Assessment of indoor secondhand tobacco smoke emission levels in six Lebanese cities

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Abstract

**Background:** Although clean indoor airs laws have become commonplace in many western nations, Lebanon is typical of many Eastern Mediterranean Region (EMR) countries, with no comprehensive clean indoor air laws despite ratification of the FCTC. **Lebanon has only one tobacco control law, honored more in the breach: requiring a miniscule ‘health warning’ covering 15% of any print and billboard advertising, and on packages; and banning free-sampling of cigarettes to minors.** **moreover Lebanon is the only country in the Middle East that allows cigarette advertising on television** Complicating the problem of SHS exposure in this region is the widespread use of tobacco waterpipe. While most research on SHS has involved cigarette smoking as a source of emissions, other sources, including tobacco waterpipe may be an important contributor.

**Methods:** PM\(_{2.5}\) concentrations (µg/m\(^3\)) were measured in a sample of 28 public venues located in six major Lebanese cities. Active smoker density (number of smokers/volume (100 m\(^3\))) was calculated for both cigarette and waterpipe smokers. Venues were thus categorized as higher waterpipe density or higher cigarette density, and resultant emission levels were compared between the two categories.

**Results:** Among all smoking-permitted venues, the mean PM\(_{2.5}\) concentration was 342 µg/m\(^3\). Venues with a higher density of waterpipe smokers (n =14) showed a slightly greater, although nonsignificant, median PM\(_{2.5}\) concentration (349 µg/m\(^3\)) compared with venues with a higher density of cigarette smokers (n =13; 241 µg/m\(^3\)). The average PM\(_{2.5}\) concentration in the single venue with a voluntary smoke-free policy was 6 µg/m\(^3\).
Conclusions: Despite ratification of the FCTC in 2005, both cigarette and waterpipe smoking are commonly practiced in enclosed public places throughout Lebanon. Smoke-free policies are needed in Lebanon and other EMR countries to protect the public’s health, and should apply to all forms of tobacco smoking.
What this Paper Adds:
Secondhand smoke is a major cause of preventable disease and mortality. To protect the public’s health, the World Health Organization is encouraging nations to adopt smoking restrictions in public places through its Framework Convention on Tobacco Control (FCTC).

This study assessed the prevalence of cigarette and waterpipe smoking among a convenience sample of 28 enclosed public places in six Lebanese cities, and measured PM$_{2.5}$ concentrations within those venues. Although the Lebanese government ratified the FCTC in 2005, tobacco smoking, particularly through the usage of waterpipes, was observed in 27 out of the 28 of the venues sampled. Particulate pollution within the smoking-permitted venues was observed to be at unsafe levels, with an overall mean level of 342 µg/m$^3$. Results also show that waterpipe and cigarette use often co-occur within the same venue. This can make separate measurement of each type of SHS emission difficult in field settings and research documenting waterpipe SHS is greatly needed. Venues with a majority of waterpipe smokers were found to have similar PM$_{2.5}$ levels as venues with a majority of cigarette smokers. The data suggest that waterpipe smoke emissions are an important source of indoor particulate pollution. Enforcement mechanisms are needed to ensure that ratifying nations conform to Article 8 of the FCTC.
INTRODUCTION

Exposure to secondhand tobacco smoke (SHS) is a major cause of premature death and disease in non-smokers. [1] SHS contains over 5,000 chemical constituents, of which approximately 250 are known to be toxic or carcinogenic. [2] Exposure to SHS among children is a major pediatric problem and is associated with increased risk of sudden infant death syndrome, acute respiratory infections, ear problems, and increased severity of asthma symptoms. [1] While most research on SHS has involved cigarettes as a source of emissions [3], other sources, including tobacco waterpipe may be an important contributor. [4] Tobacco waterpipes, also known as hookah, involve a unique design in which tobacco smoke is drawn through a water bubbler before reaching the smoker. The tobacco, often known as moassel, is a highly sweetened and flavored blend with high moisture content. The tobacco is heated by a burning charcoal, and it releases a caramelized sugar or fruit-scented aromas as it is smoked. [5]

Many of the constituents found in cigarette smoke have also been identified in waterpipe emissions. [6] Both sources of SHS carry respirable suspended particles [4,7] whose small diameter allow inhalation deep into the lungs, thus contributing to a range of adverse respiratory and cardiovascular effects [8]. Limited laboratory testing has suggested that particulate emissions arising from active waterpipe smoking may be comparable to or greater than cigarette emissions. Waterpipe sessions lasting 30 minutes may generate similar emission levels as a single cigarette smoked for about 10 minutes. [4]
A growing number of countries have enacted legislation to address this widespread public health problem by prohibiting indoor smoking in public places. To encourage broader adoption of such policies, Article 8 of the World Health Organization’s (WHO) Framework Convention on Tobacco Control (FCTC), the world’s first global public health treaty, calls for implementation of effective measures to protect all people from exposure to SHS. [9] Currently, no Eastern Mediterranean Region (EMR) countries have comprehensive laws banning indoor smoking. Lebanon ratified the FCTC in December of 2005; however, no restrictions on smoking in workplaces, public transit, or indoor public places have yet been enacted.

A comprehensive policy response to SHS exposure first requires the development of an appropriate research base to document the nature and extent of the problem. At the current time, only one known investigation has monitored air quality in environments in which smoking occurs in Lebanon. [7] However, the number of Lebanese venues sampled in this investigation was relatively small (n = 9) and no information on the number of cigarette and waterpipe smokers in these venues was reported. Further, data demonstrating the contribution of waterpipe smoking, a favored form of tobacco use in Lebanon, to SHS smoke emissions is urgently needed. The present study aimed to document the prevalence and effect of indoor smoking in Lebanon, by measuring SHS emissions from both major forms of tobacco smoking - cigarette and waterpipe.

**MATERIALS AND METHODS**
Between June and September of 2008, indoor air quality was measured inside 28 enclosed public places in the Lebanese cities of Antelias, Batroun, Beirut, Koura, Saida, and Tripoli. The six cities were chosen based on their geographic and economic diversity: Antelias is located in the Mount Lebanon region; the northern city of Batroun is known for its entertainment and nightlife; the central coastal city of Beirut is the nation’s capital and largest city; Koura is an intellectual district in the north; Saida is the nation’s third largest city and is located in the south; the northern city of Tripoli is the country’s second largest city.

The types of venues visited included a range of hospitality venues (cafés, restaurants, pubs, and night clubs) where cigarette and waterpipe smoking are commonly found. In addition, hospital cafeterias and a shopping mall were included. Within each city, efforts were made to visit hospitality venues in at least two popular entertainment districts. For logistical reasons, venues were selected on the basis of convenience by the research staff while attempting nevertheless to recruit venues that were representative in terms of size, location and clientele, for each region. To ensure the sampling of at least one smoke-free venue, a café with a known voluntary smoke-free policy was included.

The TSI SidePak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, MN) was used to sample and record the levels of respirable suspended particles. The Sidepak uses a sampling pump to draw air into the device and the concentration of particulate matter is determined using light scattering technology. [7] A 2.5µm impactor was employed to
measure the levels of particulate matter with a mass-median aerodynamic diameter \( \leq 2.5 \) \( \mu \text{m} \) (PM\(_{2.5}\)). A sidepak calibration factor of 0.32 was used.

The air monitoring device was positioned in a central location inside each venue and air within occupants’ normal breathing area was sampled. Data was collected unobtrusively to ensure natural behavior of patrons and employees. The number of cigarette and waterpipe smokers was also counted upon entry into each venue and each subsequent 15 minute interval. A minimum of 15 minutes was spent monitoring air quality in each venue, and at least two such counts were performed to calculate mean number of smokers (cigarette and waterpipe).

The internal volume of each venue was measured using an AEG UM 15L Sonic Measure (AEG Elektrowerkzeuge, Winnenden, Germany).

**RESULTS**

Descriptive statistics for the 28 venues are provided in Table 1. Both cigarette smoking and waterpipe smoking were present in 14 of the venues, in contrast to 12 venues in which cigarette smoking only occurred. Waterpipe smoking alone was found in a single venue. Smoking (either cigarettes or waterpipe) thus was observed in all venues except the one café with a known voluntary smoke-free policy (Venue 28).

**TABLE 1 ABOUT HERE**
Across all smoking-permitted venues, the median number of cigarette smokers was 3.0 and waterpipe smokers was 2.3. The number of cigarette smokers in each of the smoking-permitted venues ranged from 0 to 175, while the number of waterpipe smokers ranged from 0 to 72.

Average PM$_{2.5}$ levels among all smoking-permitted venues ranged from 28-1324 µg/m$^3$ and the overall mean for these venues was 342 µg/m$^3$. In the only smoke-free venue, the average PM$_{2.5}$ concentration was 6 µg/m$^3$, which was the lowest average PM$_{2.5}$ level observed for all venues visited.

The active cigarette, waterpipe, and total (cigarette + waterpipe) smoker densities (ASD$_{CIG}$; ASD$_{WP}$; & ASD$_{TOTAL}$) were calculated by dividing the average number of cigarette or waterpipe smokers by venue volume (100 m$^3$). Results are reported in Table 1. Among all venues sampled, ASD$_{TOTAL}$ was positively correlated with PM$_{2.5}$ concentration (Spearman’s rho = 0.467; p= 0.012).

The smoking-permitted venues were then classified into two groups: those with a higher density of waterpipe smokers (n = 14) and those with a higher density of cigarette smokers (n = 13). Median PM$_{2.5}$ levels were found to be greater for venues with higher ASD$_{WP}$ (349 µg/m$^3$) compared with those with higher ASD$_{CIG}$ (241 µg/m$^3$), but this difference was not statistically significant (2-sample Wilcoxon Rank Sum Test z=-1.407;
Figure 1 shows PM$_{2.5}$ concentrations for venues with greater waterpipe and cigarette smoker densities, with the median for each group represented in a horizontal line. Also detailed are the relative proportions of waterpipe and cigarette smokers observed in each venue.

**DISCUSSION**

The present study assessed indoor air quality among a sample of enclosed public places in multiple cities in Lebanon. Despite ratification of the FCTC by the Lebanese government in December of 2005, the absence of a comprehensive clean indoor air law has allowed the continuation of widespread indoor smoking. Cigarette and/or waterpipe use was observed in 27 of the 28 venues visited. Among these venues the mean PM$_{2.5}$ concentration was 342 $\mu$g/m$^3$. In contrast, the mean PM$_{2.5}$ concentration in the one smoke-free venue was 6 $\mu$g/m$^3$.

To put the measured PM$_{2.5}$ levels into perspective, a comparison can be made to the WHO’s Air Quality Guideline[8], a standard established to protect the public’s health from exposure to ambient air pollution. According to this standard, exposure to PM$_{2.5}$ pollution should not exceed a daily average of 25 $\mu$g/m$^3$ (see Figure 1). Among the 27 smoking-permitted venues, the overall mean PM$_{2.5}$ concentration far exceeded this value, with the most polluted venue having an average concentration of 1324 $\mu$g/m$^3$. Due to such elevated levels, individuals working in many of these venues, and thus exposed for prolonged periods, multiple times per week, are likely to be at risk of exposure to unsafe PM$_{2.5}$ levels, as well as exposure to multiple toxic smoke constituents, including a
number of known carcinogens. [1] The elevated levels of indoor air pollution are consistent with measurements taken within smoking-permitted venues in other countries [7] and underscore the urgent need to implement smoke-free policies to protect employees and patrons. In jurisdictions that have enacted smoke-free legislation, significant declines in PM$_{2.5}$ pollution [10-12] and related health risks and outcomes [13-15] have resulted after implementation.

The holiday of Ramadan occurred during the timeframe of the current investigation. During this holy month it is customary for many families to eat in the evenings in large “Ramadan tents,” where waterpipe smoking is common. Four of the venues sampled (2, 3, 4, and 17) hosted such festive meals, smoking was present in each, and high levels of air pollution were found. The mean PM$_{2.5}$ level for these 4 venues was 538 µg/m$^3$. Such unsafe levels are of particular concern given the presence of children in these venues. Smoking was also observed in other types of venues commonly frequented by children, such as hospital cafeterias, restaurants, and cafes.

A small, but growing body of research has addressed waterpipe use and the resulting emissions, but there is still relatively little research documenting the effect of waterpipe use on indoor air quality. The present study is among the first to report indoor air quality in venues where waterpipe smoking occurs. The data reveal that indoor waterpipe smoking in Lebanese cities is common, and was found in 15 (55%) of the venues visited. Waterpipe smoking has the potential to generate high levels of PM$_{2.5}$ emissions. In the one venue where only waterpipe smoking was observed the mean PM$_{2.5}$ concentration
was 355 µg/m³. Moreover, venues with greater density of waterpipe smokers had (nonsignificantly) higher levels of particulate pollution, compared to those with a greater density of cigarette smokers. Despite practical limitations, which prevented separate measurement of waterpipe and cigarette emissions, the data suggest that waterpipe smoking is a major contributor to indoor air pollution, and may contribute similar levels of PM₂.₅ as cigarette smoking. The present data suggest that to fully protect the public’s health from this source of indoor air pollution, smoking restrictions should apply to venues where waterpipe smoking occurs.

Limitations of the study design poses problems in distinguishing between cigarette and waterpipe emissions and isolating their relative contributions to observed PM₂.₅ levels. A direct comparison between waterpipe and cigarette PM₂.₅ emissions would require separate measurements of each emission source while controlling for venue characteristics such as internal volume, air exchange rate and other factors influencing the aerodynamic behavior of fine particles, as well as smoker density and smoker puffing behavior. Practical limitations make this difficult, if not impossible, to undertake in the field. Future research might partially resolve this problem by monitoring air quality in cigarette- and waterpipe-only venues, as well as dual use venues. However, this may be difficult to achieve (at least in Lebanon) because cigarette smoking commonly co-occurs with waterpipe smoking, as revealed by the observational data collected in this investigation. Additional strategies for measuring SHS might also be employed. Waterpipe emissions contain high levels of carbon monoxide which arises from the burning coal heat source [6]. The measurement of CO in addition to particulate matter
would provide important additional information about air quality in venues in which waterpipe is used. Moreover, factors not controlled in this study, such as room ventilation, individual smoking style, and PM$_{2.5}$ arising from other sources such as ambient air pollution and cooking methods can modify the variability in PM$_{2.5}$. Nonetheless, previous research demonstrating immediate and significant declines in indoor particulate pollution following implementation of smoking restrictions reveals that smoking is the main contributor to elevated particulate levels in indoor environments.

[10-12]

Unsafe levels of indoor air pollution were found in public places in multiple cities, and indoor smoking was commonly found in various types of public venues in Lebanon. Policies that prohibit smoking indoors are the most effective strategy to reduce non-smokers’ exposure to SHS, which may translate into improved health outcomes. The usage of a waterpipe to smoke tobacco, which has cultural importance to the entire EMR, was observed in more than half of the venues sampled. Due to the fact that waterpipe smoking is a major contributor to indoor air pollution, policies designed to protect the public from exposure to SHS through smoking restrictions should also apply to waterpipes. Lebanon’s signing and ratification of the FCTC is an important step in achieving the nation’s public health goals and demonstrates their commitment to the protection of their citizens. However, the implementation of smoke-free legislation is needed to ensure full protection from this serious, but preventable public health problem.
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REFERENCES


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Figure 1. PM$_{2.5}$ levels for higher waterpipe and higher cigarette density venues

*Venue 28 (6 µg/m$^3$) was smokefree and is not included.