Lung cancer correlates in Lebanese adults: A pilot case–control study

Joseph Aoun, Nadine Saleh, Mirna Waked, Joseph Salamé, Pascale Salameh

Lung cancer correlates in Lebanese adults: A pilot case–control study

Joseph Aoun [a], Nadine Saleh [a], Mirna Waked [b], Joseph Salamé [c], Pascale Salameh [a,*]

[a] Faculty of Public Health, Section II, Lebanese University, Beirut, Lebanon
[b] Saint Georges Hospital, Beirut, Lebanon
[c] Faculty of Medical Sciences, Lebanese University, Beirut, Lebanon

Abstract *Background*: Lung cancer is one of the most prevalent types of cancers. However, there are no epidemiological studies concerning lung cancer and its risk factors in Lebanon. This study was carried out to determine the association between lung cancer and its most common risk factors in a sample of the Lebanese population.

Methods: A hospital-based case–control study was conducted. Patients were recruited in a tertiary health care center. A questionnaire in Arabic was designed to assess the possible risk factors for lung cancer.

Results: For females, cigarette smoking (ORa = 9.76) and using fuel for heating (ORa = 9.12) were found to be the main risk factors for lung cancer; for males, cigarette smoking (ORa = 156.98), living near an electricity generator (ORa = 13.26), consuming low quantities of fruits and vegetables (ORa = 10.54) and a family history of cancer (ORa = 8.75) were associated with lung cancer. Waterpipe smoking was significantly correlated with lung cancer in the bivariate analysis.

Conclusion: In this pilot study, it was found that in addition to smoking, outdoor and indoor pollution factors were potential risk factors of lung cancer. Additional studies would be necessary to confirm these findings.

© 2013 Ministry of Health, Saudi Arabia. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

Lung cancer is one of the most prevalent types of cancer, and it is one of the most commonly diagnosed cancers as well as the leading cause of cancer death, particularly in males [1,2]. Cigarette smoking is the main risk factor for the onset of lung

cancer [3,4]. Although waterpipe tobacco contains the same chemicals found in cigarettes, few studies have assessed the association between waterpipe smoking and lung cancer: a review of the available evidence showed that waterpipe smoking may probably be associated with lung cancer [5], and a recent Indian study found a 6-times elevated risk for lung cancer in waterpipe smokers, in a region where waterpipe smoking is popular [6].

In addition, air pollution contributes to the occurrence of lung cancer [7–9]. Outdoor pollution such as urban dwelling [10,11], living near factories [12], and heavy traffic [13,9,14], and indoor pollutants such as environmental tobacco smoke [15], and the use of coal and fuel in cooking or heating increased the risk of lung cancer [16,17]. Other factors, such as a low consumption of fruits and vegetables [18–21], and occupational factors such as asbestos [22–24], metals and silica [25], diesel exhaust [26], pesticides [27,28] and organic dust [29] exposures also increase the risk of lung cancer. Furthermore, individuals with a positive family history of lung cancer [30,31] and a previous history of chronic obstructive pulmonary disease, emphysema, chronic bronchitis, pneumonia and tuberculosis have a higher risk for lung cancer [32].

In Lebanon, there are no epidemiological studies concerning lung cancer risk factors, although lung cancer is thought to be of primary importance in the region [33] and has a relatively high incidence in Lebanon, particularly in males [34]. This study was carried out to determine the association between the most common risk factors and lung cancer in a sample of the Lebanese population; more specifically, the present study aimed to investigate the association of lung cancer with waterpipe smoking and electricity generator exposure (a potential source of diesel exhaust to the community), two common exposures in the Lebanese population.

2. Materials and methods

2.1. Study design and population

The present study is a hospital-based, case—control study conducted between March and June 2012. Patients were recruited in a tertiary health care center on an ongoing prospective basis, when visiting for a medical consultation, or for receiving a treatment for lung cancer. Inclusion criteria were a medical diagnosis of any type of lung cancer; however, lung cancer patients who simultaneously had another type of cancer were excluded. All cases satisfying inclusion criteria were referred by physicians to the researchers; potential partici-

pants were approached by an interviewer to fill out the standardized questionnaire. The first 50 patients who agreed to participate in the study were enrolled.

Controls were selected from patients visiting the same hospital for other reasons and other visitors who had no medical problems. All patients admitted for urinary, kidney, orthopedic, endocrinology and gynecologic problems during the study period, in addition to their accompanying persons with no medical problems, were considered eligible; they were referred to the researchers by the physicians. Controls that had any type of cancer were excluded from the control group. For each case, two controls of the same sex were selected; the first 100 controls who agreed to participate in the study were enrolled.

2.2. Data collection

After informed consent, a questionnaire in Arabic was administered by a face-to-face interview for cases and controls to assess the possible risk factors for lung cancer. This questionnaire had been pretested with 15 persons to make sure that the questions were well understood and could be adequately answered. Data was collected between March and June 2012. Information gathered comprised: socio-demographic characteristics (age, sex, education level, marital status, income, height and weight); current and past smoking habits (cigarette and waterpipe smoking, age of starting, number of cigarettes or waterpipes, age of quitting); current and past occupations; exposure to gases or toxic substances; living area and pollution (urban or rural, near the road, near an electricity generator); indoor pollution and passive smoking (heating, cooking, smokers at the house, smokers at work); fruits and vegetables consumption; nutritional supplements intake; past pulmonary diseases or affections (chronic respiratory symptom or disease, and childhood respiratory infection or problem); and cancer and lung cancer history in the family. For lung cancer patients, additional information was collected concerning their affection (age at diagnosis, cancer type, and treatment).

2.3. Sample size

This pilot study was conducted to ascertain the relationship between waterpipe smoking and electricity generator exposure (a potential source of diesel exhaust to the community) with lung cancer; however, there was no reference value to base the sample size calculations on; therefore it was decided to take the first 50 cancer patients as cases

and the first 100 controls who would agree to participate in the study.

2.4. Statistical analysis

Data was entered and analyzed using SPSS, version 18.0. Descriptive analysis was performed to observe the distribution of the participants. Bivariate analysis was computed to observe the distribution of various socio-demographic and other independent variables among the main outcome variable which is ''having lung cancer''. Chi-square test and Fisher's exact test (when expected values were lower than 5) were used for dichotomous variables. The odds ratio was calculated for each of the variables with its 95% confidence interval. Moreover, stratification analysis by gender was also performed to detect any interaction or confounding factors.

Significant associations were subsequently entered to perform multivariate analysis for each gender separately. A stepwise forward logistic regression analysis was chosen to determine the predictors of having lung cancer, therefore the exponential β coefficient was used in order to estimate the adjusted odds ratio for each independent factor, with its 95% confidence interval; ''having lung cancer'' was the dependent variable. Hosmer—Lemeshow test was carried out to measure goodness of fit; a Hosmer—Lemeshow test >0.05 indicated that the model is adequate. For all analyses, p-values <0.05 were considered to be statistically significant.

3. Results

3.1. Description of the sample

There was a very low refusal rate (<5%). The final sample consisted of 150 participants of whom 50 were lung cancer patients [adenocarcinoma (32%), non-small cell carcinoma (10%), small cell lung carcinoma (28%), squamous-cell cancers (16%) and non-specified (14%)]; no significant difference was found between males and females regarding cancer histological types ($p = 0.893$).

Controls were 100 individuals [59% of the controls were patients visiting for other medical problems (urinary, kidney, orthopedic, endocrinologic and gynecologic problems) and 41% were visitors that had no medical problems; they were accompanying other patients]. Moreover, 62% of the participants were males and 38% were females. The average age for cases and controls was 59.58 years (±6.03) and 59.82 years (±6.31), respectively. Socio-demographic characteristics for cases and

controls are shown in Table 1. No significant difference was found between cases and controls for any of the socio-demographic variables: age (p-value = 0.663), gender (p-value = 1.000), region (p-value = 0.769), marital status (p-value = 0.430), educational level (p-value = 0.511), monthly income (p-value = 0.129), and body mass index (p-value = 0.098) (Table 1).

3.2. Lung cancer and smoking

Table 2 shows the bivariate analysis results. It can be seen that former cigarette smokers had a 17-times higher risk of lung cancer compared with non-smokers (OR = 16.55/95% CI: 5.53—49.55). Also, former waterpipe smokers had a significant 6-times higher risk compared with non-smokers (OR = 6.0/95% CI: 1.78—20.26).

In smokers, those who smoked 25—35 cigarettes daily had a 7-times higher risk than those who smoked less than 25 cigarettes daily (OR = 7.33/95% CI: 1.99—26.95), while smokers who smoked more than 35 cigarettes daily had a much higher risk with an OR of 20.42 (95% CI: 5.28—79.03) compared with the reference group. No significant differences were found between different histological types and smoking ($p = 0.632$).

3.3. Lung cancer and pollutants

Bivariate analysis also shows an association between outdoor and indoor pollution and lung cancer. People living in urban areas had a higher risk of lung cancer compared with those living in rural areas (OR = 3.92/95% CI: 1.10—13.89). People who have lived near road traffic and near a generator had a higher risk than those who never did, with an OR of 2.59 (95% CI: 1.21—5.54) and 2.57 (95% CI: 1.23—5.35), respectively. People who used fuel for heating also had a higher risk of lung cancer with an OR of 2.83 (95% CI: 1.41—5.71) compared with those who did not.

Exposure to passive smoking at home and at work is also associated with a higher risk of lung cancer: people exposed to passive smoking at home had an OR of 2.25 (95% CI: 1.12—4.52), and those exposed at work had an OR of 2.28 (95% CI: 1.14—4.56) compared with non-exposed. Analysis concerning the use of fuel in cooking was not computed because all of the 150 participants used butane gas for cooking. Moreover, no significant differences were found between different histological types and other factors, particularly for those living close to electricity generators ($p = 0.410$).

Table 1 Socio-demographic characteristics of the study participants.

Variable	Total	Cases	Controls	*p*-Value
Age				
<50 years	1 (0.7%)	1 (2%)		
50—60 years	85 (56.7%)	27 (54%)	58 (58%)	
60—70 years	52 (34.7%)	18 (36%)	34 (34%)	
>70 years	12 (8%)	4 (8%)	8 (8%)	0.663[b]
Gender				
Males	93 (62%)	31 (62%)	62 (62%)	
Females	57 (38%)	19 (38%)	38 (38%)	1.000[a]
Region				
Beirut	61 (40.7%)	19 (38%)	42 (42%)	
Mount Lebanon	89 (59.3%)	31 (62%)	58 (58%)	0.769[a]
Marital status				
Single	17 (11.3%)	8 (16%)	9 (9%)	
Married	119 (79.3%)	38 (76%)	81 (81%)	
Widowed/divorced	14 (9.3%)	4 (8%)	10 (10%)	0.430[a]
Educational level				
No formal education	3 (2%)	2 (4%)	1 (1%)	
Primary	70 (46.7%)	25 (50%)	45 (45%)	
Secondary	54 (36%)	17 (34%)	37 (37%)	
University	23 (15.3%)	6 (12%)	17 (17%)	0.511[a]
Monthly income				
<1,000,000 LL	26 (17.3%)	10 (20%)	16 (16%)	
1,000,000—2,000,000 LL	59 (39.3%)	25 (50%)	34 (34%)	
2,000,000—4,000,000 LL	58 (38.7%)	13 (26%)	45 (45%)	
>4,000,000 LL	7 (4.7%)	2 (4%)	5 (5%)	0.129[a]
BMI				
Normal	100 (66.7%)	32 (64%)	68 (68%)	
Overweight	36 (24%)	16 (32%)	20 (20%)	
Obese	14 (9.3%)	2 (4%)	12 (12%)	0.098[a]

BMI, body mass index.
[a] Chi-square test.
[b] Fisher's exact test.

3.4. Fruits and vegetables intake

A low fruit and vegetable consumption is associated with an elevated risk of lung cancer with an OR of 7.70 (95% CI: 3.56—16.63/*p*-value <0.001) for people who had a low consumption of fruits and vegetables, in comparison with people who had a high consumption. But concerning the past intake of multivitamins, no significant difference was found between people who took multivitamins and those who did not (*p*-value = 0.132 > 0.05).

3.5. Occupational exposure

Concerning past occupational exposure to gases and toxins and the risk for lung cancer, people who had a past occupational exposure had a 2.6 times excess risk for developing lung cancer, compared with those who had never been exposed (OR = 2.63/95% CI: 1.27—5.44/*p*-value = 0.014).

3.6. Family and personal history

Having a chronic respiratory disease (OR = 3.19/95% CI: 1.24—8.20), chronic respiratory symptoms (OR = 3.86/95% CI: 1.58—9.40), a respiratory problem during childhood (OR = 3.71/95% CI: 1.14—12.06) or a respiratory infection during childhood (OR = 5.57/95% CI: 1.96—15.81) were all significantly associated with an elevated risk of lung cancer (*p*-values < 0.05). On the other hand, having cardio-vascular problems was not associated with a higher risk of lung cancer (*p*-value = 0.733). In addition, having a positive family history of respira-

Table 2 Comparison of potential and known risk factors between cases and controls.

Variable	Cases	Controls	OR (95% CI)[a]	p-Value
Former waterpipe smoker				
No	40 (80%)	96 (96%)	1.0 (Ref.)	
Yes	10 (20%)	4 (4%)	6.0 (1.78—20.26)	0.004[b]
Ever lived near a generator				
No	29 (58%)	78 (78%)	1.0 (Ref.)	
Yes	21 (42%)	22 (22%)	2.57 (1.23—5.35)	0.018[b]
Former cigarette smoker				
No	4 (8%)	59 (59%)	1.0 (Ref.)	
Yes	46 (92%)	41 (41%)	16.55 (5.53—49.55)	<0.001[b]
Daily cigarette consumption				
<25 cig.	4 (8.7%)	22 (53.7%)	1.0 (Ref.)	
25—35 cig.	16 (34.8%)	12 (29.3%)	7.33 (1.99—26.95)	
>35 cig.	26 (56.5%)	7 (17.1%)	20.42 (5.28—79.03)	<0.001[b]
Residence				
Rural	3 (6%)	20 (20%)	1.0 (Ref.)	
Urban	47 (94%)	80 (80%)	3.92 (1.10—13.89)	0.045[b]
Ever lived near road traffic				
No	12 (24%)	45 (45%)	1.0 (Ref.)	
Yes	38 (76%)	55 (55%)	2.59 (1.21—5.54)	0.020[b]
Use of fuel for heating				
No	22 (44%)	69 (69%)	1.0 (Ref.)	
Yes	28 (56%)	31 (31%)	2.83 (1.41—5.71)	0.005[b]
Exposure to passive smoking at home				
No	19 (38%)	58 (58%)	1.0 (Ref.)	
Yes	31 (62%)	42 (42%)	2.25 (1.12—4.52)	0.033[b]
Exposure to passive smoking at work				
No	23 (46%)	66 (66%)	1.0 (Ref.)	
Yes	27 (54%)	34 (34%)	2.28 (1.14—4.56)	0.030[b]
Fruit and vegetable consumption				
High	13 (26%)	73 (73%)	1.0 (Ref.)	
Low	37 (74%)	27 (27%)	7.70 (3.56—16.63)	<0.001[b]
Past multivitamin intake				
No	43 (87.8%)	94 (95.9%)	1.0 (Ref.)	
Yes	6 (12.2 %)	4 (4.1%)	3.28 (0.88—12.22)	0.132[b]
Past occupational exposure to gases and toxins				
No	28 (56%)	77 (77%)	1.0 (Ref.)	
Yes	22 (44%)	23 (23%)	2.63 (1.27—5.44)	0.014[b]
Chronic respiratory disease				
No	38 (76%)	91 (91%)	1.0 (Ref.)	
Yes	12 (24%)	9 (9%)	3.19 (1.24—8.20)	0.025[b]
Chronic respiratory symptoms				
No	35 (70%)	90 (90%)	1.0 (Ref.)	
Yes	15 (30%)	10 (10%)	3.86 (1.58—9.40)	0.004[b]
Cardiovascular problems				
No	37 (74%)	78 (78%)	1.0 (Ref.)	
Yes	13 (26%)	22 (225)	1.25 (0.57—2.74)	0.733[b]
Respiratory problem during childhood				
No	38 (82.6%)	88 (94.6%)	1.0 (Ref.)	
Yes	8 (17.4%)	5 (5.4%)	3.71 (1.14—12.06)	0.048[b]

(*continued on next page*)

Table 2 (*continued*)

Respiratory infection during childhood				
No	35 (72.9%)	90 (93.7%)	1.0 (Ref.)	
Yes	13 (27.1%)	6 (6.3%)	5.57 (1.96—15.81)	0.001[b]
Family history of respiratory diseases				
No	17 (34%)	15 (15%)	1.0 (Ref.)	
Yes	33 (66%)	85 (85%)	2.92 (1.31—6.51)	0.014[b]
Family history of cancer				
No	24 (48%)	21 (21%)	1.0 (Ref.)	
Yes	26 (52%)	79 (79%)	3.47 (1.67—7.24)	0.001[b]
Family history of lung cancer				
No	11 (22%)	6 (6.3%)	1.0 (Ref.)	
Yes	39 (78%)	90 (93.7%)	4.42 (1.53—12.79)	0.008[b]

CI, confidence interval; OR, odds ratio.
[a] Crude odds ratio.
[b] Chi-square test.

tory diseases (OR = 2.92/95% CI: 1.31—6.51), a positive family history of cancer (OR = 3.47/95% CI: 1.67—7.24), or a positive family history of lung cancer (OR = 4.42/95% CI: 1.53—12.79) were also significantly associated with a higher risk of lung cancer (*p*-values < 0.05).

3.7. Stratification over gender

Stratification analysis by gender detected multiple qualitative interactions. In fact, the use of fuel for heating was significantly associated with a higher risk of lung cancer in females (*p*-value = 0.002) but not in males (*p*-value = 0.396). On the other hand, waterpipe smoking was associated with a higher risk of lung cancer in males (*p*-value = 0.009) but not in females (*p*-value = 0.321). Moreover, a positive significant association was found in males

who lived near a generator (*p*-value = 0.013), who were exposed to passive smoking at work (*p*-value = 0.007) and who had an occupational exposure to gases and toxins (*p*-value = 0.028), but no association was found in females (*p*-values >0.05).

3.8. Multivariate analysis

Multivariate analysis results for females and males are shown in Table 3. For females, 2 variables were retained in the model: use of fuel for heating (ORa = 9.76/95% CI: 2.15—44.30/*p*-value = 0.003) and cigarette smoking (ORa = 9.12/95% CI: 1.81—46.00/*p*-value = 0.007). The model is adequate with a non-significant Hosmer—Lemeshow test (*p*-value = 0.457). 40.2% of the variability of the dependent variable is explained by the two variables retained in the model.

Table 3 Multivariate analysis: risk factors for lung cancer by stepwise forward logistic regression.

Variables retained in the model for females[a]	ORa	95% CI	*p*-Value	Nagelkerke *R* square
Use of fuel for heating	9.76	2.15—44.30	0.003	0.402
Cigarette smoking	9.12	1.81—46.00	0.007	
Variables retained in the model for males[b]				
Cigarette smoking	156.98	5.90—417.4	0.003	0.684
Living near a generator	13.26	1.85—95.04	0.010	
Low fruit and vegetable consumption	10.54	1.76—63.24	0.010	
Family history of cancer	8.75	1.22—63.03	0.031	

[a] Variables included but not retained in the model: age, waterpipe smoking, residence, occupational exposure, living near a road, living near a generator, fruits and vegetables consumption, exposure to passive smoking at home, exposure to passive smoking at work, having respiratory problems, having a respiratory problem during childhood, family history of respiratory disease, family history of cancer and family history of lung cancer.
[b] Variables included but not retained in the model: age, waterpipe smoking, residence, occupational exposure, living near a road, use of fuel for heating, exposure to passive smoking at home, exposure to passive smoking at work, having respiratory problems, having a respiratory problem during childhood, family history of respiratory disease and family history of lung cancer.

For males, four variables were retained in the model: cigarette smoking (ORa = 156.98/95% CI: 5.90—417.4/p-value = 0.003), living near a generator (ORa = 13.26/95% CI: 1.85—95.04/p-value = 0.010), low fruit and vegetable consumption (ORa = 10.54/95% CI: 1.76—63.24/p-value = 0.010), and a positive family history of cancer (ORa = 8.75/95% CI: 1.22—63.03/p-value = 0.031). The model is adequate with a non-significant Hosmer—Lemshow test (p-value = 0.968). 68.4% of the variability of the dependent variable is explained by the four variables retained in the model.

4. Discussion

This study revealed a number of associations between probable risk factors and lung cancer in the Lebanese population. First, it was noted that the number of males with lung cancer in the sample was more than females. The higher number of males probably reflects the fact that males are at a higher risk of developing lung cancer compared with females [2]. However, the selection method of the cases and controls did not allow for excess risk assessment of lung cancer in males compared with females.

The results of this case—control study revealed that cigarette smoking is the main risk factor for developing lung cancer in the Lebanese population. Former cigarette smokers had an important elevated risk of lung cancer compared with never smokers. This result was expected because cigarette smoking has been established as the main risk factor for developing lung cancer in multiple studies in different countries [3,4]. In addition, there is biological evidence that the smoke itself contains known carcinogenic chemicals that promote the initiation and growth of tumors [35,36].

Female smokers had a 9-times elevated risk compared with female non-smokers, and male smokers a 157-times elevated risk compared with male non-smokers; this number is definitely higher than expected owing to the small number of participants. The relatively low risk related to cigarette smoking in females compared with males could be explained by the fact that the prevalence of heavy smoking in females in the general population is less than the prevalence of heavy smoking in males of the Lebanese population [37].

In addition, a dose—effect relationship was found in this study. People who smoked 25—35 cigarettes daily had more risk of having lung cancer compared with those who smoked less than 25 cigarettes daily, considered as the reference group. And a very high risk was found in those who smoked more than 35 cigarettes compared with the reference group. This is concordant with the results of another study that found that the risk of developing lung cancer is directly related to the number of cigarettes smoked [38].

Although waterpipe smoking has not been retained in the multivariate analysis, it showed an important association with lung cancer in the bivariate analysis. An excess of lung cancer risk was found in waterpipe smokers compared with non-smokers, similar to the one found in a recent Indian study [6]. Waterpipe smoking could have been excluded from the multivariate model because of the small number of waterpipe smokers in the sample or because waterpipe smoking was not popular in the past decades as it is in young adults nowadays; moreover, mixed smoking of waterpipe and cigarettes could also explain these results. Additional studies are necessary to clarify this issue.

In the multivariate analysis for females, one variable was retained in the model, in addition to cigarette smoking, which is the use of fuel for heating. Females who lived in houses where fuel was used for heating had an elevated risk of having lung cancer compared with those who did not. This association between the use of fuel and especially solid fuel for heating and cooking and an elevated risk of lung cancer is found in multiple studies [16,17,39]. But this risk factor was not retained in the multivariate analysis model for males despite its significant association with lung cancer in the bivariate analysis. When the stratification by gender was performed, some variables appeared to be not significantly associated with the risk of lung cancer in females. There were only 57 female participants in the study, of which only 19 were lung cancer patients; the small number of female participants could be a possible explanation for the small number of variables retained in the multivariate analysis model for females.

For males, in addition to cigarette smoking, three variables were also retained in the model as risk factors for lung cancer. Males living in a residence near a generator had a higher risk of having lung cancer than those who never did. The presence of generators near the residence, a potential source of diesel exhausts, is frequent in Lebanon. The risk of lung cancer related to this factor has not been assessed in other studies, but living near a generator could be viewed as an indicator of the air pollution near the residence, and air pollution has been identified as an important risk factor of developing lung cancer in different studies [7—9], and exposure to diesel exhaust has been shown to increase the risk of lung cancer [26]. A low

consumption of fruits and vegetables was also associated with an excess risk of lung cancer in males. This result does not show the association between specific types of fruits or vegetables and lung cancer risk, but it is concordant with the results of different studies that showed that a high consumption of fruits and vegetables protects against lung cancer [18—20]. Finally males who had a positive family history of cancer had more risk of developing lung cancer compared with those whose family history of cancer was negative. A Turkish study found that the presence of different types of cancer in the history of the family increased the risk of lung cancer [31]. Another American study found an increased risk of lung cancer in association with a positive family history of different types of cancer in non-smokers [40].

In fact, other factors have also shown an association with lung cancer risk in bivariate analysis, like living in an urban area and near road traffic, the exposure to passive smoking at home and at work, and past occupational exposure to gases and toxic substances. Having a personal respiratory disease history, a family history of respiratory disease, and a family history of lung cancer were all associated with a higher risk of lung cancer in bivariate analyses, but none of these factors was retained in the multivariate analysis model; this could be owing to confounding by other factors or to a low power of the study. The small sample size might also explain high adjusted OR for some factors (due to sparse data), very wide confidence intervals obtained in the multivariate analysis and non-significant differences among cancer subtypes. More research, using a larger number of participants, should be done to verify these associations.

A selection bias is present in this study; this bias is frequently found in the case—control design. Since the participants were recruited at the same hospital and were all from Beirut and Mount Lebanon, this sample may not geographically represent the general Lebanese population. However, there is no reason to believe that controls do not represent the Lebanese population from the exposure point of view for two reasons: there were very few refusals (<5%) and percentages of exposure in controls are similar to those in the general population, according to a previous study conducted in Lebanon [41]. An admission bias is also possible because the patients and controls were recruited at the hospital and might have the same risk factors, but for another health problem; this may underestimate the association of some factors with the disease.

There are also different information biases present in the study. The questionnaire comprised an important number of questions that needed information recall, which may have generated a recall bias. There is a risk of bias on the part of the interviewer; being aware of the different risk factors, the interviewer might be more insistent when interviewing cases than controls. Nevertheless, the interviewer was trained to pass the questionnaires in a standardized manner, which decreases the likelihood of this bias. The number of cigarettes was also calculated based on the information reported by the participants, which also affects the classification of the participants.

Owing to the multiple qualitative interactions detected in the stratification analysis, multivariate analysis was done, for each sex separately, to adjust variables to possible confounding factors. Nevertheless, cases did not differ from controls in their socio-demographic characteristics, which reduce the risk of confounding bias. However, some variables may have been left not studied which may cause some residual confounding.

In addition, the nature of the study does not allow the researchers to prove any cause effect relationship, and the small number of participants does not allow for generalization of these results to the general Lebanese population or to study the subtypes of lung cancer, but it does highlight associations that may probably be risk factors for lung cancer in the Lebanese population and that would invite further research and investigations. Larger scale studies with participants from all the Lebanese regions should be done to confirm these results; using biomarkers of exposure and of effect will also be useful in such studies.

Meanwhile, adapting public health education efforts to control the tobacco epidemic should be culturally adapted to the Lebanese population, using modified versions of the WHO's FCTC recommendations and introducing elements of smoking behavior and of pollution that are specific to Lebanon: exposure to waterpipe smoking and to electricity generators, which have been shown to be related to several chronic respiratory diseases, such as chronic bronchitis and chronic obstructive pulmonary diseases [42—45]. Including these cultural elements in public health policies seems of utmost importance to affect people's behavior [46].

5. Conclusion

This study is the first Lebanese study that aimed to assess the risk factors for developing lung cancer in

the Lebanese population. Its results showed that cigarette smoking can be seen as the major risk factor for developing the disease. More awareness campaigns should be carried out to remind people of the harm caused by tobacco smoking for human health. Other factors, related to indoor and outdoor pollutants, also showed an association with the risk of lung cancer and can also be viewed as possible risk factors. Additional studies are necessary to confirm these results.

Conflict of interest

None declared.

References

[1] World Health Organization. The global burden of disease: 2004 update. Geneva: World Health Organization; 2008.

[2] Jemal A, Bray F, et al. Global cancer statistics. CA Cancer J Clin 2011;61:69—90.

[3] Cornfield J, Haenszel W, et al. Smoking and lung cancer: recent evidence and a discussion of some questions. Int J Epidemiol 2009;38:1175—91.

[4] World Health Organization, International Agency for Research on Cancer. IARC monographs on the evaluation of carcinogenic risks to humans, vol 83.

[5] Akl EA, Gaddam S, et al. The effects of waterpipe tobacco smoking on health outcomes: a systematic review. Int J Epidemiol 2010;39(3):834—57.

[6] Koul PA, Hajni MR, et al. Hookah smoking and lung cancer in the Kashmir valley of the Indian subcontinent. Asian Pac J Cancer Prev 2011;12(2):519—24.

[7] Cohen AJ, Pope III CA. Lung cancer and air pollution. Environ Health Perspect 1995;103(Suppl.):219—24.

[8] Pope III CA, Burnett RT, et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA 2002;287:1132—41.

[9] Nyberg F, Gustavsson P, et al. Urban air pollution and lung cancer in Stockholm. Epidemiology 2000;11:487—95.

[10] Hitosugi M. Epidemiological study of lung cancer with special reference to the effect of air pollution and smoking habit. Bull Inst Pub Health 1968;17:236—55.

[11] Samet JM, Humble CG, et al. History of residence and lung cancer risk in New Mexico. Am J Epidemiol 1987;125:800—11.

[12] Lopez-Cima MF, Garcia-Perez J, et al. Lung cancer risk and pollution in an industrial region of northern Spain: a hospital-based case—control study. Int J Health Geograph 2011;10:10.

[13] Vena JE. Air pollution as a risk factor in lung cancer. Am J Epidemiol 1982;116:42—56.

[14] Raaschou-Nielsen O, Andersen ZJ, et al. Lung cancer incidence and long-term exposure to air pollution from traffic. Environ Health Perspect 2011;119:860—5.

[15] Taylor R, Cumming R, et al. Passive smoking and lung cancer: a cumulative meta-analysis. Aust N Z J Pub Health 2001;25:203—11.

[16] Kurmi OP, Lam KB, Ayres JG. Indoor air pollution and the lung in low and medium income countries. Eur Respir J 2012 [Epub ahead of print].

[17] Lissowska J, Bardin-Mikolajczak A, et al. Lung cancer and indoor pollution from heating and cooking with solid fuels: the IARC international multicentre case—control study in Eastern/Central Europe and the United Kingdom. Am J Epidemiol 2005;162:326—33.

[18] Smith-Warner S, Spiegelman D, et al. Fruits, vegetables and lung cancer: a pooled analysis of cohort studies. Int J Cancer 2003;107:1001—11.

[19] Galeone C, Negri E, et al. Dietary intake and fruit and vegetable and lung cancer risk: a case—control study in Harbin, northeast China. Ann Oncol 2007;18:388—92.

[20] Dosil-Diaz O, Ruano-Ravina A, et al. Consumption of fruit and vegetables and risk of lung cancer: a case—control study in Galicia, Spain. Nutrition 2008;24:407—13.

[21] Linseisen J, Rohrmann S, et al. Fruit and vegetable consumption and lung cancer risk: updated information from the European Prospective Investigation into Cancer and Nutrition (EPIC). Int J Cancer 2007;121:1103—14.

[22] Karjalainen A, Anttila S, et al. Asbestos exposure and the risk of lung cancer in a general urban population. Scand J Work Environ Health 1994;20:243—50.

[23] Goodman M, Morgan RW, et al. Cancer in asbestos-exposed occupational cohorts: a meta-analysis. Cancer Causes Control 1999;10:453—65.

[24] Billings CG, Howard P, et al. Asbestos exposure, lung cancer and asbestosis. Monaldi Arch Chest Dis 2000;55:151—6.

[25] Olsson AC, Gustavsson P, et al. Lung cancer risk attributable to occupational exposures in a multicenter case—control study in Central and Eastern Europe. J Occup Environ Med 2011;53:1262—7.

[26] Olsson AC, Gustavsson P, et al. Exposure to diesel motor exhaust and lung cancer risk in a pooled analysis from case—control studies in Europe and Canada. Am J Respir Crit Care Med 2011;183:941—8.

[27] Dinham B. Prolonged exposure to some agricultural pesticides may increase the risk of lung cancer in agricultural worker. Evid Based Healthc Pub Health 2005;9:203—5.

[28] Ganesh B, Sushama S, et al. A case—control study of risk factors for lung cancer in Mumbai, India. Asian Pac J Cancer Prev 2011;12:357—62.

[29] Peters S, Kromhout H, et al. Occupational exposure to organic dust increases lung cancer risk in the general population. Thorax 2012;67:111—6.

[30] Coté ML, Liu M, et al. Increased risk of lung cancer in individuals with a family history of the disease: a pooled analysis from the International Lung Cancer Consortium. Eur J Cancer 2012 [Epub ahead of print].

[31] Ergün D, Savaş I, et al. Lung cancer and family history of cancer. Tuberk Toraks 2009;57(3):251—8.

[32] Brenner DR, McLaughlin JR, et al. Previous lung diseases and lung cancer risk: a systematic review and meta-analysis. PLoS One 2011;6(3):e17479.

[33] Salim EI, Moore MA, Bener A, Habib OS, Seif-Eldin IA, Sobue T. Cancer epidemiology in South-West Asia — past, present and future. Asian Pac J Cancer Prev 2010;11(Suppl.):33—48.

[34] Shamseddine A, Sibai AM, Gehchan N, Rahal B, El-Saghir N, Ghosn M, et al. Lebanese cancer epidemiology group. Cancer incidence in postwar Lebanon: findings from the first national population-based registry, 1998. Ann Epidemiol 2004;14(9):663—8.

[35] Hung RJ, McKay JD, Gaborieau V, Boffetta P, Hashibe M, Zaridze D, et al. A susceptibility locus for lung cancer maps to nicotinic acetylcholine receptor subunit genes on 15q25. Nature 2008;452:633—7.

[36] Alberg AJ, Samet JM. Epidemiology of lung cancer. Chest 2003;123(Suppl. 1):21S—49S.

[37] Salameh P, Khayat G, Waked M. Smoking in Lebanese women: a lower prevalence but a higher risk of waterpipe dependence. Women Health 2012;52:1—16.

[38] Etzel CJ, Amos CI, Spitz MR. Risk for smoking-related cancer among relatives of lung cancer patients. Cancer Res 2003;63:8531—5.

[39] Hosgood III HD, Boffetta P, et al. In-home coal and wood use and lung cancer risk: a pooled analysis of the International Lung Cancer Consortium. Environ Health Perspect 2010;118(12):1743—7.

[40] Mayne ST, Buenconsejo J, Janerich DT. Familial cancer history and lung cancer risk in United States non-smoking men and women. Cancer Epidemiol Biomarkers Prev 1999;8(12):1065—9.

[41] Waked M, Khayat G, Salameh P. COPD prevalence in Lebanon: a cross-sectional descriptive study. Clin Epidemiol 2011;3:315—23.

[42] Salameh P, Khayat G, Waked M, Dramaix M. Waterpipe smoking and dependence are associated with chronic obstructive pulmonary disease: a case—control study. Open Epidemiol J 2012;5:36—44.

[43] Salameh P, Salame J, Khayat G, Akhdar A, Ziadeh C, Azizi S, et al. Exposure to outdoor air pollution and Chronic Bronchitis in adults: a pilot case—control study. Int J Occup Environ Med 2012;3(4):157—69.

[44] Waked M, Salamé J, Khayat G, Salameh P. COPD and chronic bronchitis correlates in non smokers: data from a cross-national study. Int J COPD 2012;7:577—85.

[45] Salameh P, Waked M, Khayat G, Khoury F, Akiki Z, Nasser Z, et al. Waterpipe smoking and dependence are associated with chronic bronchitis: a case control study. East Mediterr Health J 2012;18(10):996—1004.

[46] Nagler R, Viswanath K. Implementation and research priorities for FCTC articles 13 and 16: tobacco advertising, promotion, and sponsorship and sales to and by minors. Nicotine Tob Res; 2013. Available from: http://ntr.oxford-journals.org/content/early/2013/01/04/ntr.nts331.full.pdf+html.