Secondhand tobacco smoke: an occupational hazard for smoking and non-smoking bar and nightclub employees

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ABSTRACT

Background In the absence of comprehensive smoking bans in public places, bars and nightclubs have the highest concentrations of secondhand tobacco smoke, posing a serious health risk for workers in these venues.

Objective To assess exposure of bar and nightclub employees to secondhand smoke, including non-smoking and smoking employees.

Methods Between 2007 and 2009, the authors recruited approximately 10 venues per city and up to five employees per venue in 24 cities in the Americas, Eastern Europe, Asia and Africa. Air nicotine concentrations were measured for 7 days in 238 venues. To evaluate personal exposure to secondhand smoke, hair nicotine concentrations were also measured for 625 non-smoking and 311 smoking employees (N=936).

Results Median (IQR) air nicotine concentrations were 3.5 (1.5—8.5) μg/m³ and 0.2 (0.1—0.7) μg/m³ in smoking and smoke-free venues, respectively. Median (IQR) hair nicotine concentrations were 6.0 (1.6—16.0) ng/mg and 1.7 (0.5—5.5) ng/mg in smoking and non-smoking employees, respectively. After adjustment for age, sex, education, living with a smoker, hair treatment and region, a twofold increase in air nicotine concentrations was associated with a 30% (95% CI 23% to 38%) increase in hair nicotine concentrations in non-smoking employees and with a 10% (2% to 19%) increase in smoking employees.

Conclusions Occupational exposure to secondhand smoke, assessed by air nicotine, resulted in elevated concentrations of hair nicotine among non-smoking and smoking bar and nightclub employees. The high levels of airborne nicotine found in bars and nightclubs and the contribution of this exposure to employee hair nicotine concentrations support the need for legislation measures that ensure complete protection from secondhand smoke in these venues.

INTRODUCTION

Secondhand tobacco smoke exposure is a major cause of respiratory, cardiovascular and cancer morbidity and mortality around the world.[1 2] As of 2004, over 10 million disability-adjusted life years, 0.7% of total worldwide burden of disease, were lost due to secondhand smoke exposure.[2] Of all public places, bars and nightclubs have the highest air levels of secondhand smoke,[3–5] posing a serious health risk for employees spending long hours in their work environment.[6] Epidemiological studies have shown that hospitality employees have 50%—60% greater risk of lung cancer compared with other populations.[7 8] To protect all people including workers from exposure to secondhand smoke, Article 8 of WHO Framework Convention on Tobacco Control (FCTC) calls for comprehensive smoke-free legislation eliminating tobacco smoking in all indoor public places and workplaces.[9 10] As of 2011, however, only 11% of the world's population was protected by smoke-free policies that included bars, restaurants and nightclubs.[11] These venues have largely been excluded from smoke-free workplace and public place legislation due to the tobacco industry's influence on the hospitality sector to oppose smoking regulations.[12 13] In this study, we assessed secondhand smoke exposure in bar and nightclub employees from large cities around the world. To assess personal exposure to secondhand smoke, we evaluated the relationship of workplace air nicotine concentrations with hair nicotine concentrations, a biomarker of internal dose, in both smoking and in non-smoking employees.

METHODS

Design and population

This study is part of a multi-city effort designed to assess tobacco control measures in bars, cafes/tea houses and nightclubs around the world.[14] By design, the study recruited approximately 10 venues per city and up to five employees per venue in 24 large cities in the Americas, Eastern Europe, Asia and Africa. Study sites, located in countries with a wide range of smoking legislation in public places (online appendix 1), were selected based on previous collaborations[3 15] and the presence of a within-country study coordinator and team with experience in tobacco control research. Training of the study coordinators was conducted centrally, in person or online following a training manual, simulated interviews and question-by-question guidelines. Each study coordinator was responsible for the training of the fieldworkers.

A total of 238 venues were recruited between January 2007 (Baltimore) and September 2009 (Ulaanbaatar, Mongolia), ranging from six venues in Kremenchug, Ukraine, to 11 venues in Baltimore, USA, and Mexico City, Mexico (online appendix 1). In each city, bars, cafes/tea houses or nightclubs were recruited from two to three neighbourhoods with a high concentration of public places where people, especially young adults, spend time or gather socially. Venues were selected from popular areas, covering different socioeconomic sectors and neighbourhoods using a door-to-door sampling strategy, except in Manila where venues were randomly selected from rosters by public health inspectors. If voluntary smoke-free venues existed in the city, at least two of the selected venues were required to be smoke free. If smoke-free legislation existed in the city or country, all venues were supposedly smoke free (online appendix 1).

The minimal requirements for a venue to be in the study included owner agreement and that at least one smoking and one non-smoking employee were willing to provide a hair sample. Venue median response rate was 59% and ranged from 8% in Bishkek, Kyrgyzstan, to 91% in Bangkok, Thailand (online appendix 1). In Buenos Aires, Argentina, only smoke-free establishments agreed to participate. Informed consent was required for the participating venue owners/managers and employees. The goal was to recruit at least one smoking and two non-smoking employees (up to five employees per venue). A total of 936 employees (625 non-smokers and 311 smokers) were recruited, ranging from 20 in Buenos Aires, Argentina, to 76 in St. Louis, USA. The study protocol and consent forms were approved by the Institutional Review Board of the Johns Hopkins Bloomberg School of Public Health and by a local ethics committee in each participating city. All participants provided written informed consent.

Data collection

The bar owner/manager and the employees completed standardised questionnaires administered in the local language of the country by trained interviewers during work hours but before the venues were open to the public. The employees were asked to provide information on demographics, smoking behaviour, exposure to secondhand smoke at work, home and other places, and opinions about secondhand smoke legislation. Employees were classified as non-smokers if they had not smoked a cigarette in the past 12 months and as smokers if they had smoked in the past 12 months. To confirm the smoking or non-smoking status of the employees, an extra question was asked before the hair sample collection to enquire about smoking (even a single puff) in the last 30 days. The bar owners/managers were asked to describe general characteristics of the venue, including number of employees, hours of operation, occupancy, ventilation systems and smoking policy (smoke free or smoking allowed).

Air nicotine monitoring

Time-weighted average air nicotine concentrations in each venue were measured for 1 week using passive samplers originally developed by Hammond and Leaderer.[16] Samplers comprised a filter treated with sodium bisulphate, placed in 37 mm sampling cassette and covered with a porous diffusion membrane. Two monitors were placed in each bar/nightclub with locations selected to represent areas of the venue where employees most frequently worked. A total of nine samplers were lost or stolen during the fieldwork. At the end of the sampling period, the remaining 467 samplers were securely closed and shipped to the Exposure Assessment Laboratory of the Institute for Global Tobacco Control at the Johns Hopkins Bloomberg School of Public Health where the nicotine collected by each sampler was extracted and analysed using gas chromatography with nitrogen-selective detection. The airborne concentration of nicotine was estimated by dividing the amount of nicotine collected by the filter (micrograms) per volume of air sampled (cubic metre). The volume of air sampled is equal to the total of sampling time in minutes multiplied by the flow rate (25 ml/min).

Air nicotine concentrations from samplers placed in the same venue were comparable and concentrations are presented as the average of the two air nicotine samplers in each venue. For quality control purposes, 10% of samplers were duplicates and/or blanks. The intraclass correlation coefficient between duplicate samples was 0.94. Blanks were used to determine the blank-corrected nicotine concentrations and to calculate the nicotine limit of detection (range 0.002–0.009 $\mu g/m^3$). A total of six samples had air nicotine concentrations below the limit of detection. For samples below the limit of detection, a value of half the limit of detection was assigned for statistical analyses.

Hair nicotine

Hair samples from the employees were collected on the day the nicotine samplers were installed. A small hair sample (~30–50 strands) was obtained near the hair root from the back of the scalp where there is the most uniform growth pattern between individuals. Hair samples were placed in labelled sealed plastic bags and shipped to the Exposure Assessment Laboratory of the Institute for Global Tobacco Control at the Johns Hopkins Bloomberg School of Public Health. Up to 3 cm of hair from the scalp, thoroughly cleaned to remove any nicotine in the outside of the hair, was used to evaluate secondhand smoke exposure during the most recent months. Hair nicotine was measured by gas chromatography–mass spectrometry following the method described by Kim *et al*.[17 18] Hair nicotine concentrations were calculated by dividing the amount of nicotine measured in each hair sample (nanograms) by the mass of hair analysed (grams). The limit of detection was 0.02 ng/mg for a 30 mg hair sample, and 87 samples were below the limit of detection and were assigned a value of half the detection limit. The per cent coefficient of variation ranged from 12% to 20% for higher (approximately 3 ng/mg) and low (approximately 0.5 ng/mg) hair nicotine concentrations, respectively. For quality control purposes, duplicate analysis of 10% of hair samples were analysed by the laboratory. The intraclass correlation coefficient between duplicate samples was 0.97.

Statistical analyses

Descriptive analyses were stratified by region (Americas, Eastern Europe, Asia and Africa) and/or employee smoking/non-smoking status. Distributions of air and hair nicotine concentrations were described using the median and IQR. We used crude- and multivariable-adjusted mixed-effect linear models with city-specific intercepts to evaluate the dose–response relationship between air nicotine and hair nicotine concentrations. Hair nicotine concentrations (independent variable) was log-transformed to improve normality. Air nicotine was modelled using different strategies to evaluate the shape of the dose–response using tertiles, $\log_2$-transformed and the original scale. In tertile models, we computed ratios (95% CI) of the geometric mean of hair nicotine concentrations comparing tertiles 2 and 3 to the lowest tertile of air nicotine. In $\log_2$-transformed models, we evaluated the ratio of the geometric mean of hair nicotine concentration with a doubling in air nicotine concentrations. In models with air nicotine concentrations in the original scale, we evaluated the ratio of the geometric mean of hair nicotine with a change in 1 $\mu g/m^3$ of air nicotine concentrations. Multivariable models for the association between air and hair nicotine concentrations were adjusted for age, sex, education, living with a smoker, hair treatment and region. Models for non-smokers were further adjusted for never/former smoking status. For smokers, further adjustment for number of cigarettes smoked per day did not change

Table 1 Venue characteristics by region

	All	Americas	Eastern Europe	Asia	Africa
N	238	88	56	75	19
Response rate	47	54	22	49	62
Smoke-free venues	18	31	5	16	11
Maximum occupancy	100 (60–200)	150 (80–250)	80 (60–120)	100 (40–200)	125 (50–300)
Number of employees	15 (8–26)	15 (8–26)	14 (10–23)	18 (7–30)	15 (9–24)
Serves full menu	61	61	82	43	74
Dance space	41	37.5	43	35	68
Live music	43	52	40	34	44
Cigarette sale	68	53	89	68	68
Tobacco promotion	29	21	54	15	56
Outdoor space	49	57	41	39	68
Air nicotine concentrations (μg/m^3)					
All venues	2.3 (0.6–6.7)	1.5 (0.3–3.9)	7.1 (2.9–12.9)	2.1 (0.8–5.4)	1.5 (0.3–2.9)
Smoking allowed	3.5 (1.5–8.5)	3.0 (1.2–5.7)	8.5 (3.6–13.4)	3.4 (0.9–6.8)	1.6 (1.0–2.9)
Smoke free	0.2 (0.1–0.7)	0.2 (0.1–0.4)	0.1 (0.03–0.2)	0.9 (0.4–1.1)	0.03 (0.03–0.04)

Values represent per cent or median (IQR).

estimates (not shown). Multiple imputation,[19] assuming data were missing at random, was used to impute values for employees missing data on age (N=2), education (N=5), living with a smoker (N=13), hair treatment (N=16) and number of cigarettes smoked per day (N=56). To assess differences in the association of air and hair nicotine concentrations across employee characteristics, we also estimated the ratio of hair nicotine concentrations by air nicotine concentrations for subgroups defined by sex, age, region, education, living with a smoker and hair treatment. Analyses were conducted using Stata V.11.1 (Stata corporation). The statistical significance level was set at $\alpha=0.05$. All statistical analyses were two sided.

RESULTS

Venue characteristics

Among the 238 venues included in the study, 18% were smoke free as reported by the owner/manager (table 1, online appendix 1). The median maximum legal occupancy ranged

Table 2 Employee characteristics by region

	All	Americas	Eastern Europe	Asia	Africa
N	936	269	235	338	94
Age	26 (22–32)	28 (23–38)	25 (22–31)	25 (21–31)	26.5 (23–32)
Men	50	56	23	61	62
Education					
< High school	14	9	0.4	27	13
High school	50	48	55	42	66
>High school education	37	43	44	31	22
Bartenders/waiters	62	59	62	65	53
Hours per week at work	48 (40–60)	40 (27–50)	51 (40–65)	54 (48–63)	60 (48–72)
Smoking status					
Never-smoker	59	39	60	69	89
Former smoker	7	14	7	4	2
Current smoker	33	47	33	29	9
Living with a smoker					
Yes	46	40	60	51	10
No	54	60	40	49	90
Support smoke-free policies					
Yes	57	57	52	60	61
No	33	32	42	29	26
Does not matter	10	11	6	11	13
Prefer work in smoke-free places					
Yes	78	72	78	83	82
No	9	11	10	9	0
Does not matter	13	18	12	9	18
Hair chemical treatment					
Yes	46	36	54	50	43
No	54	64	46	50	57
Hair nicotine (ng/mg)					
Never-smokers	1.8 (0.6–6.0)	1.6 (0.3–5.1)	1.2 (0.5–3.9)	2.3 (0.8–7.6)	1.9 (0.3–6.5)
Former smokers	1.1 (0.4–4.4)	1.0 (0.2–4.0)	0.7 (0.4–1.6)	2.7 (1.1–8.0)	2.2 (0.1–4.4)
Non-smokers	1.7 (0.5–5.5)	1.3 (0.3–4.8)	1.1 (0.5–3.6)	2.4 (0.9–7.7)	1.9 (0.3–6.4)
Current smokers	6.0 (1.6–16.0)	5.0 (1.3–14.6)	1.8 (0.7–6.6)	13.2 (4.5–26.1)	7.1 (4.6–16.8)

Values represent per cent or median (IQR).

from 80 in venues recruited in Eastern European cities to 150 in venues recruited in American cities. The median number of employees per venue was 15 with small differences across regions. For descriptive purposes, 61%, 41% and 43% of the venues served a full menu, had dance space and offered live music, respectively; 68% sold cigarettes at the bar counter or from a vending machine and 29% reported receiving promotional items from tobacco companies.

Employee characteristics

Fifty per cent of the participants were male, the mean age was 29 years old, 37% had a college-level education and 62% were bartenders or waiters (table 2, online appendix 1). The median (IQR) hours worked per week was 48 (40–60). Among non-smoking employees, 11% were former smokers. Forty-six per cent (43% and 52% of non-smoking and smoking employees, respectively) reported living with a smoker. Fifty-seven per cent (64% non-smokers and 44% smokers) supported smoke-free policies, and 78% (87% non-smokers and 61% smokers) reported they would prefer to work in a smoke-free environment.

Air and hair nicotine concentrations

Median (IQR) air nicotine concentrations were 3.5 (1.5–8.5) $\mu g/m^3$ and 0.2 (0.1–0.7) $\mu g/m^3$ in smoking and smoke-free venues, respectively (table 1, online appendix 2). Median (IQR) hair nicotine concentrations were 6.0 (1.6–16.0) ng/mg and 1.7 (0.5–5.5) ng/mg in smoking employees and non-smoking, respectively (table 2, online appendix 2). Median (IQR) hair nicotine concentrations for all employees working in smoking and smoke-free venues were 2.7 (0.8, 9.2) ng/mg and 1.3 (0.3, 6.5) ng/mg, respectively.

After adjustment for age, sex, education, living with a smoker, hair treatment and region (and former smoking status for non-smokers), a twofold increase in air nicotine concentrations was associated with a 30% (95% CI 23% to 38%) and a 10% (95% CI 2% to 19%) increase in hair nicotine concentrations in non-smoking and smoking employees, respectively (table 3). For non-smokers, the hair nicotine concentrations were 2.54 (95% CI 1.91 to 3.39) and 3.77 (95% CI 2.62 to 5.42) higher for tertiles 2 and 3 of air nicotine concentrations compared with tertile 1 (p value for trend <0.001). The corresponding ratios comparing tertiles 2 and 3 with the lowest tertile were 1.55 (95% CI 1.03 to 2.34) and 1.53 (95% CI 0.95 to 2.46), respectively, among smokers (p value for trend =0.02). For each 1 $\mu g/m^3$ increase in air nicotine concentrations, hair nicotine concentrations increased 5% (95% CI 3% to 8%) and 3% (95% CI 1% to 6%), respectively, for non-smoking and smoking employees. After multivariable adjustment, hair nicotine concentrations were higher among men and among employees without chemical hair treatment in the past month (table 3). Concentrations were also significantly lower in smoking employees in Eastern Europe compared with other regions.

The association between air nicotine and hair nicotine concentrations was similar across participant characteristics except for evidence of a stronger relationship among smoking employees without chemically treated hair compared with those with chemical treatment (p value for interaction =0.05) (figure 1).

DISCUSSION

Exposure to secondhand tobacco smoke in the workplace, assessed by air nicotine, resulted in elevated concentrations of

Table 3 Ratio (95% CI) of the geometric mean of hair nicotine concentrations by air nicotine concentrations and other characteristics*

	Non-smoking employees			Smoking employees		
	N	Crude	Adjusted	N	Crude	Adjusted
Air nicotine ($\mu g/m^3$)						
<1.3	203	1.00 (reference)	1.00 (reference)	109	1.00 (reference)	1.00 (reference)
1.3–5.2	210	2.51 (1.86 to 3.37)	2.54 (1.91 to 3.39)	105	1.67 (1.08 to 2.57)	1.55 (1.03 to 2.34)
>5.2	212	3.42 (2.35 to 4.99)	3.77 (2.62 to 5.42)	97	1.55 (0.94 to 2.55)	1.53 (0.95 to 2.46)
p Value for trend		<0.0001	<0.0001		0.04	0.02
Per doubling of air nicotine	625	1.30 (1.22 to 1.38)	1.30 (1.23 to 1.38)	311	1.09 (1.00 to 1.19)	1.10 (1.02 to 1.19)
Sex						
Male	302	1.00 (reference)	1.00 (reference)	169	1.00 (reference)	1.00 (reference)
Female	323	0.48 (0.38 to 0.63)	0.57 (0.43 to 0.75)	142	0.44 (0.31 to 0.63)	0.67 (0.45 to 0.99)
Age (years)						
<26	310	1.00 (reference)	1.00 (reference)	137	1.00 (reference)	1.00 (reference)
≥26	315	0.93 (0.73 to 1.18)	0.92 (0.73 to 1.15)	172	1.13 (0.81 to 1.57)	1.18 (0.85 to 1.62)
Region						
Americas	142	1.00 (reference)	1.00 (reference)	127	1.00 (reference)	1.00 (reference)
Eastern Europe	157	0.88 (0.35 to 2.23)	0.55 (0.26 to 1.18)	78	0.41 (0.17 to 0.99)	0.45 (0.21 to 0.97)
Asia	240	2.34 (1.00 to 5.50)	1.62 (0.81 to 3.21)	98	1.76 (0.77 to 4.04)	1.81 (0.89 to 3.67)
Africa	86	1.34 (0.36 to 4.98)	1.25 (0.44 to 3.53)	8	1.85 (0.41 to 8.48)	1.32 (0.35 to 4.95)
Education						
≤High school	410	1.00 (reference)	1.00 (reference)	179	1.00 (reference)	1.00 (reference)
>High school	212	0.72 (0.54 to 0.95)	0.79 (0.61 to 1.02)	130	0.98 (0.69 to 1.39)	0.95 (0.68 to 1.32)
Living with a smoker						
No	352	1.00 (reference)	1.00 (reference)	147	1.00 (reference)	1.00 (reference)
Yes	265	1.11 (0.86 to 1.43)	1.14 (0.90 to 1.44)	159	1.10 (0.80 to 1.53)	1.12 (0.82 to 1.53)
Hair treatment						
Yes	285	1.00 (reference)	1.00 (reference)	142	1.00 (reference)	1.00 (reference)
No	333	1.85 (1.46 to 2.34)	1.40 (1.08 to 1.81)	160	2.44 (1.76 to 3.38)	2.14 (1.49 to 3.07)

Air nicotine models were adjusted for age (<26, ≥26 years), sex, education (≤high school, >high school), living with a smoker, hair treatment, region and for former smoking status for non-smokers. Other variables were further adjusted for air nicotine concentrations ($\log_2$-transformed). p Value for trend assumes a log–log relationship between air and hair nicotine concentrations.
*Estimated using mixed effect models that allow for country-specific intercepts.

hair nicotine among both non-smoking and smoking employees. Our study extends previous findings on elevated hair nicotine concentrations in non-smoking hospitality employees[20–24] using a multi-city approach. In addition, we found that exposure to secondhand smoke is a relevant occupational hazard for both non-smoking and smoking employees. Comprehensive smoke-free legislation is needed to protect hospitality employees from involuntary exposure to tobacco smoke at work.

The negative health impact of exposure to secondhand smoke was well established.[25] Levels of air nicotine and indoor fine particulate matter have been shown to be much greater in bars, restaurants and nightclubs compared with other public places.[3–5 26] The health effects of exposure to secondhand smoke among this occupational group have also been investigated. In 1993, a review of six studies that examined the risk of lung cancer among bar and restaurant employees controlling for active smoking concluded that there is approximately 50% (range: 10%–90%) increased lung cancer risk among these employees compared with the general population.[7] The increased lung cancer risk was attributed to their higher exposure to secondhand smoke. In the UK, among 617 lung cancer, ischaemic heart disease or stroke deaths attributable to secondhand smoke in 2003, 54 deaths were among long-term employees of the hospitality industry and almost half of these deaths were among pub, bar and nightclub employees, despite that smaller size of this sector of the workforce.[27] In New Zealand, a study of 435 bar employees found that among those exposed to secondhand smoke at work, 53% reported lung or throat irritation and 73% wanted to restrict smoking in bars.[28] Non-smokers exposed to secondhand smoke at work have more illness-related absenteeism than non-smokers without work exposure.[29] Increased hair nicotine concentration among non-smoking bar and restaurant workers has also been associated with greater number of behavioural symptoms of nicotine dependence.[30] Finally, reducing secondhand smoke exposure in bars and restaurants has been associated with decreased hair nicotine[21] and salivary[31–34] and urine[35] cotinine concentrations in employees and with decreased respiratory symptoms in studies from Norway,[36] Sweden[37] and the USA (Kentucky and California).[38 39]

Hair nicotine is a reliable and valid biomarker of secondhand smoke exposure with each centimetre of hair reflecting about 1 month of cumulative tobacco smoke exposure.[40–42] In our study, air nicotine was a major determinant of hair nicotine concentrations both in non-smokers and in smokers, although the association was stronger among non-smokers. Other determinants of hair nicotine included sex, with higher concentrations among men, chemical hair treatments including colouring, bleaching and perming in the past month, and region, with lower concentrations in participants from Eastern Europe. The lower concentrations of hair nicotine among participants with chemical hair treatment are consistent with previous findings,[43 44] including studies among hospitality employees from New Zealand[21] and among women participating in a large multi-city study evaluating secondhand smoke exposure in women and children around the world.[15] Lower hair nicotine concentrations in women from Eastern Europe versus other regions were also found in that large study.[15] Employees from

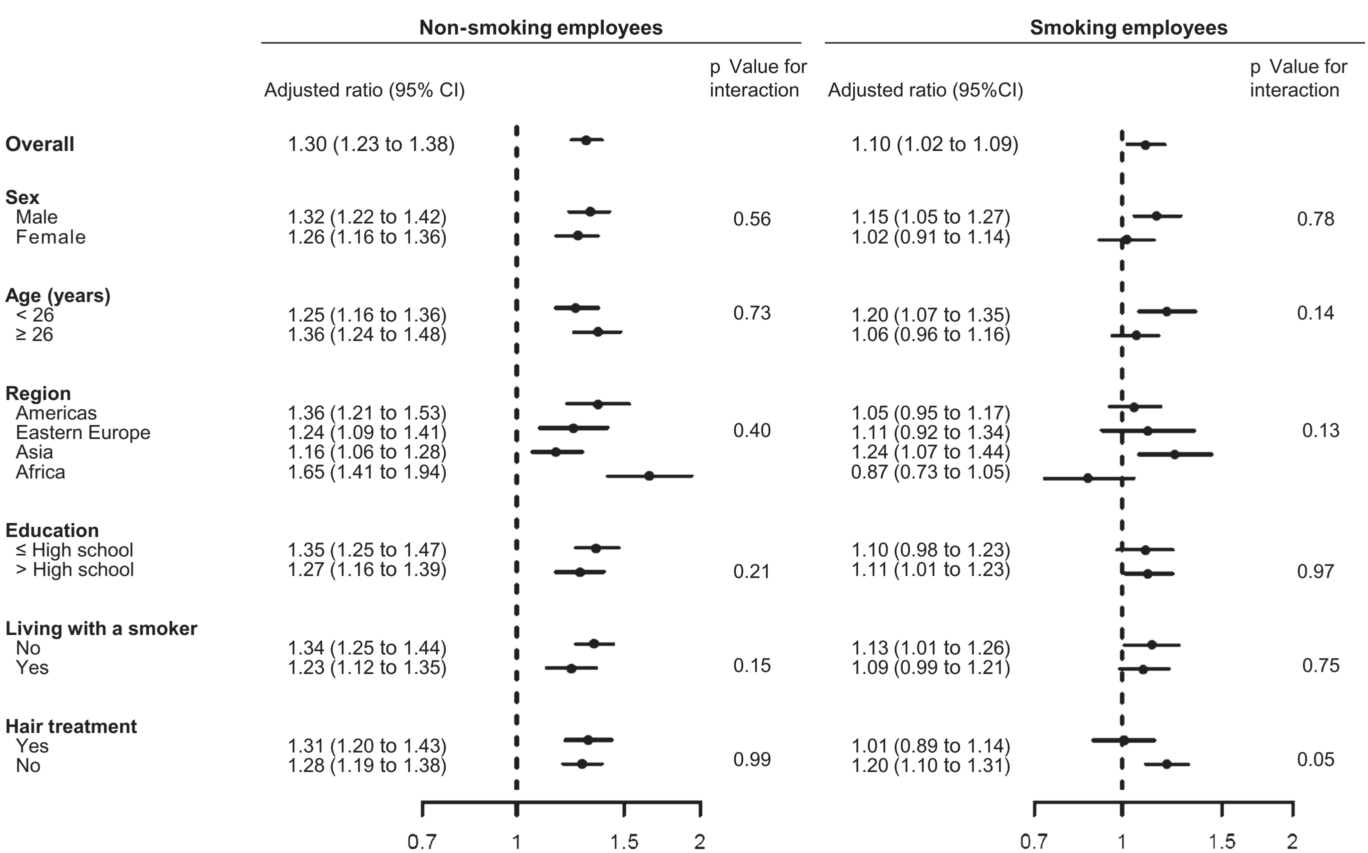

Figure 1 Ratio (95% CI) of the Geometric Mean of Hair Nicotine Concentrations per Doubling of Air Nicotine Concentrations by Employee Characteristics. Points represent the ratio of the geometric mean of hair nicotine concentrations for a doubling in air nicotine concentrations. Horizontal lines represent 95% CIs. Ratios were adjusted for age, sex, education, living with a smoker, hair treatment and region (and former smoking status for non-smokers).

Eastern Europe were more likely to be female and to use more hair treatment, but lower hair nicotine concentrations among Eastern Europe employees could be also be related to differences in hair nicotine uptake by hair colour or other characteristics or by differences in nicotine metabolism. Hair colour and nicotine metabolism could also play a role in explaining the stronger association between air nicotine and hair nicotine among non-smoking employees from Africa (figure 1).

Strengths of the study include the objective measures of secondhand smoke exposure, the multi-city study design and the standardised protocol. A few limitations should be taken into account. First, in most cities, venues and employees were selected by convenience sampling; therefore, results may not be representative of secondhand smoke exposure in a particular city. The participating venues, however, were located in areas of the cities with a high concentration of places where people gather socially. Moreover, the goal of the study was not to estimate the prevalence of secondhand smoke exposure but to evaluate the contribution of secondhand smoke exposure in the workplace to hair nicotine, a biomarker of internal dose. Although hair nicotine concentrations reflect cumulative exposure to tobacco smoke in the past months, air nicotine concentrations were only collected for 7 days. Potential differences in levels of exposure to secondhand smoke during those days could have resulted in underestimation of the relationship between air and hair nicotine concentrations. Also, while we observed lower concentrations of hair nicotine among participants with chemical hair treatment, we are unable to differentiate between different types of chemical treatment. Finally, the response rate was low in some countries, although sensitivity analyses excluding cities with low-response rates yielded similar results (data not shown).

This multi-city study confirms that secondhand smoke exposure remains an important occupational hazard for non-smoking and smoking employees in bars, cafes and nightclubs in the absence of comprehensive smoke-free legislations. At the time of the study, only 18% of venues were smoke free and only one participating city (Montevideo, Uruguay) had comprehensive smoke-free legislation, which prohibited smoking in all public places including bars and nightclubs. Since the completion of the study, comprehensive policies have been introduced in Guatemala; Mexico City, Mexico; Baltimore, USA; Poland and Shanghai, China (online appendix 1). WHO's recent report on the Global Tobacco Epidemic found that since 2008, the number of people protected by comprehensive smoke-free laws has increased >385 million, representing a 6% increase of the world population that is protected.[11] Article 8 of WHO FCTC mandates participating nations to implement policies to prevent exposure to tobacco smoke in indoor workplaces, public transport and indoor public places and workplaces including restaurants, bars and nightclubs.[9 10] Many of these countries are now approaching their sixth year of implementation and are thus required to adopt comprehensive legislation to protect individuals from exposure to secondhand smoke in all indoor workplaces and indoor public places. With the exceptions of Argentina, Armenia, Guyana, Indonesia and the USA, all countries in our study had ratified the FCTC at the time of the study.

In conclusion, the high levels of airborne nicotine found in bars and nightclubs and the contribution of this exposure to employee hair nicotine concentrations support the need for legislation that regulates smoking in these environments and provides complete protection from secondhand smoke for all employees. This is an opportune moment for countries to honour their commitments under the FCTC and expand the number of people protected from secondhand smoke worldwide. In countries with comprehensive legislation, efforts are needed to ensure complete enforcement. By eliminating secondhand tobacco smoke in socialising and hospitality venues, smoke-free legislations can reduce the burden of disease related to secondhand smoke exposure.

What this paper adds

- All bar and nightclub employees, including smoking employees, are exposed to elevated concentrations of secondhand tobacco smoke in the absence of comprehensive smoke-free legislations.
- Increasing air nicotine concentrations in the workplace result in elevated concentrations of hair nicotine concentrations among both non-smoking and smoking employees.
- Secondhand smoke is an occupational hazard and comprehensive smoke-free legislations are needed to protect workers in the hospitality industry.

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Contributors AN-A, JMS and PNB had the idea for the study. AN-A, HW and SS directed the fieldwork. The FAMRI Bar Study Investigators directed the fieldwork within their country. AN-A, EAT and MRJ prepared the study database and planned statistical analyses. PNB is responsible for the air nicotine and hair laboratory analysis, quality control and assurance and interpretation of air and hair nicotine data. MRJ and AN-A analysed the data and drafted the manuscript. All authors participated in the interpretation of the results and contributed to the writing of the manuscript.

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