

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

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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.<sup>1</sup> 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.<sup>1</sup> 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.<sup>1</sup> As of 2 January 2014, 26 states, the District of Columbia, Puerto Rico<sup>2</sup> and 598 communities<sup>3</sup> 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.<sup>4</sup> However, many states and local jurisdictions with commercial casinos allow smoking in these venues, placing casino employees and patrons at risk for SHS exposure.<sup>2–5</sup>

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'.<sup>6</sup> As more states authorise and build casinos, the list of states that have casinos is in flux, and other organisations have slightly different lists.<sup>2–5</sup> Of these 23 states, only 8 (Colorado, Delaware, Florida, Illinois, Maryland, New York, Ohio and South Dakota) prohibit smoking in these venues.<sup>2–5</sup> (Maine prohibits smoking in casinos but not racinos.<sup>2–5</sup>) The remaining 15 states have either weaker or no smoking restrictions in casinos.<sup>2–5</sup> 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).<sup>2</sup> Some cities and counties have also implemented local smoking restrictions in casinos.<sup>5</sup> Because of tribal sovereignty, tribal casinos are not subject to state or local smoke-free laws,<sup>1</sup> 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.<sup>7–8</sup> Few non-tribal commercial casinos have voluntarily adopted smoke-free policies.<sup>7</sup>

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.<sup>6</sup> It is estimated that 34% of US adults, visited a casino in 2012, with 32% of US adults reporting gambling at a casino.<sup>6</sup> 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.<sup>6</sup>

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

<sup>1</sup>In 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.<sup>9</sup> 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.<sup>1-6</sup>

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<sub>2.5</sub>). 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<sub>2.5</sub> is a commonly used marker for SHS exposure.<sup>1-10</sup> 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.<sup>11</sup> 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.<sup>12-14</sup>

High concentrations of PM<sub>2.5</sub> 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.<sup>1-10, 12</sup> 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<sub>2.5</sub> exposure of  $35 \mu\text{g}/\text{m}^3$ .<sup>11</sup> The impact of SHS on indoor air quality in casinos can be assessed by comparing the levels of PM<sub>2.5</sub> inside smoking-permitted casinos with (1) this standard, (2) outdoor air or (3) non-smoking casinos.<sup>1-10, 12</sup> For example, a study of 66 US casinos found that the geometric mean PM<sub>2.5</sub> level in casinos which allowed smoking was  $53.8 \mu\text{g}/\text{m}^3$ , compared with a geometric mean PM<sub>2.5</sub> 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.<sup>13</sup> 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.<sup>13</sup> Similarly, a study of 36 tribal casinos in California conducted on weekend and holiday evenings found that PM<sub>2.5</sub> 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.<sup>15</sup>

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.<sup>16</sup> 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.<sup>16</sup> NIOSH found that naphthalene was present in personal breathing zones (as measured by personal air monitors) and in the air of gaming areas.<sup>16</sup>

## 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.<sup>1-10</sup> 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  $3.7 \text{ ng}/\text{m}^3$ .<sup>12</sup> 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.<sup>17</sup>

In contrast, partial smoking restrictions such as separate smoking and non-smoking areas cannot eliminate exposures of non-smokers to SHS in casinos.<sup>1</sup> For example, a study of 36 tribal casinos found that PM<sub>2.5</sub> 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.<sup>15</sup> 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.<sup>18</sup> Average PM<sub>2.5</sub> 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.<sup>18</sup> 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.<sup>14</sup> An annual excess mortality of six deaths per 10 000 casino workers was estimated to be associated with these levels of exposure.<sup>14</sup> The 2008 Pennsylvania Clean Indoor Air Act exempted casinos, allowing smoking in up to 50% of gaming floors.<sup>14</sup>

## BIOMARKERS OF SHS EXPOSURE

Six of the studies reviewed have used biomarkers as an objective measure of SHS exposure in casinos<sup>9 14 16 17 19 20</sup> (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.<sup>1 21</sup> 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.<sup>1</sup> NNAL is a metabolite of, and a biomarker for, the tobacco-specific lung carcinogen NNK (4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone).<sup>1 22</sup> The presence of NNAL in the urine indicates that a person has absorbed this carcinogen.<sup>1</sup> NNAL's half-life is up to 45 days, making it possible to assess non-smokers' SHS exposure over longer periods.<sup>1</sup>

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.<sup>19</sup> 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.<sup>14</sup> Workers spending longer periods of time in such casinos on a daily basis would be expected to be more heavily exposed than patrons.<sup>1</sup>

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.<sup>16</sup> 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.<sup>13</sup> 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.<sup>9</sup> 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.<sup>9</sup> 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.<sup>13</sup> 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.<sup>9</sup> 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.<sup>20</sup>

## HEALTH OUTCOMES

Non-smoking workers who are exposed to SHS on the job are at increased risk of heart disease and lung cancer.<sup>1 10 23</sup> 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.<sup>1 10</sup> 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.<sup>1 10 23</sup> 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.<sup>1</sup>

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.<sup>20</sup> 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.<sup>24</sup>

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.<sup>25</sup> 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.<sup>26</sup>

## SMOKING PREVALENCE AMONG CASINO PATRONS

Some observers have expressed concerns that implementing smoke-free policies in casinos could negatively impact casino business.<sup>27</sup> 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%).<sup>27</sup> Another observational study estimated smoking prevalence among Delaware slot machine patrons to be 25.5%, close to the state's smoking prevalence of 23%.<sup>12</sup> A third observational study reported a smoking rate of 20.1% among Pennsylvania casino patrons, comparable with the state smoking prevalence of 25%.<sup>14</sup> Finally, a study based on a survey of older adult primary-care patients reported that recreational gambling was not significantly



associated with smoking.<sup>28</sup> 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%).<sup>15</sup>

### 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%).<sup>29</sup> 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.<sup>29</sup> Another Connecticut study found that more than 43% of problem gamblers calling a gambling hotline reported daily smoking.<sup>30</sup> A California study found that pathological gamblers smoke more cigarettes per day than non-pathological gamblers.<sup>31</sup> Two studies from New Zealand and Australia based on surveys also reported a significant relationship between problem gambling and smoking.<sup>32 33</sup> 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.<sup>34</sup> 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.<sup>35</sup> 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.<sup>36</sup> 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.<sup>37</sup> 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.<sup>28</sup>

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.<sup>38 39</sup>

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.<sup>1 10 40 41</sup> 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.<sup>1 10 40 41</sup> 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.<sup>42</sup> Their analysis found that the state smoke-free law did not have a significant effect on either of these indicators.<sup>42</sup> 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.<sup>43</sup> A subsequent study by Pakko expanded on the methods in his letter and reached a similar finding.<sup>44</sup> 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.<sup>45</sup> 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.<sup>45</sup> 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.<sup>46</sup>

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.<sup>38</sup> 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.<sup>38</sup> 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.<sup>38</sup> 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.<sup>38</sup> 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.<sup>38</sup> 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.<sup>39</sup>

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.<sup>47</sup> 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.<sup>2 5 47</sup> 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.<sup>47</sup> 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.<sup>47</sup>

### 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.<sup>1</sup> Elderly patrons may have underlying health risks that increase their vulnerability to SHS.<sup>48</sup> 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.<sup>49</sup> 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.<sup>6 8 49</sup> 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  $\geq 50$  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.<sup>50</sup> 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.<sup>15 50</sup> 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.<sup>1 10</sup> The 2006 NIOSH health hazard evaluation of occupational SHS exposure in Nevada casinos recommended that these casinos ban smoking on their premises.<sup>16</sup> 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.<sup>1</sup> 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.<sup>1</sup> 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."<sup>51</sup> 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.<sup>52</sup> 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.<sup>53</sup>

### 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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