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Occupational secondhand smoke is the main determinant of hair nicotine concentrations in bar and restaurant workers

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ABSTRACT

Objective: To evaluate the relative contribution of occupational vs. non-occupational secondhand tobacco smoke exposure to overall hair nicotine concentrations in non-smoking bar and restaurant employees.
Method: We recruited 76 non-smoking employees from venues that allowed smoking ($n=9$), had mixed policies (smoking and non-smoking areas, $n=13$) or were smoke-free ($n=2$) between April and August 2008 in Santiago, Chile. Employees used personal air nicotine samplers during working and non-working hours for a 24-h period to assess occupational vs. non-occupational secondhand tobacco smoke exposure and hair nicotine concentrations to assess overall secondhand tobacco smoke exposure.
Results: Median hair nicotine concentrations were 1.5 ng/mg, interquartile range (IQR) 0.7 to 5.2 ng/mg. Time weighted average personal air nicotine concentrations were higher during working hours (median 9.7, IQR 3.3–25.4 μg/m^3) compared to non-working hours (1.7, 1.0–3.1 μg/m^3). Hair nicotine concentration was best predicted by personal air nicotine concentration at working hours. After adjustment, a 2-fold increase in personal air nicotine concentration in working hours was associated with a 42% increase in hair nicotine concentration (95% confidence interval 14–70%). Hair nicotine concentration was not associated with personal air nicotine concentration during non-working hours (non-occupational exposure).
Conclusions: Personal air nicotine concentration at working hours was the major determinant of hair nicotine concentrations in non-smoking employees from Santiago, Chile. Secondhand tobacco smoke exposure during working hours is a health hazard for hospitality employees working in venues where smoking is allowed.

1. Introduction

Exposure to secondhand tobacco smoke (SHS) remains a major public health problem worldwide (Jones et al., 2013; Oberg et al., 2011). In the absence of smoke-free legislations, studies in Europe, United States, Australia and South America have identified bars, pubs, restaurants and discos as the work environments with the highest concentrations of tobacco smoke (Bolte et al., 2008; Gorini et al., 2008; Navas-Acien et al., 2004; Nebot et al., 2005; Rosen et al., 2008; Siegel and Skeer, 2003) resulting in high secondhand tobacco smoke exposure among the employees who work for long hours in these venues (Agbenyikey et al., 2011; Jones et al., 2013).

Chile had implemented a partial smoking ban in public venues at the time of this research (National Congress of Chile, 2006). The legislation required separate areas for smokers and nonsmokers in bars, restaurants and pubs with surface for public use exceeding 100 m^2. In venues with surface less than 100 m^2, the owner could decide the smoking status of the venue (National Congress of Chile, 2006). Workers in venues that allowed smoking were unprotected compared to workers in smoke-free venues. Similar to other research conducting environmental assessment in hospitality

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venues (Apelberg et al., 2013), we found that air nicotine concentration in smoking venues from Santiago, Chile, was 10 times higher than concentrations of smoke-free venues (Erazo et al., 2010).

To assess internal dose, previous studies in hospitality venues have measured and compared secondhand tobacco smoke biomarkers among employees (e.g. urine cotinine or hair nicotine) according to the smoking status of the workplace (Al-Delaimy et al., 2001; Ellingsen et al., 2006; Jensen et al., 2010). Some studies have also evaluated the relationship between environmental measures in the workplace (e.g. air nicotine concentrations or particulate matter $< 2.5\ \mu m^2$) and secondhand tobacco smoke biomarker concentrations (Agbenyikey et al., 2011; Jones et al., 2013; Valente et al., 2007). However, no other study of bar and restaurant employees have assessed both work and non-work environment simultaneously and linked those environmental data with a tobacco-specific biomarker of internal dose. Non-occupational sources of SHS, especially smoking exposure at home, could be particularly important in countries with a relatively high prevalence of smoking, such as Chile (National Health Survey, Chile, 2009–2010).

The main objective of this study was to evaluate the relative contribution of occupational vs. non-occupational secondhand tobacco smoke exposure to overall exposure as measured by hair nicotine concentrations in non-smoking employees in bars and restaurants in Santiago, Chile. To measure occupational vs. non-occupational secondhand tobacco smoke exposure, we used personal air nicotine samplers during working and non-working hours for a 24-h period. To measure overall secondhand tobacco smoke exposure, we used hair nicotine, because it is a reliable and accurate biomarker of past tobacco smoke exposure that integrates multiple sources, including exposure at work, home and transportation.

2. Methods

2.1. Study design and participant recruitment

This cross-sectional study is part of a larger tobacco control project conducted between April and August 2008 in Santiago, Chile, aimed to evaluate a partial smoking ban legislation that had been enacted in Chile in 2006 (National Congress of Chile, 2006). We visited bars and restaurants located in 4 neighborhoods with a high concentration of public places where people, especially young adults, spend time or gather socially. A total of 63 venues were visited using a door-to-door sampling strategy. In each venue we explained the study aims to the manager/owner and evaluated eligibility (be bar, pub or restaurant and have two or more non-smoking employees). A non-smoking employee was defined as a worker who stated that he/she had not smoked in the last year. To be included in the study, owners/managers had to agree to answer a questionnaire, allow install air nicotine samplers in the venues for one week and allow the employees to be interviewed.

Of 63 visited venues, 25 refused to participate and 13 did not meet the inclusion criteria. We also excluded one venue because the air sampler was lost during the fieldwork. For this report we used information from 24 venues (9 allowed smoking, 13 had smoking area and non-smoking area (mixed) and 2 were smoke-free). To be included in the study, employees from the venues had to be non-smoking, be present on the first day of venue air nicotine concentration measurement, answer a questionnaire, wear two personal passive air samplers to measure air nicotine concentrations during 24 h (one sampler for working hours and another sampler for non-working hours), be present the next day at the same hour (to collect the personal samplers), and provide a hair sample. A total of 97 non-smoking workers were invited to participate and 2 refused. All participants provided informed consent and the study protocol was approved by the ethical committee of the Faculty of Medicine, Universidad de Chile, Santiago, Chile. The feasibility of the study procedures were assessed in a pilot study. Data were collected by trained fieldworkers using a standardized protocol.

2.2. Data collection

After scheduling an appointment with the owner/manager, the field team visited the venue during working hours but before the venue was open to public for data collection. Trained interviewers administered two standardized questionnaires (one for the owner/manager and another for the non-smoking employee). The owners/managers were asked data on general characteristics of the bar or restaurant, including smoking policy (allowed, total ban, or mixed), opening hours, legal occupancy, self-reported average occupancy, and ventilation systems. The non-smoking employees were asked to provide information on demographic characteristics (age, gender, education, job title (bartenders/ waiters/ owner/ manager/ cook)), chemical hair treatment, number of work days per week in the venue, work shift, hours of secondhand tobacco smoke exposure per week at work and/or in other environments and number of cigarettes smoked per day by other household members.

2.2.1. Air nicotine

After the interviews with owners and employees, the fieldworkers placed the air nicotine samplers in the venue and provided air nicotine samplers to the employees. The passive samplers were designed and analyzed following the method originally developed by Hammond and Leaderer (1987). The sampler consists of a 37-mm plastic cassette containing a support pad, a filter treated with sodium bisulfate and a polycarbonate diffusion membrane, which were assembled at the Secondhand Smoke Exposure Assessment Laboratory of the Johns Hopkins Institute for Global Tobacco Control.

To measure air nicotine concentrations in each venue, the fieldworker placed two samplers at around two-meter height in a central area in the venues that allowed smoking and in the smoke-free venues. In mixed venues, the fieldworker placed one sampler in the smoking section and another sampler in the non-smoking section making sure that the front side of the sampler faced the room being monitored. After the sampler was placed, the fieldworker filled the sampler sheet information recording the date and time installation. 10% duplicate samplers following the same process were used during the fieldwork. All venue samplers were left for 7 days (sampling for 24 h per day). Fieldworkers visited the venue at an hour of maximum public attendance to verify the correct placement of the sampler and to record information on the estimated number of customers and the number of smokers over a period of 15 min.

The measurement of personal air nicotine concentration started immediately after finishing the employee's questionnaire. To measure personal exposure to secondhand tobacco smoke during working (occupational) and non-working hours (non-occupational), each participant was provided with and instructed to use two samplers, one personal sampler during working hours and another personal sampler to be used out of working hours (since the employee left work until he/she returned the next day) up to a total of 24-h (Aceituno et al., 2010). The fieldworker showed the participant how to clip the personal sampler to his/her clothes, to store them safely at the end of the sampling time (covered with caps and isolated in plastic containers), and to record the amount of sampling time for each sampler. At the end of the 24-h sampling period, the fieldworkers retrieved the personal samplers and stored them in a smoke-free place until shipment to the Exposure Assessment Facility at the Bloomberg School of Public Health.

In the laboratory, air nicotine concentration was analyzed using gas chromatography with nitrogen selective detection. The airborne concentration of nicotine was calculated by dividing the amount of nicotine collected by each filter (μg) by the volume of air sampled (m^3). The volume of air sampled is equal to the minutes of sampling multiplied by the sampler flow rate (25 ml/min) (Hammond and Leaderer, 1987). The limit of detection was $0.014\ \mu g/m^3$. Three personal samplers used during non-working hours had nicotine concentration below this value and were replaced by the limit of detection divided by square root of 2 (Hornung and Reed, 1990).

2.2.2. Hair nicotine

A small hair sample (approximately 30–50 strands) was cut near the hair root from the back of the scalp, where there is most uniform growth pattern among individuals. Hair samples were stored in a smoke-free environment at room temperature and shipped in labeled plastic bags to the Exposure Assessment Facility at the John Hopkins Bloomberg School of Public Health for analysis of nicotine content. After removing the nicotine attached externally to the hair using a 30 min bath in dichloromethane, the hair samples were digested with sodium hydroxide and the nicotine extracted using dichloromethane. The extracts were analyzed by gas chromatography with mass detector (Kim et al., 2009). To calculate the hair nicotine concentration, the amount of nicotine (ng) was divided by the mass of hair analyzed (mg). Seven samples with hair nicotine concentrations below the limit of detection (0.02 ng/mg) were replaced by the limit of detection divided by square root of 2 (Hornung and Reed, 1990).

2.3. Statistical analyses

Descriptive analyses (proportion, median, interquartile range, and range) were conducted to summarize participants and venue characteristics. To determine if hair nicotine concentration, personal air nicotine (at working hours and non-working hours) and venue air nicotine were normally distributed, we applied Shapiro–Wilk test. Since data did not distribute normally, they were transformed to the natural logarithm. The bivariate relationship between hair nicotine concentrations and air nicotine concentration (raw data) was explored using Spearman correlation.