

Secondhand smoke and smoking restrictions in casinos: a review of the evidence

Stephen Babb,¹ Carrie McNeil,² Judy Kruger,¹ Michael A Tynan¹

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¹Office on Smoking and Health, Centers for Disease Control and Prevention, Atlanta, Georgia, USA

²Global Environmental Health Department, Rollins School of Public Health, Emory University, Atlanta, Georgia, USA

Correspondence to

Dr Stephen Babb, Office on Smoking and Health, Centers for Disease Control and Prevention, 4770 Buford Highway, NE, Mailstop F-79, Atlanta, GA 30341; zur4@cdc.gov

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ABSTRACT

Objective There is no safe level of secondhand smoke (SHS) exposure. Most US casinos continue to allow smoking, thus exposing workers and patrons to the hazards of SHS. This paper reviews the scientific literature on air quality, SHS exposure, health effects and economic outcomes related to SHS and smoking restrictions in casinos, as well as on smoking prevalence among casino patrons and problem gamblers.

Data sources Peer reviewed studies published from January 1998 to March 2011.

Data synthesis Evidence from air quality, biomarker and survey studies indicates that smoking in casinos is a significant public health problem. Workers and patrons in casinos that allow smoking are exposed to high levels of SHS, as documented by elevated levels of SHS constituents in the air of casinos and by elevated levels of tobacco-specific biomarkers in non-smokers' blood, urine and saliva. Partial smoking restrictions in casinos do not effectively protect non-smokers from SHS. Findings suggest that the smoking prevalence of casino patrons is comparable with that of the general public, although this prevalence may be higher among problem gamblers. Few studies have examined the economic impact of smoke-free policies in casinos, and the results of these studies are mixed.

Conclusions Employees and patrons are exposed to SHS in casinos, posing a significant, preventable risk to their health. Policies completely prohibiting smoking in casinos would be expected to greatly reduce or eliminate SHS exposure in casinos, thereby protecting the health of casino workers and patrons.

INTRODUCTION

Secondhand smoke (SHS) causes heart disease, heart attacks and lung cancer in non-smoking adults.¹ SHS is responsible for an estimated 46 000 heart disease deaths and 3400 lung cancer deaths among non-smoking adults in the USA each year.¹ The only way to fully protect non-smokers from SHS exposure is to eliminate smoking in all indoor areas; separating smokers from non-smokers, cleaning the air and ventilating buildings cannot eliminate SHS exposure.¹ As of 2 January 2014, 26 states, the District of Columbia, Puerto Rico² and 598 communities³ have implemented comprehensive smoke-free laws that completely prohibit indoor smoking in private workplaces, restaurants and bars, and just under half of Americans are protected by such comprehensive state or local smoke-free laws.⁴ However, many states and local jurisdictions with commercial casinos allow smoking in these venues, placing casino employees and patrons at risk for SHS exposure.^{2–5}

According to the American Gaming Association, 23 states (Colorado, Delaware, Florida, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Michigan, Mississippi, Missouri, Nevada, New Jersey, New Mexico, New York, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota and West Virginia) have non-tribal commercial casinos and/or combined racetracks and casinos, commonly known as 'racinos'.⁶ As more states authorise and build casinos, the list of states that have casinos is in flux, and other organisations have slightly different lists.^{2–5} Of these 23 states, only 8 (Colorado, Delaware, Florida, Illinois, Maryland, New York, Ohio and South Dakota) prohibit smoking in these venues.^{2–5} (Maine prohibits smoking in casinos but not racinos.^{2–5}) The remaining 15 states have either weaker or no smoking restrictions in casinos.^{2–5} The weaker restrictions include provisions establishing smoking and non-smoking gaming areas (eg, Pennsylvania), or allowing smoking on the gaming floor while prohibiting smoking in other areas of casinos, such as restaurants (eg, Nevada).² Some cities and counties have also implemented local smoking restrictions in casinos.⁵ Because of tribal sovereignty, tribal casinos are not subject to state or local smoke-free laws,¹ which poses a special challenge to efforts to reduce SHS exposure in these settings; most tribal casinos permit smoking, although some tribal casinos have voluntarily adopted smoke-free policies or partial smoking restrictions such as separate smoking and non-smoking areas.^{7–8} Few non-tribal commercial casinos have voluntarily adopted smoke-free policies.⁷

The lack of smoke-free casinos poses a serious public health problem, given the large numbers of people who work in and patronise casinos. As of 2012, there were 513 commercial (non-tribal) casinos in the USA (including 464 land-based or riverboat casinos and 49 racetrack casinos) employing more than 332 000 workers, as well as another 466 tribal casinos.⁶ It is estimated that 34% of US adults, visited a casino in 2012, with 32% of US adults reporting gambling at a casino.⁶ Commercial casinos brought in gross gaming revenues of \$37.34 billion in 2012, and are estimated to have paid \$8.6 billion in 2012 in direct state and local gaming taxes.⁶

This analysis reviews the published literature on several topics related to the impact of smoking and

¹In 1987, in *California v Cabazon Band of Mission Indians*, the US Supreme Court ruled that a state could not regulate tribal gaming if it allowed any type of gaming, such as a lottery. In 1988, Congress passed the Indian Gaming Regulatory Act to establish a regulatory framework for tribal gaming.



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smoking restrictions in casinos, including air quality, SHS exposure, health outcomes, the smoking prevalence of casino patrons and problem gamblers, and the economic impact of smoke-free policies on casinos.

METHODS

We conducted a search of the peer reviewed literature in PubMed, Medline and Ovid using the following search terms: (*casino* OR gambl* OR gaming OR poker OR card room OR racetrack OR racino*) AND (*smokefree OR secondhand smoke OR nonsmoking OR smok* tobacco*) AND (*policy OR legislation OR public health OR jurisprudence OR air quality OR air pollution, indoor OR tobacco smoke pollution OR regulation OR casino employee**). We limited the search to domestic and international peer reviewed studies reporting primary research published from January 1998 through March 2011. The starting date was selected because the first peer reviewed study on SHS in casinos we were able to identify was published in 1998.⁹ We also included additional studies and reports identified through cross-referencing. Overall, 90 individual articles were identified, of which 41 were excluded because they focused on non-casino gaming, smoking cessation treatment, the treatment of gambling disorders or marijuana; 19 of the remaining 49 studies were not included because they did not directly address the topics of interest. In reviewing the identified studies, we have focused on research specific to casinos, as opposed to other types of gaming venues, because these are the gambling venues in the USA where the largest numbers of employees and patrons spend time and are likely to be exposed to SHS.¹⁻⁶

Studies were grouped into six non-mutually exclusive categories: (1) air quality, (2) biomarkers of SHS exposure, (3) health outcomes, (4) smoking prevalence among casino patrons and among problem gamblers, (5) the economic impact of smoke-free policies on casinos and (6) population disparities related to SHS exposure in casinos. Using a standardised abstraction form, one author reviewed and abstracted every eligible study. Studies found to be relevant were included in the paper and online supplementary tables. Because of the small number of studies identified on population disparities specific to SHS exposure in casinos, this topic is only discussed briefly.

IMPACT OF SHS ON CASINO AIR QUALITY

Studies examining the impact of SHS on air quality in casinos are summarised in online supplementary table 1. Many of these studies assessed concentrations of respirable suspended particulates or particles (RSPs). The specific class of RSPs typically used to assess SHS levels is particulate matter with a diameter $\leq 2.5 \mu\text{m}$ (PM_{2.5}). While these particles are not specific to tobacco smoke, smoking is typically the primary source of these particles in indoor settings where smoking is occurring, and PM_{2.5} is a commonly used marker for SHS exposure.¹⁻¹⁰ RSPs can be inhaled deep into the lungs, and may be associated with lung disease, decreased lung function, asthma attacks, heart attacks and cardiac arrhythmias.¹¹ Three of the studies reviewed also measured levels of particulate polycyclic aromatic hydrocarbons (PPAHs), constituents of SHS which have been linked to cancer, heart disease and stroke.¹²⁻¹⁴

High concentrations of PM_{2.5} and PPAHs have been found in the air of hospitality venues that allow smoking, including casinos, indicating that non-smoking workers and patrons in these venues are exposed to substantial levels of SHS and related health risks.^{1-10, 12} While no US federal agency has set indoor air quality standards, the Environmental Protection Agency (EPA) has established an outdoor air quality standard

for average 24-h PM_{2.5} exposure of $35 \mu\text{g}/\text{m}^3$.¹¹ The impact of SHS on indoor air quality in casinos can be assessed by comparing the levels of PM_{2.5} inside smoking-permitted casinos with (1) this standard, (2) outdoor air or (3) non-smoking casinos.^{1-10, 12} For example, a study of 66 US casinos found that the geometric mean PM_{2.5} level in casinos which allowed smoking was $53.8 \mu\text{g}/\text{m}^3$, compared with a geometric mean PM_{2.5} level of $3.1 \mu\text{g}/\text{m}^3$ in three casinos with smoke-free policies and a $4.3 \mu\text{g}/\text{m}^3$ level measured outdoors using the same method.¹³ The same study found that levels of PPAHs on weekends in four Reno, Nevada casinos that allowed smoking averaged $17 \text{ ng}/\text{m}^3$, compared with $2.3 \text{ ng}/\text{m}^3$ in a non-smoking casino and $4.6 \text{ ng}/\text{m}^3$ measured outdoors using the same method.¹³ Similarly, a study of 36 tribal casinos in California conducted on weekend and holiday evenings found that PM_{2.5} levels averaged $63 \mu\text{g}/\text{m}^3$ in smoking-permitted casino gaming areas, compared with $5.4 \mu\text{g}/\text{m}^3$ in a smoke-free casino and $5.5 \mu\text{g}/\text{m}^3$ measured outdoors using the same method.¹⁵

In 2006, as part of a comprehensive health hazard evaluation, the National Institute for Occupational Safety and Health (NIOSH) tested air quality in three Las Vegas casinos that allow smoking.¹⁶ The resulting report found that a number of SHS components—including nicotine, RSPs, solanesol, benzene, naphthalene and formaldehyde—were present in the air of these casinos.¹⁶ NIOSH found that naphthalene was present in personal breathing zones (as measured by personal air monitors) and in the air of gaming areas.¹⁶

IMPACT OF SMOKE-FREE LAWS ON CASINO AIR QUALITY

Policies completely prohibiting smoking in bars where smoking had previously been allowed have been associated with substantial and rapid improvements in indoor air quality, with levels of particulate matter falling by 80–90% within months of the policies taking effect.¹⁻¹⁰ Studies have also reported improved air quality in casinos that have implemented smoke-free policies (see online supplementary table 1). For example, a study found that the average level of particulate matter $\leq 3.5 \mu\text{m}$ in diameter in a Delaware casino on a Friday evening fell from $205 \mu\text{g}/\text{m}^3$ before a state law eliminating smoking in casinos took effect in 2002 to $9.4 \mu\text{g}/\text{m}^3$ afterwards, while the average PPAH level fell from $163 \text{ ng}/\text{m}^3$ to $3.7 \text{ ng}/\text{m}^3$.¹² Similarly, a study from Sweden found that a national smoke-free law was associated with a substantial reduction in airborne nicotine levels in casinos and bingo halls, from a median of $11.0 \mu\text{g}/\text{m}^3$ before the law took effect to $0.22 \mu\text{g}/\text{m}^3$ afterwards.¹⁷

In contrast, partial smoking restrictions such as separate smoking and non-smoking areas cannot eliminate exposures of non-smokers to SHS in casinos.¹ For example, a study of 36 tribal casinos found that PM_{2.5} levels in non-smoking gaming areas in smoking-permitted casinos averaged $22 \mu\text{g}/\text{m}^3$ ($43 \mu\text{g}/\text{m}^3$ for areas with no separation from smoking gaming areas, $20 \mu\text{g}/\text{m}^3$ for areas with semiseparation and $7.9 \mu\text{g}/\text{m}^3$ for areas with complete separation), compared with $5.4 \mu\text{g}/\text{m}^3$ in a smoke-free casino and a $7 \mu\text{g}/\text{m}^3$ level measured outdoors using the same method.¹⁵ Similarly, a study assessing air quality on casino gaming floors and in casino restaurants after implementation of Nevada's 2006 Clean Indoor Air Act found that partial smoking restrictions had limited effect.¹⁸ Average PM_{2.5} levels (measured from Thursdays to Saturdays from 13:00 to 22:00) were significantly lower in casino restaurants, where smoking was prohibited, than in adjacent gaming areas, where smoking was permitted; however, in many cases, levels in both settings exceeded annual ($15 \mu\text{g}/\text{m}^3$ at the time of this study, since revised to $12 \mu\text{g}/\text{m}^3$) or 24-h ($35 \mu\text{g}/\text{m}^3$) outdoor EPA

standards.¹⁸ Finally, a study found that average RSP and PPAH levels in Pennsylvania casinos measured on a Wednesday morning, a Wednesday afternoon and a Friday evening were six times and four times higher, respectively, than outdoor levels measured outside using the same method.¹⁴ An annual excess mortality of six deaths per 10 000 casino workers was estimated to be associated with these levels of exposure.¹⁴ The 2008 Pennsylvania Clean Indoor Air Act exempted casinos, allowing smoking in up to 50% of gaming floors.¹⁴

BIOMARKERS OF SHS EXPOSURE

Six of the studies reviewed have used biomarkers as an objective measure of SHS exposure in casinos^{9 14 16 17 19 20} (see online supplementary table 2). Biomarkers that have been used for this purpose include cotinine and NNAL (4-(methylnitrosamino)-1-(3-pyridyl)-1-butanol). Cotinine, the primary metabolite of nicotine, has a half-life of approximately 16–18 h, and can be measured in blood, urine and saliva.^{1 21} Studies have found that non-smokers who are exposed to SHS often have serum cotinine levels of the order of 1 ng/mL, with levels up to 10 ng/mL found in non-smokers with exceptionally heavy SHS exposure.¹ NNAL is a metabolite of, and a biomarker for, the tobacco-specific lung carcinogen NNK (4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone).^{1 22} The presence of NNAL in the urine indicates that a person has absorbed this carcinogen.¹ NNAL's half-life is up to 45 days, making it possible to assess non-smokers' SHS exposure over longer periods.¹

One study reported mean increases of 456% and 112% in cotinine and NNAL levels, respectively, in the urine of non-smoking patrons after they spent 4 hours in a US casino that permitted smoking.¹⁹ Another study found that cotinine levels in the urine of eight non-smoking casino patrons increased by an average of 1.9 ng/mL following a 4–5 h visit to smoking-permitted Pennsylvania casinos.¹⁴ Workers spending longer periods of time in such casinos on a daily basis would be expected to be more heavily exposed than patrons.¹

Several studies have directly assessed SHS levels in casino workers using biomarkers. The NIOSH assessment of worker SHS exposure in three Las Vegas casinos in 2006 found that levels of NNAL in the urine of casino dealers who reported that they did not use any tobacco products and that they were not living with someone who smokes inside the home increased over their 8-h work shift, indicating occupational SHS exposure.¹⁶ In a separate study, Repace estimates that the average geometric mean NNAL level reported for casino dealers in this study is above the 80th centile of a representative sample of US non-smoking adults.¹³ In a previous study, NIOSH found that the serum cotinine levels of workers in a New Jersey casino averaged 1.34 ng/mL prior to their work shift and 1.85 ng/mL after their shift.⁹ These levels exceeded the average serum cotinine level of 0.65 ng/mL reported for non-smoking subjects in the Third National Health and Nutrition Examination Survey who reported SHS exposure at work.⁹ In a separate study, Repace notes that the average of the prework shift and postwork shift geometric mean cotinine concentrations reported in this NIOSH study for non-smoking workers exposed at work exceeded the corresponding population geometric mean for a national sample of US non-smoking workers exposed at work by a factor of 5.¹³ In the older NIOSH study, dealers at tables where smoking was not allowed had cotinine levels similar to those at smoking-permitted tables, suggesting that partial smoking restrictions are not effective in protecting casino employees from SHS.⁹ Finally, researchers in Victoria, Australia found that non-smoking workers in smoking-permitted casinos

had significantly higher average before-after shift saliva cotinine levels (ie, the average of cotinine levels collected immediately before and after employees' work shifts) per hour worked than non-smoking workers in smoke-free office settings.²⁰

HEALTH OUTCOMES

Non-smoking workers who are exposed to SHS on the job are at increased risk of heart disease and lung cancer.^{1 10 23} A number of studies have found that occupational exposure to SHS is associated with increased sensory and respiratory symptoms and reduced lung function in non-smoking bar workers.^{1 10} However, relatively few studies have examined health outcomes in casino workers and patrons who are exposed to SHS. When they have been conducted, studies of SHS-related health outcomes in casino workers, like studies of such health outcomes in bar workers, have focused primarily on short-term outcomes such as respiratory and sensory symptoms (see online supplementary table 2). However, a broader evidence base not specific to the casino setting indicates that non-smoking casino employees would also be at increased risk for long-term health outcomes due to their occupational SHS exposure.^{1 10 23} As with bar workers, casino workers would be expected to be at greater risk of experiencing SHS-related health effects than patrons because they are exposed to SHS for longer periods and on a more regular basis.¹

Several studies have used surveys to assess self-reported sensory and respiratory symptoms in casino workers who were exposed to SHS on the job (see online supplementary table 2). For example, one study found that casino workers in Victoria, Australia were more likely than office workers to report sore throat and eye irritation.²⁰ Similarly, another study reported that 91% of surveyed London casino workers reported one or more sensory irritation symptoms, such as watery eyes or runny nose, while 84% reported at least one respiratory symptom, such as cough or wheeze.²⁴

One study assessing arterial endothelial function in young, asymptomatic non-smoking casino workers in China reported that SHS exposure was the strongest predictor of impaired flow-mediated dilation.²⁵ Finally, a study published after the cut-off for our literature search that used an interrupted time series analysis reported that ambulance calls originating from casinos in Gilpin County, Colorado fell by 19.1% after the Colorado smoke-free law was extended to apply to casinos.²⁶

SMOKING PREVALENCE AMONG CASINO PATRONS

Some observers have expressed concerns that implementing smoke-free policies in casinos could negatively impact casino business.²⁷ This concern is based, in part, on the assumption that casino patrons are more likely to be smokers than the general population. Several studies have tested this assumption by examining smoking prevalence among casino patrons (see online supplementary table 3).

Most of these studies have found that casino patrons smoke at a rate similar to that of the general public. For example, an observational study found that the smoking prevalence among Nevada casino patrons (20.2%) did not differ significantly from that of the US population (20.9%).²⁷ Another observational study estimated smoking prevalence among Delaware slot machine patrons to be 25.5%, close to the state's smoking prevalence of 23%.¹² A third observational study reported a smoking rate of 20.1% among Pennsylvania casino patrons, comparable with the state smoking prevalence of 25%.¹⁴ Finally, a study based on a survey of older adult primary-care patients reported that recreational gambling was not significantly

associated with smoking.²⁸ In contrast, one observational study found that the smoking prevalence among patrons in California tribal casinos (33%) appeared to be much higher than that of the general public in California (13%).¹⁵

SMOKING PREVALENCE AMONG PROBLEM GAMBLERS

While the available studies generally indicate that smoking prevalence among casino patrons overall is similar to that of the general public, several studies suggest that smoking prevalence may be higher among problem or pathological gamblers (see online supplementary table 4). These studies generally identify individuals who fall into these categories using various screening tests and survey questions that are based on standardised diagnostic criteria. This finding could have implications for the economic impact of smoke-free policies on casinos if problem gamblers spend more time and money in these establishments than non-problem gamblers.

A study in Connecticut reported that smoking rates appear to be substantially higher among treatment-seeking gamblers (62%) than in the overall state population (22%).²⁹ This study also found that treatment-seeking gamblers who were daily smokers reported gambling more days and spending greater amounts of money gambling in the past month than treatment-seeking gamblers who had never smoked daily.²⁹ Another Connecticut study found that more than 43% of problem gamblers calling a gambling hotline reported daily smoking.³⁰ A California study found that pathological gamblers smoke more cigarettes per day than non-pathological gamblers.³¹ Two studies from New Zealand and Australia based on surveys also reported a significant relationship between problem gambling and smoking.^{32 33} A study of 465 subjects seeking treatment for pathological gambling found that almost half (44.9%) were current daily smokers, and found that subjects who were daily smokers had more severe gambling problems as measured by symptom scales.³⁴ Another study of 225 adults who were recruited for treatment of pathological gambling found that 48.9% of the subjects were current daily smokers, with another 21.8% being prior daily smokers; subjects who were current and prior daily smokers were found to have stronger urges to gamble.³⁵ Finally, a review of the literature on this topic found that a number of studies suggest that the rate of tobacco dependence is higher among problem gamblers than in the general population, and speculates that tobacco addiction and problem gambling may be mediated by similar neurobiological, genetic and environmental mechanisms.³⁶ In contrast, a study of 584 outpatients presenting at a Virginia naval psychiatry clinic over a 6-month period found that smokers had 3.2 times greater odds of problem gambling compared with non-smokers, but that these results were not statistically significant.³⁷ Similarly, a study based on a survey of older adult primary-care patients found that at-risk gambling (defined as reporting having wagered more than \$100 on a single bet and/or having bet more than one could afford to lose in the last year) was not significantly associated with smoking.²⁸

Given that some research suggests that problem gambling and smoking may be comorbid behaviours, some studies have speculated that smoke-free policies could reduce problem gambling by leading problem gamblers to take smoking breaks, which could disrupt their gambling patterns.^{38 39}

Taken together, the available research suggests that the prevalence of smoking may be elevated among problem gamblers, but not among casino patrons in general.

ECONOMIC IMPACT OF SMOKE-FREE POLICIES ON CASINOS

Numerous studies have assessed the economic effects of smoke-free laws on restaurants and bars.^{1 10 40 41} These studies, which have typically examined taxable sales revenue and/or employment levels, have concluded that smoke-free laws do not have an adverse economic impact on these venues.^{1 10 40 41} By contrast, few studies have examined the economic impact of smoke-free policies on casinos, in part because until recently relatively few casinos had implemented such policies. The studies that have been conducted on this topic have yielded mixed results (see online supplementary table 5). None of the studies on this topic appear to have explored the potential cost savings and other economic benefits that could accrue from smoke-free laws as a result of reduced employee healthcare costs, improved employee productivity, decreased cleaning and maintenance costs, or decreased fire and property insurance premiums.

Studies on the economic impact of the 2002 Delaware Clean Air Act on casinos have yielded conflicting findings. Mandel, Alamar and Glantz (2005) examined total gaming revenue and average revenue per video lottery machine using a linear regression model which accounted for time, machine, income and seasonal effects.⁴² Their analysis found that the state smoke-free law did not have a significant effect on either of these indicators.⁴² Using a different analytical model, Pakko (2006) submitted a letter in response to the Mandel, Alamar and Glantz study concluding that total gaming revenues and revenues per video lottery machine fell significantly after the Delaware law was implemented.⁴³ A subsequent study by Pakko expanded on the methods in his letter and reached a similar finding.⁴⁴ However, in a published response to Pakko's letter (2006), Alamar and Glantz questioned the appropriateness of the model used by Pakko, particularly with regards to the method used to control for differences in the variance of error terms across observations, and noted that Pakko does not present statistical evidence that the new model he presents is correctly specified.⁴⁵ Alamar and Glantz also noted that the Delaware racinos did not cite the state smoke-free law as a reason for revenue loss in filings with the Securities and Exchange Commission.⁴⁵ A study by Thalheimer and Ali that used equations to estimate demand for slot machines found that the Delaware smoke-free law reduced demand in the state's three racinos by 15.9%, but found no significant difference in the impact across the racinos.⁴⁶

Lal and Siahpush (2008) used time-series modelling to examine the impact of a smoke-free law in the Australian state of Victoria on electronic gaming machine (EGM) expenditures.³⁸ The study assessed the ratio of monthly EGM expenditures in Victoria to monthly EGM expenditures in the Australian state of South Australia, which had minimal smoking restrictions at the time, from 1998 to 2005.³⁸ The authors found that the implementation of the smoke-free law in 2002 resulted in an abrupt, long-term decline in EGM expenditures in Victoria.³⁸ The authors concluded that, in addition to protecting workers and patrons from SHS exposure, the law may also have slowed gambling losses among problem gamblers.³⁸ The study notes that Victoria implemented the smoke-free law in conjunction with policies intended to reduce problem gambling, and speculates that the law may have combined with these policies to contribute to such a reduction.³⁸ A separate commentary on the impact of the Victoria smoke-free law on EGM revenue and problem gambling speculates that this might result in part from problem gamblers interrupting their gambling to go outside to smoke, thereby also interrupting the

gambling 'trance', recognising that they had lost a substantial amount of money, and stopping gambling sooner than they would otherwise have done.³⁹

Finally, a study that was published after the cut-off for our literature search used a multilevel model to examine monthly casino admissions collected from state gaming commission websites for all non-tribal casinos in Illinois, Indiana, Iowa and Missouri.⁴⁷ Illinois implemented a comprehensive state law on 1 January 2008 that made non-tribal, commercial casinos completely smoke-free; the other three adjoining states do not restrict smoking in casinos.^{2 5 47} After controlling for economic conditions, the analysis found that Illinois casino admissions did not fall significantly relative to casino admissions in the other three states, and that casino admissions did not increase in the other three states.⁴⁷ The authors concluded that reported reductions in Illinois casino revenues did not result from patrons leaving Illinois casinos to patronise casinos in neighbouring states where they are allowed to smoke.⁴⁷

POPULATION DISPARITIES RELATED TO SHS EXPOSURE IN CASINOS

Despite the potential for casino workers and patrons to experience disparities in SHS exposure and related health outcomes, few published studies were identified that touched on this topic. Employees who spend large amounts of time in casinos where smoking is allowed would be expected to have high cumulative exposure to SHS—higher, for example, than casino patrons.¹ Elderly patrons may have underlying health risks that increase their vulnerability to SHS.⁴⁸ The University of California, Los Angeles American Indian Research Program has reported that American Indian populations may be at higher risk for asthma and cardiovascular disease, and that these diseases may be exacerbated by SHS exposure.⁴⁹ This finding is of particular concern given the large numbers of American Indians who are exposed to SHS as employees or patrons in tribal casinos.^{6 8 49} A study published after the cut-off date for our review found that, among respondents to the 2008 California Tobacco Survey, non-Hispanic African Americans and Hispanics (compared with non-Hispanic Caucasians), individuals aged ≥ 50 years, current smokers and residents of sparsely populated regions of California (which tended to have higher concentrations of tribal casinos) were more likely than other demographic groups to visit California tribal casinos.⁵⁰ While the available literature provides some limited evidence suggesting that certain groups may be disproportionately affected by SHS in casinos, this evidence is not sufficient to arrive at firm findings on this topic.

CONCLUSION

The studies of air quality and biomarkers reviewed in this paper indicate that non-smokers who spend time in casinos where smoking is permitted, whether as workers or patrons, are exposed to high levels of SHS. Studies have consistently found that, while partial smoking protections in casinos can sometimes reduce SHS exposure, substantial levels of SHS are present in non-smoking areas of smoking-permitted casinos.

The available evidence suggests that the prevalence of smoking among casino patrons and the general population is comparable, although smoking prevalence may be higher in problem gamblers. We identified few studies that have assessed the economic impact of smoke-free laws on casinos; the studies that have been conducted on this topic have arrived at conflicting results. In addition, no studies appear to have examined the potential cost savings that could result from implementing smoke-free policies in casinos.

The findings in this paper are subject to at least four limitations. First, this review did not consider studies published prior to 1998, unpublished and non-peer reviewed research, relevant legislation and case law, conference proceedings, and government or industry reports. Second, it is possible that our keyword search missed some relevant studies. Third, this study does not include studies that were published after March 2011. The fourth and final limitation is that this review focuses exclusively on casinos, and does not consider other types of gaming venues which are increasingly permitted and operating in many US states.

Given the standardised, validated methods and measures used in the air quality and biomarker studies quantifying SHS exposure reviewed in this paper and the consistent findings of these studies across study sites, these findings can be taken as well-established. In contrast, relatively few studies have examined the economic impact of smoke-free policies on casinos, and uncertainty exists in the scientific community with regards to best practices for conducting such an analysis. Finally, we were able to identify few studies systematically exploring population disparities related to SHS exposure, smoke-free policies and related health effects in casinos. In particular, we found few studies that assessed SHS exposure in tribal casinos.^{15 50} It would be helpful for future research to address these gaps in the existing literature.

Specifically, there is a need for studies assessing the economic impact of smoke-free policies on casinos using objective indicators such as sales revenue and employment, and for studies analysing the potential savings that casinos could realise in healthcare, cleaning, maintenance and insurance costs if they were to implement smoke-free policies. Studies are also needed to identify populations at special risk of SHS exposure in casinos, which could include elderly casino patrons and American Indians who work in or patronise tribal casinos, and to assess the effects of casino smoking restrictions on SHS exposure and smoking rates in these populations. Other studies that would be useful to address gaps in the literature include studies examining SHS exposure (as measured by air quality and/or biomarkers) and related short-term health outcomes in non-smoking casino employees before and after implementation of smoke-free policies and studies further exploring the mechanisms underlying the link between problem gambling and smoking.

However, even without further research, the findings reported in this review clearly establish that non-smoking employees and patrons in casinos where smoking is allowed are exposed to high levels of SHS, which is a known human carcinogen and a serious health hazard.^{1 10} The 2006 NIOSH health hazard evaluation of occupational SHS exposure in Nevada casinos recommended that these casinos ban smoking on their premises.¹⁶ This recommendation is consistent with the conclusion of the 2006 Surgeon General's report that eliminating smoking in indoor spaces is the only approach that fully protects non-smokers from SHS.¹ The Surgeon General's report also concluded that separating smokers from non-smokers, cleaning the air and ventilating buildings cannot eliminate non-smokers' SHS exposure.¹ Similarly, the American Society of Heating, Refrigerating and Air-Conditioning Engineers has concluded that "At present, the only means of effectively eliminating health risk associated with indoor (SHS) exposure is to ban smoking activity."⁵¹ However, many casinos continue to use ineffective separation and ventilation techniques to attempt to control SHS exposure. As a result, thousands of casino workers and millions of casino patrons continue to be needlessly exposed to SHS and

its health risks. As one example of casino workers' attitudes towards this situation, a survey of casino workers in 25 casinos in London, England found that 83% of respondents reported being nearly always exposed to SHS at work, 78% stated that they minded if people smoke near them at work, 57% believed they had suffered health problems as a result of SHS exposure at work and 65% supported banning smoking in all customer/working areas of their casinos.⁵² In 2009, the National Council of Legislators from Gaming States adopted a resolution supporting 100% smoke-free gaming venues, citing the importance of protecting worker and patron health.⁵³

Key messages

- There is no safe level of secondhand smoke (SHS) exposure.
- Most US casinos continue to allow smoking, thus exposing workers and patrons to the hazards of SHS.
- Workers and patrons in casinos that allow smoking are exposed to high levels of SHS.
- Partial smoking restrictions in casinos do not effectively protect nonsmokers from SHS.
- Policies completely prohibiting smoking in casinos would be expected to greatly reduce or eliminate SHS exposure in casinos, thereby protecting the health of casino workers and patrons.

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Supplementary Tables: Secondhand Smoke and Smoking Restrictions in Casinos: A Review of the Evidence

SUPPLEMENTARY TABLE 1: Impact of SHS on Casino Air Quality in Casinos

Author Year Published	Study Site(s)	Smokefree Policies	Air Quality		Conclusions
			Smoking-Permitted Venues	Smokefree Venues or Other Comparison	
Achutan (2011) ¹⁶	Nevada 3 casinos	Smoking is permitted in casino gaming areas with exception of a poker room in one of the casinos.	<p>PBZs: geometric means: Nicotine 5.32 $\mu\text{g}/\text{m}^3$ RSP 42.1 $\mu\text{g}/\text{m}^3$.</p> <p>Solanesol 0.226 $\mu\text{g}/\text{m}^3$.</p> <p>Casino floor area geometric means: Nicotine 6.69 $\mu\text{g}/\text{m}^3$ RSP 41.4 $\mu\text{g}/\text{m}^3$.</p> <p>Solanesol 0.242 $\mu\text{g}/\text{m}^3$.</p> <p>Of 16 PAHs measured in PBZs and area air samples, only naphthalene was found in both.</p> <p>Area nicotine levels similar to PBZ nicotine levels, indicating that area levels are representative.</p>	NA	A number of SHS components, including nicotine, RSP, solanesol, benzene, naphthalene, and formaldehyde, were detected in the air of 3 casinos where smoking was allowed.

			PBZ and area nicotine levels and area RSP levels similar to those reported by Trout (1998).		
Jiang (2011)¹⁵	36 California tribal casinos 8 Reno, Nevada casinos	2006 Nevada Clean Indoor Air Act bans smoking in restaurants.	Mean PM _{2.5} levels: CA smoking-permitted casinos: –Smoking-permitted gaming areas: 63 µg/m ³ . –Nonsmoking gaming areas: 22 µg/m ³ (43 µg/m ³ for areas with no separation from smoking gaming areas, 20 µg/m ³ for areas with semi-separation, and 7.9 µg/m ³ for areas with complete separation). –Nonsmoking restaurants: 29 µg/m ³ . Reno smoking-permitted casinos: –Smoking-permitted gaming areas: 37 µg/m ³ . –Nonsmoking restaurants: 17 µg/m ³ .	Mean PM _{2.5} levels: Outdoors CA smoking-permitted casinos: 7 µg/m ³ . Outdoors Reno smoking-permitted casinos: 1.2 µg/m ³ . Smokefree CA casino: 5.4 µg/m ³ Outdoors CA smokefree casino: 5.5 µg/m ³ . Reno smokefree casino: 0.6 µg/m ³ . Outdoors Reno smokefree casino: 1.2 µg/m ³ .	Mean PM _{2.5} levels in smoking-permitted casinos are substantially higher than outdoor levels, even in many nonsmoking areas. Incremental PM _{2.5} levels were positively correlated with area smoker density. These results indicate that SHS is the predominant cause of the elevated PM _{2.5} levels. For 90% of casino visits, mean concentrations in smoking areas averaged over 0.5-1 hour exceeded 35 µg/m ³ .
Larsson (2008)¹⁷	Sweden 15 casino workers 22 bingo hall workers 54 bar and restaurant	Sweden National smokefree law extended to hospitality workplaces in 2005.	Pre-law: Median airborne nicotine level = 11.0 µg/m ³ . % of casino and bingo hall workers with levels ≥ 0.5 µg/m ³ = 100%	One year after law: Median airborne nicotine level = 0.22 µg/m ³ . % of casino and bingo hall workers with levels ≥ 0.5	The national smokefree law was associated with a substantial reduction in SHS exposure, as measured objectively by airborne nicotine levels. No notable change was observed in lung function, as measured by

	workers		(based on PBZ sampling for nonsmokers and area sampling for smokers).	$\mu\text{g}/\text{m}^3 = 22\%$ (based on PBZ sampling for nonsmokers and area sampling for smokers).	spirometry.
Repace (2004)¹²	Delaware 1 casino	Wilmington, Delaware Clean Indoor Air Act 2002	Before state smokefree law took effect: Average RSP = $205 \mu\text{g}/\text{m}^3$. Average PPAH = $163 \text{ ng}/\text{m}^3$.	After state smokefree law took effect: Average RSP = $9.4 \mu\text{g}/\text{m}^3$. Average PPAH = $3.7 \text{ ng}/\text{m}^3$.	RSP level after law took effect was 4.6% of baseline RSP level. PPAH level after law took effect was 2.3% of baseline PPAH level.
Repace (2009)¹⁴	Pennsylvania 3 casinos	One casino had a nonsmoking section.	Mean RSP: –Casino smoking areas: $106 \mu\text{g}/\text{m}^3$ (range: $84 \mu\text{g}/\text{m}^3$ – $133 \mu\text{g}/\text{m}^3$) –Casino nonsmoking area (1 casino): $36 \mu\text{g}/\text{m}^3$ Mean PPAH: –Casino smoking areas: $20 \text{ ng}/\text{m}^3$ (range: $14 \text{ ng}/\text{m}^3$ – $29 \text{ ng}/\text{m}^3$).	Mean RSP outdoors: $18 \mu\text{g}/\text{m}^3$ (range: $11 \mu\text{g}/\text{m}^3$ – $28 \mu\text{g}/\text{m}^3$). Mean PPAH outdoors: $5 \text{ ng}/\text{m}^3$ PPAH (range: $3 \text{ ng}/\text{m}^3$ – $6 \text{ ng}/\text{m}^3$).	Despite high ventilation rates, the average RSP level in casino smoking areas was 6 times the average outdoor level. The average PPAH level in casino smoking areas was 4 times the average outdoor level. In the only casino with a separate nonsmoking floor, considerable amounts of RSPs and PPAHs infiltrated this floor. Based on cotinine-derived RSP levels, SHS exposure in Pennsylvania casinos is estimated to produce an excess mortality of approximately 6 deaths per year per 10,000 workers at risk.
Repace (2011)¹³	66 casinos in California, Delaware, Nevada, New Jersey, and Pennsylvania that	NA	Geometric mean, $\text{PM}_{2.5}$: –66 smoking-permitted casinos: $53.8 \mu\text{g}/\text{m}^3$ (range:	Geometric mean, $\text{PM}_{2.5}$: –3 smokefree casinos: $3.1 \mu\text{g}/\text{m}^3$ (range:	Across all 66 casinos, $\text{PM}_{2.5}$ levels averaged 10 times outdoor levels, while $\text{PM}_{2.5}$ levels in smokefree casinos were slightly less than

	<p>allowed smoking.</p> <p>Three smokefree casinos</p>	<p>18.5 $\mu\text{g}/\text{m}^3$–205 $\mu\text{g}/\text{m}^3$). –Subset of 21 Reno and Las Vegas smoking-permitted casinos: Gaming areas: 45.2 $\mu\text{g}/\text{m}^3$ (95% CI: 37.7 $\mu\text{g}/\text{m}^3$–52.7 $\mu\text{g}/\text{m}^3$) –Adjacent nonsmoking casino restaurants: 27.2 $\mu\text{g}/\text{m}^3$ (95% CI: 17.5 $\mu\text{g}/\text{m}^3$–36.9 $\mu\text{g}/\text{m}^3$)</p> <p>Geometric mean, PPAH: –4 Reno smoking-permitted casinos: 17 ng/m^3 (SD: 11 ng/m^3). –Nonsmoking casino restaurants: 3.5 ng/m^3 (SD: 1.8 ng/m^3).</p>	<p>0.6 $\mu\text{g}/\text{m}^3$–9 $\mu\text{g}/\text{m}^3$. –Outside casinos: 4.3 $\mu\text{g}/\text{m}^3$ (range: 0.26 $\mu\text{g}/\text{m}^3$–29.7 $\mu\text{g}/\text{m}^3$). –Outside subset of 21 Reno and Las Vegas casinos: 3.9 $\mu\text{g}/\text{m}^3$ (95% CI: 2.5 $\mu\text{g}/\text{m}^3$–5.3 $\mu\text{g}/\text{m}^3$).</p> <p>Geometric mean, PPAH: –Reno nonsmoking casino: 2.3 ng/m^3 (SD: 1.5 ng/m^3). –Nonsmoking casino’s restaurant: 2.2 ng/m^3 (SD: 1.4 ng/m^3). –Outside 4 Reno smoking casinos: 4.6 ng/m^3 (SD: 0.5 ng/m^3). –Outside nonsmoking casino: 2.2 ng/m^3 (SD: 0.5 ng/m^3).</p>	<p>outdoor levels.</p> <p>PPAH levels in 8 smoking casinos in 3 states averaged 4 times outdoors PPAH levels.</p> <p>Ventilation and air cleaning failed to control $\text{PM}_{2.5}$, with drifting $\text{PM}_{2.5}$ infiltrating unseparated nonsmoking areas. Eliminating smoking inside casinos reduces $\text{PM}_{2.5}$ by about 90%, bringing indoor $\text{PM}_{2.5}$ levels down to outdoor levels, and reduces PPAH levels by at least 80%.</p>
Trout (1998) ⁹	New Jersey	<p>Casino data based on 18 PBZ samples for nicotine and 10 area samples for nicotine vapor PBZ nicotine levels, expressed as time-weighted averages.</p>	<p>Outside air 275-300ppm RSP</p>	<p>Elevated levels of airborne nicotine consistent with SHS exposure found in PBZ samples; elevated levels of airborne nicotine and respirable dust consistent with SHS exposure found in area samples.</p>

			<p>First evening, geometric mean: 8 $\mu\text{g}/\text{m}^3$ range: 6 $\mu\text{g}/\text{m}^3$ – 12 $\mu\text{g}/\text{m}^3$.</p> <p>Second evening, geometric mean: 10 $\mu\text{g}/\text{m}^3$ range: 4 $\mu\text{g}/\text{m}^3$ – 15 $\mu\text{g}/\text{m}^3$.</p> <p>Air nicotine levels, expressed as time- weighted averages. –First evening, geometric mean: 8 $\mu\text{g}/\text{m}^3$ range: 6 $\mu\text{g}/\text{m}^3$ – 12 $\mu\text{g}/\text{m}^3$.</p> <p>–Second evening, geometric mean: 11 $\mu\text{g}/\text{m}^3$ range: 8 $\mu\text{g}/\text{m}^3$ – 16 $\mu\text{g}/\text{m}^3$.</p>		
York (2010) ¹⁸	<p>Nevada</p> <p>16 smoking-permitted gaming areas in casinos; 16 nonsmoking casino hotel restaurants</p>	2006 Nevada Clean Indoor Air Act	<p>Mean PM_{2.5} levels: Gaming areas; 48 $\mu\text{g}/\text{m}^3$ (range: 20 $\mu\text{g}/\text{m}^3$ – 73 $\mu\text{g}/\text{m}^3$).</p> <p>Restaurants: 31 $\mu\text{g}/\text{m}^3$ (range: 5 $\mu\text{g}/\text{m}^3$ – 101 $\mu\text{g}/\text{m}^3$).</p>	Outside air 5 $\mu\text{g}/\text{m}^3$	<p>Employees and patrons are exposed to dangerously high levels of PM_{2.5} in Nevada casinos due to SHS.</p> <p>Unhealthy levels of PM_{2.5} were also found in many nonsmoking restaurants in Nevada casinos.</p> <p>PM_{2.5} levels in most casino gaming areas and restaurants exceeded</p>

	16/16 gaming areas and 12/16 restaurants exceeded the then-EPA annual outdoor air quality standard of 15 µg/m ³ . (Note: The EPA has since revised this standard to 12 µg/m ³ .)	annual EPA standards.
	13/16 gaming areas and 5/16 restaurants exceeded EPA 24-hour standard of 35 µg/m ³ .	

Abbreviations: PBZ = personal breathing zone; PM_{2.5} = particulate matter < 2.5 mm in diameter; PAH = polynuclear aromatic hydrocarbons; PPAH = particulate polycyclic aromatic hydrocarbons; RSP = respirable suspended particulates.

SUPPLEMENTARY TABLE 2: SHS Exposure and Health Outcomes of Smoking in Casinos

Author Year Published	Study Site and Participants	Smokefree Policy	SHS Exposure (Biomarkers) and Health Outcomes		Conclusions
			Smoking Casinos	Smokefree Casinos	
Achutan (2011) ¹⁶	Nevada	Smoking is permitted in casino gaming areas with exception of a poker room in one of the casinos.	Dealer exposure (all 3 casinos):		Study documents an increase in urinary levels of NNAL over a work shift in casino dealers, which provides evidence that the increase is due to workplace SHS exposure. These findings are consistent with studies that have shown an increase in NNAL levels in bar and restaurant
	3 casinos		Urinary cotinine and NNAL levels unadjusted for creatinine increased significantly during an 8-hour shift ($p < 0.01$).		
	124 nonsmoking dealers		Urinary NNAL levels adjusted for creatinine increased significantly over an 8-hour shift		

			<p>($p = 0.03$). However, this was not the case for urinary cotinine levels adjusted for creatinine.</p> <p>Pre-shift unadjusted urinary cotinine levels were positively correlated with pre-shift urinary NNAL levels ($r = 0.53$, $p < 0.01$) and post-shift urinary cotinine levels were positively correlated with post-shift urinary NNAL levels ($r = 0.53$, $p < 0.01$).</p>		<p>workers who are exposed to SHS over a work shift and in casino patrons exposed over a 4-hour casino visit.</p>
Anderson (2003) ¹⁹	<p>Casino in Midwest region, U.S.</p> <p>18 nonsmoking patrons</p>	Casino allows smoking.	<p>Exposure:</p> <p>Cotinine levels in urine samples showed a statistically significant mean increase of 0.044 nmol/mg (95% CI: 0.028 nmol/mg, 0.061 nmol/mg), or 456%, from a single spot check collected before 4-hour casino visits compared to samples collected for 24 hours after these visits.</p> <p>Total NNAL levels in urine samples showed a statistically significant mean increase of 0.018 pmol/mg (95% CI: 0.010 pmol/mg, 0.025 pmol/mg), or 112%, from before to after the visits.</p>	NA	<p>SHS exposure among nonsmokers in a casino results in uptake of a tobacco-specific lung carcinogen.</p> <p>Cotinine and NNAL levels in this study are consistent with levels reported in other studies of SHS exposure.</p> <p>Results suggest that carcinogen levels in nonsmoking casino employees would increase as a result of SHS exposure at work.</p>

Larsson (2008)¹⁷	Sweden	National smokefree law extended to hospitality workplaces in 2005.	Exposure pre-law: 65% (59 of 91) of respondents reported being exposed to SHS at work for 75% or more of the time; 37% (16 of 43) of nontobacco users had urinary cotinine levels under the limit of detection.	Exposure one year after law: 1% (1 of 71) of respondents reported being exposed to SHS at work for ≥ 75% of the time; 67% (29 of 43) of nontobacco users had urinary cotinine levels below the limit of detection.	The national smokefree law was associated with substantial reductions in self-reported and objectively measured SHS exposure and with a substantial reduction in respiratory and sensory symptoms among nonsmoking gaming workers.
	15 casino workers				
	22 bingo hall workers				
	54 bar and restaurant workers			Health: Frequency of self-reported respiratory and sensory symptoms was approximately halved among nonsmoking gaming and hospitality workers.	
Pilkington (2007)²⁴	London, England	Smoking allowed in casinos	Exposure: 83% of respondents	NA	In multivariate analysis, the most important determinant of reporting

	25 casinos		reported being nearly always exposed to SHS at work; 74% rated their intensity of exposure as "heavy"; 71% reported that they were nearly always exposed to heavy SHS levels.		sensory or respiratory symptoms was workplace SHS exposure. The presence of respiratory symptoms was also associated with the number of hours worked per week.
	559 respondents among 1,568 unionized casino workers who received a postal survey				
	22% of respondents were current smokers; 39% were never smokers		Health: 91% of respondents reported at least one sensory irritation symptom in the past 4 weeks. 84% of respondents reported at least one respiratory irritation symptom in the past 4 weeks.		
Repace (2009)¹⁴	Pennsylvania	Smoking allowed in casinos	Exposure:	NA	Cotinine levels were converted into RSP levels using a formula developed by the author; these RSP levels were in turn used to estimate that SHS exposure in Pennsylvania casinos produces an excess mortality of 6 deaths per year per 10,000 workers.
	3 casinos		Average increase in urine cotinine following roughly 4-hour casino visits: 1.9 ng/mL.		
	8 volunteer patrons				
Trout (1998)⁹	New Jersey casino		Smoking allowed in casino		
	18 dealers				
	11 supervisors			Dealer exposure: Serum cotinine geometric means, overall: Pre- shift =	Both pre- and post-shift serum cotinine geometric means exceed 0.65 ng/mL geometric mean for NHANES III respondents who reported SHS

1.34 ng/mL
(GSD: 1.9)
Post-shift =
1.85 ng/mL
(GSD: 1.4)

Dealers at smoking-
permitted tables:
Pre-shift =
1.22 ng/mL
Post-shift =
1.77 ng/mL

Dealers at
nonsmoking tables:
Pre-shift =
2.30 ng/mL
Post-shift =
2.41 ng/mL

Urine cotinine
geometric means:
Pre-shift =
23.0 ng/mL
(GSD: 2.2)
Post-shift =
33.3 ng/mL
(GSD: 2.0)

exposure at work.

Designating nonsmoking
tables was not effective in
reducing exposure.

A sample of employees
working in a casino
gaming area were
exposed to ETS at levels
greater than those
observed in a
representative sample of
the U.S. population, and
that both serum and urine
cotinine levels of these
employees increased
during their work shifts.

Wakefield (2005) ²⁰	Victoria, Australia 91 nonsmoking workers from casinos (44), clubs (24), and offices (23)	Casinos and clubs have partial or no smoking restrictions; offices are 100% smokefree.	Exposure: Casino mean before-after shift saliva cotinine level per hour worked: 0.18 ng/mL/hr worked. Health: Casino employees were more likely than office employees to report sore eyes and sore throats. Odds ratios for other symptoms were in the predicted direction, but did not reach statistical significance.	Exposure: Office mean before-after shift in saliva cotinine level per hour worked: 0.03 ng/mL/hr worked	Compared with office workers, casino workers had significantly higher levels of mean before-after shift saliva cotinine per hour worked and were more likely to report sore eyes and sore throats. The authors conclude that SHS exposure is associated with increased risk of respiratory symptoms, and that air-conditioning reduces, but fails to eliminate, worker SHS exposure.
Woo (2000) ²⁵	Macau, China 20 nonsmoking, asymptomatic casino workers who had been exposed to SHS for > 8 hrs/day, 6 days/week, for at least 2 years; 20 matched controls London, England 25 casinos	Smoking allowed in casinos	Health: Casino workers: mean flow-mediated dilation 6.6 +/- 3.4%	Health: Controls: mean flow-mediated dilation 10.6 +/- 2.3%	Flow-mediated dilation, an indicator of arterial endothelial function, was significantly lower in the casino workers than in the controls ($p < 0.0001$). In multivariate analysis, SHS exposure was found to be the strongest predictor of impaired flow-mediated dilation.
Pilkington (2006) ⁵²	559 respondents among 1,568 unionized casino workers who received a postal survey	94% of respondents report that customers can smoke in most or all areas of their casinos where staff work	83% of respondents reported being		The majority of casino workers surveyed

22% of respondents were current smokers;
39% were never smokers

nearly always
exposed to SHS at
work;
78% stated that they
minded if people
smoke near them at
work;
57% believed they
had suffered health
problems as a result
of SHS exposure at
work;
65% supported
banning smoking in
all casino customer/
working areas

reported being bothered
by SHS, being concerned
about the effects that SHS
was having on their
health, and supporting
banning smoking in all
customer/working areas
of the casino.

Abbreviations: GSD = Geometric standard deviation; NNAL = (4-(methylnitrosamino)-1-(3-pyridyl)-1-butanol)-a tobacco-specific lung carcinogen.

SUPPLEMENTARY TABLE 3: Smoking Prevalence among Casino Patrons

Author Year Published	Study Site and Participants	Smoking Prevalence		Conclusions
		Casino Patrons	Comparison Group	
Jiang (2011) ¹⁵	36 California tribal casinos 8 Reno, Nevada casinos Casino patrons	Active smoking prevalence (defined as total number of active smokers divided by total number of patrons x 100%): California tribal casinos: 11% (range: 5%–25%) 16% in small casinos (casinos with < 500 slot machines) vs. 10% in medium and large casinos (casinos with 500–1,400 and > 1,400 slot machines, respectively) ($p < 0.05$). Adult smoking prevalence: 33%, calculated by multiplying the observed prevalence x 3, on the rationale that one third of smokers are smoking cigarettes at any given time. Reno casinos: 10% (range: 7%–12%) Adult smoking prevalence: 30% Casino overall smoking prevalence 33%	California adult overall prevalence = 13%	The adult smoking prevalence in California smoking-permitted casinos appears to be much higher than California's overall adult smoking prevalence of 13%.
Levens (2005) ²⁸	Pennsylvania Primary care patients aged ≥ 65	Recreational gamblers (persons who reported at least one gambling activity in the last year but who did not report either at-risk gambling behaviors described below): 8.8% At-risk gamblers (persons who reported gambling more than \$100 on a single bet and/or betting more than they could afford to lose in the last year): 10%	All respondents: 8.2% Non-gamblers (persons who reported no gambling activity in the last year): 6.3%	At-risk and recreational gambling were not significantly associated with smoking in this survey of older adult primary care patients.

Pritsos (2008) ²⁷	Nevada 14,052 gamblers at 18 casinos, including 8 in Las Vegas, 7 in Reno/Sparks, and 3 on the South Shore of Lake Tahoe.	Overall, 947 of 14,052 gamblers observed were smoking, which, multiplied by 3 on the rationale that one third of smokers are smoking cigarettes at any given time, yields a prevalence of 20.2% (95% CI: 0.7%), This prevalence did not significantly differ from the U.S. adult smoking prevalence of 20.9% (95% CI:0.6%) ($p < 0.0001$) Overall, smoking prevalence was higher among gamblers at slot machines (771/10,830 x 3 = 21.3%) than among gamblers at table games (176/3,222 x 3 = 16.4%).	U.S.: 20.9% (same year as casino prevalence)	The percentage of gamblers who smoke in Nevada casinos is not significantly different from the 2005 U.S. adult smoking prevalence.
Repace (2004) ¹²	Wilmington, Delaware 1 casino NA	Casino central salon: 25.5%, calculated by multiplying the observed prevalence by 3, on the rationale that one third of smokers are smoking cigarettes at any given time.	Delaware adults: 23% (2002)	The smoking prevalence among casino patrons was slightly higher than the state adult smoking prevalence.
Repace (2009) ¹⁴	Pennsylvania 3 casinos NA	Casino patrons: Estimated average smoking prevalence: 20.1% (range: 13.8%–29.1%), calculated by multiplying the observed prevalence of 6.7% (range: 4.6%–9.7%) by 3, on the rationale that one third of smokers are smoking cigarettes at any given time.	State adult smoking prevalence: 25% (range: 23%–29%) (2007)	The smoking prevalence among casino patrons was lower than the state adult smoking prevalence.

SUPPLEMENTARY TABLE 4. Smoking Prevalence among Problem/Pathological Gamblers*

Study Year Published	Study Site and Population	Smoking Prevalence		Conclusions
		Problem/Pathological Gamblers	Comparison Group	
Potenza (2004) ³⁰	Connecticut 601 callers to state helpline for problem gambling.	Problem gamblers: Of 601 callers for whom tobacco use status was available, 259 (43.1%) were current daily tobacco users. 43 (7.1%) were past daily tobacco users, suggesting low quit rates in this population. and 299 (49.7%) were never daily tobacco users. Almost 91% of current smokers reported onset of smoking before onset of gambling, and 82.48% reported onset of daily smoking before onset of gambling.	U.S. 23% (2000)	A high proportion of problem gamblers calling a state gambling hotline reported daily smoking. In these gamblers, smoking was associated with a number of other problems, including mental health and substance abuse problems. The findings highlight the need for the identification and implementation of effective smoking cessation interventions for problem gamblers.
Fong (2011) ³¹	Southern California casino 176 casino patrons. Problem gamblers = a score of 3 or 4 on the 17-item NORC DSM-IV Screen for	Probable pathological gamblers: smoked ≥ 20 cigarettes/day: 18.5%. nonsmokers: 57.4%. Pathological gamblers reported smoking more cigarettes per day relative to other groups (Kruskal–Wallis test, $p = 0.02$). Self-identified smokers had significantly higher mean	Non-problem gamblers: smoked ≥ 20 cigarettes/day: 5.7% nonsmokers: 81.1%	Pathological gamblers smoked more cigarettes per day than non-pathological gamblers. Smokers had higher scores than nonsmokers on a screen assessing gambling pathology. Interventions for smoking cessation are needed for casino patrons with gambling problems.

	Gambling Problems; pathological gamblers = a score of 5 or higher.	scores (3.9, SD: 3.5) on the NORC DSM-IV Screen for Gambling Problems than patrons who reported not smoking (2.5, SD: 3.0); $p < 0.05$].		
Rodda (2004)³³	<p>Victoria, Australia</p> <p>81 electronic gaming machine players, 29 (35, 8%) of whom scored above the SOGS cut-off for problem gambling.</p>	<p>Problem gamblers: 82.8% (24/29) (C.L.: 68.2%, 97.4%).</p> <p>SOGS scores predicted both smoking status and tobacco dependence scores (calculated using a 10-item Tobacco Dependence Scale).</p> <p>Anxiety scores were positively correlated with smoking status, SOGS scores, and tobacco dependence scores.</p>	<p>Non-problem gamblers: 46.2% (24/52) (C.L.: 32.1, 60.2)</p> <p>The difference in smoking prevalence between problem and non-problem gamblers was significant (likelihood-ratio chi-square = 11.05, $p < 0.001$).</p> <p>Victoria smoking prevalence: 25%.</p>	<p>Found a high smoking rate in a sample of untreated problem gamblers.</p> <p>Significant linear relationships existed between problem gambling, measured by SOGS, the likelihood of participants reporting smoking, and nicotine dependence scores.</p> <p>The authors speculate that smoking cessation treatments, smokefree policies, and efforts to address the underlying issue of negative affect/anxiety in gambling venues might help reduce high smoking rates among problem gamblers.</p>
Mason (2007)³²	<p>New Zealand</p> <p>12,529 respondents aged ≥ 15 years to the 2002/03 New Zealand Health Survey.</p> <p>Problem gamblers were identified using a 10-question screen that was specially</p>	<p>Problem gamblers: Prevalence of daily smoking: 58.3% (95% CI: 46.5%-70.0%)</p>	<p>Non-problem gamblers: Prevalence of daily smoking: 22.5% (95% CI: 21.3%–23.6%)</p> <p>OR: 2.96 (95% CI: 1.68–5.21).</p> <p>This association remained statistically significant when controlling for other variables (including sex, age, ethnicity, deprivation,</p>	<p>Problem gambling was significantly associated with daily smoking.</p> <p>The authors speculate that laws making gambling venues smokefree could affect both smokers' gambling behavior and the amount that they smoke, and call for studies on the impact of such laws on the prevalence of problem gambling.</p>

	developed for this survey.		household size, education, and employment status) with regression analysis.	
			Problem gamblers were also more likely to increase the amount smoked while gambling (61.2%) compared to non-problem gamblers (32.4%).	
Weis (2007)³⁷	<p>Virginia</p> <p>584 naval psychiatric outpatients</p> <p>Prevalence of pathological gambling (SOGS score ≥ 5): 1.4% (n = 8).</p> <p>Prevalence of problem gambling (SOGS score ≥ 3): 2.7% (n = 16).</p>	<p>Pathological gamblers: 5/8</p>	<p>All study participants: 201/584 (34.5%).</p>	<p>Smokers had 3.2 times greater odds of problem gambling compared with nonsmokers, but these results were not statistically significant ($p = 0.094$).</p> <p>Smokers had statistically significantly higher mean SOGS scores (0.42 vs. 0.21).</p> <p>Smoking is a risk factor for gambling problems.</p>
Petry (2002)²⁹	<p>Connecticut</p> <p>345 persons starting treatment for gambling; 317 persons included in final analysis</p>	<p>Breakdown of initial 345 subjects:</p> <p>62% current daily smokers</p> <p>6% former daily smokers</p> <p>32% never daily smokers (Thus, only 9% of gamblers who were ever daily smokers had quit, a very low rate.)</p> <p>Breakdown of 317 subjects</p>	<p>Connecticut smoking prevalence (1998): 22%</p>	<p>Smoking rates among treatment-seeking gamblers appear to be substantially higher than rates of smoking in the general population.</p> <p>This study suggests that treatment-seeking gamblers who smoke daily may differ from treatment-seeking gamblers who do not smoke daily on a number</p>

		<p>included in final analysis: 66.2% daily smokers; 33.8% never daily smokers</p> <p>Although life-time SOGS scores did not differ between daily smokers and never daily smokers, past-month SOGS scores were significantly higher in the daily smokers ($p < 0.001$).</p> <p>At treatment entry, daily smokers reported greater cravings for gambling and lower perceived ability to control their gambling compared to never daily smokers ($F_{1,278} = 7.00$ and 9.94, $p < 0.01$).</p> <p>Compared to never daily smokers, daily smokers also gambled more days ($F_{1,304} = 10.54$, $p < 0.001$) and spent greater amounts of money gambling ($F_{1,304} = 13.17$, $p < 0.001$) in the past month.</p>		<p>of dimensions, including having more severe current gambling problems.</p> <p>The association between daily smoking and increased gambling problems could result from nicotine enhancing gambling experiences, gambling reinforcing nicotine's effects, or each behavior serving as a cue for the other.</p> <p>Efforts to treat gambling disorders may benefit from considering the role played by nicotine dependence.</p> <p>Research should explore whether smoking adversely affects gambling treatment or outcomes.</p>
Grant (2008)³⁴	<p>A Midwest public university hospital and an East coast private university hospital</p> <p>465 adult</p>	<p>44.9% of the subjects were current daily smokers Subjects who were daily smokers had more severe gambling symptoms based on several indicators, including SOGS and DSM-IV criteria.</p>	<p>General U.S. population: 16.7% to 22.4%</p>	<p>Daily smoking is more common in pathological gamblers than in the general population. Pathological gamblers who are daily smokers tend to have more severe gambling symptoms than pathological gamblers who are not daily smokers. Daily smoking is common in pathological gamblers and has important</p>

	outpatients seeking treatment for pathological gambling			clinical implications.
Grant (2005)³⁵	225 adults recruited for pharmacological treatment for pathological gambling	48.9% of the subjects were current daily smokers; 21.8% of the subjects were prior daily smokers Current and prior daily smokers had stronger urges to gamble, based on several measures of gambling severity.	NA	Daily smoking is common in treatment-seeking pathological gamblers, and is associated with more severe urges to gamble.
McGrath (2009)³⁶	Literature review of articles published in English between 1980 and 2008 based on search of MEDLINE, PsychINFO, Web of Science, Science Direct, and Proquest focused on empirical studies of the comorbidity of smoking and gambling.	NA	NA	A number of studies suggest that the rate of tobacco dependence is higher among problem gamblers than in the general population. Tobacco addiction and problem gambling may be mediated by similar neurobiological, genetic, and environmental mechanisms.

Abbreviations: CI = confidence interval; OR = odds ratio; SOGS = South Oaks Gambling Screen.

*As defined here, a person is diagnosed as a pathological gambler if they meet standardized diagnostic criteria related to “persistent” or “maladaptive” gambling behavior.

SUPPLEMENTARY TABLE 5: Economic Impact of Smokefree Policies on Casinos

Study Year Published	Study Site and Timeframe	Smokefree Policy	Economic Impact	Conclusions
Lal (2008)³⁸	Victoria, Australia 1998– 2005	Victoria Smoke- Free Policy of 2002	<p>The study examined the ratio of monthly electronic gaming machine (EGM) expenditure for the Australian state of Victoria to monthly EGM expenditure for the Australian state of South Australia from July 1998 to December 2005.</p> <p>Victoria implemented a law making most areas of gaming venues smokefree in September 2002. South Australia had minimal smoking restrictions for gaming venues during the study period.</p> <p>The study found that the ratio decreased by 0.73 and the mean monthly expenditure level decreased by 13.8% following implementation of the Victoria law.</p>	<p>The study finds that the Victoria law resulted in an abrupt, long-term decrease in EGM expenditure.</p> <p>Separate measures to reduce problem gambling and limit gamblers' losses were implemented in January 2003.</p> <p>The study suggests that, in addition to protecting gaming workers and patrons from SHS, Victoria's smokefree law may have helped to reduce problem gambling.</p>
Harper (2003)³⁹	Victoria, Australia 2001-2003		The commentary notes early reports that the Victoria smoke-free law may have resulted in reduced gambling revenue and speculates on potential explanations.	The commentary speculates that smokers who interrupt their gambling to go outside to smoke may emerge from the "trance" induced by gambling, take stock of their losses, and break off gambling earlier than they would have done otherwise.
Mandel (2005)⁴²	Delaware 1996– 2004	Delaware Indoor Air Law of 2002	Linear regression controlling for underlying economic conditions and seasonal effects found that the Delaware smokefree law was associated with no significant effect on total gaming revenue or average revenue per video lottery terminal.	A state law making casinos smokefree had no detectable effect on total gaming revenue or average gaming revenue per video lottery terminal.
Pakko (2006)⁴³	Delaware 1996– 2004	Delaware Indoor Air Law of 2002	A re-analysis of Mandel's data using alternative approaches to control for differences in the variance of error terms across observations yielded a different result from that study. The new analysis found that both total gaming revenues and revenues per video lottery terminal fell significantly after the	The study concludes that Delaware's smokefree law had a statistically significant negative effect on gaming revenue. The study estimates that these losses could amount to about \$6.5 million per month in inflation

			implementation of Delaware's smokefree law.	adjusted 2004 dollars, representing a revenue loss of nearly 13% compared to the year preceding the implementation of the law.
Pakko (2008)⁴⁴	Delaware 1997-2005	Delaware Indoor Air Law of 2002	Pakko revisits his 2006 analysis and arrives at similar findings. In addition, he finds that the revenue losses were greater at racinos facing competition from smoking-permitted gambling facilities in neighboring states.	The study arrives at the same finding as Pakko's 2006 analysis, namely that the Delaware smoke-free law negatively impacted racino revenues.
Thalheimer (2008)⁴⁶	Delaware 1996-2004	Delaware Indoor Air Law of 2002	Using equations to estimate the demand for slot machines, the study finds that the Delaware law had a negative impact on this demand in the state's three racinos, reducing this demand (handle) by 15.9%, and that this impact did not vary across the racinos	The study finds that the Delaware smoke-free law reduced the demand for video lottery terminal wagering at the state's racinos.