Evaluation of the Immediate Impact of the Washington, D.C., Smoke-Free Indoor Air Policy on Bar Employee Environmental Tobacco Smoke Exposure

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SYNOPSIS

Objective. On January 2, 2007, the Washington, D.C., City Council banned smoking in restaurants and bars. We sought to determine the immediate impact of the ban on cotinine-confirmed environmental tobacco smoke (ETS) levels and respiratory symptom reports of a random sample of bar employees.

Methods. We conducted an assessment of 66 employees from 41 randomly selected bars in December 2006, a month before the ban went into effect. After analyses of baseline data, 52 employees were eligible and 49 of them (94%) had a post-ban assessment in February 2007. Three participants were excluded due to high cotinine levels at the post-ban assessment, yielding a final sample size of 46 bar employees. ETS exposure levels were documented using saliva cotinine analyses by tandem liquid chromatography and mass spectrometry. Employee respiratory and sensory symptoms reports were assessed by a standardized, validated form: the International Union Against Tuberculosis and Lung Disease Bronchial Symptoms Questionnaire. Employee ETS exposure reports at work were eliminated after the ban.

Results. Sensory symptoms reports (at ≤4 weeks) declined significantly by 70% to 100% ($p=0.0016$); respiratory symptoms results were inconclusive due to a lack of data. Saliva cotinine medians declined significantly by 70% ($p<0.0001$), from a pre-ban mean of 2.11 nanograms per millileter (ng/mL) to a post-ban mean of 0.29 ng/mL, confirming reports of no ETS exposure at work.

Conclusion. We concluded that the indoor air law was effective, eliminating employee ETS exposure reports, dramatically reducing their cotinine levels, and almost eliminating reports of sensory symptoms.

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Multiple studies and meta-analyses have established that environmental tobacco smoke (ETS) exposure causes adverse health effects.[1–4] According to the 2006 Surgeon General's report, even small levels of ETS exposure increase risks of coronary heart disease, lung cancer, stroke, and respiratory symptoms.[2] Although the evidence of increased risk is well-documented, workplaces continue to be the most common sources of ETS exposure among American adults.[1–14]

In reviews of risk by type of employment, food-service employees have the highest ETS exposure rates.[5,12] Smoke-free indoor air laws protected only 58% of food-service employees in 1999.[14] When only bartenders were considered, the percentage protected by workplace smoke-free indoor air laws dropped even further to 13%. Bartenders are the only occupation group in the United States reporting less than 15% coverage by smoke-free indoor air policies.[12]

During the last decade, a large number of communities, states, and countries have passed smoking bans in restaurants and bars to protect employees. Evaluations of the impact of these laws have consistently reported improvements in employee health.[5,8–20] In April 2006, the Washington, D.C., (DC) City Council approved an amendment to the Department of Health Functions Clarification Act of 2001, creating a smoke-free indoor air law.[21] On January 2, 2007, the indoor smoking ban was initiated in bars, restaurants, and pool halls. Tobacco bars or establishments that earned ≥10% of their income from tobacco sales could apply for an "economic hardship" exemption, as could any bar that could demonstrate a 15% drop in sales during a three-month period after the ban compared with the previous two years.

The passage of a new public health law presented a unique opportunity to evaluate its immediate impact on one of the most highly ETS-exposed group of employees. Only two similar types of evaluations that have used cotinine tests of food/beverage-service employee ETS exposure have been conducted in the U.S.[15,17] Both recruited participants through newspaper ads, potentially biasing the sample population toward those most affected by ETS exposure. The primary aim of this evaluation was to test the hypothesis that implementation of the smoking ban significantly reduced by ≥50% DC bar employees' cotinine-confirmed ETS exposure and respiratory and sensory symptoms reports. This study recruited participants directly from their place of employment to avoid the potential self-selection of those most heavily affected by ETS.

METHODS

Study population

This evaluation, approved by the George Washington University Institutional Review Board, focused only on employees who worked in establishments defined as a "club," "brew pub," "nightclub," or "tavern" by the DC Official Code 25-101. As of May 2005, DC employed about 1,950 bartenders.[22] A Yahoo! search for "club," "nightclub," "bar," "tavern," or "brew pub" identified 273 sites. A comparison with the DC Alcoholic Beverage Regulation Administration records confirmed that this was a complete list of bars with current liquor licenses located in the target neighborhoods. We excluded 11 bars that had enforced restricted smoking policies prior to the ban, or were exempt from the ban.

Seven high-density areas where a large number of adult customers congregated seven days a week were included in our sampling frame: Adams-Morgan, U Street, Cleveland Park, Dupont Circle, Midtown, Capitol Hill, and Georgetown. Of the 262 eligible sites, 184 (70%) were located in these areas. Because of time and resource restraints, we could not include 78 small neighborhood bars distributed throughout the city. Using a power of 0.80, alpha = 0.05, a one-tailed test, and a hypothesized effect size of ≤50% in cotinine levels based on employee ETS research, we needed ≥35 site/employee pre-ban and post-ban assessments. Forty-one (22%) eligible sites were included in our study.

Site and employee recruitment

Recruitment was made difficult by the fact that few bar employees completely abstain from tobacco use. We created a list of bars in random order using a random number table. Bar managers were approached in this order by mail and phone to describe the study aims and seek permission to approach employees. These were ineffective recruitment methods. Therefore, 12 trained volunteer assessment staff approached site managers in person from December 2 to December 21, 2006, using the same randomized list, but sorted by neighborhood to facilitate data collection. They asked permission to conduct the study and recruit employees prior to the ban. Due to the bars' busy environments and lack of nonsmoking employees, assessment staff rotated through the entire randomized list of bars several times before achieving an adequate sample size.

Participants had to meet the following criteria: (*1*) be a nonsmoker, (*2*) not use other forms of tobacco or nicotine replacement, (*3*) live in a smoke-free home, and (*4*) be employed ≥20 hours per week at the site. Assessments were typically performed between 10 p.m.

and 1 a.m., after the employees had been at work for more than four hours.

Fifty-two (78%) employees identified themselves as bartenders. Other categories of hospitality staff—including six servers, three barbacks, three managers, one owner, and one host—were recruited if they met all screening criteria and regularly served customers. After receiving informed consent, staff collected baseline information, saliva samples, ETS exposure and respiratory and sensory symptoms reports, and attitudes on the smoking ban (O_1). Employee assessment procedures (O_2) were replicated from February 1 to February 21, 2007, after the ban took effect.

Salivary cotinine assessment

The study's primary impact measure was employee cotinine level, the "biomarker of choice" for tobacco smoke exposure according to the 2006 Surgeon General's report.[2] Cotinine, the major proximal metabolite of nicotine, is present in an exposed person's bodily fluids, including blood, saliva, and urine.[23–25] Cotinine's half-life of 18 hours makes it a convenient, valid measure for regular ETS exposure.[24,26] This study used a ≤10 nanograms per milliliter (ng/mL) cutoff recommended to confirm nonsmoking self-reports by the Society for Research of Nicotine and Tobacco.[24] While new research suggests that this cutoff may be too conservative for African Americans, who may metabolize cotinine at a slower rate than other racial/ethnic groups, no participant excluded from analysis due to high cotinine levels came close to the 10 ng/mL cutoff point.

Saliva samples were collected using a Salivette sample vial and frozen for ≤3 hours after collection. Samples were thawed, centrifuged, and shipped in dry ice to Dr. Neal Benowitz, Director of the Clinical Pharmacology Laboratory at San Francisco General Hospital/University of California, San Francisco, for analysis. Saliva cotinine concentrations were measured using liquid chromatography-tandem mass spectrometry (LC-MS/MS). The mass spectrometer was operated in the positive ion mode using atmospheric pressure chemical ionization. This analysis is the most sensitive type of cotinine measurement (minimum detectable level = 0.05 ng/mL) and has excellent specificity.[25,26]

Self-reported symptoms

After eligibility screening, participants completed a questionnaire that elicited descriptive information, respiratory and sensory symptoms, and attitudes toward the ban. Our respiratory and sensory symptoms questions were based on a standardized, validated form: the International Union Against Tuberculosis and Lung Disease (IUATLD) Bronchial Symptoms Questionnaire.[27] The respiratory questions elicited reports of shortness of breath, wheezing, coughing, and phlegm in the past four weeks. The sensory questions assessed eye, nose, and throat irritation in the same time period. The questionnaire has high specificity and moderate sensitivity in the general population to detect asthma-like symptoms,[28] and has been used in comparable employee assessment studies.[7,16,17,19] A copy of our IUATLD scale is provided in the Figure.

Statistical analysis

Analyses of changes were restricted to employees who participated in both O_1 and O_2 assessments, were cotinine confirmed nonsmokers, and worked at the same bar during the collection periods. Salivary cotinine levels and symptom data were analyzed by computing O_1 and O_2 differences. Respiratory and sensory symptoms were analyzed by change in the number of symptoms.

We examined our data for normalcy using a Shapiro-Wilks test and observing the data's histograms and scatter plots. As the data at both observations were skewed to the right, we analyzed cotinine data with both Wilcoxon's signed rank test for a difference in medians, and a paired t-test for a difference in means. The 95% confidence interval (CI) for the difference in medians was obtained by bootstrapping the data using 1,000 sample repetitions. We analyzed differences in respiratory and sensory symptoms with McNemar's Chi-square test to obtain a *p*-value for the change in median number of symptoms, and bootstrapped the data using 1,000 repetitions to obtain the 95% CI for the difference. Analyses were completed using SAS® Version 8.02 and Stata® 10.0.[29,30]

RESULTS

Of the 102 employees approached at the 41 bars, one did not understand enough English to give consent, and one worked in a bar with existing ETS restrictions. Of the 100 remaining, 17 (17%) were ineligible because they were smokers and 17 (17%) refused to participate; however, these results did not reflect the large number of employees who did not have the time to interact with the recruitment staff, or who indicated a lack of interest before recruitment staff were able to administer the screening questionnaire. Between December 2 and December 21, 2006, staff recruited 66 employees who met initial screening eligibility requirements and were working at least four hours at the time (starting at 8 p.m.) of baseline cotinine collection. Of the 66 assessed, 14 were not eligible for follow-up; two reported smoking; and 12 were ineligible due to a change of job (six),

Figure. International Union Against Tuberculosis and Lung Disease scale adaptation

Question	*Response*
1. Have you had a cold, flu, sinus infection, or other upper respiratory infection in the past four weeks?	Yes/No
2. Have you, at any time in the last four weeks, had wheezing or whistling in your chest?	Yes/No
3. Have you, at any time in the last four weeks, woken up with a feeling of tightness in your chest first thing in the morning?	Yes/No
4. Have you, at any time in the last four weeks, had an attack of shortness of breath that came on during the day when you were not doing anything strenuous?	Yes/No
5. Have you, at any time in the last four weeks, had an attack of shortness of breath that came on after you stopped exercising?	Yes/No
6. Have you, at any time in the last four weeks, been woken at night by an attack of shortness of breath?	Yes/No
7. Have you, at any time in the last four weeks, been woken at night by an attack of coughing?	Yes/No
8. Do you usually cough first thing in the morning?	Yes/No
9. If YES to #8, do you usually bring up phlegm from your chest first thing in the morning?	Yes/No
10. Which one of the following statements best describes your breathing? (Circle only one.)	I never or rarely have trouble with my breathing.
	I get repeated trouble with my breathing, but it always gets completely better.
	My breathing is never quite right.
11. Have you, at any time in the last four weeks, had red, teary, or irritated eyes after finishing work?	Yes/No
12. Have you, at any time in the last four weeks, had a runny nose, sneezing, or nose irritation after finishing work?	Yes/No
13. Have you, at any time in the last four weeks, had a sore or scratchy throat after finishing work?	Yes/No

bar closing (six), bar exemption (one), or death (one). This change in participant eligibility also reduced our pool of sites from 41 to 29, with 26 (90%) bars yielding one or two participants, two bars yielding three participants, and one bar yielding four participants, for a total of 52 eligible participants.

Only two eligible participants were lost to follow-up or were unreachable at work or by phone. In addition, one employee refused the second assessment, citing lack of time and worry about negative consequences of participation from her employer. Thus, follow-up data were collected on 49 of 52 (94%) eligible employees. The final sample size of 46 participants was due to the exclusion of three participants with O_2 saliva cotinine levels higher than 10 ng/mL, indicating that they had resumed smoking during the winter holiday season. Of the remaining 46 participants, all but two described their job position as bartender. The remaining two participants were a bar manager and a barback.

Most participants were male (89%), worked ≥35 hours/week, had been employed in the hospitality industry for ≥5 years, and had worked a mean of five years in their current job. Privacy concerns prevented us from eliciting more explicit demographic information, such as race and age. Of the three employees not followed up, they were more likely to be female and had worked fewer years in the hospitality industry.

Two employee cotinine samples at O_2 were below levels of laboratory quantification. We imputed their O_2 cotinine levels to be 0.05 ng/mL. Six saliva samples did not have sufficient volume for analysis at either O_1 or O_2. We imputed their cotinine values by assuming, conservatively, no change between baseline or follow-up values. Excluding the imputed values of the six from the analysis did not change the results or conclusions of the study.

As shown in Table 1, the cotinine levels of the 46 employees declined significantly by 70%, from a median of 2.11 ng/mL at baseline to 0.29 ng/mL at follow-up. The number of hours participants reported working did not change significantly between O_1 and O_2, nor did their reported hours of ETS exposure outside of work. The number of hours exposed to ETS at work declined from a median of 30 hours a week at O_1 to zero hours a week at O_2.

Attitudes toward the new law were measured on a

Table 1. ETS exposure at baseline and follow-up of bar employees in Washington, D.C., 2006–2007

Measurement	*Baseline median (IQR)*	*Follow-up median (IQR)*	*P-value*	*Percentage difference (95% CI)*
Saliva cotinine level (ng/mL)	2.11 ng/mL (1.23 ng/mL, 2.83 ng/mL)	0.29 ng/mL (0.13 ng/mL, 56 ng/mL)	<0.0001	70.1 (50.0, 86.3)
Number of hours worked in past week (range)	35 (25–40)	35 (25–50)	0.43	0
Number of hours of ETS at work in past week (range)	30 (18–40)	0 (0–1)	<0.001	−30.0 (22.5, 37.5)

ETS = environmental tobacco smoke
IAQ = indoor air quality
CI = confidence interval
ng/mL = nanograms per milliliter

scale of 1 to 10, with 1 being "very strongly against" and 10 being "very strongly support." Employees' attitudes toward the law, a median of 9.0 at baseline and 10 at follow-up, did not significantly change (p=0.0995).

Employee sensory symptoms reports declined significantly by 70% to 100% (p=0.0016), from a median of 2 to a median of 0. The difference in respiratory symptom reports was inconclusive. McNemar's Chi-square test found a significant difference (p=0.0082); however, the 95% CI for the difference in medians included zero (95% CI 0.98, 0.98). Three participants neglected to answer at least one symptom question at O_1 and O_2. We imputed their values by assuming, conservatively, no change in their responses. Eliminating these three participants from analysis did not change the data analysis.

DISCUSSION

This evaluation documented that the January 2007 indoor smoking ban in DC eliminated hospitality employees' reports of exposure to ETS at work and almost eliminated employee sensory symptoms reports. The follow-up salivary cotinine levels dropped by 70%, confirming employee ETS exposure reports.

Six previous evaluation studies—two of which were in the U.S.[15,17]—evaluated the impact of smoking bans on hospitality employees' exposure to ETS using pre-ban and post-ban salivary, urinary, or serum cotinine.[15–20] Table 2 presents a comparison only of the cotinine results of the six previous studies and the results of the current study. The magnitude of the impact of a ban on employee cotinine levels in this study was consistent with previous evaluations. All evaluations documented significant decreases in cotinine confirmed, self-reported ETS exposure levels for participants. The mean decrease in cotinine levels of the 620 employees from the seven studies was 77%: 4.41 ng/mL to 1.02 ng/mL. These data, and the results of other employee ETS studies, confirmed the hypothesis that smoke-free indoor air laws eliminate employees' ETS exposure at work.

Limitations

This evaluation used a one-group pre-ban and post-ban design with the subjects as their own controls. This design had three major categories of potential bias to the internal validity of results: measurement bias, selection bias, and historical bias. Each bias to the validity of an evaluation needs to be examined to determine if it rather than the ETS law was a plausible explanation of reported results. If none was a plausible explanation of the significant effects, then attribution of the type and level of observed impact on ETS exposure to the public health law can be made with confidence. These methodological issues have not been discussed in previous employee evaluation ETS reports.[31]

In this study, we used standardized laboratory methods to independently document employee baseline and follow-up cotinine levels and ETS exposure at work. We used one of the most highly recognized reference laboratories in the United States (Clinical Pharmacology Laboratory at San Francisco General Hospital/University of California, San Francisco) and the most sensitive method of measuring cotinine—high-performance liquid chromatography–mass spectrometry—to document employee ETS exposure. The magnitude of the observed impact on cotinine levels was consistent with other studies that used precise cotinine measures to evaluate ETS exposure. In the very few cases for which we did not have a baseline or follow-up for an employee, we applied a conservative measurement policy, imputing a value reflecting no change. There was no intersite variability in reported exposure: employees reported 100% reduction in ETS

exposure at work at O_2, indicating that adherence to the ban was very high in participating bars. We concluded that the observed significant changes in employee ETS exposure and cotinine values were not attributable to measurement error.

We applied a standardized and validated instrument used by multiple employee ETS exposure studies to assess employee respiratory and sensory reports. While the IUATLD instrument has confirmed validity, because employees could not be blinded to the primary aim of the citywide ban and our evaluation, the respiratory and sensory reports in this study (and the results of all other studies) may have, in part, reflected socially desirable responses. In addition, the study was conducted during winter months, and seasonal variation in respiratory symptoms could have been responsible for some or all of the employee reports. Thus, it is not clear whether the elimination of the employee reports of respiratory and sensory symptoms were attributable to the ETS ban.

Although our sampling frame of 184 sites included a large proportion (70%) of the population of eligible sites in DC, 78 smaller, older bars distributed in neighborhoods throughout the city were not included in the sampling frame and random selection of sites. If we had randomly sampled 20% of these older sites, it would have added 15 sites and employees to the study. While the exclusion of small, neighborhood bars suggests some degree of selection bias, the most recent Surgeon General's report[2] and the 2004 ETS study by Repace in Delaware documented that larger bars with more open spaces have significantly lower ETS concentrations of breathable particles and carcinogens than smaller bars.[32] Almost all sites randomly selected in this evaluation were new, recently renovated, large-capacity bars. The completed ETS research on bar size, ventilation, and structure suggests that if we had included a random sample of 15 smaller neighborhood bars in the study, employee reports of ETS exposure and baseline cotinine levels may have been the same or slightly higher than the levels we documented. Thus, exclusion of the smaller neighborhood bars may have produced a small underestimate of employee baseline saliva cotinine levels and reports of ETS exposure at work.

This study encountered several practical implementation problems. Two of the original eligibility requirements were changed during recruitment. Although some participants reported not being regular smokers in the last six months, a small number reported

Table 2. Cotinine-confirmed employee ETS exposure studies

Reference	N	*Cotinine test*	*O_1 ng/mL*	*O_2 ng/mL*	*Percent difference*
Allwright et al., Ireland, 1998[a]	158	Saliva	5.10	0.90	<82.3
Farrelly et al., U.S., 2005[b]	104	Saliva	3.60	0.80	<77.8
Mulcahy et al., Ireland, 2005[c]	35	Saliva	1.60	0.50	<68.8
Abrams et al., U.S., 2006[d]	107	Urine	4.93	0.30	<93.9
Menzies et al., Scotland, 2006[e]	105	Serum	5.15	2.93	<43.1
Goodman et al., Ireland, 2007[f]	65	Saliva	5.10	0.60	<81.0
Pearson et al., U.S., 2007[g]	46	Saliva	2.37	0.49	<70.1

[a]Allwright S, Paul G, Greiner B, Mullally BJ, Pursell L, Kelly A, et al. Legislation for smoke-free workplaces and health of bar workers in Ireland: before and after study. BMJ 2005;331:1117.

[b]Farrelly MC, Nonnemaker JM, Chou R, Hyland A, Peterson KK, Bauer UE. Changes in hospitality workers' exposure to secondhand smoke following implementation of New York's smoke-free law. Tob Control 2005;14:236-41.

[c]Mulcahy M, Evans DS, Hammond SK, Repace JL, Byrne M. Secondhand smoke exposure and risk following the Irish smoking ban: an assessment of salivary cotinine concentrations in hotel workers and air nicotine levels in bars. Tob Control 2005;14:384-8.

[d]Abrams SM, Mahoney MC, Hyland A, Cummings KM, Davis W, Song L. Early evidence on the effectiveness of clean indoor air legislation in New York State. Am J Public Health 2006;96:296-8.

[e]Menzies D, Nair A, Williamson PA, Schembri S, Al-Khairalla MZH, Barnes M, et al. Respiratory symptoms, pulmonary function, and markers of inflammation among bar workers before and after a legislative ban on smoking in public places. JAMA 2006;296:1742-8.

[f]Goodman P, Agnew M, McCaffrey M, Paul G, Clancy L. Effects of the Irish smoking ban on respiratory health of bar workers and air quality in Dublin pubs. Am J Respir Crit Care Med 2007;175:840-5.

[g]Pearson J, Windsor R, El-Mohandes A, Perry DC. Evaluation of the immediate impact of the Washington, D.C., smoke-free indoor air policy on bar employee environmental tobacco smoke exposure. Public Health Rep 2009;124 (Suppl 1):135-42.

ETS = environmental tobacco smoke

O_1 = first data collection

O_2 = second data collection

ng/mL = nanograms per milliliter

occasional smoking, such as taking a drag off a customer's cigarette. We included these employees only if their saliva cotinine value was ≤10 ng/mL at each observation. We found that 20% of the nonsmoking employees lived with tobacco smokers. We changed our eligibility criterion to exclude employees who lived with a smoker who smoked inside the home and include those who reported living with a smoker who only smoked outside the home.

A related weakness was the potential lack of independence between our measures. Due to the rarity of eligible employees and the need to recruit enough participants before the ban went into effect, we allowed recruitment of all eligible individuals without regard to how many participants came from a single bar. Although participants from the same bar were rarely working on the same day as one another, the bar's physical layout, ventilation system, and popularity with smokers could have jeopardized the measures' independence. Future studies should not recruit more than one participant per site, but should plan extra time to recruit appropriate participants.

Strengths

A strength of this study was that it defined the population of sites for a specific geographical area and used a random selection process. The other two studies conducted in the U.S. that used cotinine analyses to document bar employee ETS exposure—Farrelly et al. and Abrams et al.—used posters, newspaper, and radio advertisements to recruit employees. Random sampling of sites, combined with documentation of an 83% eligible employee baseline recruitment rate and a 94% employee follow-up assessment rate, enhanced the citywide generalization of our results.[15,17] We concluded that a significant selection bias was not a plausible explanation of the results.

The very short time span between the O_1 assessments in December, implementation of the law in January, and O_2 assessments in February made it unlikely that an independent, external public health intervention could have compromised the validity of our results. There were no other legislative actions, public health campaigns, or external historical events that could have reduced or eliminated employee ETS exposure in DC, Maryland, or Virginia during the evaluation periods or calendar years 2006 and 2007.

Overall, we concluded that the ETS law and public health policy banning smoking in bars were the only plausible explanations for the significant positive changes in employee ETS exposure and cotinine levels. The employee respiratory symptom reports may have had some degree of social desirability. As was shown by our attitude measure, participants were highly in favor of the ban.

CONCLUSION

While validly documenting significant reductions of cotinine-confirmed employee ETS exposure and improved employee respiratory health, a meta-evaluation of this body of literature revealed several weaknesses. Many studies have been conducted among small, non-randomly selected convenience samples. Future research should define the population of eligible bars/employees, use random sampling procedures, and include larger, representative samples of sites and employees. These procedures are essential for an evaluation to have sufficient sample size and statistical power to measure changes in employee pulmonary function and respiratory morbidity.

Although it would incur higher costs, because the stability of baseline and follow-up impact rates have not been confirmed in previous research in this area, at least two employee pre-ban assessments at <6 months (O_1) and <3 or <1 month (O_2), and two post-ban assessments at >1 or >3 months (O_3) and >12 months (O_4) need to be conducted. Future studies may also consider including site air monitoring of breathable and carcinogenic particles,[32] air quality levels,[20,33] LC-MS/MS saliva or urine cotinine analyses,[24,25,27] and appropriate pulmonary assessment.[7,27,28] A combination of these methods would produce the most comprehensive and strongest evidence of the immediate and long-term impact of a new ETS law on employee exposure and respiratory health.

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REFERENCES

1. California Environmental Protection Agency. Health effects of exposure to environmental tobacco smoke. Sacramento (CA): California Environmental Protection Agency, Office of Environmental Health Hazard Assessment; 1997.
2. Department of Health and Human Services, Office of Smoking and Health (US). The health consequences of involuntary exposure to tobacco smoke: a report of the Surgeon General. Washington: DHHS; 2006.
3. Mokdad AH, Marks JS, Stroup DF, Gerberding JL. Actual causes of death in the United States, 2000. JAMA 2004;291:1238-45.
4. Samet JM, Dominici F, Curriero FC, Coursac I, Zeger SL. Fine particulate air pollution and mortality in 20 U.S. cities. N Engl J Med 2000;343:1742-9.
5. Brownson RC, Hopkins DP, Wakefield MA. Effects of smoking restrictions in the workplace. Annu Rev Public Health 2002;23:333-48.
6. Eagan TML, Hetland J, Aarø LE. Decline in respiratory symptoms in service workers five months after a public smoking ban. Tob Control 2006;15:242-6.

7. Eisner MD, Smith AK, Blanc PD. Bartenders' respiratory health after establishment of smoke-free bars and taverns. JAMA 1998;280:1909-14.
8. Fowles J, Christophersen A, Fernando D, Lea R, Woodward A, Dickson S, et al. Secondhand tobacco smoke exposure in New Zealand bars: results prior to implementation of the bar smoking ban. NZ Med J 2006;119:U1931.
9. Glantz SA, Parmley WW. Even a little secondhand smoke is dangerous. JAMA 2001;286:462-3.
10. Heloma A, Jaakkola MS, Kähkönen E, Reijula K. The short-term impact of national smoke-free workplace legislation on passive smoking and tobacco use. Am J Public Health 2001;91:1416-8.
11. Jarvis MJ, Foulds J, Feyerabend C. Exposure to passive smoking among bar staff. Br J Addict 1992;87:111-3.
12. Shopland DR, Anderson CM, Burns DM, Gerlach KK. Disparities in smoke-free workplace policies among food service workers. J Occup Environ Med 2004;46:347-56.
13. Wakefield M, Siahpush M, Scollo M, Lal A, Hyland A, McCaul K, et al. The effect of a smoke-free law on restaurant business in South Australia. Aust NZ J Public Health 2002;26:375-82.
14. Wortley PM, Caraballo RS, Pederson LL, Pechacek TF. Exposure to secondhand smoke in the workplace: serum cotinine by occupation. J Occup Environ Med 2002;44:503-9
15. Abrams SM, Mahoney MC, Hyland A, Cummings KM, Davis W, Song L. Early evidence on the effectiveness of clean indoor air legislation in New York State. Am J Public Health 2006;96:296-8.
16. Allwright S, Paul G, Greiner B, Mullally BJ, Pursell L, Kelly A, et al. Legislation for smoke-free workplaces and health of bar workers in Ireland: before and after study. BMJ 2005;331:1117.
17. Farrelly MC, Nonnemaker JM, Chou R, Hyland A, Peterson KK, Bauer UE. Changes in hospitality workers' exposure to secondhand smoke following implementation of New York's smoke-free law. Tob Control 2005;14:236-41.
18. Goodman P, Agnew M, McCaffrey M, Paul G, Clancy L. Effects of the Irish smoking ban on respiratory health of bar workers and air quality in Dublin pubs. Am J Respir Crit Care Med 2007;175:840-5.
19. Menzies D, Nair A, Williamson PA, Schembri S, Al-Khairalla MZH, Barnes M, et al. Respiratory symptoms, pulmonary function, and markers of inflammation among bar workers before and after a legislative ban on smoking in public places. JAMA 2006;296:1742-8.
20. Mulcahy M, Evans DS, Hammond SK, Repace JL, Byrne M. Secondhand smoke exposure and risk following the Irish smoking ban: an assessment of salivary cotinine concentrations in hotel workers and air nicotine levels in bars. Tob Control 2005;14:384-8.
21. Department of Health Functions Clarifications Act of 2001. D.C. Law 14-28; D.C. Official Code 7-731 (Supp. 2006).
22. Department of Labor, Bureau of Labor Statistics (US). Occupational employment and wages, May 2005: 35-3011 bartenders [cited 2009 Jan 8]. Available from: URL: http://www.bls.gov/oes/2005/may/oes353011.htm
23. Benowitz NL. Biomarkers of environmental tobacco smoke exposure. Environ Health Perspect 1999;107 Suppl 2:S349-55.
24. SRNT Subcommittee on Biochemical Verification. Biochemical verification of tobacco use and cessation. Nicotine Tob Res 2002;4:149-59.
25. Song L, Davis W, Abrams SM, Hemiup J, Kazim AL, Cummings KM, et al. Sensitive and rapid method for determination of urinary cotinine in non-smokers: an application from studies assessing exposure to environmental tobacco smoke (ETS). Anal Chim Acta 2005;2:200-8.
26. Ho SY, Lam TH, Chung SF, Lam TP. Cross-sectional and prospective associations between passive smoking and respiratory symptoms at the workplace. Ann Epidemiol 2007;17:126-31.
27. Burney PG, Laitinen LA, Perdrizet S, Huckauf H, Tattersfield AE, Chinn S, et al. Validity and reliability of the IUATLD Bronchial Symptoms Questionnaire (1984): an international comparison. Eur Respir J 1989;2:940-5.
28. Ravault C, Kauffmann F. Validity of the IUATLD (1986) questionnaire in the EGEA study. Int J Tuberc Lung Dis 2001;5:191-6.
29. SAS Institute Inc. SAS: Version 8.02. Cary (NC): SAS Institute Inc.; 2000.
30. StataCorp. Stata: Release 10.0. College Station (TX): StataCorp.; 2007.
31. Windsor R. Formative and impact evaluations. In: Windsor R, Clark N, Boyd NR, Goodman RM. Evaluation of health promotion, health education, and disease prevention programs. 3rd ed. New York: McGraw-Hill; 2003. p. 215-63.
32. Repace J. Respirable particles and carcinogens in the air of Delaware hospitality venues before and after a smoking ban. J Occup Environ Med 2004;46:887-905.
33. Hammond SK, Sorenson G, Youngstrom R, Ockene JK. Occupational exposure to environmental tobacco smoke. JAMA 1995;274:956-60.