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## Secondhand tobacco smoke exposure and pulmonary function among non-smoking employees of bar and restaurants in Santiago, Chile

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## Secondhand tobacco smoke exposure and pulmonary function among non-smoking employees of bar and restaurants in Santiago, Chile

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## Abstract

**Introduction.** The workplace remains a significant source of secondhand smoke (SHS) exposure. This pollutant is known to be associated with respiratory and cardiovascular problems, but its effects on specific pulmonary function parameters remain largely unexplored. The objectives of this study were to measure SHS exposure among non-smoking employees of bar and restaurants in Santiago, Chile and to evaluate the effects of such exposure on pulmonary function.

**Methods.** Cross-sectional design. The study sample included non-smoking workers from 57 restaurants and bars in Santiago, Chile. The outcome variable was pulmonary function and the exposure variables were urine cotinine concentration, a biomarker for current SHS exposure, and years of SHS exposure in the workplace as proxy of chronic exposure. Personal and occupational variables were also recorded. Data analysis was performed using linear regression models adjusted by confounders.

**Results.** The median age of the workers was 35 years and the median employment duration at the analysed venues was 1 year. Workers in smoking facilities reported greater SHS exposure (36 hours per week) than workers in smoke-free locations (4 hours per week). Urine cotinine levels were inversely correlated with forced vital capacity (FVC), but the finding was not statistically significant ( $\beta = -0.0002$ ; 95% CI: -0.007 to 0.006). Years of exposure to SHS showed to be significantly associated with FEF<sub>25 / 75</sub> ( $\beta = -0.006$ ; 95% CI: -0.010 to -0.0004).

**Conclusion.** These findings suggest that cumulative exposure to SHS at work may contribute to deterioration of pulmonary function in non-smoking employees.

**Keywords:** Secondhand smoke exposure, chronic exposure, pulmonary function, urine cotinine, workers.

#### Strengths and limitations of this study

- The effects of occupational SHS exposure on specific pulmonary function parameters has been scarcely explored.
- This study is the first in Chile to evaluate occupational SHS exposure and its association with specific pulmonary function parameters.
- The use of the variable "number of years exposed to SHS at workplace" was appropriate to studied chronic SHS exposure.
- Our sample included mainly young workers being reasonable to infer that the sample not accumulated sufficient years of SHS exposure to register greater changes in pulmonary function.
- Daily fluctuations of the timing of the spirometry measurements may have affected the results, since these were performed at various times of day, according to the availability and shifts of the workers and establishments.

#### Introduction

Secondhand smoke (SHS) is the smoke that remains in the air after someone has consumed tobacco, including the smoke coming from the burning end of the cigarette and the smoke exhaled by the smoker<sup>1, 2, 3, 4</sup>. SHS is a common indoor pollutant in restaurants and bars

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4 that poses a serious health risk for non-smokers as it contains over 50 substances known to  
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6 be carcinogenic in humans. There is no known safe exposure level <sup>1,4</sup>.

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9 Because SHS contains the same toxic substances that a smoker inhales, SHS exposure can  
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11 lead to the same health problems associated with active smoking <sup>5</sup>, with risk levels  
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13 increasing as a function of hours of exposure <sup>6,7,8,9,10</sup>. Common scenarios associated with  
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15 chronic SHS exposure include living with a spouse or parent who smokes and working in a  
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17 location where smoking is allowed <sup>2,4</sup>. Previous studies have not been consistent in  
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19 showing a decline in specific pulmonary function parameters in people affected by SHS  
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21 exposure at work or at home (Table 1). This lack of evidence may be attributable to the  
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23 methods use to measure SHS exposure, which range from self-report <sup>11,12,13,14</sup> to  
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25 measurement of exposure biomarkers <sup>11,12,13,14,15</sup>.

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**Table 1. Effects of passive smoking on pulmonary function parameters**

Author (year)	Sample size	Exposure assessment	Source of exposure	Main results
<b>Kunzli et al. (2000)</b>	3534	Questionnaire	Occupational	FEV <sub>1</sub> (β= -0.1%; CI95% -1.3 to 1.1%) FVC (β= -0.7%; CI95% -0.4 to 1.8%) FEF 25/75 (β=-1.9%; CI95% -4.2 to 0.5%)
<b>Janson et al. (2001)</b>	7882	Questionnaire	Total exposure*	FEV <sub>1</sub> (β= -63 ml; CI95% -111 to -15 ml)
<b>Chen et al. (2001)</b>	301	Questionnaire. Are you regularly exposed to tobacco smoke from other people? Three sources of exposure of SHS were given; workplace, home, and other places. On average, for how many hours a day are you exposed to other people's tobacco smoke?. Blood cotinine	Occupational	FEV <sub>1</sub> (β= -254 ml; CI95% -84 to -240 ml) FVC (β= -273 ml; CI95% -60 to -480 ml)
<b>Eisner (2002)</b>	10581	Questionnaire. Does anyone who lives here smoke cigarettes in the home? At work, how many hours per day are you close enough of people who smoke so that you can smell the smoke? Exposure dif was ≥ 1 hr a day. Blood cotinine.	Total exposure*	FEV <sub>1</sub> (β= -100 ml; CI95% -143 to -56 ml) FVC (β= -119 ml; CI95% -168 to -69 ml) FEV <sub>1</sub> /CVF (β= -1,77%; CI 95% -2.18 to -1.36%)
<b>Fidan et al. (2004)</b>	207	Questionnaire	Occupational	FEV <sub>1</sub> (β= -5.1%; p value=0.011) FVC (β= -3.4%; p value=0.080)
<b>Alipour et al. (2005)</b>	302	Questionnaire	Occupational Total exposure*	FEV <sub>1</sub> (β= 2.45%; CI95% -5.17 to -0.28%) FEV <sub>1</sub> (β= 2.90%; CI95% -5.59 to -0.23%) FVC (β= -3.16%; CI95% -5.67 to -0.64%) FEF 25/75 (β= -9.87%; p value=0.009)
<b>Fahim et al. (2012)</b>	55	Questionnaire	Occupational	FVC (β= -6%; p value=0.041) VEF <sub>1</sub> /FVC (β= -4.2%; p value=0.001) FEF <sub>75</sub> (β= -7.5%; p value=0.017)

One of the most common ways of measuring SHS exposure is measuring concentration of cotinine, the principle metabolite of nicotine. Cotinine can be measured in the blood or urine and shows high sensitivity and specificity for acute SHS exposure (over the past 3–4 days), although some authors have also used it to evaluate longer-term exposure<sup>16, 17, 18</sup>. Chronic exposure to SHS has been measured through questionnaire and by hair nicotine concentration<sup>19, 20</sup>.

In 2010, the time at which this study was performed, Chilean law prohibited tobacco smoking in public areas and workplaces. However, there were exceptions for "hospitality"

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4 venues, such as casinos, bars, pubs, restaurants, and cafés. Bars, pubs, and restaurants with  
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6 areas smaller than 100 m<sup>2</sup> could choose to allow smoking indoors or not, while facilities  
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8 with an area larger than 100 m<sup>2</sup> were required to offer separate sections for smokers and  
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10 nonsmokers. Therefore, "hospitality" workers were unprotected from SHS exposure,  
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12 becoming the workplace, in many cases, the main source of SHS exposure<sup>21,22</sup>.  
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16 The objectives of this study were to measure SHS exposure among non-smoking workers in  
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18 restaurants and bars in Santiago, Chile and to evaluate the effects of such exposure on  
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20 pulmonary function.  
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## 23 **Methods**

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25 This cross-sectional study was performed as part of a larger project, "Impact of involuntary  
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27 exposure to tobacco smoke on respiratory health: study of pub and restaurant workers",  
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29 carried out in Santiago, Chile between September 2010 and January 2011. This study was  
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31 approved by the University of Chile School of Medicine's Ethics Committee.  
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### 34 *Population and sample*

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36 The selection process for participating facilities has been previously described in detail<sup>23</sup>.  
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38 In brief, the sampling framework included the 5 municipalities with the largest numbers of  
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40 facilities, according to data provided by the National Institute of Statistics (Spanish  
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42 acronym INE, for *Instituto Nacional de Estadísticas*). Study staff visited 690 locations and  
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44 used a brief survey to record the venue's name, address, type of facility (bar/pub, restaurant,  
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46 or other), smoking status (smoking allowed in all areas; designated smoking/non smoking  
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48 areas; or smoke-free), and number of non-smoking workers. Of the 690 facilities, 207 met  
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50 inclusion criteria (be a bar-pub or restaurant and have non-smoking workers). Of them, 108  
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52 were visited or contacted by telephone to invite the owner or manager to participate in the  
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4 study. In 63 establishments they agreed to participate (58%). For logistical reasons, only 59  
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6 of the facilities were included<sup>23</sup>. Non-smoking workers in these facilities were then invited  
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8 to participate in the study. Workers were excluded if they did not provide a urine sample  
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10 (n=5) or had a contraindication for spirometry (n=1)<sup>24, 25</sup>. A total of 92 non-smoking  
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12 workers participated in the study after providing written informed consent.  
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#### 15 16 *Outcome variables*

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18 *Pulmonary function parameters:* Certified personnel used an *Easy One Diagnostic*® to  
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20 measure forced vital capacity (FVC) and forced expiratory volume in 1s (FEV<sub>1</sub>), and then  
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22 calculated the FEV<sub>1</sub> to FVC ratio (FEV<sub>1</sub>/FVC) and forced expiratory flow as 25%–75% of  
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24 FVC (FEF<sub>25-75</sub>). Spirometry measurements were performed during working hours. In  
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26 compliance with international norms on collecting and interpreting spirometry data, age,  
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28 sex, weight, height, and race of each participant were also recorded<sup>24, 25</sup>. A maximum of 8  
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30 spirometry trials were performed. The criteria for including a participant's spirometry data  
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32 in the analysis was achieving at least 3 acceptable and 2 reproducible trials, as described in  
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34 the norms published by Spanish Society of Pneumology and Thoracic Surgery (Spanish  
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36 acronym SEPAR, for *Sociedad Española de Neumología y Cirugía Torácica*)<sup>24, 25</sup>. The  
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38 equipment was calibrated weekly.  
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#### 45 46 *Exposure variables*

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48 *Urine cotinine concentration.* Each worker was asked to provide urine sample the morning  
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50 after the spirometry measurements. The sample was provided, retrieved, and frozen on the  
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52 same day. Urine cotinine concentration was measured using ELISA at a sensitivity of 1  
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54 ng/ml. The cut-off value typically used in the literature to distinguish smokers from non-  
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4 smokers is 10 ng/ml<sup>26</sup>. As a quality control, duplicate samples were obtained and analyzed.  
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7 There was a strong correlation between the original and duplicate samples (Spearman's  
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9 correlation=0.96; p-value=0.0005). Chronic exposure to SHS was measured as *the number*  
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11 *of years exposed to SHS at workplace* (number of years worked at their 3 most recent job  
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13 positions and whether it involved SHS exposure).  
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#### 15 16 17 *Covariables*

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19 The questionnaire included items about the participant's health history (asthma diagnosis,  
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21 smoking habits); occupational history (job function at the facility, secondary employment at  
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23 another facility, number of hours per day and days per week worked); occupational  
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25 exposure (number of hours per day and days per week exposed to SHS); and the type of  
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27 facility (smoking, mixed, or non-smoking).  
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#### 30 31 32 *Statistical analysis*

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34 Data analysis was performed using the program STATA 12. The quantitative variables  
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36 were assessed for normality using the Shapiro-Wilk test. Descriptive statistics were  
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38 calculated, including median and interquartile ranges (P<sub>25</sub>–P<sub>75</sub>) for quantitative variables  
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40 and relative frequency for qualitative variables. Quantitative exposure variables and  
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42 covariables, such as number of hours per week of SHS exposure or age were dichotomized  
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44 using the median as cutoff. Kruskal Wallis test and Wilcoxon test were used to assess  
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46 difference of pulmonary parameters and exposure variables between the categories of the  
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48 covariables. Finally, the association between pulmonary function parameters and exposure  
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50 to SHS was analyzed using multiple linear regression models adjusted by covariates  
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potentially associated with both, the outcome and the exposure considering a p-value of  $<0.10$ <sup>27</sup>, as well as variables commonly controlled for in the literature.

## Results

A total of 17 participants (18.5%) were excluded due to spirometry results that failed to meet the criteria for acceptability and reproducibility. The final sample was 75 workers. Median age was 35 years (P<sub>25</sub>–P<sub>75</sub>: 19–68 years), and 61% of participants were male. On average, participants had worked at the studied venue for 12 months. Independent of the facility type, the sample was mainly composed of waiting staff, bartenders, and cashiers (58.7%), followed by owners or managers (28%), and finally cooks (13.3%). The number of hours worked per week was similar for workers in smoking, mixed, and non-smoking facilities. Workers in smoking facilities reported higher number of weekly hours and number of years exposed to SHS compared to workers in mixed and non-smoking facilities (Table 2).

**Table 2. Characteristics of the study sample. Santiago, Chile 2010-2011.**

	Smoking status restaurant/bar/pub		
	Smoking	Mixed	Non-smoking
N° employees (%)	27 (36.0)	31 (41.3)	17 (22.7)
<b>Sociodemographic characteristics</b>			
Age, Median (P <sub>25</sub> -P <sub>75</sub> )	40.0 (32.0-47.0)	35.0 (24.0-47.0)	31.0 (23.0-42.0)
Sex, n (%)			
Male	17 (63.0)	19 (61.3)	10 (59.0)
Scholarship, n (%)			
≤8 years	3 (11.1)	2 (6.5)	-
9-12 years	11 (40.8)	19 (61.3)	11 (64.7)

>12 years	13 (48.1)	10 (32.2)	6 (35.3)
Asthma, n (%)			
Yes	1 (3.7)	7 (22.6)	-
No	26 (96.3)	24 (77.4)	17 (100)
<b>Occupational exposure</b>			
Job function at the facility, n (%)			
Owners/managers	7 (25.9)	1 (3.2)	13 (76.5)
Wait staff/bartenders/cashiers	13 (48.2)	27 (87.1)	4 (23.5)
Cooks	7 (25.9)	3 (9.7)	-
Number of months of work in the local, Median (P <sub>25</sub> -P <sub>75</sub> )	12.0 (1.0-192.0)	9.0 (1.0-468.0)	12.0 (2.0-60.0)
Number of weekly working hours, Median (P <sub>25</sub> -P <sub>75</sub> )	48.0 (40.0-54.0)	48.0 (40.0-60.0)	45.0 (40.0-48.0)
Number of hour per week exposed to SHS, Median (P <sub>25</sub> -P <sub>75</sub> )	36.0 (21.0-56.0)	28.0 (6.0-48.0)	4.0 (2.0-7.0)
Number of years exposed to SHS workplace, Median (P <sub>25</sub> -P <sub>75</sub> )	3.0 (0.9-7.1)	2.2 (0.8-6.9)	1.5 (0.0-5.0)

As shown in Table 3 we compared the results for pulmonary function and urine cotinine concentration based on covariables. Males had greater pulmonary function values than females, except for FEV<sub>1</sub>/FVC ratio, where no differences were observed. In terms of the occupational exposure variables, employees working in the kitchen had lower values for FVC, FEV<sub>1</sub>, and FEF<sub>25/75</sub> than the group of wait staff, bartenders, cashiers, and managers. Regarding the number of hours per week of SHS exposure and pulmonary function, exposure greater than 26 hours per week was associated with a 0.02% decrease in FEV<sub>1</sub>/FVC and a 230 ml decrease in FEF<sub>25/75</sub>, although these results were not statistically significant. Workers in smoking venues had FEF<sub>25/75</sub> 400 ml lower and FEV<sub>1</sub>/FVC ratios 0.03% lower than those of workers in non-smoking venues. In terms of urine cotinine concentration, owners and managers had the highest levels, followed by kitchen workers

and then finally the group of wait staff, bartenders, and cashiers (44.4 ng/ml, 25.0 ng/ml, and 13.2 ng/ml, respectively). Urine cotinine concentration varied by number of hours per week of SHS exposure as self-reported by participants and by the smoking status of the facility. Workers with over 26 hours per week of SHS exposure had urine cotinine values 24.5 ng/ml higher than those who reported 26 or fewer hours of exposure per week, while workers in smoking facilities show levels of urine cotinine 17.7 ng/ml higher than workers in non-smoking facilities.

**Table 3. Urine cotinine concentration and pulmonary function at non-smoking workers.**

**Santiago, 2010-2011.**

Variables	Pulmonary function parameters				Urine cotinine concentration (ng/ml) Med (P <sub>25</sub> -P <sub>75</sub> )	
	n	FVC ml (RIC)*	FEV <sub>1</sub> ml (RIC)*	FEV <sub>1</sub> /FVC (%)		FEF <sub>25%/75%</sub> (ml)
<b>Sex</b>						
Male	46	4.82 (4.23-5.42)	3.94 (3.41-4.38)	0.81 (0.76-0.84)	3.95 (3.00-4.66)	18.6 (6.2-39.5)
Female	29	3.48 (3.16-3.90)	2.89 (2.65-3.34)	0.81 (0.79-0.89)	3.25 (2.56-3.83)	13.6 (7.3-41.1)
p value ±		0.0001	0.0001	0.116	0.014	0.944
<b>Age</b>						
≤35 years *	38	4.79 (3.93-5.36)	3.91 (3.37-4.38)	0.83 (0.79-0.88)	4.07 (3.27-4.59)	21.4 (5.1-40.7)
>36 year	37	3.78 (3.21-4.42)	2.95 (2.61-3.62)	0.80 (0.78-0.83)	3.12 (2.53-3.95)	15.2 (9.7-38.1)
p value ±		0.0002	0.0001	0.049	0.0009	0.787
<b>Job function at the facility</b>						
Owners/managers	8	4.84 (3.47-6.09)	3.94 (2.66-4.48)	0.77 (0.72-0.80)	3.22 (2.19-3.90)	44.4 (29.3-46.1)
Wait staff/bartenders/cashiers	53	4.42 (3.74-5.17)	3.56 (3.14-4.20)	0.82 (0.79-0.86)	3.94 (3.11-4.59)	13.2 (5.1-39.5)
Cooks	14	3.38 (2.96-4.24)	2.81 (2.56-3.62)	0.82 (0.79-0.86)	3.08 (2.53-3.80)	25.0 (9.7-36.9)
p value +		0.03	0.04	0.04	0.03	0.08
<b>Hours per week exposed to SHS</b>						

≤26 hrs*	39	4.05 (3.58-4.75)	3.44 (2.85-3.91)	0.82 (0.78-0.87)	3.81 (2.89-4.59)	11.3 (3.0-26.6)
>27 hrs	36	4.40 (3.45-5.40)	3.64 (2.89-4.32)	0.80 (0.77-0.84)	3.58 (2.78-4.38)	35.8 (11.6-48.4)
p value±		0.279	0.457	0.173	0.603	0.0003
Facility						
Smoking/mixed	58	4.24 (3.32-5.26)	3.49 (2.85-4.23)	0.81 (0.77-0.84)	3.58 (2.73-4.44)	21.8
Non-smoking	17	4.24 (3.83-4.55)	3.49 (3.28-3.83)	0.84 (0.80-0.88)	3.98 (3.25-4.48)	4.1
p value ±		0.825	0.845	0.06	0.176	0.0012

\*Variable dichotomized in median value; + Kruskal Wallis test; ± Wilcoxon Test

Consistent with the literature, sex, age and weight were significantly associated with pulmonary function parameters (Table 4). In terms of job function, the owners and managers had FEV<sub>1</sub>/FVC values 60% lower and FEF<sub>25/75</sub> values 830 ml lower than the group of wait staff, bartenders, and cashiers. The kitchen workers had 700 ml lower FVC values, 640 ml lower FEV<sub>1</sub> values, and 772 ml lower FEF<sub>25/75</sub> than the group of wait staff, bartenders, and cashiers. Workers in smoking facilities had 413 ml lower FEF<sub>25/75</sub> and 3% lower FEV<sub>1</sub>/FVC than workers in non-smoking venues.

**Table 4. Bivariate association of pulmonary function parameters in non-smokers workers according to covariables of interest.**

	FVC (ml)		FEV <sub>1</sub> (ml)		FEV <sub>1</sub> /FVC (ml)		FEF <sub>25/75</sub> (ml)	
	β (CI95%)	R <sup>2</sup>	β (CI95%)	R <sup>2</sup>	β (CI95%)	R <sup>2</sup>	β (CI95%)	R <sup>2</sup>
<b>Sociodemographic variables</b>								
Sex								
Male	1,260 (0.880 to 1.650)	0.371	0.91 (0.601 to 1.213)	0.321	-0.03 (-0.064 to -0.0003)	0.053	0.61 (0.110 to 1.103)	0.076
Age	-0.03 (-0.05 to -0.02)	0.161	-0.03 (-0.04 to -0.02)	0.237	-0.001 (-0.003 to -0.003)	0.083	-0.037 (-0.055 to -0.019)	0.189
Weight	0.04	0.207	0.02	0.154	-0.001	0.056	0.014	0.029

	(0.02 to 0.05)		(0.01 to 0.04)		(-0.002 to -0.0001)		(-0.004 to 0.034)	
Size								
	0.08	0.596	0.06	0.595	-0.001	0.009	0.052	0.222
	(0.07 to 0.10)		(0.050 to 0.074)		(-0.002 to 0.001)		(0.029 to 0.076)	
Asthma								
Yes	0.04	0.001	-0.17	0.004	-0.054	0.071	-0.673	0.038
	(-0.731 to 0.802)		(-0.750 to 0.422)		(-0.100 to -0.010)		(-1.470 to 0.122)	
<b>Occupational exposure variables</b>								
Job function at the facility								
Wait staff/bartenders/cashiers	<i>Ref.</i>	0.097	<i>Ref.</i>	0.104	<i>Ref.</i>	0.1	<i>Ref.</i>	0.113
Owners/managers	0.37		0.003		-0.06		-0.828	
	(-0.370 to 1.110)		(-0.570 to 0.570)		(-0.113 to -0.021)		(-1.613 to -0.047)	
Cooks	-0.7		-0.64		-0.02		-0.772	
	(-1.290 to -0.120)		(-1.090 to -0.190)		(-0.061 to 0.022)		(-1.391 to -0.151)	
Hours per weekworked								
	0.001	0.0003	-0.003	0.003	-0.001	0.034	-0.014	0.035
	(-0.02 to 0.02)		(-0.02 to 0.01)		(-0.002 to 0.0002)		(-0.02 to 0.003)	
Hours per weekexposedto SHS								
	0.01	0.077	0.01	0.046	-0.0004	0.022	0.002	0.002
	(0.002 to 0.020)		(-0.0005 to 0.014)		(-0.001 to 0.0002)		(-0.008 to 0.011)	
Years of work								
	-0.01	0.005	-0.001	0.0001	0.003	0.061	0.028	0.017
	(-0.06 to 0.03)		(-0.04 to 0.04)		(0.0003 to 0.006)		(-0.021 to 0.078)	
Facility								
Non-smoking	<i>Ref.</i>	0.002	<i>Ref.</i>	0.001	<i>Ref.</i>	0.044	<i>Ref.</i>	0.026
Smoking/mixed	0.1		-0.05		-0.03		-0.413	
	(-0.460 to 0.672)		(-0.486 to 0.381)		(-0.071 to 0.003)		(-1.003 to 0.177)	

### Association between pulmonary function and SHS exposure

The crude model revealed that the association between pulmonary function and urine cotinine concentration was not statistically significant (Table 5). The multivariate analysis was based on a parsimonious model that included the covariate "job function", as this variable was related to pulmonary function and urine cotinine concentration with a  $p$ -value  $< 0.10$ , as well as the variables sex, age, weight, height, and asthma status, all of which are recognized as variables that affect pulmonary function according to SEPAR<sup>24, 27</sup>. The

adjusted model did not demonstrate a significant relation between urine cotinine concentration and decreased pulmonary function. Conversely, the number of years of SHS exposure in workplace showed an inverse and significant association with FEV<sub>1</sub>. Each year of SHS exposure was associated with a 200 ml decrease in FEV<sub>1</sub> (95% CI -0.042 to -0.001). The other pulmonary function variables were also inversely associated with years of SHS exposure in workplace, although the association in these cases did not reach significance. The adjusted model showed an inverse and in some cases statistically significant association between the number of years of SHS exposure and pulmonary function parameters, specifically in FEF<sub>25/75</sub> ( $\beta = -0.006$ ; 95% CI -0.010 to -0.0004).

**Table 5. Crude and adjusted association between pulmonary function parameters and SHS exposure of non-smoking workers of bars and restaurants.**

	FVC (ml)		FEV <sub>1</sub> (ml)		FEV <sub>1</sub> /FVC (ml)		FEF <sub>25/75</sub> (ml)	
	$\beta$ (CI95%)	R <sup>2</sup>	$\beta$ (CI95%)	R <sup>2</sup>	$\beta$ (CI95%)	R <sup>2</sup>	$\beta$ (CI95%)	R <sup>2</sup>
<b>Urine cotinine</b>								
Crude model	0.002 (-0.010 to 0.010)	0.002	0.002 (-0.010 to 0.010)	0.003	0.0002 (-0.001 to 0.001)	0.002	0.002 (-0.010 to 0.010)	0.002
Adjusted model	-0.0002 (-0.007 to 0.006)*	0.781	0.001 (-0.003 to 0.006)*	0.795	0.0004 (-0.0003 to 0.001)+	0.33	0.005 (-0.006 to 0.015)+	0.672
<b>Number of years exposed to SHS at work</b>								
Crude model	-0.025 (-0.051 to 0.002)	0.0462	-0.022 (-0.042 to -0.001)	0.061	-0.0008 (-0.002 to 0.0008)	0.013	-0.022 (-0,050 to 0,006)	0.032
Adjusted model	-0.013	0.79	-0.01	0.802	0.0006	0.324	-0.006	0.964



(-0.030 to 0.0025)\*

(-0.022 to 0.002)\*

(-0.001 to 0.002)+

(-0,010 to -0,0004)+

\*Adjusted by sex, age, weight, size and job function at the facility; + Adjusted by sex, age, size, asthma status and job function at the facility

## Discussion

This study is the first in Chile to evaluate occupational SHS exposure and its association with specific pulmonary function parameters. The results indicate that there was an inverse association between the number of years of SHS exposure in workplace and pulmonary function parameters as FEV<sub>1</sub> and FEF<sub>25/75</sub>. In terms of job function, kitchen workers showed lower pulmonary function values than the group of wait staff, bartenders, and cashiers as compared to the owners and managers. One possible explanation for these findings is that the SHS exposure had an additive effect with exposure to other pollutants emitted in the kitchen. In the literature has been reported that workers in kitchens with gas stoves show lower pulmonary function parameters than those in kitchens with electric stoves, due to greater exposure to toxic substances in the air after cooking with gas<sup>28</sup>. In our study, it was not possible to analyze differences according this variable because 100% of the establishments used gas stoves.

Although the present study was not able to find a significant association between FVC and urine cotinine concentration a trend can be observed. A possible explanation for these results is the use of urine cotinine concentration as biomarker of exposure. As noted above, urine cotinine levels reflect recent exposure to tobacco smoke<sup>16, 17, 26</sup> while chronic exposure to SHS is likely implicated in a decline in pulmonary function parameters. In fact, analysis of the exposure variable *number of years of SHS exposure in workplace* (including the 3 most recent job positions) did reveal significant associations between SHS exposure

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4 and FEV<sub>1</sub> ( $\beta = -0.022$ ; 95% CI -0.042 to -0.001) and FEF<sub>25/75</sub> ( $\beta = -0.006$ ; 95% CI -0.010 to -  
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6 0.0004), suggesting that this variable is useful in studies of cumulative SHS exposure. It  
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8 should also be noted that our sample included mainly young workers being reasonable to  
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10 infer that the sample not accumulated sufficient years of SHS exposure to register  
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12 significant changes in pulmonary function. Other studies that have addressed this topic  
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14 have produced varying results<sup>11, 12, 13, 16, 17, 26, 29, 30</sup> reported a significant inverse association  
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16 between SHS exposure (evaluated through self-report) and FVC and FEV<sub>1</sub>. In our study,  
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18 self-reported SHS exposure measured in *hours per week* was inversely correlated with  
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20 FEV<sub>1</sub>/FVC and FEF<sub>25-75</sub>, but the association did not reach significance. As in our study,  
21  
22 Chen et al. did not find a significant association when serum cotinine was assess as  
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24 exposure variable, but did when exposure to SHS was measured through self-report<sup>12</sup>.  
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29 A possible limitation of this study was that the median time worked at the location was  
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31 only about 1 year. About 25% of the sample had worked at the given facility for less than 3  
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33 months, and 75% of the sample had worked at the location for fewer than 2 years. This  
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35 condition of high turnover rate, along with the relative youth of the workers contributes to  
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37 assume that the sample not accumulated enough years of SHS exposure to register  
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39 significant changes in pulmonary function.  
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44 Another potential limitation was the timing of the spirometry measurements. The literature  
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46 reports that pulmonary function varies throughout the day according to circadian rhythm,  
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48 decreasing from a high point in the early morning until about noon and then rising again to  
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50 peak between about 4 and 5 in the afternoon. These daily fluctuations may have affected  
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4 the results, as the lung function measurements were performed at various times of day,  
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6 according to the availability and shifts of the workers and establishments.  
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9 While this study did not find a significant association between years of SHS exposure in  
10 workplace and urine cotinine concentration ( $\beta=0.060$ ,  $p\text{-value}=0.264$ ;  $R^2=0.017$ ) there was  
11 a significant association between weekly hours of exposure and urine cotinine ( $\beta= 0.365$ ,  $p\text{-}$   
12  $value<0.001$ ;  $R^2=0.24$ ). This finding suggests that a self-reported weekly hour of exposure  
13 is an acceptable qualitative biomarker of recent exposure if quantitative measurements are  
14 not available.  
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### 23 **Conclusion**

24 The years of exposure to SHS in workplace as proxy of chronic exposure were inverse and  
25 significantly associated with the FEF<sub>25/75</sub>, and inverse but not significant with FVC and  
26 FEV<sub>1</sub>. These findings suggest that cumulative exposure to SHS at work may contribute to  
27 deterioration of pulmonary function in non-smoking employees.  
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37 participate in this study. Also to the Department of Research of the Universidad de Los  
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### 46 **Competing interest**

47 The authors have no conflict of interest to declare.  
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## References

1. Alwan A. World Health Organization. 2009. WHO Report on the Global Tobacco Epidemic. Implementing smoke-free environments; [Cited 2016 Jun 24]. Available from: [http://who.int/tobacco/mpower/2009/gtcr\\_download/en/index.html](http://who.int/tobacco/mpower/2009/gtcr_download/en/index.html)
2. Bello Sergio, Michalland Susana, Soto Marina, Contreras Carla, Salinas Judith. 2005. Effects in passive smokers of environmental tobacco smoke exposure. *Rev Chil Enf Respir* 21:179-192.
3. Chan-Yeung Moira, Dimich-Ward Helen. 2003. Respiratory health effects of exposure to environmental tobacco smoke. *Respirology* 8(2):131-139.
4. Collishaw Neil E, Kirkbride John, Wigle Donald. 1984. Tobacco smoke in the workplace: an occupational health hazard. *Can Med Assoc J* 131(10):1191-1204.
5. Aceituno Paulina, Iglesias Verónica, Erazo Marcia, Droppelmann Andrea, Orellana Cecilia, Navas-Acién Ana. 2010. The work environment as a source of exposure to secondhand smoke: a study in workers of bars and restaurants of Santiago, Chile. *Rev Med Chile* 138:1517-1523.
6. Coultas David. 1998. Health effects of passive smoking. Passive smoking and risk of adult asthma and COPD: an update. *Thorax* 53(5):381-387.
7. De Vito Eduardo, Rojas Ramón. 2005. Environmental tobacco smoke. *Medicina (B. Aires)* 65(6):545-549.

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8. Jaakkola Maritta, Jaakkola Jouni, Becklake Margaret, Ernst Pierre. 1995. Passive smoking and evolution of lung function in young adults. An 8-year longitudinal study. *J Clin Epidemiol* 48(3):317-327.
9. Jayet Pierre-Yves, Schindler Christian, Schwartz Joel, Kunzli Nino, Zellweger Pierre, Ackermann-Lieblich Ursula, Leuenberger Phillippe. 2005. Passive smoking exposure among adults and the dynamics of respiratory symptoms in a prospective multicenter cohort study. *Scand J Work Environ Health* 31(6):465-473.
10. Rizzi Maurizio, Sergi Margherita, Andreoli Arnaldo, Pecis Marica, Bruschi Claudio, Fanfulla Francesco. 2004. Environmental tobacco smoke may induce early lung damage in healthy male adolescents. *Chest* 125(4):1387-1393.
11. Alipour Shahryar, Deschamps Frédéric, Lesage François-Xavier. 2005. Effects of Environmental Tobacco Smoke on Respiratory Symptoms and Pulmonary Function. *Inhal Toxicol* 18(8):569-573.
12. Chen Ruoling, Tunstall-Pedoe H, Tavendale R. 2001. Environmental tobacco smoke and lung function in employees who never smoked: the Scottish MONICA study. *Occup Environ Med* 58(9):563-568.
13. Fidan F, Cimrin AH, Ergor G, Sevinc C. 2004. Airway disease risk from environmental tobacco smoke among coffeehouse workers in Turkey. *Tob Control* 13(2):161-6.
14. Janson Christer, Chinn Susan, Jarvis Deborah, Zock Jan-Paul, Torén Kjell, Burney Peter. 2001. Effects of passive smoking on respiratory symptoms, bronchial

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responsiveness, lung function, and total serum IgE in the European Community Respiratory Health survey: a cross sectional study. *Lancet* 358(2):103-109.

15. Eisner Mark D. 2002. Environmental tobacco smoke exposure and pulmonary function among adults in NHANES III: impact on the general population and adults with current asthma. *Environ Health Perspect* 110(8):765-70.

16. Benowitz Neal L. 1999. Biomarkers of environmental tobacco smoke exposure. *Environ Health Perspect* 107(2):349-55.

17. Tutka Piotr, Mosiewicz Jerzy, Wielosz Marian. 2005. Pharmacokinetics and metabolism of nicotine. *Pharmacol Rep* 57(2):143-53.

18. Centers for Disease Control and Prevention. 2017. National Report of Human Exposure to Environmental Chemicals; [Cited 2017 March 15]. Available from: <https://www.cdc.gov/exposurereport/>

19. Al-Delaimy WK, Crane J, Woodward A. 2000. Questionnaire and hair measurement of exposure to tobacco smoke. *J Expo Anal Environ Epidemiol* 10:378-384.

20. Al-Delaimy WK. 2002. Hair as a biomarker for exposure to tobacco smoke. *Tob Control* 11:176-182.

21. Iglesias Verónica, Erazo Marcia, Droppelmann Andrea, Steenland Kyle, Aceituno Paulina, Orellana Cecilia, Acuña Marisol, Peruga Armando, Breysse Patrick N, Navas-Acien Ana. 2014. Occupational secondhand smoke is the main determinant of hair nicotine concentrations in bar and restaurant workers. *Environ Res* 132:206–211.

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22. Salud OMS. 2003. “Convenio Marco de la OMS para el control del tabaco”; [Cited 2016 Jun 24]. Available from: [http://www.who.int/fctc/text\\_download/es/](http://www.who.int/fctc/text_download/es/).
23. Muñoz Claudio, Droppelmann Andrea, Erazo Marcia, Aceituno Paulina, Orellana Cecilia, Parro Javiera, Mesias Stephanie, Marchetti Nella, Navas-Acien Ana, Iglesias Verónica. 2016. Occupational exposure to polycyclic aromatic hydrocarbons: A cross-sectional study in bars and restaurants in Santiago, Chile. *Am J Ind Med*. Version of record online: 28 Jun 2016.
24. Burgos Felipe, Casan Pere, Del Campo Félix, Gáldiz Juan, Giner Jordi, González-Mangado Nicolás, Ortega Francisco, Puente Luis, García Francisco, Calle Myriam. SEPAR Regulation: Forced Spirometry. 2013; [Cited 2016 Jun 24]. Available from: <http://www.ics.gencat.cat/3clics/guies/184/img/--guiasepar20131.pdf>
25. Gutiérrez C. Mónica, Beroíza Teresa, Barzone Gisella, Caviedes Iván, Céspedes Iván, Céspedes Juan, Gutiérrez N. Mónica, Moreno Rodrigo, Oyarzún Manuel, Palacios Sylvia, Schonffeldt Patricia. 2007. Spirometry: Procedures Manual. Chilean Society of Respiratory Diseases, 2006. *Rev Chil Enf Respir* 23:31-42.
26. Vine Marilyn, Hulka Barbara, Margolin Barry, Truong Young, Hu Ping-chuan, Schramm Margaret, Griffith Jack, McCann Margaret, Everson Richard. 1993. Cotinine Concentrations in Semen, Urine, and Blood of Smokers and Nonsmokers. *Am J Public Health* 83(9):1335-1338.
27. Tong Shilu, Lu Ying. 2001. Identification of confounders in the assessment of the relationship between lead exposure and child development. *Ann Epidemiol* 11(1): 38-45.



- 1  
2  
3  
4 28. Wong Tze Wai, Wong Andromeda H, Lee Frank S, Qiu Hong. 2011. Respiratory health  
5 and lung function in Chinese restaurant kitchen workers. *Occup Environ Med* 68(10):746-  
6  
7 752.  
8  
9  
10  
11  
12 29. Kunzli N, Schwartz J, Stutz EZ, Ackermann-Lieblich U, Leuenberger P. 2000.  
13 Association of environmental tobacco smoke at work and forced expiratory lung function  
14 among never smoking asthmatics and non-asthmatics. The SAPALDIA-Team. Swiss Study  
15 on Air Pollution and Lung Disease in Adults. *Soz Praventivmed* 45(5):208-17.  
16  
17  
18  
19  
20  
21  
22 30. Skogstad M, Kjaerheim K, Fladseth G, Gjølstad M, Daae HL, Olsen R, Molander P,  
23 Ellingsen DG. 2006. Cross shift changes in lung function among bar and restaurant workers  
24 before and after implementation of a smoking ban. *Occup Environ Med* 63:482-487.  
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## Contributorship statement

Parro Javiera. Substantial contributions to the conception and design of the work on pulmonary function parameters; acquisition, analysis and interpretation of data, drafting the work, and final approval of the version to be published;

Aceituno Paulina. Substantial contributions to the conception and design of the work, revising it critically for important intellectual content, final approval of the version to be published.

Droppelman Andrea. Substantial contributions to the conception, design of the work and interpretation of exposure data, final approval of the version to be published.

Mesías Sthepanie. Substantial contributions to the acquisition and analysis of exposure data, final approval of the version to be published.

Muñoz Claudio. Substantial contributions to the acquisition, analysis and interpretation of data, final approval of the version to be published.

Marchetti Nella. Substantial contributions to the conception of the work and interpretation of data, final approval of the version to be published.

Iglesias Verónica. Substantial contributions to the conception and design of the work, analysis and interpretation of data for the work; drafting the work, final approval of the version to be published, agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>YES</b>
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>YES</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>YES</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>YES</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>YES</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>YES</b>
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants <b>YES</b>
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>YES</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>YES</b>
Bias	9	Describe any efforts to address potential sources of bias <b>YES</b>
Study size	10	Explain how the study size was arrived at <b>YES</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b>YES</b>
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
		(b) Describe any methods used to examine subgroups and interactions
		(c) Explain how missing data were addressed
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy <b>YES</b>
		(e) Describe any sensitivity analyses <b>NO</b>

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<b>Results</b>		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <b>YES</b>
		(b) Give reasons for non-participation at each stage <b>YES</b>
		(c) Consider use of a flow diagram <b>NO</b>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>YES</b>
		(b) Indicate number of participants with missing data for each variable of interest <b>YES</b>
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <b>YES</b>
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures <b>YES</b>
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <b>YES</b>
		(b) Report category boundaries when continuous variables were categorized <b>YES</b>
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period <b>NO</b>
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>NO</b>
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives <b>YES</b>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <b>YES</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>YES</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>YES</b>
<b>Other information</b>		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <b>YES</b>

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Secondhand tobacco smoke exposure and pulmonary function: a cross-sectional study among non-smoking employees of bar and restaurants in Santiago, Chile

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Manuscripts

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3 **Secondhand tobacco smoke exposure and pulmonary function: a cross-sectional**  
4 **study among non-smoking employees of bar and restaurants in Santiago, Chile.**  
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## Abstract

**Introduction.** The workplace remains a significant source of secondhand smoke (SHS) exposure. This pollutant is known to be associated with respiratory and cardiovascular problems, but its effects on specific pulmonary function parameters remain largely unexplored. The objectives of this study were to measure SHS exposure among non-smoking employees of bar and restaurants in Santiago, Chile and to evaluate the effects of such exposure on pulmonary function.

**Methods.** Cross-sectional design. The study sample included non-smoking workers from 57 restaurants and bars in Santiago, Chile. The outcome variable was pulmonary function and the exposure variables were urine cotinine concentration, a biomarker for current SHS exposure, and years of SHS exposure in the workplace as proxy of chronic exposure. Personal and occupational variables were also recorded. Data analysis was performed using linear regression models adjusted by confounders.

**Results.** The median age of the workers was 35 years and the median employment duration at the analysed venues was 1 year. Workers in smoking facilities reported greater SHS exposure (36 hours per week) than workers in smoke-free locations (4 hours per week). Urine cotinine levels were inversely correlated with forced vital capacity (FVC), but the finding was not statistically significant ( $\beta=-0.0002$ ; 95% CI: -0.007 to 0.006). Years of exposure to SHS showed to be significantly associated with FEF<sub>25 / 75</sub> ( $\beta = -0.006$ ; 95% CI: -0.010 to -0.0004).

**Conclusion.** These findings suggest that cumulative exposure to SHS at work may contribute to deterioration of pulmonary function in non-smoking employees.



**Keywords:** Secondhand smoke exposure, chronic exposure, pulmonary function, urine cotinine, workers.

#### Strengths and limitations of this study

- The effects of occupational SHS exposure on specific pulmonary function parameters has been scarcely explored.
- This study is the first in Chile to evaluate occupational SHS exposure and its association with specific pulmonary function parameters.
- The use of the variable "number of years exposed to SHS at workplace" was appropriate to studied chronic SHS exposure.
- Our sample included mainly young workers being reasonable to infer that the sample not accumulated sufficient years of SHS exposure to register greater changes in pulmonary function.
- Daily fluctuations of the timing of the spirometry measurements may have affected the results, since these were performed at various times of day, according to the availability and shifts of the workers and establishments.

#### Introduction

The secondhand smoke (SHS) is the smoke that remains in the air after someone has consumed tobacco, including the smoke coming from the burning end of the cigarette (side-stream smoke) and the smoke exhaled by the smoker (mainstream smoke)<sup>1, 2, 3, 4, 5</sup>.

Exposure to side-stream smoke is more harmful than exposure to mainstream smoke as it contains a greater amount of toxic gases and smaller particles that reach greater depth in the

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3 lungs when inhaled<sup>6</sup>. SHS is a common indoor pollutant in restaurants and bars that poses  
4 a serious health risk for non-smokers as it contains over 50 substances known to be  
5 carcinogenic in humans<sup>7,8</sup>. There is no known safe exposure level<sup>1,4</sup>. Some of the highest  
6 and most sustained occupational exposure to SHS occur in bar staff, with non-smoking  
7 areas providing only limited protection<sup>9</sup>.

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10 SHS exposure can lead to the same health problems associated with active smoking<sup>1,7,8</sup>,  
11 with risk levels increasing as a function of hours of exposure<sup>10,11,12,13,14</sup>. Common  
12 scenarios associated with chronic SHS exposure include living with a spouse or parent who  
13 smokes and working in a location where smoking is allowed<sup>3,5</sup>. Previous studies have not  
14 been consistent in showing a decline in specific pulmonary function parameters in people  
15 affected by SHS exposure at work or at home<sup>9,15,16,17,18,19,20</sup>. This lack of evidence may  
16 be attributable to the methods use to measure SHS exposure, which range from self-report  
17 to measurement of exposure biomarkers<sup>15,16,17,18,19</sup>.

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20 One of the most common ways of measuring SHS exposure is measuring concentration of  
21 cotinine, the principle metabolite of nicotine. Cotinine can be measured in the blood or  
22 urine and shows high sensitivity and specificity for acute SHS exposure (over the past 3–4  
23 days), although some authors have also used it to evaluate longer-term exposure<sup>21,22,23</sup>.  
24 Chronic exposure to SHS has been measured through questionnaire and by hair nicotine  
25 concentration<sup>24,25</sup>.

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28 In 2010, the time at which this study was performed, Chilean law prohibited tobacco  
29 smoking in public areas and workplaces. However, there were exceptions for "hospitality"  
30 venues, such as casinos, bars, pubs, restaurants, and cafés. Bars, pubs, and restaurants with  
31 areas smaller than 100 m<sup>2</sup> could choose to allow smoking indoors or not, while facilities

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3 with an area larger than 100 m<sup>2</sup> were required to offer separate sections for smokers and  
4 nonsmokers. Therefore, "hospitality" workers were unprotected from SHS exposure,  
5 becoming the workplace, in many cases, the main source of SHS exposure<sup>26,27</sup>.  
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10 The objectives of this study were to measure SHS exposure among non-smoking workers in  
11 restaurants and bars in Santiago, Chile and to evaluate the effects of such exposure on  
12 pulmonary function.  
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## 15 16 17 **Methods**

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19 This cross-sectional study was performed as part of a larger project, "Impact of involuntary  
20 exposure to tobacco smoke on respiratory health: study of pub and restaurant workers",  
21 carried out in Santiago, Chile between September 2010 and January 2011. This study was  
22 approved by the University of Chile School of Medicine's Ethics Committee.  
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### 28 29 *Population and sample*

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31 The selection process for participating facilities has been previously described in detail<sup>28</sup>.  
32 In brief, the sampling framework included the 5 municipalities with the largest numbers of  
33 facilities, according to data provided by the National Institute of Statistics (Spanish  
34 acronym INE, for *Instituto Nacional de Estadísticas*). Study staff visited 690 locations and  
35 used a brief survey to record the venue's name, address, type of facility (bar/pub, restaurant,  
36 or other), smoking status (smoking allowed in all areas; designated smoking/non smoking  
37 areas; or smoke-free), and number of non-smoking workers. Of the 690 facilities, 207 met  
38 inclusion criteria (be a bar-pub or restaurant and have non-smoking workers). Of them, 108  
39 were visited or contacted by telephone to invite the owner or manager to participate in the  
40 study. In 63 establishments they agreed to participate (58%). For logistical reasons, only 59  
41 of the facilities were included<sup>28</sup>. Smoking and non-smoking workers in these facilities were  
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3 invited to participate in the main study. Only those who had not smoked in the last year  
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5 were included in the current study. Workers were excluded if they did not provide a urine  
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7 sample (n=5) or had a contraindication for spirometry (n=1)<sup>29,30</sup>.

#### 10 *Outcome variables*

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12 *Pulmonary function parameters:* Certified personnel used an *Easy One Diagnostic*® to  
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14 measure forced vital capacity (FVC) and forced expiratory volume in 1s (FEV<sub>1</sub>), and then  
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16 calculated the FEV<sub>1</sub> to FVC ratio (FEV<sub>1</sub>/FVC) and forced expiratory flow as 25%–75% of  
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18 FVC (FEF<sub>25-75</sub>). Spirometry measurements were performed during working hours. In  
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20 compliance with international norms on collecting and interpreting spirometry data, age,  
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22 sex, weight, height, and race of each participant were also recorded<sup>29,30</sup>. A maximum of 8  
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24 spirometry trials were performed. The criteria for including a participant's spirometry data  
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26 in the analysis was achieving at least 3 acceptable and 2 reproducible trials, as described in  
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28 the norms published by Spanish Society of Pneumology and Thoracic Surgery (Spanish  
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30 acronym SEPAR, for *Sociedad Española de Neumología y Cirugía Torácica*)<sup>29,30</sup>. The  
31  
32 equipment was calibrated weekly.

#### 33 *Exposure variables*

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35 *Urine cotinine concentration.* Each worker was asked to provide urine sample the morning  
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37 after the spirometry measurements. The sample was provided, retrieved, and frozen on the  
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39 same day. Urine cotinine concentration was measured using ELISA at a sensitivity of 1  
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41 ng/ml. The cut-off value typically used in the literature to distinguish smokers from non-  
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43 smokers is 10 ng/ml<sup>31</sup>. As a quality control, duplicate samples were obtained and analyzed.  
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45 There was a strong correlation between the original and duplicate samples (Spearman's  
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47 correlation=0.96; p-value=0.0005). Chronic exposure to SHS was measured as *the number*  
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3 *of years exposed to SHS at workplace* (number of years worked at their 3 most recent job  
4 positions and whether it involved SHS exposure).  
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### 7 8 *Covariables*

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10 The questionnaire included items about the participant's health history (asthma diagnosis,  
11 smoking habits); occupational history (job function at the facility, secondary employment at  
12 another facility, number of hours per day and days per week worked); occupational  
13 exposure (number of hours per day and days per week exposed to SHS); and the type of  
14 facility (smoking, mixed, or non-smoking).  
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### 21 22 *Statistical analysis*

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24 Data analysis was performed using the program STATA 12. The quantitative variables  
25 were assessed for normality using the Shapiro-Wilk test. Descriptive statistics were  
26 calculated, including median and interquartile ranges (P<sub>25</sub>–P<sub>75</sub>) for quantitative variables  
27 and relative frequency for qualitative variables. Quantitative exposure variables and  
28 covariables, such as number of hours per week of SHS exposure or age were dichotomized  
29 using the median as cutoff. Kruskal Wallis test and Wilcoxon test were used to assess  
30 difference of pulmonary parameters and exposure variables between the categories of the  
31 covariables. Finally, the association between pulmonary function parameters and exposure  
32 to SHS was analyzed using multiple linear regression models adjusted by covariates  
33 potentially associated with both, the outcome and the exposure considering a p-value  
34 of <0.10<sup>32</sup>, as well as variables commonly controlled for in the literature.  
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### 50 51 **Results**

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53 The non-smoking workers evaluated in the study were 92. 17(18.5%) were excluded due to  
54 spirometry results failed to meet the criteria for acceptability and reproducibility. The final  
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sample was 75 workers. Median age was 35 years (P<sub>25</sub>-P<sub>75</sub>: 19-68 years), and 61% of participants were male. 29.3% were former smokers and the median of time they quit smoking was 8.5 years (RIC 2 to 15 years). They were homogeneously distributed at the different facility type. On average, participants had worked at the studied venue for 12 months. Independent of the facility type, the sample was mainly composed of waiting staff, bartenders, and cashiers (58.7%) followed by owners or managers (28%), and finally cooks (13.3%). Workers in smoking facilities reported higher number of weekly hours exposed to SHS compared to workers in mixed and non-smoking facilities (p-value=0.0001) (Table 1).

**Table 1. Characteristics of the study sample. Santiago, Chile 2010-2011.**

	Smoking status restaurant/bar/pub				p value
	Total	Smoking	Mixed	Non-smoking	
N° employees n (%)	75 (100)	27 (36.0)	31 (41.3)	17 (22.7)	
<b>Sociodemographic characteristics</b>					
Age, Median (P <sub>25</sub> -P <sub>75</sub> )	35.0 (19.0-62)	40.0 (29.0-52.0)	35.0 (21.0-57.0)	31.0 (22.0-44.0)	0.081*
Sex, n (%)					
Male	46 (61.3)	17 (63.0)	19 (61.3)	10 (59.0)	0.963**
Asthma, n (%)					
Yes	8 (10.7)	1 (3.7)	7 (22.6)	-	0.018**
No	67 (89.3)	26 (96.3)	24 (77.4)	17 (100)	
<b>Occupational exposure</b>					
Job function at the facility, n (%)					
Owners/managers	21 (28.0)	7 (25.9)	1 (3.2)	13 (76.5)	
Wait staff/bartenders/cashiers	44 (58.7)	13 (48.2)	27 (87.1)	4 (23.5)	0.005**
Cooks	10 (13.3)	7 (25.9)	3 (9.7)	-	
Number of months of work in the local, Median (P <sub>25</sub> -P <sub>75</sub> )	12.0 (0.08-8.0)	12.0 (1.0-192.0)	9.0 (1.0-468.0)	12.0 (2.0-60.0)	0.606*
Number of hour per week exposed to SHS, Median (P <sub>25</sub> -P <sub>75</sub> )	25.0 (0-77.0)	36.0 (21.0-56.0)	28.0 (6.0-48.0)	4.0 (2.0-7.0)	0.0001*
Number of years exposed to SHS workplace, Median (P <sub>25</sub> -P <sub>75</sub> )	2.2 (0-26.0)	3.0 (0.9-7.1)	2.2 (0.8-6.9)	1.5 (0.0-5.0)	0.369*

\* Kruskal Wallis; \*\* Chi2.

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3 As shown in Table 2 we compared the results for pulmonary function and exposure to SHS  
4 based on covariables. Males had greater pulmonary function values than females, except for  
5 FEV<sub>1</sub>/FVC ratio, where no differences were observed. No differences in pulmonary  
6 function were observed between former smokers and never smokers groups. In terms of the  
7 occupational exposure variables, employees working in the kitchen had lower values for  
8 FVC, FEV<sub>1</sub>, and FEF<sub>25/75</sub> than the group of wait staff, bartenders, cashiers, and managers.  
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10 Regarding the number of hours per week of SHS exposure and pulmonary function,  
11 exposure greater than 26 hours per week was associated with a 0.02% decrease in  
12 FEV<sub>1</sub>/FVC and a 230 ml decrease in FEF<sub>25/75</sub>, although these results were not statistically  
13 significant. Workers in smoking venues had FEF<sub>25/75</sub> 400 ml lower and FEV<sub>1</sub>/FVC ratios  
14 0.03% lower than those of workers in non-smoking venues. In terms of urine cotinine  
15 concentration, owners and managers had the highest levels, followed by kitchen workers  
16 and then finally the group of wait staff, bartenders, and cashiers (44.4 ng/ml, 25.0 ng/ml,  
17 and 13.2 ng/ml, respectively). Urine cotinine concentration varied by number of hours per  
18 week of SHS exposure as self-reported by participants and by the smoking status of the  
19 facility. Workers with over 26 hours per week of SHS exposure had urine cotinine values  
20 24.5 ng/ml higher than those who reported 26 or fewer hours of exposure per week, while  
21 workers in smoking facilities show levels of urine cotinine 17.7 ng/ml higher than workers  
22 in non-smoking facilities. The number of years exposed to SHS workplace varied according  
23 to sex, age and smoking status of employees.  
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**Table 2. Pulmonary function and exposure to secondhand smoke at non-smoking workers. Santiago, 2010-2011.**

Variables	Pulmonary function parameters					Urine cotinine concentration (ng/ml)	Number of years exposed to SHS at workplace
	n	FVC ml (RIC)	FEV <sub>1</sub> ml (RIC)	FEV <sub>1</sub> /FVC % (RIC)	FEF <sub>25%/75%</sub> ml (RIC)		
Sex							
Male	46	4.82 (4.23-5.42)	3.94 (3.41-4.38)	0.81 (0.76-0.84)	3.95 (3.00-4.66)	18.6 (6.2-39.5)	3.5 (1.0-11.3)
Female	29	3.48 (3.16-3.90)	2.89 (2.65-3.34)	0.81 (0.79-0.89))	3.25 (2.56-3.83)	13.6 (7.3-41.1)	1.0 (0.16-4.0)
p value ±		0.0001	0.0001	0.116	0.014	0.944	0.01
Age*							
≤35 years	38	4.79 (3.93-5.36)	3.91 (3.37-4.38)	0.83 (0.79-0.88)	4.07 (3.27-4.59)	21.4 (5.1-40.7)	1.0 (0.25-5.0)
>36 year	37	3.78 (3.21-4.42)	2.95 (2.61-3.62)	0.80 (0.78-0.83)	3.12 (2.53-3.95)	15.2 (9.7-38.1)	4.0 (1.0-11.7)
p value ±		0.0002	0.0001	0.049	0.0009	0.787	0.02
Smoking status							
Never smokers	53	4.23 (3.45-4.89)	3.49 (2.88-4.06)	0.81 (0.79-0.86)	3.69 (2.85-4.39)	21.7 (5.7-43.8)	1.0 (0.75-5.0)
Former smokers	22	4.33 (3.58-5.32)	3.53 (2.99-4.26)	0.81 (0.76-0.85)	3.77 (3.0-4.59)	12.9 (9.4-36.8)	6.3 (0.83-11.7)
p value ±		0.767	0.684	0.452	0.907	0.629	0.04
Job function at the facility							
Owners/managers	8	4.84 (3.47-6.09)	3.94 (2.66-4.48)	0.77 (0.72-0.80)	3.22 (2.19-3.90)	44.4 (29.3-46.1)	1.0 (0.8-4.1)
Wait staff/bartenders/cashiers	53	4.42 (3.74-5.17)	3.56 (3.14-4.20)	0.82 (0.79-0.86)	3.94 (3.11-4.59)	13.2 (5.1-39.5)	3.0 (0.4-7.1)
Cooks	14	3.38 (2.96-4.24)	2.81 (2.56-3.62)	0.82 (0.79-0.86)	3.08 (2.53-3.80)	25.0 (9.7-36.9)	1.6 (0.8- 4.0)
p value +		0.03	0.04	0.04	0.03	0.08	0.711
Hours per week exposed to SHS*							
≤26 hrs	39	4.05 (3.58-4.75)	3.44 (2.85-3.91)	0.82 (0.78-0.87)	3.81 (2.89-4.59)	11.3 (3.0-26.0)	2.0 (0.25-6.9)
>27 hrs	36	4.40 (3.45-5.40)	3.64 (2.89-4.32)	0.80 (0.77-0.84)	3.58 (2.78-4.38)	35.8 (11.6-48.1)	3.3 (0.9-7.04)
p value ±		0.279	0.457	0.173	0.603	0.0003	0.474
Facility							
Smoking/mixed	58	4.24 (3.32-5.26)	3.49 (2.85-4.23)	0.81 (0.77-0.84)	3.58 (2.73-4.44)	21.8 (10.5-44.7)	1.5 (0-5.0)
Non-smoking	17	4.24 (3.83-4.55)	3.49 (3.28-3.83)	0.84 (0.80-0.88)	3.98 (3.25-4.48)	4.1 (1.5-26.0)	2.6 (0.9-7.0)



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p value ±	0.825	0.845	0.06	0.176	0.0012	0.161
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\*Variable dichotomized in median value; + Kruskal Wallis test; ± Wilcoxon Test

Consistent with the literature, sex, age and weight were significantly associated with pulmonary function parameters (Table 3). In terms of job function, the owners and managers had FEV<sub>1</sub>/FVC values 60% lower and FEF<sub>25/75</sub> values 830 ml lower than the group of wait staff, bartenders, and cashiers. The kitchen workers had 700 ml lower FVC values, 640 ml lower FEV<sub>1</sub> values, and 772 ml lower FEF<sub>25/75</sub> than the group of wait staff, bartenders, and cashiers. Workers in smoking facilities had 413 ml lower FEF<sub>25/75</sub> and 3% lower FEV<sub>1</sub>/FVC than workers in non-smoking venues.

**Table 3. Bivariate association of pulmonary function parameters in non-smokers workers according to covariables of interest.**

	FVC (ml)	FEV <sub>1</sub> (ml)	FEV <sub>1</sub> /FVC (ml)	FEF <sub>25/75</sub> (ml)
	β (CI95%)	β (CI95%)	β (CI95%)	β (CI95%)
<b>Sociodemographic variables</b>				
Sex				
Male	1,260 (0.880 to 1.650)	0.91 (0.601 to 1.213)	-0.03 (-0.064 to -0.0003)	0.61 (0.110 to 1.103)
Age	-0.03 (-0.05 to -0.02)	-0.03 (-0.04 to -0.02)	-0.001 (-0.003 to -0.003)	-0.037 (-0.055 to -0.019)
Weight	0.04 (0.02 to 0.05)	0.02 (0.01 to 0.04)	-0.001 (-0.002 to -0.0001)	0.014 (-0.004 to 0.034)
Size	0.08 (0.07 to 0.10)	0.06 (0.050 to 0.074)	-0.001 (-0.002 to 0.001)	0.052 (0.029 to 0.076)
Asthma				
Yes	0.04 (-0.731 to 0.802)	-0.17 (-0.750 to 0.422)	-0.054 (-0.100 to -0.010)	-0.673 (-1.470 to 0.122)

**Occupational exposure variables**

Job function at the facility

Wait staff/bartenders/cashiers	<i>Ref.</i>	<i>Ref.</i>	<i>Ref.</i>	<i>Ref.</i>
Owners/managers	0.37 (-0.370 to 1.110)	0.003 (-0.570 to 0.570)	-0.06 (-0.113 to -0.021)	-0.828 (-1.613 to -0.047)
Cooks	-0.7 (-1.290 to -0.120)	-0.64 (-1.090 to -0.190)	-0.02 (-0.061 to 0.022)	-0.772 (-1.391 to -0.151)
Hours per week exposed to SHS	0.01 (0.002 to 0.020)	0.01 (-0.0005 to 0.014)	-0.0004 (-0.001 to 0.0002)	0.002 (-0.008 to 0.011)
Facility				
Non-smoking	<i>Ref.</i>	<i>Ref.</i>	<i>Ref.</i>	<i>Ref.</i>
Smoking/mixed	0.1 (-0.460 to 0.672)	-0.05 (-0.486 to 0.381)	-0.03 (-0.071 to 0.003)	-0.413 (-1.003 to 0.177)

### Association between pulmonary function and SHS exposure

The crude model revealed that the association between pulmonary function and urine cotinine concentration was not statistically significant (Table 4). The multivariate analysis was based on a parsimonious model that included the covariate "job function", as this variable was related to pulmonary function and urine cotinine concentration with a  $p$ -value  $< 0.10$ , as well as the variables sex, age, weight, height, and asthma status, all of which are recognized as variables that affect pulmonary function according to SEPAR<sup>29, 32</sup>. The adjusted model did not demonstrate a significant association between urine cotinine concentration and decreased pulmonary function. Conversely, the number of years of SHS exposure in workplace showed an inverse and significant association with FEV<sub>1</sub>. Each year of SHS exposure was associated with a 200 ml decrease in FEV<sub>1</sub> (95% CI -0.042 to -0.001). The other pulmonary function variables were also inversely associated with years of SHS exposure in workplace, although the association in these cases did not reach significance. The adjusted model showed an inverse and in some cases statistically significant

association between the number of years of SHS exposure and pulmonary function parameters, specifically in FEF<sub>25/75</sub> ( $\beta = -0.006$ ; 95% CI -0.010 to -0.0004).

**Table 4. Crude and adjusted association between pulmonary function parameters and SHS exposure of non-smoking workers of bars and restaurants.**

	FVC (ml)		FEV <sub>1</sub> (ml)		FEV <sub>1</sub> /FVC (ml)		FEF <sub>25/75</sub> (ml)	
	$\beta$ (CI95%)	R <sup>2</sup>	$\beta$ (CI95%)	R <sup>2</sup>	$\beta$ (CI95%)	R <sup>2</sup>	$\beta$ (CI95%)	R <sup>2</sup>
<b>Urine cotinine</b>								
Crude model	0.002 (-0.010 to 0.010)	0.002	0.002 (-0.010 to 0.010)	0.003	0.0002 (-0.001 to 0.001)	0.002	0.002 (-0.010 to 0.010)	0.002
Adjusted model	-0.0002 (-0.007 to 0.006)*	0.781	0.001 (-0.003 to 0.006)*	0.795	0.0004 (-0.0003 to 0.001)+	0.33	0.005 (-0.006 to 0.015)+	0.672
<b>Number of years exposed to SHS at work</b>								
Crude model	-0.025 (-0.051 to 0.002)	0.0462	-0.022 (-0.042 to -0.001)	0.061	-0.0008 (-0.002 to 0.0008)	0.013	-0.022 (-0,050 to 0,006)	0.032
Adjusted model	-0.013 (-0.030 to 0.0025)*	0.79	-0.01 (-0.022 to 0.002)*	0.802	0.0006 (-0.001 to 0.002)+	0.324	-0.006 (-0,010 to -0,0004)+	0.964

\*Adjusted by sex, age, weight, size and job function at the facility; + Adjusted by sex, age, size, asthma status and job function at the facility

## Discussion

This study is the first in Chile to evaluate occupational SHS exposure and its association with specific pulmonary function parameters. We did not find an inverse association between pulmonary function parameters and urine cotinine concentration, but when we considered number of years exposed to SHS in workplace, we found an inverse association with FVC (ml), FEV<sub>1</sub> (ml), FEV<sub>1</sub>/FVC (ml) and FEF<sub>25/75</sub> being significant only for the last parameter. Similar findings were described by other researchers who reported a reduction in FVC and FEF<sub>25/75</sub><sup>20, 33</sup>, in FVC<sup>15</sup>, in FVC and FEV<sub>1</sub><sup>16</sup> in subjects exposed to environmental tobacco smoke. In terms of job function, kitchen workers showed lower pulmonary function values than the group of wait staff, bartenders, and cashiers as compared to the owners and managers. One possible explanation for these findings is that the SHS exposure had an additive effect with exposure to other pollutants emitted in the kitchen. In the literature has been reported that workers in kitchens with gas stoves show lower pulmonary function parameters than those in kitchens with electric stoves, due to greater exposure to toxic substances in the air after cooking with gas<sup>34</sup>. In our study, it was not possible to analyze differences according this variable because 100% of the establishments used gas stoves.

As noted above, we did not find a significant association between pulmonary function parameters and urine cotinine concentration. A possible explanation for these results is that, urine cotinine levels reflect recent exposure to tobacco smoke<sup>21, 22, 31</sup> while chronic exposure to SHS is likely implicated in a decline in pulmonary function parameters. In fact, in Table 4 we can see that the proportion of the variance ( $R^2$ ) explained by *number of years of SHS exposure in workplace* is greater than that explained by the current *urine cotinine*

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3 *concentration*, suggesting that this variable (*number of years of SHS exposure*) may be  
4 more appropriate when we are studying chronic effects. Other studies that have addressed  
5 this topic have produced varying results<sup>15, 16, 17, 20, 21, 22, 31, 35</sup> reported a significant inverse  
6 association between SHS exposure (evaluated through self-report) and FVC and FEV<sub>1</sub>. As  
7 in our study, Chen et al. did not find a significant association when serum cotinine was  
8 assess as exposure variable, but did when exposure to SHS was measured through self-  
9 report<sup>16</sup>.

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20 Our results are not as strong as those described in other studies<sup>12, 13, 14, 20, 33</sup>. It should be  
21 noted that our sample included mainly young workers being reasonable to infer that the  
22 sample not accumulated sufficient years of SHS exposure to register significant changes in  
23 pulmonary function. Also the median time worked at the location was only about 1 year.  
24 About 25% of the sample had worked at the given facility for less than 3 months, and 75%  
25 of the sample had worked at the location for fewer than 2 years. This condition of high  
26 turnover rate, along with the relative youth of the workers contributes to assume that the  
27 sample not accumulated enough years of SHS exposure to register significant changes in  
28 pulmonary function. A second limitation was that although all participants were non-  
29 smokers, those who worked in non-smoking venues reported be exposed to SHS at least 4  
30 hours a week. Also in this group the median urine cotinine concentration was 4.1 ng/ml.  
31 The lack of a true control group could have lead to underestimating the effect of SHS  
32 exposure. Another potential limitation was the timing of the spirometry measurements. The  
33 literature reports that pulmonary function varies throughout the day according to circadian  
34 rhythm, decreasing from a high point in the early morning until about noon and then rising  
35 again to peak between about 4 and 5 in the afternoon. These daily fluctuations may have  
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3 affected the results, as the lung function measurements were performed at various times of  
4 day, according to the availability and shifts of the workers and establishments. Finally, our  
5 small sample size along with the weak correlation between exposure to SHS and pulmonary  
6 function prevent us to have enough power to demonstrate a strongest association as shown  
7 in other studies.  
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11 Notwithstanding the above, our study shows that exposure to SHS among non-smoking  
12 employees working in venues where smoking is allowed appear to be substantially higher  
13 than those found in employees working in venues where smoking is not allow. The median  
14 urine cotinine in non-smoking employees working in a venue were smoking is allowed was  
15 40.0 ng/ml, in a mixed venue was 13.5 ng/ml and where smoking was not allow was 4.1  
16 ng/ml. Given that SHS is a proven carcinogen in humans to which non-smoking workers of  
17 this type of venues are exposed involuntarily, a total smoking ban would provide a major  
18 protection to employees working in such venues.  
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### 34 **Conclusion**

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36 The years of exposure to SHS in workplace as proxy of chronic exposure were inverse and  
37 significantly associated with the FEF<sub>25/75</sub>, and inverse but not significant with FVC and  
38 FEV<sub>1</sub>. These findings suggest that cumulative exposure to SHS at work may contribute to  
39 deterioration of pulmonary function in non-smoking employees.  
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### 45 **Acknowledgments**

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49 Andes-Chile for the support given to translate this article.  
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## Competing interest

The authors have no conflict of interest to declare.

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## References

1. Aceituno Paulina, Iglesias Verónica, Erazo Marcia, Droppelmann Andrea, Orellana Cecilia, Navas-Acién Ana. 2010. The work environment as a source of exposure to secondhand smoke: a study in workers of bars and restaurants of Santiago, Chile. *Rev Med Chile* 138:1517-1523.
2. Alwan A. World Health Organization. 2009. WHO Report on the Global Tobacco Epidemic. Implementing smoke-free environments; [Cited 2016 Jun 24]. Available from: [http://who.int/tobacco/mpower/2009/gtcr\\_download/en/index.html](http://who.int/tobacco/mpower/2009/gtcr_download/en/index.html)
3. Bello Sergio, Michalland Susana, Soto Marina, Contreras Carla, Salinas Judith. 2005. Effects in passive smokers of environmental tobacco smoke exposure. *Rev Chil Enf Respir* 21:179-192.
4. Chan-Yeung Moira, Dimich-Ward Helen. 2003. Respiratory health effects of exposure to environmental tobacco smoke. *Respirology* 8(2):131-139.
5. Collishaw Neil E, Kirkbride John, Wigle Donald. 1984. Tobacco smoke in the workplace: an occupational health hazard. *Can Med Assoc J* 131(10):1191-1204.

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6. EPA. Proposed identification of environmental tobacco smoke as a Toxic Air Contaminant. Tobacco Control. Surveys and Program Evaluations from Outside UCSF Paper CALEPA2005 2005 [cited 2017 July 18]; Available from: <https://oehha.ca.gov/media/downloads/air/report/app32005.pdf>
7. Department of Health and Human Services USA. 2014. The consequences of smoking on health. 50 years of progress. Report of the US Department of Health and Human Services USA. Executive Summary.
8. OMS-OPS. 2016. Report on tobacco control in the Region of the Americas. 10 years of the Framework Convention of the World Health Organization for tobacco control. Washington D.C.
9. Allwright Shane, Paul Gillian, Greiner Birgit, Mullally Bernie J, Pursell Lisa, Kelly Alan et al. Legislation for smoke-free workplaces and health of bar workers in Ireland: before and after study. *BMJ* 2006 332(7534):151.
10. Coultas David. 1998. Health effects of passive smoking. Passive smoking and risk of adult asthma and COPD: an update. *Thorax* 53(5):381-387.
11. De Vito Eduardo, Rojas Ramón. 2005. Environmental tobacco smoke. *Medicina (B. Aires)* 65(6):545-549.
12. Jaakkola Maritta, Jaakkola Jouni, Becklake Margaret, Ernst Pierre. 1995. Passive smoking and evolution of lung function in young adults. An 8-year longitudinal study. *J Clin Epidemiol* 48(3):317-327.
13. Jayet Pierre-Yves, Schindler Christian, Schwartz Joel, Kunzli Nino, Zellweger Pierre, Ackermann-Liebrich Ursula, Leuenberger Phillippe. 2005. Passive smoking exposure



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2  
3 among adults and the dynamics of respiratory symptoms in a prospective multicenter  
4 cohort study. *Scand J Work Environ Health* 31(6):465-473.  
5  
6  
7  
8 14. Rizzi Maurizio, Sergi Margherita, Andreoli Arnaldo, Pecis Marica, Bruschi Claudio,  
9 Fanfulla Francesco. 2004. Environmental tobacco smoke may induce early lung damage  
10 in healthy male adolescents. *Chest* 125(4):1387-1393.  
11  
12  
13 15. Alipour Shahryar, Deschamps Frédéric, Lesage François-Xavier. 2005. Effects of  
14 Environmental Tobacco Smoke on Respiratory Symptoms and Pulmonary Function.  
15 *Inhal Toxicol* 18(8):569-573.  
16  
17  
18 16. Chen Ruoling, Tunstall-Pedoe H, Tavendale R. 2001. Environmental tobacco smoke  
19 and lung function in employees who never smoked: the Scottish MONICA study.  
20 *Occup Environ Med* 58(9):563-568.  
21  
22  
23 17. Fidan F, Cimrin AH, Ergor G, Sevinc C. 2004. Airway disease risk from environmental  
24 tobacco smoke among coffeehouse workers in Turkey. *Tob Control* 13(2):161-6.  
25  
26  
27 18. Janson Christer, Chinn Susan, Jarvis Deborah, Zock Jan-Paul, Torén Kjell, Burney  
28 Peter. 2001. Effects of passive smoking on respiratory symptoms, bronchial  
29 responsiveness, lung function, and total serum IgE in the European Community  
30 Respiratory Health survey: a cross sectional study. *Lancet* 358(2):103-109.  
31  
32  
33 19. Eisner Mark D. 2002. Environmental tobacco smoke exposure and pulmonary function  
34 among adults in NHANES III: impact on the general population and adults with current  
35 asthma. *Environ Health Perspect* 110(8):765-70.  
36  
37  
38 20. Kunzli N, Schwartz J, Stutz EZ, Ackermann-Liebrich U, Leuenberger P. 2000.  
39 Association of environmental tobacco smoke at work and forced expiratory lung  
40 function among never smoking asthmatics and non-asthmatics. The SAPALDIA-Team.  
41  
42  
43  
44  
45  
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2  
3 Swiss Study on Air Pollution and Lung Disease in Adults. *Soz Praventivmed* 45(5):208-  
4  
5 17.  
6  
7  
8 21. Benowitz Neal L. 1999. Biomarkers of environmental tobacco smoke exposure.  
9  
10 *Environ Health Perspect* 107(2):349-55.  
11  
12 22. Tutka Piotr, Mosiewicz Jerzy, Wielosz Marian. 2005. Pharmacokinetics and  
13  
14 metabolism of nicotine. *Pharmacol Rep* 57(2):143-53.  
15  
16  
17 23. Centers for Disease Control and Prevention. 2017. National Report of Human Exposure  
18  
19 to Environmental Chemicals; [Cited 2017 March 15]. Available from:  
20  
21 <https://www.cdc.gov/exposurereport/>  
22  
23  
24 24. Al-Delaimy WK, Crane J, Woodward A. 2000. Questionnaire and hair measurement of  
25  
26 exposure to tobacco smoke. *J Expo Anal Environ Epidemiol* 10:378-384.  
27  
28  
29 25. Al-Delaimy WK. 2002. Hair as a biomarker for exposure to tobacco smoke. *Tob*  
30  
31 *Control* 11:176-182.  
32  
33  
34 26. Iglesias Verónica, Erazo Marcia, Droppelmann Andrea, Steenland Kyle, Aceituno  
35  
36 Paulina, Orellana Cecilia, Acuña Marisol, Peruga Armando, Breyse Patrick N, Navas-  
37  
38 Acien Ana. 2014. Occupational secondhand smoke is the main determinant of hair  
39  
40 nicotine concentrations in bar and restaurant workers. *Environ Res* 132:206–211.  
41  
42  
43 27. Salud OMS. 2003. “Convenio Marco de la OMS para el control del tabaco”; [Cited  
44  
45 2016 Jun 24]. Available from: [http://www.who.int/fctc/text\\_download/es/](http://www.who.int/fctc/text_download/es/).  
46  
47  
48 28. Muñoz Claudio, Droppelmann Andrea, Erazo Marcia, Aceituno Paulina, Orellana  
49  
50 Cecilia, Parro Javiera, Mesias Stephanie, Marchetti Nella, Navas-Acien Ana, Iglesias  
51  
52 Verónica. 2016. Occupational exposure to polycyclic aromatic hydrocarbons: A cross-  
53  
54  
55  
56  
57  
58  
59  
60

- sectional study in bars and restaurants in Santiago, Chile. *Am J Ind Med*. Version of record online: 28 Jun 2016.
29. Burgos Felipe, Casan Pere, Del Campo Félix, Gáldiz Juan, Giner Jordi, González-Mangado Nicolás, Ortega Francisco, Puente Luis, García Francisco, Calle Myriam. SEPAR Regulation: Forced Spirometry. 2013; [Cited 2016 Jun 24]. Available from: <http://www.ics.gencat.cat/3clics/guies/184/img/--guiasepar20131.pdf>
30. Gutiérrez C. Mónica, Beroíza Teresa, Barzone Gisella, Caviedes Iván, Céspedes Iván, Céspedes Juan, Gutiérrez N. Mónica, Moreno Rodrigo, Oyarzún Manuel, Palacios Sylvia, Schonffeldt Patricia. 2007. Spirometry: Procedures Manual. Chilean Society of Respiratory Diseases, 2006. *Rev Chil Enf Respir* 23:31-42.
31. Vine Marilyn, Hulka Barbara, Margolin Barry, Truong Young, Hu Ping-chuan, Schramm Margaret, Griffith Jack, McCann Margaret, Everson Richard. 1993. Cotinine Concentrations in Semen, Urine, and Blood of Smokers and Nonsmokers. *Am J Public Health* 83(9):1335-1338.
32. Tong Shilu, Lu Ying. 2001. Identification of confounders in the assessment of the relationship between lead exposure and child development. *Ann Epidemiol* 11(1): 38-45.
33. Fahim Aymn Ekram, El-Prince Mahmoud. Passive smoking, pulmonary function and bronchial hyper-responsiveness among indoor sanitary workers. *Industrial health* 2012 59: 516-520.
34. Wong Tze Wai, Wong Andromeda H, Lee Frank S, Qiu Hong. 2011. Respiratory health and lung function in Chinese restaurant kitchen workers. *Occup Environ Med* 68(10):746-752.

1  
2  
3 35. Skogstad M, Kjaerheim K, Fladseth G, Gjølstad M, Daae HL, Olsen R, Molander P,  
4  
5 Ellingsen DG. 2006. Cross shift changes in lung function among bar and restaurant  
6  
7 workers before and after implementation of a smoking ban. *Occup Environ Med*  
8  
9 63:482-487.  
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### 12 **Contributorship statement**

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15 Parro Javiera. Substantial contributions to the conception and design of the work on  
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17 pulmonary function parameters; acquisition, analysis and interpretation of data, drafting the  
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19 work, and final approval of the version to be published;  
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22  
23 Aceituno Paulina. Substantial contributions to the conception and design of the work,  
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25 revising it critically for important intellectual content, final approval of the version to be  
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27 published.  
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31 Droppelman Andrea. Substantial contributions to the conception, design of the work and  
32  
33 interpretation of exposure data, final approval of the version to be published.  
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37 Mesías Sthepanie. Substantial contributions to the acquisition and analysis of exposure  
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39 data, final approval of the version to be published.  
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43 Muñoz Claudio. Substantial contributions to the acquisition, analysis and interpretation of  
44  
45 data, final approval of the version to be published.  
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49 Marchetti Nella. Substantial contributions to the conception of the work and interpretation  
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51 of data, final approval of the version to be published.  
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55 Iglesias Verónica. Substantial contributions to the conception and design of the work,  
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57 analysis and interpretation of data for the work; drafting the work, final approval of the  
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version to be published, agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

For peer review only

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract page 1 line 1-2 (b) Provide in the abstract an informative and balanced summary of what was done and what was found page 2 line 1-22
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported page 3-5
Objectives	3	State specific objectives, including any prespecified hypotheses page 5 line 4
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper page 5 line 8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection page 5 line 13-23
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants page 5 line 13-23 (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable page 6 line 4-23, page 7 line 1-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group page 6 line 4-23, page 7 line 1-8
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at NO
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why page 7 line 19-22, page 8 line 1-8.
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding page 7 line 10-20 (b) Describe any methods used to examine subgroups and interactions page 7 line 10-20 (c) Explain how missing data were addressed not apply (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of

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sampling strategy page 7 line 10-20

(e) Describe any sensitivity analyses NO

Continued on next page

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**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <a href="#">page 8 line 1-8</a> (b) Give reasons for non-participation at each stage <a href="#">page 8 line 1-8</a> (c) Consider use of a flow diagram <b>NO</b>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <a href="#">page 8 table 1</a> (b) Indicate number of participants with missing data for each variable of interest <b>not apply</b> (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures <b>NO</b>
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <a href="#">page 13 Table 4</a> (b) Report category boundaries when continuous variables were categorized <a href="#">page 10 Table 2</a> (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period <b>NO</b>
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>NO</b>

**Discussion**

Key results	18	Summarise key results with reference to study objectives <a href="#">page 14 line 2-17</a>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <a href="#">page 15 line 8-23</a> <a href="#">page 16 line 1-5</a>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <a href="#">page 16 line 15-18</a>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>NO</b>

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <a href="#">page 17 line 2</a>
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\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).



# BMJ Open

## Secondhand tobacco smoke exposure and pulmonary function: a cross-sectional study among non-smoking employees of bar and restaurants in Santiago, Chile

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Manuscripts

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3 1 **Secondhand tobacco smoke exposure and pulmonary function: a cross-sectional**  
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5 2 **study among non-smoking employees of bar and restaurants in Santiago, Chile**  
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1  
2  
3 **Abstract**

4 **Introduction.** The workplace remains a significant source of secondhand smoke (SHS)  
5 exposure. This pollutant is known to be associated with respiratory and cardiovascular  
6 problems, but its effects on specific pulmonary function parameters remain largely  
7 unexplored. The objectives of this study were to measure SHS exposure among non-  
8 smoking employees of bar and restaurants in Santiago, Chile and to evaluate the effects of  
9 such exposure on pulmonary function.

10 **Methods.** Cross-sectional design. The study sample included non-smoking workers from  
11 57 restaurants and bars in Santiago, Chile. The outcome variable was pulmonary function  
12 and the exposure variables were urine cotinine concentration, a biomarker for current SHS  
13 exposure, and years of SHS exposure in the workplace as proxy of chronic exposure.  
14 Personal and occupational variables were also recorded. Data analysis was performed using  
15 linear regression models adjusted by confounders.

16 **Results.** The median age of the workers was 35 years and the median employment duration  
17 at the analysed venues was 1 year. Workers in smoking facilities reported greater SHS  
18 exposure (36 hours per week) than workers in smoke-free locations (4 hours per week).  
19 Urine cotinine levels were inversely correlated with forced vital capacity (FVC), but the  
20 finding was not statistically significant ( $\beta=-0.0002$ ; 95% CI: -0.007 to 0.006). Years of  
21 exposure to SHS showed to be significantly associated with FEF<sub>25 / 75</sub> ( $\beta = -0.006$ ; 95%  
22 CI: -0.010 to -0.0004).

23 **Conclusion.** These findings suggest that cumulative exposure to SHS at work may  
24 contribute to deterioration of pulmonary function in non-smoking employees.

- 1 **Keywords:** Secondhand smoke exposure, chronic exposure, pulmonary function, urine  
2 cotinine, workers.

#### Strengths and limitations of this study

- The effects of occupational SHS exposure on specific pulmonary function parameters has been scarcely explored.
- This study is the first in Chile to evaluate occupational SHS exposure and its association with specific pulmonary function parameters.
- The use of the variable "number of years exposed to SHS at workplace" was appropriate to studied chronic SHS exposure.
- Our sample included mainly young workers being reasonable to infer that the sample not accumulated sufficient years of SHS exposure to register greater changes in pulmonary function.
- Daily fluctuations of the timing of the spirometry measurements may have affected the results, since these were performed at various times of day, according to the availability and shifts of the workers and establishments.

3

#### 4 **Introduction**

5 The secondhand smoke (SHS) is the smoke that remains in the air after someone has  
6 consumed tobacco, including the smoke coming from the burning end of the cigarette (side-  
7 stream smoke) and the smoke exhaled by the smoker (mainstream smoke)<sup>1-5</sup>. Side-stream  
8 smoke contains higher concentration of harmful substances than main stream as it contains  
9 a greater amount of toxic gases and smaller particles that reach greater depth in the lungs

3

1 when inhaled<sup>6</sup>. SHS is a common indoor pollutant in restaurants and bars that poses a  
2 serious health risk for non-smokers as it contains over 50 substances known to be  
3 carcinogenic in humans<sup>7, 8</sup>. There is no known safe exposure level<sup>1, 4</sup>. Some of the highest  
4 and most sustained occupational exposure to SHS occur in bar staff, with non-smoking  
5 areas providing only limited protection<sup>9</sup>.

6 SHS exposure can lead to the same health problems associated with active smoking<sup>1, 7, 8</sup>,  
7 with risk levels increasing as a function of hours of exposure<sup>10-14</sup>. Common scenarios  
8 associated with chronic SHS exposure include living with a spouse or parent who smokes  
9 and working in a location where smoking is allowed<sup>3, 5</sup>. Previous studies have not been  
10 consistent in showing a decline in specific pulmonary function parameters in people  
11 affected by SHS exposure at work or at home<sup>9, 15-20</sup>. This lack of evidence may be  
12 attributable to the methods use to measure SHS exposure, which range from self-report to  
13 measurement of exposure biomarkers<sup>15-19</sup>.

14 One of the most common ways of measuring SHS exposure is measuring concentration of  
15 cotinine, the principle metabolite of nicotine. Cotinine can be measured in the blood or  
16 urine and shows high sensitivity and specificity for acute SHS exposure (over the past 3–4  
17 days), although some authors have also used it to evaluate longer-term exposure<sup>21-23</sup>.  
18 Chronic exposure to SHS has been measured through questionnaire and by hair nicotine  
19 concentration<sup>24, 25</sup>.

20 In 2010, the time at which this study was performed, Chilean law prohibited tobacco  
21 smoking in public areas and workplaces. However, there were exceptions for "hospitality"  
22 venues, such as casinos, bars, pubs, restaurants, and cafés. Bars, pubs, and restaurants with  
23 areas smaller than 100 m<sup>2</sup> could choose to allow smoking indoors or not, while facilities

1 with an area larger than 100 m<sup>2</sup> were required to offer separate sections for smokers and  
2 nonsmokers. Therefore, "hospitality" workers were unprotected from SHS exposure,  
3 becoming the workplace, in many cases, the main source of SHS exposure<sup>26,27</sup>.

4 The objectives of this study were to measure SHS exposure among non-smoking workers in  
5 restaurants and bars in Santiago, Chile and to evaluate the effects of such exposure on  
6 pulmonary function.

## 7 **Methods**

8 This cross-sectional study was performed as part of a larger project, "Impact of involuntary  
9 exposure to tobacco smoke on respiratory health: study of pub and restaurant workers",  
10 carried out in Santiago, Chile between September 2010 and January 2011. This study was  
11 approved by the University of Chile School of Medicine's Ethics Committee.

### 12 *Population and sample*

13 The selection process for participating facilities has been previously described in detail<sup>28</sup>. In  
14 brief, the sampling framework included the 5 municipalities with the largest numbers of  
15 facilities, according to data provided by the National Institute of Statistics (Spanish  
16 acronym INE, for *Instituto Nacional de Estadísticas*). Study staff visited 690 locations and  
17 used a brief survey to record the venue's name, address, type of facility (bar/pub, restaurant,  
18 or other), smoking status (smoking allowed in all areas; designated smoking/non smoking  
19 areas; or smoke-free), and number of non-smoking workers. Of the 690 facilities, 207 met  
20 inclusion criteria (be a bar-pub or restaurant and have non-smoking workers). Of them, 108  
21 were visited or contacted by telephone to invite the owner or manager to participate in the  
22 study. In 63 establishments they agreed to participate (58%). For logistical reasons, only 59  
23 of the facilities were included<sup>28</sup>. Smoking and non-smoking workers in these facilities were

1 invited to participate in the main study. Only those who had not smoked in the last year  
2 were included in the current study. Workers were excluded if they did not provide a urine  
3 sample (n=5) or had a contraindication for spirometry (n=1)<sup>29,30</sup>.

#### 4 *Outcome variables*

5 *Pulmonary function parameters:* Certified personnel used an *Easy One Diagnostic*® to  
6 measure forced vital capacity (FVC) and forced expiratory volume in 1s (FEV<sub>1</sub>), and then  
7 calculated the FEV<sub>1</sub> to FVC ratio (FEV<sub>1</sub>/FVC) and forced expiratory flow as 25%–75% of  
8 FVC (FEF<sub>25-75</sub>). Spirometry measurements were performed during working hours. In  
9 compliance with international norms on collecting and interpreting spirometry data, age,  
10 sex, weight, height, and race of each participant were also recorded<sup>29,30</sup>. A maximum of 8  
11 spirometry trials were performed. The criteria for including a participant's spirometry data  
12 in the analysis was achieving at least 3 acceptable and 2 reproducible trials, as described in  
13 the norms published by Spanish Society of Pneumology and Thoracic Surgery (Spanish  
14 acronym SEPAR, for *Sociedad Española de Neumología y Cirugía Torácica*)<sup>29,30</sup>. The  
15 equipment was calibrated weekly.

#### 16 *Exposure variables*

17 *Urine cotinine concentration.* Each worker was asked to provide urine sample the morning  
18 after the spirometry measurements. The sample was provided, retrieved, and frozen on the  
19 same day. Urine cotinine concentration was measured using ELISA at a sensitivity of 1  
20 ng/ml. The cut-off value typically used in the literature to distinguish smokers from non-  
21 smokers is 10 ng/ml<sup>31</sup>. As a quality control, duplicate samples were obtained and analyzed.  
22 There was a strong correlation between the original and duplicate samples (Spearman's  
23 correlation=0.96; p-value=0.0005). Chronic exposure to SHS was measured as *the number*

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3 1 *of years exposed to SHS at workplace* (number of years worked at their 3 most recent job  
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6 2 positions and whether it involved SHS exposure).

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8 3 *Covariables*

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10 4 The questionnaire included items about the participant's health history (asthma diagnosis,  
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12 5 smoking habits); occupational history (job function at the facility, secondary employment at  
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14 6 another facility, number of hours per day and days per week worked); occupational  
15  
16 7 exposure (number of hours per day and days per week exposed to SHS); and the type of  
17  
18 8 facility (smoking, mixed, or non-smoking).

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22 9 *Statistical analysis*

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24 10 Data analysis was performed using the program STATA 12. The quantitative variables  
25  
26 11 were assessed for normality using the Shapiro-Wilk test. Descriptive statistics were  
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28 12 calculated, including median and interquartile ranges (P<sub>25</sub>–P<sub>75</sub>) for quantitative variables  
29  
30 13 and relative frequency for qualitative variables. Quantitative exposure variables and  
31  
32 14 covariables, such as number of hours per week of SHS exposure or age were dichotomized  
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34 15 using the median as cutoff. Kruskal Wallis test and Wilcoxon test were used to assess  
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36 16 difference of pulmonary parameters and exposure variables between the categories of the  
37  
38 17 covariables. Finally, the association between pulmonary function parameters and exposure  
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40 18 to SHS was analyzed using multiple linear regression models adjusted by covariates  
41  
42 19 potentially associated with both, the outcome and the exposure considering a p-value  
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44 20 of <0.10<sup>32</sup>, as well as variables commonly controlled for in the literature.

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50 21 **Results**

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53 22 The non-smoking workers evaluated in the study were 92. 17(18.5%) were excluded due to  
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55 23 spirometry results failed to meet the criteria for acceptability and reproducibility. The final



1 sample was 75 workers. Median age was 35 years (P<sub>25</sub>–P<sub>75</sub>: 19–68 years), and 61% of  
 2 participants were male. 29.3% were former smokers and the median of time they quit  
 3 smoking was 8.5 years (RIC 2 to 15 years). They were homogeneously distributed at the  
 4 different facility type. On average, participants had worked at the studied venue for 12  
 5 months. Independent of the facility type, the sample was mainly composed of waiting staff,  
 6 bartenders, and cashiers (70.7%). Workers in smoking facilities reported higher number of  
 7 weekly hours exposed to SHS compared to workers in mixed and non-smoking facilities (p-  
 8 value=0.0001) (Table 1).

9 **Table 1. Characteristics of the study sample. Santiago, Chile 2010-2011.**

	Smoking status restaurant/bar/pub				p value
	Total	Smoking	Mixed	Non-smoking	
N° employees n (%)	75 (100)	27 (36.0)	31 (41.3)	17 (22.7)	
<b>Sociodemographic characteristics</b>					
Age, Median (P <sub>25</sub> -P <sub>75</sub> )	35.0 (19.0-62)	40.0 (29.0-52.0)	35.0 (21.0-57.0)	31.0 (22.0-44.0)	0.081*
Sex, n (%)					
Male	46 (61.3)	17 (63.0)	19 (61.3)	10 (59.0)	0.963**
Asthma, n (%)					
Yes	8 (10.7)	1 (3.7)	7 (22.6)	0	0.018**
No	67 (89.3)	26 (96.3)	24 (77.4)	17 (100)	
<b>Occupational exposure</b>					
Job function at the facility, n (%)					
Owners/managers	8 (10.7)	7 (25.9)	1 (3.2)	0	
Wait staff/bartenders/cashiers	53 (70.7)	13 (48.2)	27 (87.1)	13 (76.5)	0.005**
Cooks	14 (18.7)	7 (25.9)	3 (9.7)	4 (23.5)	
Number of months of work in the local, Median (P <sub>25</sub> -P <sub>75</sub> )	12.0 (0.08-8.0)	12.0 (1.0-192.0)	9.0 (1.0-468.0)	12.0 (2.0-60.0)	0.606*
Number of hour per week exposed to SHS, Median (P <sub>25</sub> -P <sub>75</sub> )	25.0 (0-77.0)	36.0 (21.0-56.0)	28.0 (6.0-48.0)	4.0 (2.0-7.0)	0.0001*
Number of years exposed to SHS workplace, Median (P <sub>25</sub> -P <sub>75</sub> )	2.2 (0-26.0)	3.0 (0.9-7.1)	2.2 (0.8-6.9)	1.5 (0.0-5.0)	0.369*

10 \* Kruskal Wallis; \*\* Chi2.

1 As shown in Table 2 we compared the results for pulmonary function and exposure to SHS  
2 based on covariables. Males had greater pulmonary function values than females, except for  
3 FEV<sub>1</sub>/FVC ratio, where no differences were observed. No differences in pulmonary  
4 function were observed between former smokers and never smokers groups. In terms of the  
5 occupational exposure variables, employees working in the kitchen had lower values for  
6 FVC, FEV<sub>1</sub>, and FEF<sub>25/75</sub> than the group of wait staff, bartenders, cashiers, and managers.  
7 Regarding the number of hours per week of SHS exposure and pulmonary function,  
8 exposure greater than 26 hours per week was associated with a 0.02% decrease in  
9 FEV<sub>1</sub>/FVC and a 230 ml decrease in FEF<sub>25/75</sub>, although these results were not statistically  
10 significant. Workers in smoking venues had FEF<sub>25/75</sub> 400 ml lower and FEV<sub>1</sub>/FVC ratios  
11 0.03% lower than those of workers in non-smoking venues. In terms of urine cotinine  
12 concentration, although differences were observed between categories of job function and  
13 the hours per week exposed to SHS, these differences were strongly influenced by  
14 workplace's smoking policy. For example, in the case of wait staff/bartenders/cashiers  
15 working in venues where smoking was allowed, they had a median urinary cotinine  
16 concentration of 40.7 ng/ml. Employees working in mixed venues (with smoking and non-  
17 smoking areas) had a median of 13.5 ng/ml and those who working in smoke-free venues  
18 had a median of 2.5 ng/ml. In the same way, the information regarding urinary cotinine  
19 concentration in people working over 27 hours per week exposed to SHS in venues where  
20 smoking was allowed was 45.2 ng/ml, in those working in mixed venues the median was  
21 13.6 ng/ml and in those working in smoke free venues the median was 2.0 ng/ml. The  
22 number of years exposed to SHS workplace varied according to sex, age and smoking  
23 status of employees.

**1 Table 2. Pulmonary function and exposure to secondhand smoke at non-smoking workers.**  
**2 Santiago, 2010-2011.**

Variables	Pulmonary function parameters					Urine cotinine concentration (ng/ml)	Number of years exposed to SHS at workplace
	n	FVC ml (RIC)	FEV <sub>1</sub> ml (RIC)	FEV <sub>1</sub> /FVC % (RIC)	FEF <sub>25%/75%</sub> ml (RIC)		
Sex							
Male	46	4.82 (4.23-5.42)	3.94 (3.41-4.38)	0.81 (0.76-0.84)	3.95 (3.00-4.66)	18.6 (6.2-39.5)	3.5 (1.0-11.3)
Female	29	3.48 (3.16-3.90)	2.89 (2.65-3.34)	0.81 (0.79-0.89))	3.25 (2.56-3.83)	13.6 (7.3-41.1)	1.0 (0.16-4.0)
p value ±		0.0001	0.0001	0.116	0.014	0.944	0.01
Age*							
≤35 years	38	4.79 (3.93-5.36)	3.91 (3.37-4.38)	0.83 (0.79-0.88)	4.07 (3.27-4.59)	21.4 (5.1-40.7)	1.0 (0.25-5.0)
>36 year	37	3.78 (3.21-4.42)	2.95 (2.61-3.62)	0.80 (0.78-0.83)	3.12 (2.53-3.95)	15.2 (9.7-38.1)	4.0 (1.0-11.7)
p value ±		0.0002	0.0001	0.049	0.0009	0.787	0.02
Smoking status							
Never smokers	53	4.23 (3.45-4.89)	3.49 (2.88-4.06)	0.81 (0.79-0.86)	3.69 (2.85-4.39)	21.7 (5.7-43.8)	1.0 (0.75-5.0)
Former smokers	22	4.33 (3.58-5.32)	3.53 (2.99-4.26)	0.81 (0.76-0.85)	3.77 (3.0-4.59)	12.9 (9.4-36.8)	6.3 (0.83-11.7)
p value ±		0.767	0.684	0.452	0.907	0.629	0.04
Job function at the facility							
Owners/managers	8	4.84 (3.47-6.09)	3.94 (2.66-4.48)	0.77 (0.72-0.80)	3.22 (2.19-3.90)	41.0 (29.3-46.1)	1.0 (0.8-4.1)
Wait staff/bartenders/cashiers	53	4.42 (3.74-5.17)	3.56 (3.14-4.20)	0.82 (0.79-0.86)	3.94 (3.11-4.59)	13.2 (5.1-39.5)	3.0 (0.4-7.1)
Cooks	14	3.38 (2.96-4.24)	2.81 (2.56-3.62)	0.82 (0.79-0.86)	3.08 (2.53-3.80)	25.0 (9.7-36.9)	1.6 (0.8- 4.0)
p value +		0.03	0.04	0.04	0.03	0.08	0.711
Hours per week exposed to SHS*							
≤26 hrs	39	4.05 (3.58-4.75)	3.44 (2.85-3.91)	0.82 (0.78-0.87)	3.81 (2.89-4.59)	11.3 (3.0-26.0)	2.0 (0.25-6.9)
>27 hrs	36	4.40 (3.45-5.40)	3.64 (2.89-4.32)	0.80 (0.77-0.84)	3.58 (2.78-4.38)	35.8 (11.6-48.1)	3.3 (0.9-7.04)
p value ±		0.279	0.457	0.173	0.603	0.0003	0.474
Facility							
Smoking/mixed	58	4.24 (3.32-5.26)	3.49 (2.85-4.23)	0.81 (0.77-0.84)	3.58 (2.73-4.44)	21.8 (10.5-44.7)	2.6 (0.9-7.0)
Non-smoking	17	4.24 (3.83-4.55)	3.49 (3.28-3.83)	0.84 (0.80-0.88)	3.98 (3.25-4.48)	4.1 (1.5-26.0)	1.5 (0-5.0)

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p value ±	0.825	0.845	0.06	0.176	0.0012	0.161
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- 1 \*Variable dichotomized in median value; + Kruskal Wallis test; ± Wilcoxon Test
- 2
- 3 Consistent with the literature, sex, age and weight were significantly associated with
- 4 pulmonary function parameters (Table 3). In terms of job function, the owners and
- 5 managers had FEV<sub>1</sub>/FVC values 60% lower and FEF<sub>25/75</sub> values 830 ml lower than the
- 6 group of wait staff, bartenders, and cashiers. The kitchen workers had 700 ml lower FVC
- 7 values, 640 ml lower FEV<sub>1</sub> values, and 772 ml lower FEF<sub>25/75</sub> than the group of wait staff,
- 8 bartenders, and cashiers. Workers in smoking facilities had 413 ml lower FEF<sub>25/75</sub> and 3%
- 9 lower FEV<sub>1</sub>/FVC than workers in non-smoking venues.
- 10 **Table 3. Bivariate association of pulmonary function parameters in non-smokers workers**
- 11 **according to covariables of interest.**

	FVC (ml)	FEV <sub>1</sub> (ml)	FEV <sub>1</sub> /FVC (ml)	FEF <sub>25/75</sub> (ml)
	β (CI95%)	β (CI95%)	β (CI95%)	β (CI95%)
<b>Sociodemographic variables</b>				
Sex				
Male	1.26 (0.880 to 1.650)	0.91 (0.601 to 1.213)	-0.03 (-0.064 to -0.0003)	0.61 (0.110 to 1.103)
Age	-0.03 (-0.05 to -0.02)	-0.03 (-0.04 to -0.02)	-0.001 (-0.003 to -0.003)	-0.04 (-0.055 to -0.019)
Weight	0.04 (0.02 to 0.05)	0.02 (0.01 to 0.04)	-0.001 (-0.002 to -0.0001)	0.01 (-0.004 to 0.034)
Size	0.08 (0.07 to 0.10)	0.06 (0.050 to 0.074)	-0.001 (-0.002 to 0.001)	0.05 (0.029 to 0.076)
Asthma				
Yes	0.04 (-0.731 to 0.802)	-0.17 (-0.750 to 0.422)	-0.05 (-0.100 to -0.010)	-0.67 (-1.470 to 0.122)

**Occupational exposure variables**

Job function at the facility

Wait staff/bartenders/cashiers	<i>Ref.</i>	<i>Ref.</i>	<i>Ref.</i>	<i>Ref.</i>
Owners/managers	0.37 (-0.370 to 1.110)	0.003 (-0.570 to 0.570)	-0.06 (-0.113 to -0.021)	-0.83 (-1.613 to -0.047)
Cooks	-0.70 (-1.290 to -0.120)	-0.64 (-1.090 to -0.190)	-0.02 (-0.061 to 0.022)	-0.77 (-1.391 to -0.151)
Hours per week exposed to SHS	0.01 (0.002 to 0.020)	0.01 (-0.0005 to 0.014)	-0.0004 (-0.001 to 0.0002)	0.002 (-0.008 to 0.011)
Facility				
Non-smoking	<i>Ref.</i>	<i>Ref.</i>	<i>Ref.</i>	<i>Ref.</i>
Smoking/mixed	0.10 (-0.460 to 0.672)	-0.05 (-0.486 to 0.381)	-0.03 (-0.071 to 0.003)	-0.41 (-1.003 to 0.177)

1

## 2 Association between pulmonary function and SHS exposure

3 The crude model revealed that the association between pulmonary function and urine  
 4 cotinine concentration was not statistically significant (Table 4). The multivariate analysis  
 5 was based on a parsimonious model that included the covariate "job function", as this  
 6 variable was related to pulmonary function and urine cotinine concentration with a p-  
 7 value < 0.10, as well as the variables sex, age, weight, height, and asthma status, all of which  
 8 are recognized as variables that affect pulmonary function according to SEPAR<sup>29, 32</sup>. The  
 9 adjusted model did not demonstrate a significant association between urine cotinine  
 10 concentration and decreased pulmonary function. Conversely, the number of years of SHS  
 11 exposure in workplace showed an inverse and significant association with FEV<sub>1</sub>. Each year  
 12 of SHS exposure was associated with a 200 ml decrease in FEV<sub>1</sub> (95% CI -0.042 to -0.001).  
 13 The other pulmonary function variables were also inversely associated with years of SHS  
 14 exposure in workplace, although the association in these cases did not reach significance.  
 15 The adjusted model showed an inverse and in some cases statistically significant

1 association between the number of years of SHS exposure and pulmonary function  
 2 parameters, specifically in FEF<sub>25/75</sub> ( $\beta = -0.006$ ; 95% CI -0.010 to -0.0004).

3  
 4 **Table 4. Crude and adjusted association between pulmonary function parameters and**  
 5 **SHS exposure of non-smoking workers of bars and restaurants.**

	FVC (ml)		FEV <sub>1</sub> (ml)		FEV <sub>1</sub> /FVC (ml)		FEF <sub>25/75</sub> (ml)	
	$\beta$ (CI95%)	R <sup>2</sup>	$\beta$ (CI95%)	R <sup>2</sup>	$\beta$ (CI95%)	R <sup>2</sup>	$\beta$ (CI95%)	R <sup>2</sup>
<b>Urine cotinine</b>								
Crude model	0.002 (-0.010 to 0.010)	0.002	0.002 (-0.010 to 0.010)	0.003	0.0002 (-0.001 to 0.001)	0.002	0.002 (-0.010 to 0.010)	0.002
Adjusted model	-0.0002 (-0.007 to 0.006)*	0.781	0.001 (-0.003 to 0.006)*	0.795	0.0004 (-0.0003 to 0.001)+	0.33	0.005 (-0.006 to 0.015)+	0.672
<b>Number of years exposed to SHS at work</b>								
Crude model	-0.025 (-0.051 to 0.002)	0.046	-0.022 (-0.042 to -0.001)	0.061	-0.0008 (-0.002 to 0.0008)	0.013	-0.022 (-0,050 to 0,006)	0.032
Adjusted model	-0.013 (-0.030 to 0.0025)*	0.79	-0.01 (-0.022 to 0.002)*	0.802	0.0006 (-0.001 to 0.002)+	0.324	-0.006 (-0,010 to -0,0004)+	0.964

\*Adjusted by sex, age, weight, size and job function at the facility; + Adjusted by sex, age, size, asthma status and job function at the facility

6

7

## 1 Discussion

2 This study is the first in Chile to evaluate occupational SHS exposure and its association  
3 with specific pulmonary function parameters. We did not find an inverse association  
4 between pulmonary function parameters and urine cotinine concentration, but when we  
5 considered number of years exposed to SHS in workplace, we found an inverse association  
6 with FVC (ml), FEV<sub>1</sub> (ml), FEV<sub>1</sub>/FVC (ml) and FEF<sub>25/75</sub> being significant only for the last  
7 parameter. Similar findings were described by other researchers who reported a reduction  
8 in FVC and FEF<sub>25/75</sub><sup>20, 33</sup>, in FVC<sup>15</sup>, in FVC and FEV<sub>1</sub><sup>16</sup> in subjects exposed to  
9 environmental tobacco smoke. In terms of job function, kitchen workers showed lower  
10 pulmonary function values than the group of wait staff, bartenders, and cashiers as  
11 compared to the owners and managers. One possible explanation for these findings is that  
12 the SHS exposure had an additive effect with exposure to other pollutants emitted in the  
13 kitchen. In the literature has been reported that workers in kitchens with gas stoves show  
14 lower pulmonary function parameters than those in kitchens with electric stoves, due to  
15 greater exposure to toxic substances in the air after cooking with gas<sup>34</sup>. In our study, it was  
16 not possible to analyze differences according this variable because 100% of the  
17 establishments used gas stoves.

18 As noted above, we did not find a significant association between pulmonary function  
19 parameters and urine cotinine concentration. A possible explanation for these results is that,  
20 urine cotinine levels reflect recent exposure to tobacco smoke<sup>21, 22, 31</sup> while chronic  
21 exposure to SHS is likely implicated in a decline in pulmonary function parameters. In fact,  
22 in Table 4 we can see that the proportion of the variance ( $R^2$ ) explained by *number of years*  
23 *of SHS exposure in workplace* is greater than that explained by the current *urine cotinine*

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2  
3 1 *concentration*, suggesting that this variable (*number of years of SHS exposure*) may be  
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5 2 more appropriate when we are studying chronic effects. Other studies that have addressed  
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7  
8 3 this topic have produced varying results<sup>15-17, 20-22, 31, 35</sup> reported a significant inverse  
9  
10 4 association between SHS exposure (evaluated through self-report) and FVC and FEV<sub>1</sub>. As  
11  
12 5 in our study, Chen et al. did not find a significant association when serum cotinine was  
13  
14 6 assess as exposure variable, but did when exposure to SHS was measured through self-  
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16 7 report<sup>16</sup>.

17  
18  
19 8 Our results are not as strong as those described in other studies<sup>12-14, 20, 33</sup>. It should be noted  
20  
21 9 that our sample included mainly young workers being reasonable to infer that the sample  
22  
23 10 not accumulated sufficient years of SHS exposure to register significant changes in  
24  
25 11 pulmonary function. Also the median time worked at the location was only about 1 year.  
26  
27 12 About 25% of the sample had worked at the given facility for less than 3 months, and 75%  
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29 13 of the sample had worked at the location for fewer than 2 years. This condition of high  
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31 14 turnover rate, along with the relative youth of the workers contributes to assume that the  
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33 15 sample not accumulated enough years of SHS exposure to register significant changes in  
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35 16 pulmonary function. A second limitation was that although all participants were non-  
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37 17 smokers, those who worked in non-smoking venues reported be exposed to SHS at least 4  
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39 18 hours a week. Also in this group the median urine cotinine concentration was 4.1 ng/ml.  
40  
41 19 The lack of a true control group could have lead to underestimating the effect of SHS  
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43 20 exposure. Another potential limitation was the timing of the spirometry measurements. The  
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45 21 literature reports that pulmonary function varies throughout the day according to circadian  
46  
47 22 rhythm, decreasing from a high point in the early morning until about noon and then rising  
48  
49 23 again to peak between about 4 and 5 in the afternoon. These daily fluctuations may have



1 affected the results, as the lung function measurements were performed at various times of  
2 day, according to the availability and shifts of the workers and establishments. Finally, our  
3 small sample size along with the weak correlation between exposure to SHS and pulmonary  
4 function prevent us to have enough power to demonstrate a strongest association as shown  
5 in other studies.

6 Notwithstanding the above, our study shows that exposure to SHS among non-smoking  
7 employees working in venues where smoking is allowed appear to be substantially higher  
8 than those found in employees working in venues where smoking is not allow. The median  
9 urine cotinine in non-smoking employees working in a venue were smoking is allowed was  
10 38.1 ng/ml, in a mixed venue was 12.5 ng/ml and where smoking was not allow was 4.1  
11 ng/ml. Given that SHS is a proven carcinogen in humans to which non-smoking workers of  
12 this type of venues are exposed involuntarily, a total smoking ban would provide a major  
13 protection to employees working in such venues.

#### 14 **Conclusion**

15 The years of exposure to SHS in workplace as proxy of chronic exposure were inverse and  
16 significantly associated with the FEF<sub>25/75</sub>, and inverse but not significant with FVC and  
17 FEV<sub>1</sub>. These findings suggest that cumulative exposure to SHS at work may contribute to  
18 deterioration of pulmonary function in non-smoking employees.

#### 19 **Acknowledgments**

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21 participate in this study. Also to the Department of Research of the Universidad de Los  
22 Andes-Chile for the support given to translate this article.

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3 **1 Data Sharing**

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5  
6 2 No additional data available.

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9 **3 Competing interest**

10  
11  
12 4 The authors have no conflict of interest to declare.

13  
14  
15 **5 Funding**

16  
17  
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19  
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23  
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25  
26  
27 9 Center, NIH Research Grant #D43TW005746-02.

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29 **10 References**

- 30  
31 1. Aceituno P, Iglesias V, Erazo M, Droppelmann A, Orellana C, Navas-Acién A. The  
32  
33 12 work environment as a source of exposure to secondhand smoke: a study in workers of  
34  
35  
36 13 bars and restaurants of Santiago, Chile. *Rev Med Chile* 2010;138:1517-1523.
- 37  
38 14 2. Alwan A. World Health Organization. WHO Report on the Global Tobacco Epidemic.  
39  
40  
41 15 Implementing smoke-free environments, 2009. [Cited 2016 Jun 24]. Available from:  
42  
43 16 [http://who.int/tobacco/mpower/2009/gtcr\\_download/en/index.html](http://who.int/tobacco/mpower/2009/gtcr_download/en/index.html)
- 44  
45 17 3. Bello S, Michalland S, Soto M, Contreras C, Salinas J. Effects in passive smokers of  
46  
47 18 environmental tobacco smoke exposure. *Rev Chil Enf Respir* 2005;21:179-192.
- 48  
49  
50 19 4. Chan-Yeung M, Dimich-Ward H. Respiratory health effects of exposure to  
51  
52  
53 20 environmental tobacco smoke. *Respirology* 2003;8(2):131-139.
- 54  
55  
56  
57  
58  
59  
60

- 1 5. Collishaw NE, Kirkbride J, Wigle D. Tobacco smoke in the workplace: an occupational  
2 health hazard. *Can Med Assoc J* 1984;131(10):1191-1204.
- 3 6. EPA. Proposed identification of environmental tobacco smoke as a Toxic Air  
4 Contaminant. Tobacco Control. Surveys and Program Evaluations from Outside UCSF  
5 Paper CALEPA, 2005. [cited 2017 July 18]; Available from:  
6 <https://oehha.ca.gov/media/downloads/air/report/app32005.pdf>
- 7 7. Department of Health and Human Services USA. The consequences of smoking on  
8 health. 50 years of progress. Report of the US Department of Health and Human  
9 Services USA. Executive Summary, 2014.
- 10 8. OMS-OPS. Report on tobacco control in the Region of the Americas. 10 years of the  
11 Framework Convention of the World Health Organization for tobacco control.  
12 Washington D.C, 2016.
- 13 9. Allwright S, Paul G, Greiner B, Mullally BJ, Pursell L, Kelly A, et al. Legislation for  
14 smoke-free workplaces and health of bar workers in Ireland: before and after study.  
15 *BMJ* 2006;332(7534):151.
- 16 10. Coultas D. Health effects of passive smoking. Passive smoking and risk of adult asthma  
17 and COPD: an update. *Thorax* 1998;53(5):381-387.
- 18 11. De Vito E, Rojas R. Environmental tobacco smoke. *Medicina (B. Aires)*  
19 *2005*;65(6):545-549.
- 20 12. Jaakkola M, Jaakkola J, Becklake M, Ernst P. Passive smoking and evolution of lung  
21 function in young adults. An 8-year longitudinal study. *J Clin Epidemiol*  
22 *1995*;48(3):317-327.

- 1  
2  
3 13. Jayet PY, Schindler C, Schwartz J, Kunzli N, Zellweger P, Ackermann-Liebrich U,  
4  
5 2 Leuenberger P. Passive smoking exposure among adults and the dynamics of  
6  
7 3 respiratory symptoms in a prospective multicenter cohort study. *Scand J Work Environ*  
8  
9 4 *Health* 2005;31(6):465-473.
- 10  
11  
12 14. Rizzi M, Sergi M, Andreoli A, Pecis M, Bruschi C, Fanfulla F. Environmental tobacco  
13  
14 5 smoke may induce early lung damage in healthy male adolescents. *Chest*  
15  
16 6 2004;125(4):1387-1393.
- 17  
18  
19 15. Alipour S, Deschamps F, Lesage F. Effects of Environmental Tobacco Smoke on  
20  
21 8 Respiratory Symptoms and Pulmonary Function. *Inhal Toxicol* 2005;18(8):569-573.
- 22  
23  
24 16. Chen R, Tunstall-Pedoe H, Tavendale R. Environmental tobacco smoke and lung  
25  
26 10 function in employees who never smoked: the Scottish MONICA study. *Occup Environ*  
27  
28 11 *Med* 2001;58(9):563-568.
- 29  
30  
31 17. Fidan F, Cimrin AH, Ergor G, Sevinc C. Airway disease risk from environmental  
32  
33 13 tobacco smoke among coffeehouse workers in Turkey. *Tob Control* 2004;13(2):161-6.
- 34  
35  
36 18. Janson C, Chinn S, Jarvis D, Zock JP, Torén K, Burney P. Effects of passive smoking  
37  
38 15 on respiratory symptoms, bronchial responsiveness, lung function, and total serum IgE  
39  
40 16 in the European Community Respiratory Health survey: a cross sectional study. *Lancet*  
41  
42 17 2001;358(2):103-109.
- 43  
44  
45 19. Eisner Mark D. Environmental tobacco smoke exposure and pulmonary function among  
46  
47 19 adults in NHANES III: impact on the general population and adults with current  
48  
49 20 asthma. *Environ Health Perspect* 2002;110(8):765-70.
- 50  
51  
52 20. Kunzli N, Schwartz J, Stutz EZ, Ackermann-Liebrich U, Leuenberger P. Association of  
53  
54 22 environmental tobacco smoke at work and forced expiratory lung function among never  
55  
56 23  
57  
58  
59  
60

- 1 smoking asthmatics and non-asthmatics. The SAPALDIA-Team. Swiss Study on Air  
2 Pollution and Lung Disease in Adults. *Soz Praventivmed* 2000;45(5):208-17.
- 3 21. Benowitz NL. Biomarkers of environmental tobacco smoke exposure. *Environ Health*  
4 *Perspect* 1999;107(2):349-55.
- 5 22. Tutka P, Mosiewicz J, Wielosz M. Pharmacokinetics and metabolism of nicotine.  
6 *Pharmacol Rep* 2005;57(2):143-53.
- 7 23. Centers for Disease Control and Prevention. National Report of Human Exposure to  
8 Environmental Chemicals, 2017. [Cited 2017 March 15]. Available from:  
9 <https://www.cdc.gov/exposurereport/>
- 10 24. Al-Delaimy WK, Crane J, Woodward A. Questionnaire and hair measurement of  
11 exposure to tobacco smoke. *J Expo Anal Environ Epidemiol* 2000;10:378-384.
- 12 25. Al-Delaimy WK. Hair as a biomarker for exposure to tobacco smoke. *Tob Control*  
13 2002;11:176-182.
- 14 26. Iglesias V, Erazo M, Droppelmann A, Steenland K, Aceituno P, Orellana C, Acuña M,  
15 Peruga A, Breyse PN, Navas-Acien A. Occupational secondhand smoke is the main  
16 determinant of hair nicotine concentrations in bar and restaurant workers. *Environ Res*  
17 2014;132:206–211.
- 18 27. Salud OMS. “Convenio Marco de la OMS para el control del tabaco”, 2013. [Cited  
19 2016 Jun 24]. Available from: [http://www.who.int/fctc/text\\_download/es/](http://www.who.int/fctc/text_download/es/).
- 20 28. Muñoz C, Droppelmann A, Erazo M, Aceituno P, Orellana C, Parro J, Mesias S,  
21 Marchetti N, Navas-Acien A, Iglesias V. Occupational exposure to polycyclic aromatic  
22 hydrocarbons: A cross-sectional study in bars and restaurants in Santiago, Chile. *Am J*  
23 *Ind Med* 2016; Version of record online: 28 Jun 2016.

- 1  
2  
3 1 29. Burgos F, Casan P, Del Campo F, Gáldiz J, Giner J, González-Mangado N, Ortega F,  
4  
5 2 Puente L, García F, Calle M.  
6  
7 SEPAR Regulation: Forced Spirometry, 2013. [Cited 2016 Jun 24]. Available from:  
8 3  
9 <http://www.ics.gencat.cat/3clics/guies/184/img/--guiasepar20131.pdf>  
10 4  
11  
12 5 30. Gutiérrez M, Beroíza T, Barzone G, Caviades I, Céspedes I, Céspedes J, Gutiérrez NM,  
13 6 Moreno R, Oyarzún M, Palacios S, Schonffeldt P. Spirometry: Procedures Manual.  
14 7 Chilean Society of Respiratory Diseases, 2006. *Rev Chil Enf Respir* 2007;23:31-42.  
15 8 31. Vine M, Hulka B, Margolin B, Truong Y, Hu PC, Schramm M, Griffith J, McCann M,  
16 9 Everson R. Cotinine Concentrations in Semen, Urine, and Blood of Smokers and  
17 10 Nonsmokers. *Am J Public Health* 1993;83(9):1335-1338.  
18 11 32. Tong S, Lu Y. Identification of confounders in the assessment of the relationship  
19 12 between lead exposure and child development. *Ann Epidemiol* 2001;11(1): 38-45.  
20 13 33. Fahim AE, El-Prince M. Passive smoking, pulmonary function and bronchial hyper-  
21 14 responsiveness among indoor sanitary workers. *Industrial health* 2012;59: 516-520.  
22 15 34. Wong TW, Wong AH, Lee FS, Qiu H. Respiratory health and lung function in Chinese  
23 16 restaurant kitchen workers. *Occup Environ Med* 2011;68(10):746-752.  
24 17 35. Skogstad M, Kjaerheim K, Fladseth G, Gjølstad M, Daae HL, Olsen R, Molander P,  
25 18 Ellingsen DG. Cross shift changes in lung function among bar and restaurant workers  
26 19 before and after implementation of a smoking ban. *Occup Environ Med* 2006;63:482-  
27 20 487.

21 **Contributorship statement**

1 Parro Javiera. Substantial contributions to the conception and design of the work on  
2 pulmonary function parameters; acquisition, analysis and interpretation of data, drafting the  
3 work, and final approval of the version to be published;

4 Aceituno Paulina. Substantial contributions to the conception and design of the work,  
5 revising it critically for important intellectual content, final approval of the version to be  
6 published.

7 Droppelman Andrea. Substantial contributions to the conception, design of the work and  
8 interpretation of exposure data, final approval of the version to be published.

9 Mesías Sthepanie. Substantial contributions to the acquisition and analysis of exposure  
10 data, final approval of the version to be published.

11 Muñoz Claudio. Substantial contributions to the acquisition, analysis and interpretation of  
12 data, final approval of the version to be published.

13 Marchetti Nella. Substantial contributions to the conception of the work and interpretation  
14 of data, final approval of the version to be published.

15 Iglesias Verónica. Substantial contributions to the conception and design of the work,  
16 analysis and interpretation of data for the work; drafting the work, final approval of the  
17 version to be published, agreement to be accountable for all aspects of the work in ensuring  
18 that questions related to the accuracy or integrity of any part of the work are appropriately  
19 investigated and resolved.

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract page 1 line 1-2 (b) Provide in the abstract an informative and balanced summary of what was done and what was found page 2 line 1-22
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported page 3-5
Objectives	3	State specific objectives, including any prespecified hypotheses page 5 line 4
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper page 5 line 8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection page 5 line 13-23
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants page 5 line 13-23 (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable page 6 line 4-23, page 7 line 1-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group page 6 line 4-23, page 7 line 1-8
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at NO
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why page 7 line 19-22, page 8 line 1-8.
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding page 7 line 10-20 (b) Describe any methods used to examine subgroups and interactions page 7 line 10-20 (c) Explain how missing data were addressed not apply (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of



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sampling strategy page 7 line 10-20

(e) Describe any sensitivity analyses NO

Continued on next page

For peer review only

<b>Results</b>		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <a href="#">page 8 line 1-8</a> (b) Give reasons for non-participation at each stage <a href="#">page 8 line 1-8</a> (c) Consider use of a flow diagram <b>NO</b>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <a href="#">page 8 table 1</a> (b) Indicate number of participants with missing data for each variable of interest <b>not apply</b> (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures <b>NO</b>
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <a href="#">page 13 Table 4</a> (b) Report category boundaries when continuous variables were categorized <a href="#">page 10 Table 2</a> (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period <b>NO</b>
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>NO</b>
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives <a href="#">page 14 line 2-17</a>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <a href="#">page 15 line 8-23</a> <a href="#">page 16 line 1-5</a>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <a href="#">page 16 line 15-18</a>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>NO</b>
<b>Other information</b>		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <a href="#">page 17 line 2</a>

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).