
Parents smoking during individual's childhood [n (%)]				
mother	17 (34.7)	13 (26.0)	25 (52.1)	0.001
father	22 (44.9)	17 (34.0)	23 (47.9)	0.187
Carbon monoxide level in parts per million, M±SD	3.76±1.70	26.84±8.17**	12.25±2.96**	< 0.001

* Difference significant between exposed to waterpipe and others (exposed to cigarette smoke and non-exposed); no significant difference between non-exposed and exposed to cigarette smoke.
** Significant differences between non-exposed, exposed to cigarette smoke and waterpipe smoke taken two by two.

Table 3. Personal and family disease history and respiratory symptoms

Characteristic	Non-exposed (N = 49)	Exposed to waterpipe smoke (N = 48)	Exposed to cigarette smoke (N = 50)	p
Has a family history of a chronic respiratory disease	4 (8.2)	0	1 (2.1)	0.067
Has chronic cough	8 (16.3)	29 (58.0)	26 (54.2)	< 0.001
Has chronic sputum production	3 (6.1)	3 (6.0)	1 (2.1)	0.569
Has chronic bronchitis	2 (4.1)	2 (4.0)	0	0.369
Has chronic wheezing	1 (2.0)	0	1 (2.1)	0.593
Has chronic allergy	9 (18.4)	1 (2.0)	2 (4.2)	0.006
Has a childhood history of chronic respiratory disease	1 (2.0)	1 (2.0)	1 (2.1)	0.732

exposed to cigarette smoke manifested more chronic cough (58% and 54.2% respectively) than the non-exposed students (16.3%) who had, on the other hand, a higher rate of chronic allergy (18.4%). We then looked at the effects of the number of years spent working in the same place on the respiratory symptoms of the workers in waterpipe serving restaurants. There was a significant difference in years spent working between those who suffered from chronic cough and those who did not (3.9(±4.741) and 2.19(±4.046) years

respectively, p = 0.02), and again a significant difference regarding those who suffered from morning cough and those who did not (4.86(±4.962) and 2.45(±4.169) years respectively, p = 0.008).

Multivariate analyses

The multivariate analyses that were carried out for all individuals in this study are reported in Table 4. Men (β = 2.81) and individuals having a lower education

Table 4. Multivariate analysis of carbon monoxide and respiratory symptoms

Dependent variable	Independent variable	β (95% CI)	p
For multiple regression			
carbon monoxide in parts per million*	number of weekly hours of occupational exposure to waterpipe smoke	1.46 (1.05–1.88)	< 0.001
	number of daily hours of exposure to cigarette smoke in the university	1.14 (0.69–1.58)	< 0.001
	lower education	6.03 (2.25–9.82)	0.002
	male gender versus female	2.81 (0.45–5.16)	0.020
For logistic regression			
chronic cough**	exposure to cigarette smoke in university	6.06 (2.35–15.61)	< 0.001
	occupational exposure to waterpipe smoke	7.08 (2.76–18.17)	< 0.001
chronic sputum production***	married status versus unmarried	6.40 (1.06–38.81)	0.043
	living near a heavy traffic road	9.49 (0.98–92.18)	0.052
	living near a local power generator	7.54 (1.27–44.79)	0.026
chronic allergy[a]	male gender versus female	7.81 (1.28–47.62)	0.026
	living near a local power generator	5.52 (1.24–24.61)	0.025
	family history of a chronic respiratory disease	17.01 (1.80–160.93)	0.013

β – multiple regression coefficient; CI – confidence interval.

* Multiple linear regression; R = 0.875; adjusted R^2 = 0.76; unretained variables include: age, marital status, biomass fuel use for home heating, house close to a heavy traffic road, house close to a local power generator, home exposure to tobacco smoke, and body mass index.

** Logistic regression forward stepwise likelihood ratio; Nagelkerke R Square = 0.194; P-value for Hosmer & Lemeshow test = 1.000; unretained variables in the model include: age, sex, marital status, education, house close to a heavy traffic road, house close to a local power generator, biomass fuel use for house heating, family history of chronic respiratory disease, home exposure to tobacco smoke, chronic respiratory disease during childhood, parental smoking during childhood and fetal life, and body mass index.

*** Logistic regression forward stepwise likelihood ratio; Nagelkerke R Square = 0.298; P-value for Hosmer & Lemeshow test = 0.630; unretained variables in the model include: occupational waterpipe smoke exposure, university cigarette smoke exposure, age, sex, education, biomass fuel use for house heating, family history of chronic respiratory disease, home exposure to tobacco smoke, chronic respiratory disease during childhood, parental smoking during childhood and fetal life, and body mass index.

[a] Logistic regression forward stepwise likelihood ratio; Nagelkerke R Square = 0.300; P-value for Hosmer & Lemeshow test = 0.270; unretained variables in the model include: occupational waterpipe smoke exposure, university cigarette smoke exposure, age, marital status, education, living near a heavy traffic road, using biomass fuel for heating, exposure to tobacco smoke at home, chronic respiratory disease during childhood, parental smoking during childhood and fetal life and body mass index.

(β = 6.03) exhaled higher levels of carbon monoxide. These levels are also augmented by the number of weekly hours of occupational exposure to waterpipe smoke by the workers in restaurants (β = 1.46) as well as the number of daily hours of exposure to cigarette smoke in the university (β = 1.14), showing a dose-effect relationship between duration of smoking and carbon monoxide levels. All other variables were removed from the model.

On the other hand, only exposure to cigarette smoke in university (adjusted odds ratio (ORa) = 6.06) and occupational exposure to waterpipe smoke (ORa = 7.08) were predictors of manifesting a chronic cough, whereas being married (ORa = 6.40), living near a heavy traffic road (ORa = 9.49; borderline result) or near a local power generator (ORa = 7.54) were significantly associated with chronic sputum production.

Finally, correlates of chronic allergies were: being male (ORa = 7.81), living near a local power generator (ORa = 5.52) and having a family history of chronic respiratory diseases (ORa = 17.01).

DISCUSSION

In this pilot study, we have found that the expired-air CO level was significantly higher in the breath of passive smokers exposed to waterpipe smoke, followed by those exposed to cigarette smoke and was lowest in the non-exposed. These results were confirmed by multivariate analysis and dose-effect relationship between duration of exposure and elevated level of carbon monoxide. Our results are similar to those of other authors: SHS is a significant source of exposure to CO for passive smokers [23,24]. We should note that the subjects exposed to waterpipe smoke had the lowest exposure rates at home, indicating that the majority were solely exposed to SHS in the workplace. Actually, Lam et al. [25] concluded that at work, environmental tobacco smoke [ETS] exposure had stronger effects because subjects spent more time among

a larger number of smoking individuals at work than at home. Furthermore, the workplace, in our case, consists of restaurants serving waterpipe. In a review of the literature, Siegel et al. [26] reported that the levels of ETS in restaurants and bars were 1.6 to 2.0 times higher than in other types of workplace, and 1.5 times higher than those found in homes with at least one smoker, placing ETS as a particular concern to the hospitality employees.

Usually, an expired CO of 0 to 6 ppm represents a non-smoker, 7 to 10 a light smoker, 11 to 20 a smoker, and more than 20 a heavy smoker. Thus, according to their ECO level, the non-exposed subjects in our sample would be classified as non-smokers, the exposed to cigarette smoke as smokers, and those exposed to waterpipe smokers as heavy smokers, although all declared to be non active smokers. Actually, the fact that non active smoking workers, exposed to SHS, have ECO levels that would classify them as active smokers was also seen in other studies [27,28].

In the multivariate analysis, exhaled levels of CO were also positively affected by the weekly hours of occupational exposure to waterpipe smoke by the hospitality workers, and by daily hours of exposure to cigarette smoke in universities as well, but to a lesser extent. This shows a clear dose-response relationship between exposure duration and CO level. Moreover, the greater increase due to waterpipe exposure versus cigarette is visible here: this difference might be accounted for by the difference in hours of exposure, since the restaurant workers spend 61.08 h/week exposed to waterpipe smoke, while exposure of university students was significantly lower when calculated per week. Another explanation of the difference in levels of ECO might be previous findings showing that waterpipe use is associated with greater CO exposure than cigarette use [29]. Other studies also had results similar to ours, showing that a waterpipe smoker was found to likely emit as much CO as 7, 8 or even 10 cigarette smokers [19,30,31].

On another hand, although CO has been shown to vary with age [32–35] and exposure to combustion of petroleum

derogates by cars and coal ovens [36], there were no significant differences concerning these matters between the groups. In fact, age and other sources of CO were removed in the multivariate analysis; this adjusts the age differences in our sample as well as the different exposures to generator exhausts. Some socio-demographic characteristics were kept in the model: male gender and lower education. This was similar to what was found in another study, where non-smoking male subjects had higher ECO levels compared with female subjects [35].

Carbon monoxide measurement use deserves our attention; it could be considered a strong point since self-reported passive smoke exposure was not the only proxy for true exposure levels, as objective measurements of ECO were also performed. Although urine cotinine and carboxy-hemoglobin levels were not evaluated in this study, we chose CO as a biological marker of SHS because it is quick and easy to measure, cheaper than performing a series of laboratory assays, non-invasive, thus more acceptable to the participant [36,37]. Despite the non-specificity of CO to tobacco smoke, the latter remains the most important source of CO in indoor places, and it can be used as a biomarker for passive tobacco exposure [38–40]. In fact, using carbon monoxide to evaluate passive smoking has been useful in case of cigarettes: carbon monoxide could be considered one of the most toxic substances present in the gas-phase of second-hand tobacco smoke [41]. Carbon monoxide could also be considered as an easy and rapid biomarker, i.e. primarily of interest for the assessment of the exposure and early biological effects in epidemiology as well as occupational and environmental medicine [42]: microenvironmental measurements of CO were shown to well represent the personal exposures of individuals within that microenvironment; CO can be measured accurately by instrumental means and it therefore represents an ideal tracer of exposure [43,44]. Finally, we had previously shown that carbon monoxide could be used as a biomarker of exposure to many factors in the Lebanese population, which include active smoking, passive smoking, and environmental exposure to respiratory toxins [21].

As for the respiratory symptoms, individuals exposed to waterpipe smoke and those exposed to cigarette smoke both manifested more chronic cough than non-exposed individuals who had, however, a higher rate of chronic allergy. In the multivariate analysis, chronic cough was predicted by exposure predictors. Occupational exposure to waterpipe smoke was the most predictive of it, followed by exposure to cigarette smoke in universities. Chronic cough has already been associated with passive smoking [45], and all workers exposed to smoke during their work had higher prevalence of respiratory and irritative symptoms [46]. Additionally, research studying the effects of smoking ban found that the decrease in prevalence of cough and phlegm was significant and relevant in all workers, whether they were smokers or non-smokers [47,48]. Chronic cough was also associated with higher levels of CO that may reflect the inflammation of airways [42], since a study showed that smokers who complained of frequent cough and sputum production had higher levels of ECO compared with smokers without such complaints [43]. Chronic cough and morning cough of the restaurant workers also seemed to be affected by the years working in the concerned restaurant, showing again a dose-response relationship.

On the other hand, chronic sputum and chronic allergies were mainly predicted by socio-demographic characteristics, and were both affected by living near a local power generator. In fact, epidemiological, human, and animal studies all suggest that diesel exhaust particulates, linked to traffic-related and industrial activities are involved in the pathogenesis of asthma, sputum production, allergic rhinitis, and other allergic disorders [49,50]. This may explain the higher chronic allergies rate found in non-exposed participants since they lived closest to a local power generator. Moreover, family history of chronic respiratory diseases was the main predictor of chronic allergies, as it is well known that allergies have a genetic component [51–53].

Our study may have several limitations. In our sample, the participants exposed to waterpipe smoke were only men, significantly older than other subjects. They mainly had lower education than the rest and half of them were married, whereas the other groups were all single university students. Moreover, those exposed to cigarette smoke had the highest exposure rate to maternal smoke during childhood. These differences were however adjusted for in the multivariate analysis. Also working in a restaurant that serves waterpipe does not preclude exposure to cigarette smoke; however, we expect the latter to be of minor importance since there are very low proportions of cigarette smokers in these specific restaurants (general observation).

Moreover, the design may not include people with serious respiratory symptoms who had left their job, thus the impact could be underestimated due to a possible healthy worker effect. A validation of outcome measures for respiratory symptoms was not conducted, but these measures have been tested in many other studies which found them to have a high validity [54].

Furthermore, temporal associations cannot be inferred for some variables, because of the cross-sectional nature of the design; however, we could show relationships between the duration of exposure and the health effects, supporting a causal association hypothesis. Given the small sample size of our pilot study, some results may not be significant in multivariate analyses; larger scale studies that take into account these limitations and give more stable results will be necessary to confirm our findings. This will also be useful to further apply the anti-smoking law and fix the limits of passive smoking exposure in the workplace.

CONCLUSION

In conclusion, passive smoking at restaurants serving waterpipes or at university cafeterias allowing cigarette smoking indoor was associated with an increased prevalence of chronic cough and higher ECO levels, with obvious poorer results with waterpipe exposure. In Lebanon, those who work in waterpipe serving restaurants continue to be exposed to the harmful effects of tobacco smoke. Our results can be used as ammunition in the struggle against smoking in public places, with a focus on waterpipe.

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