First-year compliance with the Nevada Clean Indoor Air Act

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ABSTRACT

Objectives: We quantitatively evaluated compliance with the Nevada Clean Indoor Air Act (NCIAA) by different types of businesses in Nevada and determined whether compliance affected indoor concentrations of benzene and 3-ethenyl pyridine (3-EP), markers of tobacco smoke.

Methods: Managers of 181 businesses in Washoe County, Nevada, were interviewed about business characteristics and practices and policies related to smoking. During unannounced visits, compliance data and air samples (n=66) were collected from interviewed businesses and from an additional sample (n = 56) of businesses without knowledge of the study.

Results: Overall compliance, as defined by the NCIAA, was low (28.2%). Benzene concentrations were higher in casino restaurants than in other businesses, although most complied with the requirements of the ban. Neither benzene nor 3-EP concentrations differed significantly between compliant and non-compliant businesses.

Conclusions: The finding that casino restaurants had poorer air quality despite their compliance with the NCIAA suggests that compliance alone may not be sufficient to reduce exposure to secondhand smoke, particularly in buildings with both nonsmoking and smoking areas.

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The state of Nevada implemented legislation limiting smoking in public places on December 8, 2006, following approval by voters in November of the same year. The Nevada Clean Indoor Air Act (NCIAA), supported by the American Heart Association, the American Cancer Society and the Nevada Medical Society, was passed to protect children and families from secondhand smoke (SHS) in most public places (Nevada Revised Statutes (NRS), 2006). The NCIAA is a partial smoking ban that prohibits the smoking of tobacco products in most public places and indoor places of employment, including restaurants and non-hospitality workplaces, and gives local health departments authority to enforce its requirements. However, the legislation exempts gaming areas of casinos, stand-alone bars, taverns and saloons not selling food, strip clubs, brothels, and retail tobacco stores, which may still allow smoking (NRS, 2006).

The NCIAA has been controversial in Nevada, where tourism and gaming are important industries. The controversy was evident early in 2006 with the introduction of an opposing, less restrictive, ballot measure supported by the Nevada Tavern Owners Association and gaming interests. Although the NCIAA received a majority of votes, business acceptance of the Act has been tenuous, especially after an economic downturn that began during the first year of its implementation (Tung & Glantz, 2008).

While recent studies have reported good compliance among restaurants and bars after enactment of smoking bans (Biener, Garrett, Skeer, Siegel & Connolly, 2007; Borland et al., 2006; Skeer, Land, Cheng & Siegel, 2004; Weber, Bagwell, Fielding & Glantz, 2003), the strong influence of the tourism and gaming industries in Nevada, coupled with the heated campaign around the competing ballot initiatives, raised questions about the extent to which businesses would comply with the NCIAA. The compliance issue was further complicated by the short interval between enactment and implementation of the law, which gave public health agencies little time to educate the public or determine how enforcement would be carried out (Tung & Glantz 2008).

The primary purpose of this study was to quantitatively evaluate compliance with the NCIAA by different types of businesses in Nevada. The secondary aim was to determine whether compliance with the NCIAA affected

indoor concentrations of benzene and 3-ethenyl pyridine, markers of tobacco smoke.

METHODS

Study Population. Businesses in Reno, Sparks, and Incline Village, Nevada, with Washoe County permits to operate as either "delicatessen", "grocery", or "restaurant" were eligible for inclusion in the study. These permit types were chosen because they include businesses that are subject to the NCIAA and may be frequented by children, but often have gaming areas where adults sit for extended periods. Study staff used a random sample of businesses from the Washoe County permits database to contact business managers or owners ("managers") until 180 businesses were enrolled in the study. (The Washoe County Health District biostatistician generated a random sample of businesses from the permits database using a random number generator.) Businesses were enrolled if managers were willing to complete a short interview, allow collection of an air sample, and be contacted again the following year. The questionnaire took about 10 minutes to complete and included general questions about the business (e.g., length of ownership, number of employees, days and hours of business) and information about practices and policies related to smoking.

Of the total sample contacted (n=370), 34.9% were not available for interview. Reasons included disconnected telephone, no answer after four attempts, failure of manager or owner to return the call after study staff had made initial contact, and language or cultural barrier preventing understanding of the study purpose. The overall participation rate of businesses for which calls were completed (n=241) was 74.7 per cent. The participation rates for the three types of permitted businesses were not materially different (range 68.8% - 77.8%). The distribution of businesses in the source population and study population were similar: delicatessens comprised 7.8% of both the source population and the study population, grocery stores comprised 33.2% of the source population and 30.6% of the study population, and restaurants comprised 58.9% of the source population and 61.7% of the study population.

Visits to Businesses. After all interviews were completed, study staff visited participating businesses and completed an additional questionnaire about business characteristics. Questionnaires included items pertaining to the requirements of the NCIAA (i.e., "no smoking" signs at all entrances, absence of ashtrays, no smoking), as well as items that might indicate the business culture around smoking (e.g., presence of cigarette butts or ashtrays outside the business, cigarette butts or odor of smoke inside the business, legal and/or health warnings about tobacco posted on the doors, outdoor eating areas with ashtrays, gaming areas, sit-down bars) or factors that might confound measured air concentrations of benzene (e.g., open entry door, gasoline pumps, parking lot near entrance). The visits were unannounced, and study staff did not interact with business employees or managers unless they were attempting to collect an air sample. None of the businesses, including those from which air samples were taken, were aware when study staff collected information for the observational questionnaire.

To test inter-rater reliability in completing the observational questionnaire, the two study staff members visited 10 businesses together before initiating data collection. Each staff member completed the questionnaire, and discrepancies were discussed and resolved at a full study team meeting. The discrepancies were related to different interpretations of questions, such as different descriptions of "No Smoking Signs", whether ashtrays outside casino restaurants comprise "outside ashtrays", whether outside eating areas included picnic tables outside convenience stores. All discrepancies were discussed and revised for the final questionnaire.

Compliance with the Smoking Ban. All of the businesses included in the study were subject to the NCIAA. Businesses were considered to be in compliance if they met the following conditions, as specified by the NCIAA: (1) "No smoking" sign at all entrances, (2) Conspicuous sign on front entrance, (3) No one smoking inside the business, (4) No ashtrays visible inside the business.

Indoor Air Samples. Radiello© diffusive passive monitors (http://www.sigmaaldrich.com /analytical-chromato-graphy/samplepreparation /radiello.html) were used for the collection of air samples from 27 restaurants and 13 convenience stores that allowed smoking before implementation of the NCIAA, and from a random sample of 20 businesses that did not allow smoking before the NCIAA (Bruno, Caselli, de Gennaro, Iacobellis & Tutino, 2008; Cocheo, Boaretto & Sacco, 1996). We did not collect air samples from drug stores and larger grocery stores because budget constraints required focused sampling, and these businesses were less likely than others to have smoky environments due to separation between store and gaming areas. With permission of business managers or em-

ployees, study staff placed the passive monitors in businesses when they visited to collect observational data.

Monitors were placed behind cashiers in convenience stores, behind the bars in businesses with sit-down bars, and in central seating areas in other restaurants. Monitors were retrieved at least 24 hours later and delivered to the Department of Natural Resources and Environmental Science at the University of Nevada, Reno, where they were analyzed by mass spectrometry/gas chromatography (MS-GC) for benzene and the presence of 3-ethenyl pyridine.

Observed Businesses. An additional random sample of businesses was selected from the Washoe County Permits database to serve as a comparison group. These businesses, which were not told about the study, were visited for the collection of observational data and air samples. The sample comprised only restaurants and convenience stores, the same business types from which we collected air samples in the interviewed study population.

In these businesses, grab samples of ambient air were collected using 1-liter Restek SilcoCan deactivated stainless steel canisters (Wang & Austin, 2006). Canisters were evacuated to 24 inches of mercury vacuum prior to sampling. Evacuated canisters were transported in a backpack or large tote bag with a 20-cm piece of 0.25-inch teflon tubing extending from the canister inlet valve to outside the bag. To collect a grab sample, the canister valve was opened and vacuum in the canister was filled with ambient air in a matter of seconds as pressure in the canister equilibrated with ambient air pressure before the canister valve was closed. Sampled canisters were delivered to Desert Research Institute's Organic Analytical Laboratory for gas chromatography-mass spectrometry (GC-MS) analysis for quantification of benzene and 3-ethenyl pyridene.

Statistical Analysis. All statistical analyses were performed using Stata/SE 10.0 for Macintosh (Stata Corporation, College Station, TX). The Pearson chi-square test (χ^2) was used to test differences in proportions among groups. Fisher's exact test was used to test differences in proportions for variables with less than 5 observations in at least one cell. Differences between means were tested using the two-sample t-test. Benzene concentrations were log-transformed for use in statistical tests. In the case of unequal variances, the Kruskal-Wallis Rank Sum test was used to test differences between means. Logistic regression was used to compute odds ratios and 95% confidence intervals. Likelihood ratio tests were used to assess effect modification in logistic regression models.

Human Subjects Protection. This study received exempt review status from the Office of Human Subjects Protection at the University of Nevada, Reno, because information about human subjects was not collected.

RESULTS

Business Characteristics. The majority of businesses participating in interviews were restaurants, which we further categorized as delicatessens, restaurants, or casino restaurants (table 1). Of all interviewed businesses, 67 (37%) had allowed smoking before implementation of the ban.

Table 1. Distribution of Businesses

		Allowed pre-ban smoking	Compliant with the NCIAA
Type of Business	**Frequency (%)**	**Frequency (%)**	**Frequency (%)**
Restaurants	127 (70.2)	39 (30.7)	34 (26.8)
Delicatessen	16 (8.8)	2 (12.5)	5 (31.3)
Restaurant	100 (55.3)	31 (31.0)	26 (26.0)
Casino Rest.	11 (6.1)	6 (54.6)	3 (27.3)
Grocery	48 (26.5)	25 (52.1) 2	14 (29.2)
Big Box	2 (1.1)	(100.0)	2 (100.0)
Convenience	28 (15.5)	18 (64.3)	8 (28.6)
Grocery	18 (9.9)	5 (27.8)	4 (22.2)
Drug Store	6 (3.3)	3 (50.0)	3 (50.0)
Total	181	67 (37.0)	51 (28.2)

Interviewed and observed businesses were similar with respect to most characteristics (table 2). For business characteristics not related to compliance, the two samples differed only with respect to outdoor seating areas (χ^2 p-value=0.0005) and the presence of children at the time of visit (χ^2 p-value = 0.02). Most businesses (86.7%) had cigarette butts outside, predominantly on the ground (85.3%) rather than in ashtrays (38.2%) or planters (27.6%) (data not shown). People were smoking outside of 21 businesses (11.6%), and 14 (66.7%) of these were less than 10 feet from the entrance of the building.

Table 2 Characteristics of businesses affected by the Nevada Clean Indoor Air Act.

Business Characteristics	Interviewed Businesses (n = 181)		Observed Businesses (n = 56)		p-value
	%	Odds Ratios (95% CI)	%	Odds Ratios (95% CI)	
Number of entrances					
1	75.7	1.00	69.9	1.00	0.81
2	21.0	0.51 (0.21–1.25)	23.2	0.36 (0.07–1.89)	
3 +	3.4	0.57 (0.06–5.21)	7.2	---	
Cigarette ads on front door	16.0	1.18 (0.50–2.79)	16.1	0.27 (0.03–2.33)	0.17
Cigarette legal warnings on front door	24.9	1.21 (0.60–2.52)	21.4	0.79 (0.18–3.42)	0.61
Cigarette health warnings on front door	1.7	1.28 (0.11–14.43)	0	---	---
Ashtrays outside business	45.3	0.71 (0.37–1.37)	58.9	0.86 (0.27–2.77)	0.78
Cigarette butts outside business	86.7	3.08 (0.88–10.83)	92.9	---	---
People smoking outside business	11.6	0.56 (0.18–1.77)	19.6	7.00 (1.68–29.23)	< 0.01
Outdoor eating area	28.2	0.44 (0.20–1.00)	25.0	1.00 (0.26–3.81)	0.32
Outdoor seating area	28.7	0.57 (0.27–1.22)	10.7	1.29 (0.21–7.83)	0.43
Gaming area	27.1	0.88 (0.42–1.85)	23.2	0.38 (0.07–1.93)	0.33
Arcade	4.4	2.66 (0.64–11.07)	1.8	---	---
Sit-down bar	27.6	0.85 (0.41–1.78)	17.9	3.18 (0.77–13.07)	0.11
Odor of smoke	11.1	1.10 (0.40–3.03)	16.1	14.78 (2.62–83.46)	<0.01
Number of customers					
None	13.8	1.00	12.5	1.00	0.82
<5	35.9	1.09 (0.35–3.42)	25.0	1.25 (0.19–8.44)	
5-10	23.8	1.41 (0.49–4.06)	32.1	0.68 (0.09–5.45)	
>10	25.4	1.25 (0.41–3.82)	30.4	1.04 (0.15–7.27)	
Number of children					
None	64.6	1.00	48.2	1.00	0.53
<5	24.9	0.64 (0.13–3.15)	28.6	0.88 (0.15–5.27)	
5-10	5.5	0.93 (0.43–2.01)	17.9	2.72 (0.71–10.41)	
>10	4.4	2.55 (0.60–10.78)	5.4	1.75 (0.13–22.78)	

Note: CI = confidence interval. Odds ratios compare compliant with non-compliant businesses. P-values are given for likelihood ratio tests of effect modification by business status (interviewed or observed).

Compliance Characteristics. Characteristics related to compliance with the NCIAA were also similar for the two samples, except that none of the observed businesses were reported to have ashtrays or cigarette butts inside (table 3). Only 51 businesses (28.2%) were considered to be compliant with the NCIAA, and only 48.6% of the businesses displayed a "No Smoking" sign on the front entrance (table 3). Customers were smoking in three businesses, one of which had a "No Smoking" sign, when they were visited (data not shown).

Overall, compliant businesses were more likely than non-compliant businesses to have cigarette butts outside (OR 3.68, 95% CI 1.07 – 12.62) and to have an odor of smoke (OR 2.32, 95% CI 1.05 – 5.13). We assessed business interview status (i.e., interviewed vs. observed) as an effect modifier of the relationships between business characteristics and compliance and found that compliant businesses were more likely than non-compliant businesses to have an odor of smoke and people smoking outside only among businesses that had not been interviewed (table 2). The characteristics of

compliant and non-compliant businesses, as obtained through manager interviews, were similar (table 4). With respect to smoking policies, however, compliant businesses were more likely than noncompliant businesses to report asking a smoking customer to stop smoking or go outside, or to inform the customer that smoking is not allowed (table 4).

Table 3. Compliance measures for all businesses.

Compliance Measures	Interviewed Businesses (n = 181) Percent	Observed Businesses (n = 56) Percent	p-value
"No Smoking" sign at front entrance	48.6	50.0	0.86
Sign at front entrance is conspicuous (among businesses with sign at front entrance)	68.2	67.9	0.91
"No Smoking" signs at every entrance	43.7	41.1	0.73
Ashtrays inside business	2.2	0	0.57
Cigarette butts inside business	1.1	0	1.00*
People smoking inside business	1.7	1.8	1.00
"No smoking" sign at every entrance, sign on front entrance is conspicuous, no ashtrays inside business, no one is smoking	28.2	28.6	0.95

P-values are given for chi-square or Fisher's exact* test of proportions.

Air Quality. Radiello passive monitors were collected from 40 (70.2%) of the 57 restaurants and convenience stores that allowed smoking before implementation of the NCIAA. Of the remaining 17 businesses, two did not allow placement of a monitor, four allowed placement but lost the monitors, two had converted to bars, and three were drive-through restaurants without customer entrances. Grab samples were taken from the remaining six businesses (two restaurants and four casino restaurants) because employees of these businesses did not have authority to give permission for placement of monitors. For interviewed businesses, the mean benzene air concentration was not significantly different between businesses that allowed smoking before the ban and those that did not allow smoking before the ban (two-sided t-test, p=0.25). Because observed businesses did not have interview data, we did not know which of those businesses allowed smoking before the ban, and thus could not compare air quality on this basis. However, observed businesses had higher benzene concentrations than interviewed businesses overall (ANOVA, $p<0.001$), especially for convenience stores (ANOVA, p= 0.005) and restaurants (ANOVA, p=0.01) (table 4b-4c). Although casino restaurants had higher benzene concentrations than other business types combined (GM 2.30 $\mu g/m^3$ and 1.33 $\mu g/m^3$ respectively, p=0.02), the concentrations in interviewed and observed casino restaurants were not substantially different. Benzene concentration did not differ by compliance status (noncompliant: GM 1.37 $\mu g/m^3$ (95% CI, 1.15–1.63); compliant: GM 1.57 $\mu g/m^3$ (95% CI, 1.11–2.23), two-sided t-test, p=0.42).

Eight (12.12%) of the interviewed businesses with air quality data (n=66) and 42 (75.0%) of the observed businesses with air quality data (n = 56) had measurable concentrations of 3-EP, a specific marker of tobacco smoke. 3-EP was positively associated with benzene concentration; each 1% increase in benzene concentration was associated with a 2.32% increase in 3-EP concentration (linear regression coefficient = 2.32, 95% CI, 0.96-3.67, p= 0.001). Mean 3-EP concentration did not vary by business type or compliance status, although compliant businesses were more likely to have higher levels (75^{th} percentile=3.64 $\mu g/m^3$) of 3-EP (OR=3.5, 95% CI, 1.05-11.69).

DISCUSSION

We evaluated first-year compliance with the Nevada Clean Indoor Air Act (NCIAA) among businesses in the Reno-Sparks, Nevada, area and found that overall compliance, as defined by the NCIAA, was low. Compliance was similar for businesses with and without knowledge of the study. Over half of the businesses

Table 4. Characteristics of compliant and non-compliant businesses

Interview Question	Compliant N = 51	Non-compliant N = 130	Odds Ratios (95% Confidence Interval)
Number of employees			
1 – 5	11 (21.6)	26 (20.0)	1.00
6 – 10	14 (27.5)	38 (29.2)	0.87 (0.34 – 2.21)
11 – 30	11 (21.6)	45 (34.6)	0.58 (0.22 – 1.52)
>30	15 (29.4)	21 (16.2)	1.69 (0.64 – 4.44)
Years under current ownership			
<1 year	6 (11.8)	18 (13.9)	1.00
1 – 3 years	10 (19.6)	41 (31.5)	0.73 (0.23 – 2.32)
4 – 9 years	15 (29.4)	37 (28.5)	1.22 (0.40 – 3.66)
10 – 20 years	9 (17.7)	16 (12.3)	1.69 (0.49 – 5.79)
>20 years	9 (17.7)	13 (10.0)	2.08 (0.59 – 7.29)
Part of a larger business	26 (51.0)	67 (51.5)	0.97 (0.50 – 1.87)
Has a place where smoking is allowed	6 (11.8)	11 (8.5)	1.44 (0.50 – 4.13)
Accommodates outdoor smokers	29 (56.9)	71 (55.0)	1.08 (0.56 – 2.07)
Provides smoking cessation benefits to employees	5 (9.8)	10 (7.7)	1.26 (0.41 – 3.89)
Trains employees on how to approach smoking customers	30 (58.8)	69 (53.1)	1.24 (0.64 – 2.41)
What happens if customer is smoking?			
Asked to stop	22 (43.1)	35 (26.9)	2.06 (1.05 – 4.05)
Informed that smoking is not allowed	25 (49.0)	42 (32.3)	2.01 (1.04 – 3.90)
Asked to smoke outside	26 (51.0)	44 (33.9)	2.03 (1.05 – 3.93)
Nothing	0	1 (0.8)	N/A
Has not happened	20 (39.2)	69 (53.1)	0.57 (0.30 – 1.10)
Who approaches the smoking person?			
An employee	24 (47.1)	64 (49.2)	0.92 (0.48 – 1.75)
Manager	42 (82.3)	107 (82.3)	1.00 (0.43 – 2.35)
Other (security, hostess, supervisor)	6 (11.8)	15 (11.5)	1.02 (0.37 – 2.80)
What happens if a customer complains about someone smoking?			
The smoking customer is told about the complaint	3 (5.9)	2 (1.5)	4.0 (0.65 – 24.68)
Customer is asked to stop smoking	9 (17.7)	27 (20.8)	0.82 (0.35 – 1.88)
Customer is informed that smoking is not allowed	15 (29.4)	23 (17.7)	1.94 (0.91 – 4.11)
Customer is asked to smoke outside?	15 (29.4)	24 (18.5)	1.84 (0.87 – 3.89)
Customer is allowed to finish	0	0	N/A
Nothing	0	3 (2.3)	N/A
Has not happened	33 (64.7)	86 (66.2)	0.94 (0.48 – 1.85)

failed to post a no-smoking sign on the front door, one of the most obvious and unchanging measures of compliance. Benzene concentrations were higher in businesses without knowledge of the study than in businesses with knowledge of the study and in casino restaurants than in other businesses. However, neither benzene nor 3-EP concentrations differed significantly between compliant and non-compliant businesses.

The findings of this study are similar to those of an earlier study that assessed compliance in retail stores in Cambridge, Massachusetts (Rigotti, Stoto, Bierer, Rosen & Schelling, 1993). In that study, posting of no-smoking signs increased from 3 months (23%) to 11 months (41%), then remained the same at 24 months. This compares with 49% in the current study, where a variety of businesses were assessed through the first

Table 4a. Benzene air concentrations (μg/m3) measured in businesses

Sample	No.	Range	AM 95% CI	GM 95% CI	p-value*
Inter.	66	0.07 – 7.92	1.71 (1.26 – 2.16)	1.11 (0.88 – 1.39)	<0.001
Obs.	56	0.34 – 9.12	2.51 (1.99 – 2.02)	1.92 (1.57 – 2.35)	

*p-value for 2-sided T- test; No.=Number of samples; AM= Arithmetic mean; GM=Geometric mean; Inter.= Interviewed Businesses; Obs.=Observed Businesses

Table 4b. Interviewed businesses, by type (n = 66)

Type	No.	Range	AM 95% CI	GM 95% CI	p-value¶
Conv. Stores	14	0.39 – 4.14	1.12 (0.58 – 1.66)	0.92 (0.65 – 1.29)	0.36
Rest.	45	0.07 – 7.30	1.58 (1.14 – 2.02)	1.07 (0.81 – 1.41)	
Casino Rest,	7	0.40 – 8.64	3.71 (0.37 – 7.05)	2.06 (0.63 – 6.74)	

Table 4c. Observed businesses (n = 56)

Type	No.	Range	AM 95% CI	GM 95% CI	p-value¶
Conv.. Stores	14	0.91 – 4.75	2.08 (1.38 - 2.79)	1.79 (1.30 - 2.48)	0.40
Rest.	33	0.34 – 9.96	2.64 (1.81 - 3.47)	1.84 (1.34 - 2.52)	
Casino Rest.	9	1.19 – 4.67	2.71 (1.89 - 3.53)	2.51 (1.80 - 3.49)	

¶ p-value for Kruskal-Wallace rank sum test

year. Compared with our study, the early study reported 1.0% (vs. 1.7%) of businesses with occupants smoking inside, 13% (vs. 12.2%) with the odor of smoke, and 36% (vs. 21.4%) in "partial" compliance (any no-smoking sign, no one smoking inside, and no odor of smoke). Compliance in our study was based on the wording of the NCIAA, which requires a conspicuous sign at the front entrance, signs at each entrance, and removal of smoking paraphernalia. We included absence of cigarette butts and people smoking inside as additional factors in the compliance measure, because presence of these would be considered noncompliance with respect to the spirit, although not necessarily the letter, of the law.

In contrast to these findings, other studies have reported high compliance with smoking bans (Biener et al., 2007; Borland et al., 2006; Skeer et al., 2004; Weber et al., 2003). Borland et al. (2006) measured reported compliance in four countries (Australia, United Kingdom (UK), Canada, the United States (US)) among smokers recruited into the International Tobacco Control Four Country Survey. In that study, support for smoking bans was higher for restaurants than for bars, reflected in reported compliance. For example, compliance in restaurants was high in Australia, the US, and Canada (97.5%, 95.8%, and 94.5%, respectively) but low in the UK (79.6%), while compliance in bars was 72.9% for the US, 68.8% in Canada, and relatively lower in Australia and the UK (47.9% and 14.9%, respectively). Two studies focused on bars in Boston, Massachusetts, after implementation of a smoke-free bar ordinance (Biener et al., 2007; Skeer et al., 2004). In the first study, the proportion of bars with posted signs increased (0% to 100%,), the proportion of bars with smokers decreased (100% to 2.9%), and the mean number of ashtrays decreased (24.4 to 0) (Skeer et al., 2004). The second study interviewed smokers before and after implementation of a smoke-free bar ordinance in Boston to assess changes in observed smoking (Biener et al., 2007). The study found that 69.2% of the Boston participants reported less smoking in bars after the ordinance, compared with 25.1% of participants in other Massachusetts towns without smoke-free bar ordinances. These studies are not directly comparable to our study, however, because of their qualitative nature and focus on bars.

Although studies have compared indoor air quality of restaurants and bars before and after implementation of smoking bans (Johnsson et al., 2006; Lee et al., 2008; McNabola, Broderick, Johnston & Gill, 2006; Repace,

Hyde & Brugge, 2006) and in smoking and non-smoking areas (Akbar-khanzadeh, Milz, Ames, Spino & Tex, 2004; Brauer & Mannetje, 1998; Kuusimaki, Peltonen & Vainiotalo, 2007; Lambert, Samet & Spengler, 1993), to our knowledge no studies have compared air quality in compliant and non-compliant businesses after passage of a smoking ban. One study found significant decreases in the average levels of benzene and 1,3-butadiene in two pubs after implementation of a smoking ban in Dublin, Ireland (McNabola et al., 2006). Benzene decreased from 4.83 $\mu g/m^3$ to 0.54 $\mu g/m^3$. We measured average post-ban concentrations in the range of 1.12 $\mu g/m^3$ (convenience stores) to 3.48 $\mu g/m^3$ (casino restaurants). The other studies, which did not measure benzene, had equivocal findings. For example, pre-ban concentrations of respirable particle air pollution (RSP) and particulate polycyclic aromatic hydrocarbons (PPAH) were 23 and 10 times higher than post-ban concentrations in six Boston bars (Repace et al., 2006). However, concentrations of nicotine, 3-EP, and total volatile organic compounds were not affected by smoking restrictions in Finnish restaurants and bars, where mixed ventilation without physical separation did not adequately separate smoking and smoke-free sections, according to the authors (Johnsson et al., 2006). Similarly, a study comparing pre- and post-ban measures of particulate matter with aerodynamic diameter of 2.5μm ($PM_{2.5}$) in hospitality venues in Lexington and Louisville, Kentucky, found differential impacts based on the type of restriction (Lee et al., 2008). Similar studies in Albuquerque, New Mexico, and Vancouver, British Columbia, emphasized that partial smoking bans may provide substantial, but not complete, protection against environmental tobacco smoke exposures (Brauer & Mannetje, 1998; Lambert et al., 1993).

In the present study, benzene concentrations were higher in casino restaurants, which generally do not have physical separation from casino gaming areas, where smoking is allowed. However, casino restaurants were also likely to be compliant with the letter of the NCIAA, suggesting that compliance alone may not be sufficient to improve air quality. The tendency of casino restaurants to be in compliance with the law despite poorer air quality may explain the paradoxical associations of having an odor of smoke and smokers outside with positive compliance status. Similarly, compliance status of businesses overall did not affect measured benzene concentrations. This could reflect the possibility that smoking continued in businesses after passage of the NCIAA, regardless of compliance with the letter of the law.

Several limitations may have affected the results of this study. First, benzene was measured using different methodologies for the interviewed and observed businesses. In order to collect covert air samples in businesses that were unaware of the study, providing an unbiased comparison group, we used a sampling strategy requiring a short period of time. Thus, grab samples were taken when study staff entered the businesses to collect observational data. Because of the high cost of these measurements, however, we used passive monitors in businesses that participated in interviews and agreed to provide air samples. Average benzene concentrations were higher in the observed businesses, and it is not possible to determine whether this was related to the sampling methodology or differences in air quality between the two samples. Nevertheless, findings were similar for both samples: casino restaurants had higher benzene levels than other businesses and compliance status did not affect benzene concentrations.

Another limitation is that each business was observed only once, and smoking may have occurred during a period that was not under observation by study staff. However, observations were completed at random so time should not introduce substantial bias into the study results. Some businesses were observed for longer periods to avoid awkwardness or suspicion. For example, data collection in a convenience store could be completed in a short visit, whereas data collection in a restaurant may have required interaction with a hostess and being seated at a table. However, the different observation times would only affect the number of smokers reported and perhaps the report of smoke odor, and not the benzene concentrations or other measures of compliance.

We did not find specific business characteristics that predict compliance with a smoking ban, especially when compliance is defined narrowly as the posting of no-smoking signs, removal of ashtrays and smoking paraphernalia, and no one smoking inside. Among the interviewed businesses, the only notable difference between compliant and non-compliant businesses was the tendency for managers of compliant businesses to report that smoking customers would be asked to stop smoking, informed that smoking is not allowed, or asked to smoke outside. All businesses had a high prevalence of cigarette butts outside the establishment, which may be an indication that people either throw out cigarettes before entering a business or stand outside and smoke. Either behavior would be an indication of compliance with the smoking ban, which is supported by the finding

that compliant businesses were more likely than non-compliant businesses to have cigarette butts outside.

To our knowledge, this is the only study that has assessed both air quality and compliance measures in businesses affected by a smoking ban. Compliance with the ban was low, and we did not find a relationship between compliance measures and air quality. However, we did find that casino restaurants had higher benzene levels than other types of businesses, although most complied with the requirements of the ban. This finding suggests that compliance alone may not be sufficient to reduce exposure to environmental tobacco smoke, particularly in buildings with both nonsmoking and smoking areas.

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