Context.—The association between environmental tobacco smoke (ETS) exposure and respiratory symptoms has not been well established in adults.

Objective.—To study the respiratory health of bartenders before and after legislative prohibition of smoking in all bars and taverns by the state of California.

Design.—Cohort of bartenders interviewed before and after smoking prohibition.

Setting and Participants.—Bartenders at a random sample of bars and taverns in San Francisco.

Main Outcome Measures.—Interviews assessed respiratory symptoms, sensory irritation symptoms, ETS exposure, personal smoking, and recent upper respiratory tract infections. Spirometric assessment included forced expiratory volume in 1 second (FEV₁) and forced vital capacity (FVC) measurements.

Results.—Fifty-three of 67 eligible bartenders were interviewed. At baseline, all 53 bartenders reported workplace ETS exposure. After the smoking ban, self-reported ETS exposure at work declined from a median of 28 to 2 hours per week (P<.001). Thirty-nine bartenders (74%) initially reported respiratory symptoms. Of those symptomatic at baseline, 23 (59%) no longer had symptoms at follow-up (P<.001). Forty-one bartenders (77%) initially reported sensory irritation symptoms. At follow-up, 32 (78%) of these subjects had resolution of symptoms (P<.001). After prohibition of workplace smoking, we observed improvement in mean FVC (0.189 L; 95% confidence interval [CI], 0.082-0.296 L; 4.2% change) and, to a lesser extent, mean FEV₁ (0.039 L; 95% CI, −0.030 to 0.107 L; 1.2% change). Complete cessation with improved mean FVC (0.287 L; 95% CI, 0.088-0.486; 6.8% change) and mean FEV₁ (0.142 L; 95% CI, 0.020-0.264 L; 4.5% change), after controlling for personal smoking and recent upper respiratory tract infections.

Conclusion.—Establishment of smoke-free bars and taverns was associated with a rapid improvement of respiratory health.
attempts. The owners of 36 bars declined study participation; 7 returned the decline postcard and 29 declined by telephone. During telephone contact, the reasons provided for declining were disagreement with the change in the Labor Code (n = 8, 28%), inconvenience (n = 3, 11%), or not stated (n = 18, 61%). Ultimately, 25 bars and taverns (30%) still in business participated. As presented later in the “Methods” section, we found no evidence of systematic bias introduced by bar or tavern nonparticipation.

**Recruitment of Bartenders**

At prearranged times, a single study investigator (M.D.E.) visited each participating bar or tavern and attempted to recruit all bartenders who worked there at least 1.1 days per week. Because study participation required about 15 minutes per subject, we were unable to conduct the study during peak business hours. The 25 participating bars and taverns employed 124 bartenders, with 67 bartenders working at least 1 weekly daytime shift. Fifty-four of the daytime bartenders (81%) completed baseline interviews and spirometry; 53 of these subjects (98%) completed follow-up. A small number of subjects (n = 3, 6%) were no longer working in bars or taverns at the time of the follow-up interview and lung function assessment (these subjects were retained for analysis). The mean interval (SD) between baseline and follow-up interviews was 56 (9) days (median, 56 days).

The estimated annual average number of bartenders employed in San Francisco was 1910 (1994 data based on the California Employment Development Department Labor Market Information Database). Our study sample of bartenders, then, represents approximately 2.8% of all bartenders employed in San Francisco.

**Interviews**

All subjects underwent a standard baseline interview conducted by a single study investigator (M.D.E.) in their workplaces. Respiratory symptoms were assessed with 5 questions from the International Union Against Tuberculosis and Lung Disease (IUATLD) Bronchial Symptoms Questionnaire. Three questions ascertained the presence of red, teary, or irritated eyes; runny nose, sneezing, or nose irritation; and sore or scratchy throat during the past 4 weeks. Personal, active cigarette smoking was measured using questions developed for the National Health Interview Survey. In 3 additional questions, we evaluated ETS exposure duration in work, home, and other settings during the previous 7 days (in hours per week).

Several questions focused on baseline health and demographic characteristics. Using a question from the National Health and Nutrition Examination Survey (NHANES), we assessed whether subjects had physician-diagnosed asthma. In addition, medication use for asthma was ascertained. We evaluated whether subjects had an upper respiratory tract infection (URI) during the past 4 weeks with the following question: “In the last 4 weeks, have you had a cold?” Finally, demographic information was collected, including age, sex, race, and education.

Conducted about 8 weeks later, follow-up interviews contained the same questions about respiratory symptoms, personal smoking, ETS exposure, and URIs. At the end of the second interview, we ascertained personal beliefs about the health effects of ETS exposure and attitudes about the prohibition of smoking in bars and taverns.

**Spirometry**

All participating bartenders underwent spirometry at both baseline and follow-up in their workplaces. We measured lung function with a portable spirometer (Creative Biomedics, San Clemente, Calif). Using a standard protocol conforming to American Thoracic Society Guidelines, we had each subject perform at least 5 forced expiratory maneuvers. Forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), and forced expiratory flow, midexpiratory phase (FEF25%-75%) were determined.

**Participating and Nonparticipating Bars and Taverns**

To assess the comparability of participating and nonparticipating establishments, we obtained information about San Francisco bars and taverns from several sources. The State of California Department of Alcoholic Beverage Control provided liquor license issuance dates and license status. We extracted data about establishment size (square meters), county health score (general rating of establishment health), cigarette use (no, yes, unknown), length of time in business (either same owner or same establishment name), and health code violations from Department of Public Health Environmental Health Section inspection records. Table 1 shows that there were no statistically significant differences between participating and nonparticipating bars (P > .40 in all cases).

To estimate how closely our sample of bartenders matched the target population of San Francisco bartenders, we reviewed demographic data for an available comparison group—unionized San Francisco bartenders (n = 462) obtained from the Hotel and Restaurant Employees and Bartenders Union Local 2 (affiliated with the American Federation of Labor–Congress of Industrial Organizations). Compared with union members, the bartenders in our sample were younger (mean [SD], 42 [14] vs 51.0 [11.4] years; P < .001) and more likely to be female (28% vs 17%; P = .05). There was no statistically significant difference in the proportion of nonwhite bartenders in our sample compared with union members (37% vs 29%; P = .25).

**Statistical Analysis**

Our general analytic framework compared the respiratory health of bartenders before and after prohibition of smoking in bars and taverns. The study had 2 central hypotheses. First, respiratory and sensory irritation symptoms would improve among bartenders after reduced ETS exposure following the legislative ban. Second, bartenders’ pulmonary function would improve after reduction in workplace ETS exposure.

Interview and spirometry data were analyzed using SAS software version 6.12 (SAS Institute Inc, Cary, NC), unless otherwise noted. We compared the change in work duration (hours per week), personal smoking, and ETS exposure using the paired t test for normally distributed variables, paired Wilcoxon signed rank test for nonnormally distributed continuous variables, and McNemar chi-square test for dichotomous variables.

To reduce the number of statistical comparisons, we defined 2 a priori primary symptom end points: any respiratory symptom (wheeze, shortness of breath, morning cough, cough during the rest of the day or night, or phlegm production) and any sensory irritation symptom (eye, nose, or throat). The McNemar chi-square test was used to compare the observed change in each symptom end point with that expected by chance. We then performed secondary analyses to evaluate the change in each symptom type during follow-up.

To address the potential confounding effect of recent URIs, we repeated the primary analyses excluding these subjects. To control for personal smoking, we also repeated the analyses stratified by smoking status. Using Stata software version 5.0 (Stata Corp, College Station, Texas), we performed the analyses using the survey commands.

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Tex), we then performed conditional logistic regression analysis on the entire sample to estimate the impact of reduced workplace ETS exposure on the 2 primary symptom outcomes, controlling for the effects of URIs and personal cigarette consumption at both interviews. The change in pulmonary function after reduction in workplace ETS exposure was examined using paired t tests. The primary end points were FEV₁, FVC, and FEF₂⁵-⁷⁵. As before, we repeated the analyses excluding subjects with URIs. We also controlled for the potential confounding effect of personal smoking by further stratifying the analysis by smoking status. Because the legislative ban was only partially successful in prohibiting smoking in some bars, we were able to examine the effect of complete (vs partial) cessation of workplace ETS exposure on each pulmonary function parameter using multiple linear regression analysis. The multivariate model controlled for personal smoking, reduced daily cigarette consumption at follow-up, and URIs during the 4 weeks prior to baseline. To evaluate a dose-response relationship, we repeated the multivariate analysis using complete workplace exposure cessation as the referent case and 2 dichotomous indicator variables for moderate exposure (1-6 hours; P < .001) after the smoke-free workplace law went into effect (Table 3). We observed a parallel decrease in other (nonwork) and total ETS exposure. Despite the prohibition of smoking, 29 subjects (55%) continued to report some ETS exposure (≥1 h/wk) while working as bartenders.

**RESULTS**

**Bartender Characteristics**

For the 53 participating bartenders completing follow-up interviews and spirometry, the average (SD) age was 42.5 (14.0) years. A substantial proportion of subjects were female (28%) and nonwhite (38%) (Table 2). The mean duration of employment at the current bar or tavern was 6.1 (SD, 7.1) years (median, 3.0 years). Other subject characteristics are summarized in Table 2.

**Cigarette Smoking and ETS Exposure**

Forty (76%) of the 53 bartenders reported a history of ever smoking, with 24 (45%) currently smoking at baseline (Table 3). There was no change in the proportion of current smokers from baseline to follow-up interviews, after prohibition of workplace smoking. Among the current smokers, there was no overall change in daily cigarette consumption during the follow-up period. At baseline, all 53 subjects reported ETS exposure while working in bars or taverns during the 7 days prior to interview. After prohibition of smoking, there was no significant change in weekly work duration from baseline (mean [SD], 33.4 [14.9] hours) to follow-up interviews (32.2 [17.5] hours; P = .48). However, self-reported workplace ETS exposure sharply declined from a median of 28 to 2 h/wk (P < .001) after the smoke-free workplace law went into effect (Table 3). We observed a parallel decrease in other (nonwork) and total ETS exposure. Despite the prohibition of smoking, 29 subjects (55%) continued to report some ETS exposure (≥1 h/wk) while working as bartenders.

**Table 1.—Comparison of Participating and Nonparticipating Bars and Taverns in San Francisco**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Participating Bars (n = 25)</th>
<th>Nonparticipating Bars (n = 58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health center location, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5 (20)</td>
<td>13 (22)</td>
</tr>
<tr>
<td>3</td>
<td>2 (9)</td>
<td>8 (14)</td>
</tr>
<tr>
<td>4</td>
<td>7 (28)</td>
<td>14 (24)</td>
</tr>
<tr>
<td>5</td>
<td>11 (44)</td>
<td>23 (40)</td>
</tr>
<tr>
<td>Establishment size, mean (SD), m²</td>
<td>143.91 (95.76)</td>
<td>128.36 (84.06)</td>
</tr>
<tr>
<td>Years in business, mean (SD), y</td>
<td>13.6 (9.5)</td>
<td>15.3 (8.3)</td>
</tr>
<tr>
<td>Current liquor license duration, mean (SD), y</td>
<td>9.9 (6.5)</td>
<td>9.0 (7.0)</td>
</tr>
<tr>
<td>Liquor license with active status, No. (%)</td>
<td>25 (100)</td>
<td>58 (100)</td>
</tr>
<tr>
<td>Any health code violation in past 1 year, No. (%)</td>
<td>11 (46)</td>
<td>25 (43)</td>
</tr>
</tbody>
</table>

*P < .01 in all comparisons of participating vs nonparticipating bars. The sources of data are the Department of Public Health Environmental Health Section inspection records (health center location, establishment size, years in business, and health code violations) and State of California Department of Alcoholic Beverage Control (liquor license information).

**Table 2.—Baseline Bartender Characteristics (n = 53)**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Participating Bars (n = 53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td></td>
</tr>
<tr>
<td>Sex, No. (%) female</td>
<td>42.5 (14.0)</td>
</tr>
<tr>
<td>Race, No. (%)</td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>15 (28)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>33 (62)</td>
</tr>
<tr>
<td>African American</td>
<td>10 (19)</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>2 (4)</td>
</tr>
<tr>
<td>College or greater</td>
<td>6 (11)</td>
</tr>
<tr>
<td>Education, highest level attained, No. (%)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>High school</td>
<td>13 (25)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>3.0 (1.5-8.0)</td>
</tr>
<tr>
<td>Median (25th-75th interquartile range)</td>
<td>6.1 (7.1)</td>
</tr>
<tr>
<td>History of physician-diagnosed asthma, No. (%)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Currently receiving asthma medications, No. (%)</td>
<td>9 (17)</td>
</tr>
</tbody>
</table>

**Table 3.—Comparison of Participating and Nonparticipating Bars and Taverns in San Francisco**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Participating Bars (n = 25)</th>
<th>Nonparticipating Bars (n = 58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health center location, No. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5 (20)</td>
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</tr>
<tr>
<td>3</td>
<td>2 (9)</td>
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<tr>
<td>Establishment size, mean (SD), m²</td>
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<td>128.36 (84.06)</td>
</tr>
<tr>
<td>Years in business, mean (SD), y</td>
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<td>15.3 (8.3)</td>
</tr>
<tr>
<td>Current liquor license duration, mean (SD), y</td>
<td>9.9 (6.5)</td>
<td>9.0 (7.0)</td>
</tr>
<tr>
<td>Liquor license with active status, No. (%)</td>
<td>25 (100)</td>
<td>58 (100)</td>
</tr>
<tr>
<td>Any health code violation in past 1 year, No. (%)</td>
<td>11 (46)</td>
<td>25 (43)</td>
</tr>
</tbody>
</table>

*P < .01 in all comparisons of participating vs nonparticipating bars. The sources of data are the Department of Public Health Environmental Health Section inspection records (health center location, establishment size, years in business, and health code violations) and State of California Department of Alcoholic Beverage Control (liquor license information).

**P < .01 in all comparisons of participating vs nonparticipating bars. The sources of data are the Department of Public Health Environmental Health Section inspection records (health center location, establishment size, years in business, and health code violations) and State of California Department of Alcoholic Beverage Control (liquor license information).**

**P < .01 in all comparisons of participating vs nonparticipating bars. The sources of data are the Department of Public Health Environmental Health Section inspection records (health center location, establishment size, years in business, and health code violations) and State of California Department of Alcoholic Beverage Control (liquor license information).**

**RESULTS**

**Bartender Characteristics**

For the 53 participating bartenders completing follow-up interviews and spirometry, the average (SD) age was 42.5 (14.0) years. A substantial proportion of subjects were female (28%) and nonwhite (38%) (Table 2). The mean duration of employment at the current bar or tavern was 6.1 (SD, 7.1) years (median, 3.0 years). Other subject characteristics are summarized in Table 2.

**Cigarette Smoking and ETS Exposure**

Forty (76%) of the 53 bartenders reported respiratory symptoms at baseline, while only 17 (32%) were still symptomatic at follow-up (Table 4). Of the 39 bartenders reporting baseline symptoms, 23 subjects (59%) no longer indicated any respiratory symptoms after prohibition of smoking (P < .001). The majority of bartenders also had at least 1 sensory irritation symptom at baseline (77%), with fewer reporting symptoms at follow-up (19%). With introduction of smoke-free workplaces, sensory symptoms were no longer present in 32 (78%) of the 41 previously symptomatic subjects (P < .001).

Since URIs can be associated with both respiratory and sensory irritation symptoms, we repeated the analyses excluding the 8 subjects who reported a recent URI at baseline interview. A majority of the remaining 45 bartenders (69%) still reported respiratory symptoms at baseline, with most of these subjects (65%) indicating resolution of symptoms at follow-up (P < .001). Similarly, most bartenders without recent URIs noted sensory irritation symptoms at baseline (76%). At follow-up interview, the majority of these subjects (79%) no longer reported any sensory symptoms (P < .001).

We recognized that smoke-free bars and taverns might lead bartenders to curtail their personal smoking, which could diminish respiratory symptoms. After stratifying the analysis by smoking status, we observed similar results. Of the previously symptomatic smoking bartenders, the majority no longer reported respiratory (63%) or sensory irritation symptoms (80%) at follow-up (P < .001 in both cases). Similarly, most nonsmoking bartenders with baseline symptoms reported resolution of respiratory (53%) or sensory irritation symptoms (76%) (P = .02 and P < .001, respectively).

Conditional logistic regression analysis was performed to estimate the independent impact of reduced bar ETS exposure on the primary symptom end points. A 5-hour reduction in workplace ETS exposure was associated with a lower risk of respiratory symptoms at follow-up (odds ratio [OR], 0.7; 95% confidence interval [CI], 0.5-0.9), after controlling for URIs and daily cigarette consumption at both interviews. In a similar analysis, a 5-hour decrement in bar ETS exposure was associated with a lower risk of respiratory symptoms at follow-up (OR, 0.5; 95% CI, 0.3-0.8). Excluding the 3 subjects no longer working as bartenders at follow-up did not appreciably affect these risk estimates.

**Pulmonary Function**

After prohibition of smoking, the mean FVC and FEV₁ both increased at follow-up (Table 5). Flow rate at midlung volumes (FEF₂⁵-⁷⁵), which was
highly variable, declined during the study period.

As with symptom end points, we performed additional analyses to control for the effects of recent URIs and personal smoking. Excluding the 8 subjects who reported URIs in the 4 weeks prior to baseline, we found a statistically significant improvement in both FVC (0.238 L; 95% CI, 0.081-0.395 L) and FEV1 (0.127 L; 95% CI, 0.002-0.403 L). In addition, the remaining 42 bartenders who reported any respiratory symptom at baseline, 23 (59%) no longer had symptoms at follow-up (P = .001 by Wilcoxon signed rank test). These subjects, exposure at follow-up was bar or tavern median, 2 (interquartile range, 0-9) hours; other, 2 (0-10) hours, and total, 10 (2-30) hours. Ellipses indicate data not applicable.

### Table 5.—Pulmonary Function in Bartenders Before and After Prohibition of Smoking in Bars (n = 53)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Baseline (Mean [SE] % Predicted)</th>
<th>Follow-up (Mean [SE] % Predicted)</th>
<th>Change (Mean [95% CI])</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV1, L</td>
<td>3.38 (0.13) [89.2 (2.4)]</td>
<td>3.42 (0.14) [89.9 (2.4)]</td>
<td>0.039 (−0.030 to 0.107)</td>
<td>1.2</td>
</tr>
<tr>
<td>FVC, L</td>
<td>4.43 (0.15) [95.5 (2.2)]</td>
<td>4.62 (0.17) [99.6 (2.4)]</td>
<td>0.189 (0.082 to 0.296)</td>
<td>4.2</td>
</tr>
<tr>
<td>FEV2/FVC, %L</td>
<td>3.37 (0.19) [81.6 (3.5)]</td>
<td>3.18 (0.17) [80.3 (3.8)]</td>
<td>−0.190 (−0.405 to 0.025)</td>
<td>−5.7</td>
</tr>
</tbody>
</table>

*FEV2 indicates forced expiratory volume in 1 second; FVC, forced vital capacity; FEV2/FVC, forced expiratory flow, midexpiratory phase; and CI, confidence interval.

Relationship Between Symptoms and Pulmonary Function

We repeated the multiple linear regression analyses to evaluate whether pulmonary function improved in 2 separate strata: subjects whose respiratory symptoms resolved (n = 23) and subjects with persistent or new symptoms (n = 30) at follow-up. In bartenders who reported resolution of respiratory symptoms, complete cessation of workplace ETS exposure was associated with improved FVC (0.464 L; 95% CI, 0.172-0.757 L) and FEV1 (0.292 L; 95% CI, 0.002-0.403 L). The subjects with continued symptoms also experienced improvement in FVC (0.146 L; 95% CI, −0.010 to 0.302 L) and FVC (0.139 L; 95% CI, −0.164 to 0.441 L), although the CIs overlap no change.

### Table 4.—Respiratory and Sensory Irritation Symptoms in Bartenders Before and After Prohibition of Smoking in Bars (n = 53)

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Baseline, No. (%)</th>
<th>Follow-up, No. (%)</th>
<th>Reduction, No.</th>
<th>Increase, No.</th>
<th>No Change, No.</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any respiratory symptom‡</td>
<td>39 (74)</td>
<td>17 (32)</td>
<td>23</td>
<td>1</td>
<td>29</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Wheezing</td>
<td>17 (32)</td>
<td>8 (15)</td>
<td>12</td>
<td>1</td>
<td>38</td>
<td>.02</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>10 (19)</td>
<td>4 (8)</td>
<td>8</td>
<td>2</td>
<td>43</td>
<td>.06</td>
</tr>
<tr>
<td>Cough, morning</td>
<td>28 (53)</td>
<td>12 (23)</td>
<td>17</td>
<td>1</td>
<td>35</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Cough, rest of day or night</td>
<td>26 (49)</td>
<td>6 (11)</td>
<td>21</td>
<td>1</td>
<td>31</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Phlegm production</td>
<td>28 (53)</td>
<td>6 (11)</td>
<td>22</td>
<td>0</td>
<td>31</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Any sensory irritation symptom‡</td>
<td>41 (77)</td>
<td>10 (19)</td>
<td>32</td>
<td>1</td>
<td>20</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Eye</td>
<td>22 (42)</td>
<td>3 (6)</td>
<td>20</td>
<td>1</td>
<td>32</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Nose</td>
<td>32 (60)</td>
<td>8 (15)</td>
<td>25</td>
<td>1</td>
<td>27</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Throat</td>
<td>13 (25)</td>
<td>7 (13)</td>
<td>9</td>
<td>3</td>
<td>41</td>
<td>.08</td>
</tr>
</tbody>
</table>

*Reduction, symptoms at baseline but none at follow-up; increase, no symptoms at baseline and new symptoms at follow-up; and no change, either systematic at both interviews or asymptomatic at both interviews.

§P = .07 by Wilcoxon signed rank test.

Excluding the 3 subjects who no longer worked in bars, median, 28 (20-40) hours; other, 2 (0-10) hours, and total, 40 (30-55) hours at follow-up.

When asked about their personal attitude toward the prohibition of smoking in bars, 24 (45%) of the 53 bartenders strongly or somewhat agreed with the legislative ban. The remaining 29 bartenders believed that ETS has a slight effect (40%) or moderate-to-severe effect (40%) on their health.

Bartenders’ Attitudes About the Health Effects of ETS and the Prohibition of Smoking

Eleven (21%) of the 53 bartenders expressed the belief that ETS has no adverse effect on their personal health. The remaining 42 bartenders believed that ETS has a slight effect (40%) or moderate-to-severe effect (40%) on their health.

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lower ETS levels.46 The present study particulate concentrations, suggesting found decreased respiratory suspended ecels.22,43,45The efficacy of smoking prohibition reflects decreased ambient ETS lev-
door airborne nicotine concentrations, re-
nes.11-14,17,18 or workplace exhibited. After smoking was pro-
tion symptoms, which initially affected the majority of bartenders, declined mark-
edly after the smoking ban. Similarly, pul-
monary function improved following re-
duction of workplace ETS exposure, after controlling for personal smoking and URIs.

In previous studies, prohibition of work-
place smoking has effectively reduced em-
ployee ETS exposure. Smoke-free work-
places have been associated with decreased personal cigarette consumption,66-68 public smoking,69 and self-reported ETS ex-
posure.70 In addition, workplace smoking bans result in dramatic reduction of indoor airborne nicotine concentrations, re-
fecting decreased ambient ETS lev-
els.22,43,46 The efficacy of smoking prohibition in bars and taverns, however, has been less well established. After smoking was pro-
hibited in a sports tavern, investigators found decreased respiratory suspended particulate concentrations, suggesting lower ETS levels.46 The present study indicates that legislative prohibition of smoking substantially reduced, but did not eliminate, self-reported workplace ETS exposure among bartenders.

In adults, the evidence linking ETS exposure with respiratory symptoms has been inconclusive. Several studies have demonstrated an association between self-reported obstructive lung disease and ETS exposure.55,64-67 A recent cross-sectional study of 4187 nonsmoking Swiss adults found an increased risk of wheeze, dyspnea, and bronchitis symptoms in subjects reporting ETS exposure during the past year.59 Similarly, workplace ETS exposure was related to increased cough, phlegm production, and dyspnea in 80 adults enrolling in a fitness program.48 Other studies, however, have not demonstrated a consistent, significant increase in respiratory symptoms in adults exposed to household11,14,17,15 or workplace ETS.17 Furthermore, a smoking ban in sev-
eral Canadian office buildings was not associated with any significant reduction in respiratory symptoms 1 year later.63 Our study, which demonstrated reduced respira-
atory symptoms after prohibition of workplace smoking, helps confirm the ad-
verse impact of ETS exposure on immediate respiratory health.

Environmental tobacco smoke contains potent respiratory irritants, such as ammonia, sulfur dioxide, acrolein, and formaldehyde,7 that could potentially impair lung function. In several cross-sectional epidemiologic studies, ETS exposure was associated with small reductions in FEV1 (2.8%-6.7%)50-52 and FVC (2.6%-5.4%)50,52 compared with unexposed subjects. An-
other study found no impact of ETS expo-
sure on FEV1 or FVC, but FEV1/FVC was reduced.54 A recent prospective investiga-
tion of 20 bar workers demonstrated a signif-
icant reduction in FEV1 (0.042 L) im-
mediately following ETS exposure during a work shift.55 Not all studies, however, have found consistent pulmonary func-
tion decrements.11,56 Although the effect of ETS exposure cessation on adult lung func-
tion has not been characterized, the salu-
tary effect of personal cigarette smoking cessation is well established. Several stud-
ies demonstrated modest increases in FEV1 (1.2%-4.3%) shortly after personal smoking cessation.72-74 Our study sug-
gests that lung function may also im-
prove, to a small degree, after cessation of heavy ETS exposure.

Although we adhered to a standard spi-
rometry protocol,75 we cannot exclude the contribution of training to the observed pulmonary function improvement. The proportionally larger increase in FVC than FEV1, in particular, could be consistent with a learning effect. The CIs, however, are broad, with overlap between the es-
pected relative improvement in FEV1 and FVC. Also, the FEV1 improvement is sim-
ilar to the acute decrement previously de-
scribed in bar workers after a work shift.55 Similarly, the unadjusted relative in-
crease in FEV1 (1.2%) is comparable with the FEV1 change described in both smoking cessation studies57-61 and cross-
sectional studies of ETS.45,52 The unad-
justed FVC improvement (4.2%) also seems compatible with the ETS-related decrements described in epidemiologic studies.45,52 Finally, the unexpected trend toward decreasing FEV1/FVC53-55,75-77 was a highly variable measure, disappeared after ad-
justment for smoking and URIs. Overall, the improvement in lung function is con-
sistent with a causal effect of reduced workplace ETS exposure.

The present study has several addi-
tional limitations, including the use of interviews to assess ETS exposure and symptom status. Interview administra-
tion by an unblinded investigator could have biased subject responses, although we attempted to maintain standard con-
ditions. Although many studies demon-
strate modest correlations between self-
reported ETS exposure and biomarker levels, such as serum cotinine,62,63 we cannot exclude some systematic misclassifi-
cation of exposure. For example, bartend-
ers with respiratory symptoms might be more likely to report ETS exposure, whereas asymptomatic subjects might under-
report exposure. Similarly, contro-
versy generated by the smoke-free bar and tavern legislation could have biased symptom reporting. If subjects who agreed with the smoking ban were more likely to report symptom reduction, the observed improvement in symptom status could be inflated. However, the ma-
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attempted to perform parsimonious regression analyses, the sample size was small for multivariate procedures. Exposure to secondhand smoking and URIs could potentially explain the observed improvement in respiratory health. After statistically controlling for these issues, we still observed improvement in respiratory symptoms and lung function after prohibition of smoking. Reliance on self-report, however, raises the possibility that unmeasured baseline URIs or reduced active smoking could still partially explain the observed improvement in respiratory health indexes.

Our study demonstrates that reduced ETS exposure, occurring after implementation of smoke-free workplace legislation, was associated with improved adult respiratory health during a short observation period. In addition to potentially reducing the long-term risk of lung cancer and cardiovascular disease, workplace smoking prohibition appears to have immediate beneficial effects on adult respiratory health.

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