

Reduced Exposure to Secondhand Smoke at Casinos in Puerto Rico after the Implementation of a Workplace Smoking Ban in 2007: a Pre-Post Design

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Objective: Tobacco use and the involuntary exposition to secondhand smoke (SHS) is one of the leading causes of cancer. The objective of this study was to assess the effect of the smoke free workplace ban implemented in March of 2007 in Puerto Rico on the exposure of casino workers to secondhand smoke measured in terms of fine particulate matter and cotinine level.

Methods: This study used a pre-post comparison design to measure exposure to secondhand smoke before (February, 2007) and after (December, 2007 to February, 2008) the workplace smoking ban was implemented. The samples included level of cotinine in saliva from 20 randomly sampled casino union workers and indoor concentrations of fine particulate matter (2.5 µm diameter, PM_{2.5}) in 10 casinos located in the San Juan metropolitan area. Paired t-tests were used to test any statistically significant change in particulate matter and cotinine levels before and after the ban went into effect.

Results: The average PM_{2.5} level in San Juan metropolitan area casinos decreased by 88.5% (95% CI: 63.9%, 96.3%) and the average cotinine level for the sample of non-smoking casino workers decreased by 52.1% (95% CI: 40.6%, 61.4%). Both reductions were statistically significant (p<0.01).

Conclusion: The implementation of the smoke free workplace ban in 2007 resulted in a significant reduction of the exposure to secondhand smoke to casino workers in the San Juan metropolitan area of Puerto Rico. [*P R Health Sci J* 2011;30:182-187]

Key words: Seconhand smoke, Workplace smoking ban, Particulate matter, Casinos, Cotinine

Previous studies suggest that workplace smoking bans are one of the most effective measures in reducing the exposition to secondhand smoke (SHS) for workers in the hospitality industry around the world (1-7). Reductions in the level of respirable particulate matter (PM_{2.5}) reported in the literature are very large and significant (8). For example, after the introduction of smoking bans, the average level of PM_{2.5} in a random sample of bars was reduced by 84% in the state of New York (6) and by 71% to 99% in the case of Austin, Texas (7). Moreover, evidence suggests that smoking bans in Scotland (9) and Italy (10) led to reductions of 86% and 68% respectfully in the average PM_{2.5} levels.

However, most smoke-free laws have usually exempted casinos, despite evidence showing that casinos have a similar level of exposure to SHS than any other establishment in the hospitality industry, and despite the support of casino employees for the imposition of smoking restrictions or bans (11-17). As a result, few studies have been able to evaluate the effect of workplace smoking bans on the exposure to SHS among casino employees (10,18). In March of 2007 Puerto Rico became one of the first jurisdictions in banning smoking in casinos as an indoor smoke-free workplace ban went into effect. The purpose of the ban was to protect

workers in workplaces, and even children (under age 13) who are passengers in private cars, from SHS exposure. This prohibition offers a unique opportunity to evaluate the effect of a workplace smoking ban on the exposition to SHS among casino workers.

In a previous study we found evidence that strongly suggest that the workplace smoking ban had the effect of reducing the exposure to SHS by 83.6% in restaurants and 95.6% in pubs and discos of the San Juan metropolitan area (3). The study objectives were the following: first, to measure and compare the levels of PM_{2.5} in casinos in the San Juan metropolitan area before and after the workplace smoking ban went into

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effect; and, second, to measure and compare the levels of cotinine among a sample of casino workers before and after the workplace smoking ban went into effect in March of 2007.

Methods

Design

This study used a pre-post comparative design. Pre-ban measurements were taken in February of 2007 and post-ban measurements were taken from December of 2007 to February of 2008. The pre-post design allows for the control of establishment and subject factors or characteristics that may affect the exposure to SHS, but remain constant between pre and post-ban measurements. If these factors remain constant, then they cannot explain any differences found in the levels of exposure to SHS.

Sampling

This study was limited to the San Juan metropolitan area, the capital of Puerto Rico, which covers the following municipalities: Bayamón, Carolina, Cataño, Guaynabo, San Juan, Toa Baja, and Trujillo Alto. The establishment sample was a census of all casinos located in the San Juan metropolitan area. A total of 11 casinos were identified of which 10 allowed smoking before the smoking ban went into effect. The casino at the Luis Muñoz Marín International Airport already prohibited smoking by federal law before the smoking ban went into effect. The final "sample" consisted of the 10 casinos that allowed smoking in their facilities before March of 2007.

In order to calculate the sample size for the workers sample we used the free licensed software called G*Power. The following parameters were assumed: a type I error of 0.05 (α), a power of 80% ($1-\beta$), and a one tail test. Also estimates for the mean and standard deviations of pre and post cotinine levels were needed. For this, measures of cotinine concentrations among waiters in Irish hotels before and after a smoking ban were used as reference (4). After assuming a retest correlation of 0.1 the minimum sample size generated by the software was 13 subjects, which after adjusted by an assumed attrition rate of 40% increased to a final sample size of 22 subjects.

Then, a random sample of 22 casino workers was selected from a list of 271 casino workers who were affiliated to labor unions and organizations from the hospitality industry after permission from the potential participants was obtained. The eligibility criterion was to be working inside a casino for at least 8 hours shifts and the exclusion criterion was to be a current smoker. Participants were not offered any type of incentive to participate in the study. Sampling with replacement was used to substitute those that refused to participate. The advantage of this method is that the probability of choosing any worker remains the same regardless of how many samples were

selected. Then final sample size was achieved after contacting a total of 88 subjects, which translates into a response rate of 25%. Selection bias is a potential problem in this sample. However, the use of a pre-post design, to some degree, diminishes the potential bias introduced in the data.

Instruments and data collection

A SidePak AM510 Personal Aerosol Monitor was used to measure the level of respirable particulate matter for particles that are less than $2.5\mu\text{m}$ in diameter ($\text{PM}_{2.5}$). After receiving the approval and support of the Puerto Rico Tourist Company, which regulates casinos in Puerto Rico, the research team contacted the administration of the hotels where the casinos are located to coordinate the visit. Then, at each casino the monitor was placed in a specific location, and for 20 minutes it obtained an air sample every 15 seconds. The monitor was placed in the exact same location for one pre-ban and one post-ban measurement at each casino. In terms of cotinine measurements, the research team collected the saliva samples using an immunoassay kit designed to measure the presence of cotinine in saliva samples. The participants came to the project facilities for this process. They were provided a plain, non-citric acid cotton salivette, which they put under their tongue until it was completely saturated. The salivette was then removed and placed in an assay tube which was deposited inside a plastic bag that was frozen at 20°C or lower. After all samples were collected, the salivettes were sent to the Salimetrics laboratories in Pennsylvania, U.S.A. via next day shipping inside a package containing dry ice. Finally, the researchers received an electronic file by e-mail with a report indicating the level of cotinine for each participant identified by a control number. This process was repeated for all 22 participants for pre-ban and post-ban measurements.

Study variables

The dependent variables in this study were two: the level of concentration of particles that are less than $2.5\mu\text{m}$ in diameter ($\text{PM}_{2.5}$) in the casinos and the level of salivary cotinine in the sample of casino workers. The level of $\text{PM}_{2.5}$ is measured in terms of milligrams per cubic meter of air (mg/m^3). Cotinine level are measured in terms of nanograms per milliliters (ng/ml). When a cigarette is smoked, nicotine is absorbed and distributed through the body within seconds and then it metabolizes, mainly by oxidation, to cotinine and nicorine-N-oxide. However, nicotine is not considered a valid marker of smoking status due to its relatively short half-life (approximately two hours) (19, 20). By contrast, cotinine in saliva has a half-life of more than ten hours. The independent variable was the implementation of the workplace smoking ban. Measurements of $\text{PM}_{2.5}$ and cotinine levels that were taken before March of 2007 were grouped as pre-ban, while those taken after March of 2007 were grouped as post-ban.

Statistical analysis

Cotinine levels in sample of casino workers

The final sample of casino workers consisted of 20 non-smoking subjects. Two subjects were excluded from the analysis because they were smokers. First, a descriptive statistical analysis was performed to show the percentage distribution of subjects in terms of gender, age, marital status, education, and job position. Secondly, paired t-tests were run to examine for any statistically significant change of cotinine levels between pre and post smoking ban measurements. Due to the right skewed distribution of the cotinine level variable, it was decided to transform the variable into its natural log in order to decrease the skewness of the variable. Thus, the paired t-test analyses were performed using cotinine level measured in their original scale and in their natural logs as well. Moreover, it is possible that the implementation of the smoking ban may have an impact on absolute differences that would vary with the baseline value. In that case, the average of relative differences would be a more consistent estimate of change than the average of absolute differences (21). Thus, by using the difference of natural logs we are measuring relative differences in cotinine levels which are more likely to have a Gaussian distribution.

The paired t-test provide an unbiased estimate of the effect of the workplace smoking ban on cotinine levels as long as most of the other important factors that affect cotinine levels remain constant. However, there are subject factors, some which we were able to measure while others were not, that perhaps may have changed over time, and which in turn, could have affected the exposition to SHS and the measurement of the cotinine levels. Examples of these factors include the number of hours that lapsed from the time the subject left his/her workplace and the time the saliva sample was taken, and the presence of a smoker at home. Exploratory regression analyses were performed estimating the effect of the workplace smoking ban controlling for those two variables. Since the results of the regression analysis validated the paired-t test results by producing basically the same estimates in terms of their magnitude, and within their confidence intervals, we decided to present the paired-t test results only for two main reasons; first, because of the limited number of degrees of freedom available to perform the regression analysis, and second, because these are simpler and parsimonious.

Particulate matter (PM_{2.5}) levels in casinos

Paired t-test analyses were performed using PM_{2.5} levels measured in their original scale and also in their natural logs. Estimates of absolute and relative differences in PM_{2.5} levels before and after the smoking ban were computed in the same manner as for cotinine levels. In addition, an exploratory regression analysis was performed controlling for the number of clients in the casino, establishment floor area, and weekday when the measurements were taken. As in the case of cotinine, the

results of the regression analysis validated the paired-t test results by producing very similar estimates in terms of their magnitude and with overlapping confidence intervals. Therefore, for the reasons already explained, we decided to present the paired-t test results only and not the regression results.

Ethical considerations

The study received final approval from the University of Puerto Rico Medical Sciences Campus Institutional Review Board (IRB) in February of 2007. Once a potential participant arrived at our facilities, he/she went through the following steps: 1) a project personnel provided them with a consent form and asked them to read it at that moment; 2) after he/she read the consent form, the project staff discussed the content with that person to confirm that he/she understood all aspects of the study; 3) if the person agreed to participate in the study, he/she was asked to sign the IRB stamped consent letter. The participant was provided with a copy of the document, and the original was stored in our facilities.

Results

Cotinine level in sample of casino workers

For the final sample of 20 non-smoking casino workers, the median age was approximately 41 years of age with 25% of the subjects being less than 35 years of age, and 25% above 47 years of age (Table 1). Most of the subjects were male (16; 80%), half were married (10; 50%), and most had a college degree (17; 85%). In terms of job positions, the largest group was comprised of croupiers (9; 45%), followed by casino inspectors (7; 35%). The rest of the subjects were cashiers, supervisors, and others (4; 20%).

Regarding the outcome variables, the baseline average cotinine level among the sample of non-smoking casino workers was 1.14 ng/ml (Table 2). After the implementation of the smoking ban, it was 0.55 ng/ml. The average pre - post difference was -0.58 ng/ml (95% CI: -0.87, -0.29) which is statistically significant ($p=0.01$). This difference is a 50.9% (95% CI: 25.1%, 76.7%) reduction in cotinine levels after the workplace smoking ban went into effect. A similar result was found when the paired-t test was performed on the natural logs of cotinine levels. The average pre and post levels for the natural log of cotinine were -0.12 and -0.85 (Table 2). The average difference of the logs was -0.74 (95% CI: -0.95, -0.52) which is statistically significant ($p=0.008$). This difference translates into a reduction of 52.1% (95% CI: 40.6%, 61.4%) in the average cotinine level after implementation of the smoking ban. Paired-t test analyses, stratified by job position, were performed and no statistical significant differences ($p>0.05$) between the two groups of workers were found. However, these analyses are not presented here because the casino workers sample was not designed to detect differences among job positions.

Table 1. Characteristics of the sample of non-smoking casino workers [n=20]

| Variables | n | % |
|----------------------------------|-----------|--------------|
| <i>Age</i> | | |
| <35 | 5 | 25.0 |
| 35 to 41 | 5 | 25.0 |
| 42 to 47 | 5 | 25.0 |
| >47 | 5 | 25.0 |
| Total | 20 | 100.0 |
| <i>Gender</i> | | |
| Female | 4 | 20.0 |
| Male | 16 | 80.0 |
| Total | 20 | 100.0 |
| <i>Marital Status</i> | | |
| Single | 6 | 30.0 |
| Married | 10 | 50.0 |
| other | 4 | 20.0 |
| Total | 20 | 100.0 |
| <i>Education level</i> | | |
| High School Diploma | 3 | 15.0 |
| College degree | 17 | 85.0 |
| Total | 20 | 100.0 |
| <i>Job Position</i> | | |
| Croupier | 9 | 45.0 |
| Casino Inspector | 7 | 35.0 |
| Other [cashier, supervisor, ...] | 4 | 20.0 |
| Total | 20 | 100.0 |

Table 2. Paired t-tests for cotinine level and for their natural log for the sample of non-smoking casino workers before and after implementation of the workplace smoking ban in March of 2007 (n=20).

| Statistics | Pre-ban | Post-ban | Diff*. | Diff.%† | P‡ |
|---|---------|----------|--------|---------|-------|
| Mean of cotinine (ng/ml) | | | | | |
| | 1.14 | 0.55 | -0.58 | -50.9 | 0.010 |
| 95% CI LL | 0.69 | 0.33 | -0.87 | -76.7 | |
| 95% CI UL | 1.59 | 0.77 | -0.29 | -25.1 | |
| Mean of natural log of cotinine [ln(ng/ml)] | | | | | |
| | -0.12 | -0.85 | -0.74 | -52.1 | 0.008 |
| 95% CI LL | -1.39 | -2.00 | -0.95 | -61.4 | |
| 95% CI UL | 1.59 | 0.73 | -0.52 | -40.6 | |

*For the cotinine level average, the difference is defined as follows: = (post-ban) – (pre-ban). For the natural log of cotinine, the difference is defined as: = log (post-ban) - log (pre-ban). Mathematically this difference is equivalent to computing the log of the ratio [(logR) = log (post-ban/pre-ban)] of the cotinine levels.

†The percentage difference for the cotinine level was computed as: = [(post-ban)-(pre-ban)] / (pre-ban)*100, and for the natural logs it was estimated using the following formula: = (e^{logR} -1)*100.

‡P value for the alternative hypothesis is that the average post-ban level was lower than the pre-ban level, thus a negative difference (one-tailed test).

Particulate matter (PM 2.5) levels in casinos

With respect to the particulate matter in the air, the average PM_{2.5} level among the ten casinos was 0.101 mg/m³ at baseline and 0.018 mg/m³ after the implementation of the smoking ban (Table 3). The mean difference was -0.083 mg/m³ (95% CI: -0.14, -0.03), which is statistically significant (p<0.01). This difference is an 82.2% (95% CI: 27.8%, 136.5 %) reduction in PM_{2.5} after the workplace smoking ban went into effect. The average log of the PM_{2.5} level in the San Juan metropolitan area casinos was 4.27 before the smoking ban and 2.11 after its implementation. The average log difference was -2.17 (95% CI: -3.31, -1.02) which is also statistically significant (p<0.01). Using the natural logs, the estimated percentage reduction in PM_{2.5} levels after the smoking ban was implemented was 88.5% (95% CI: 63.9%, 96.3%).

Table 3. Paired t-tests for particulate matter (PM_{2.5}) levels and their natural log in the sample of casinos before and after implementation of the workplace smoking ban in March of 2007 (n=10).

| Statistics | Pre-ban | Post-ban | Diff*. | Diff.%† | P‡ |
|--|---------|----------|--------|---------|-------|
| Mean of particulate matter (PM _{2.5}) (mg/m ³) | | | | | |
| | 0.10 | 0.02 | -0.08 | -82.2 | 0.008 |
| 95% CI LL | 0.06 | 0.00 | -0.14 | -136.5 | |
| 95% CI UL | 0.15 | 0.04 | -0.03 | -27.8 | |
| Mean of natural log of PM _{2.5} [ln(mg/m ³)] | | | | | |
| | 4.27 | 2.11 | -2.17 | -88.5 | 0.002 |
| 95% CI LL | 2.20 | 0.69 | -3.31 | -96.3 | |
| 95% CI UL | 5.50 | 4.69 | -1.02 | -63.9 | |

*For the cotinine level average, the difference is defined as follows: = (Post-ban) – (Pre-ban). For the natural log of cotinine, the difference is defined as: = log (Post-ban) - log (Pre-ban). Mathematically this difference is equivalent to computing the log of the ratio [(logR) = log(Post-ban/Pre-ban)] of the cotinine levels.

†The percentage difference for the cotinine level was computed as: = (((Post-ban)-(Pre-ban)) / (Pre-ban))*100, and for the natural logs it was estimated using the following formula: = (e^{logR} -1)*100.

‡P value for the alternative hypothesis is that the average post-ban level was lower than the pre-ban level, thus a negative difference (one-tailed test).

Discussion

The study results strongly suggests that extending workplace indoor smoking bans to casinos is a very effective public health measure which protects casino workers from exposure to SHS in San Juan, Puerto Rico. Therefore, the results of this study strengthen the argument in favor of promoting smoke-free legislation as a very effective public health intervention to protect workers from the exposure to SHS in the hospitality industry, including casinos.

The level of exposure to SHS, measured in terms of particulate matter, in casinos in the San Juan metropolitan area and saliva cotinine concentrations in non-smoking casino workers were substantially reduced. The reduction of 88.5% in the level of PM_{2.5} found in this study is very similar to those reported in studies conducted in other countries, states, or cities where

indoor smoking bans have been implemented in the hospitality industry (22). As mentioned previously, level of $PM_{2.5}$ in bars were reduced by 84% in the state of New York (6), from 71% to 99% reduction was reported in Austin, Texas (7), a 86% reduction occurred in Scottish pubs (9), and in Italy there was an average of 68% reduction in $PM_{2.5}$ level (10).

However, in the case of salivary cotinine level, the average 52.1% reduction found in non-smoking casino workers is somewhat lower than that found in other countries where studies have reported reductions from 57% to 89% (22). For example, in England it was found that after the implementation of an indoor smoking ban the urinary cotinine level was reduced by 85% in a sample of non-smoking bar and restaurant employees (2), and after a similar ban in Ireland, concentrations of saliva cotinine were reduced by 69% in a sample of hotel workers (4). Possible reasons that may partially explain the lower reduction of cotinine level in casino workers in this research compared with other published studies are the following: some of the casino interiors (i.e., old rugs, curtains, wallpapers, and other accessories) could have been contaminated by third-hand smoking, and exposure to SHS that occurred in other settings besides the workplace (23, 24).

Limitations of this study must be acknowledged. First, the findings are limited to the San Juan metropolitan area which covers one fourth of the Puerto Rico population. Due to limited resources, the research team was not able to include any casino outside the San Juan metropolitan area in the sample. Therefore, the results of the study are not necessarily applicable to other casinos and casino workers in other parts of the Island. Second, the sample of casino workers was a random sample of workers who are affiliated to labor organizations which is not necessarily a representative sample of all casino workers in the San Juan metropolitan area. Therefore, the cotinine level results may not be an unbiased representation of the general experience of casino workers before and after the workplace smoking ban went into effect.

In terms of future research, it is important to study the medium and long-term effects of the smoking ban on the behavior and health status of the general population and smokers. Particularly, it is very important to look at the potential effect of the smoking ban on the prevalence of smoking, smoking cessation attempts, utilization of tobacco cessation services (such as quitlines), (25, 26) expenditures on tobacco products, and, as recent research has reported, beneficial effects of the smoking ban on the health status of the population through the reduction in the incidence of myocardial events (27, 28). Another important issue which has been raised is the importance of monitoring the implementation of the law by proprietors, employees, and local authorities during the next few years after the law has been implemented. In this sense, one of the objectives of future research should be to provide policymakers and public health advocates with information and data that could help them in

improving the implementation of the smoking ban through laws and rules that govern its implementation or by amending the law if needed.

Resumen

Objetivo: El objetivo de este estudio fue el de evaluar el efecto de la prohibición del fumar en lugares de trabajo, implementada en marzo del 2007, sobre la exposición al humo secundario del cigarrillo en casinos del área metropolitana de San Juan, Puerto Rico. **Métodos:** Se utilizó un diseño pre-post comparativo en donde las medidas pre se tomaron en febrero del 2007 y las medidas post se tomaron entre diciembre del 2007 y enero del 2008. Para medir del nivel de concentración de particulado en el aire ($PM_{2.5}$) se utilizó una muestra de 10 casinos y para medir el nivel de cotinina en la saliva se utilizó una muestra aleatoria de 20 trabajadores unionados no fumadores de casinos del área metropolitana de San Juan. Se utilizaron pruebas pareadas de t para probar la significancia estadística del efecto de la prohibición del fumar en niveles de $PM_{2.5}$ y cotinina. **Resultados:** Después de la implementación de la prohibición de fumar, los casinos experimentaron una reducción en el promedio de niveles de $PM_{2.5}$ de 88.5% (95% CI: 63.9%, 96.3%) y también una reducción significativa en el promedio del nivel de cotinina en la muestra de trabajadores de casinos de un 52.1% (95% CI: 40.6%, 61.4%). **Conclusión:** La implementación de la prohibición de fumar en lugares de trabajo demostró ser efectiva en reducir la exposición al humo secundario del cigarrillo para los trabajadores en los casinos del área metropolitana de San Juan, Puerto Rico.

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