What happens in Vegas, stays in your lungs: an assessment of fine particulate matter in casinos that prohibit and allow smoking in Las Vegas, Nevada, USA

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ABSTRACT

Introduction Despite progress in adoption of smoke-free policies, smoking in casinos is allowed in some US states, including Nevada. In 2020, for the first time, a resort-style casino in Las Vegas prohibited smoking voluntarily. This study is the first to assess air quality in this casino and compare results with similar casinos that allow smoking.

Methods A real-time personal aerosol monitor evaluated particulate matter with a diameter <2.5 µm (PM2.5), a surrogate for secondhand smoke (SHS). PM2.5 was measured at eight Las Vegas casinos, including the smoke-free casino. Each casino was visited twice, and PM2.5 was assessed in smoking-permitted gaming areas and areas where smoking is otherwise prohibited.

Results Average PM2.5 levels were significantly higher in casinos that allow smoking, for both casino gaming areas and areas where smoking is otherwise prohibited ($p<0.05$). Mean PM2.5 in gaming areas was 164.9 µg/m^3 in casinos that allow smoking and 30.5 µg/m^3 in the smoke-free casino. Mean PM2.5 in areas where smoking is otherwise prohibited was 83.2 µg/m^3 in casinos which allowed smoking in gaming areas, and 48.1 µg/m^3 in the smoke-free casino.

Conclusion Despite robust evidence about the harms of SHS, tens of thousands of casino employees and tens of millions of tourists are exposed to high levels of SHS in Las Vegas casinos annually, with PM2.5 levels 5.4 times higher in gaming areas when compared with a smoke-free casino. The only way to protect people from SHS exposure is to prohibit smoking in all indoor areas.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Nearly all casinos in Las Vegas continue to allow smoking indoors. The only way to eliminate exposure to secondhand smoke (SHS) is to completely prohibit smoking indoors.

WHAT THIS STUDY ADDS

⇒ Levels of particulate matter with a diameter <2.5 µm in Las Vegas casino gaming areas that allow smoking were 5.4 times higher than in the casino gaming areas in a smoke-free casino.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These findings demonstrate the stark differences in particulate matter concentrations inside Las Vegas casinos that allow and prohibit smoking indoors.

⇒ These findings can be used by casino employees who want to understand their potential exposure risk to SHS and by public health programmes and other organisations that are working to inform people about the health risks of exposure to SHS in casinos.

INTRODUCTION

Exposure to secondhand smoke (SHS) causes more than 1.2 million global deaths annually.[1–3] There is no risk-free level of SHS exposure.[1] SHS causes respiratory disease, heart disease and lung cancer; and brief exposure can trigger acute myocardial infarction.[1 2 4]

Prohibiting smoking in all indoor areas is the only way to eliminate involuntary exposure to SHS.[1] The US Surgeon General concluded that separating smokers from non-smokers, cleaning the air and ventilation cannot eliminate exposure.[1] More than 60% of the US population lives in a state or community with a comprehensive smoke-free law.[5] However, smoking is not always prohibited in casinos, as is the case in Nevada.[6 7]

Studies have found that casinos that allow smoking have high levels of particulate matter caused by SHS, that smoke drifts from smoking-permitted areas and that ventilation does not eliminate exposure.[8–13] While casinos may suggest that ventilation mitigates SHS, previous research shows smoke density is the primary predictor of elevated particulate matter in casinos.[13]

All casinos in Las Vegas, Nevada closed during the COVID-19 pandemic in March 2020, when the governor closed all non-essential businesses. When these casinos reopened, they were not required to operate smoke-free. However, when the Park MGM casino reopened in September 2020, it voluntarily prohibited smoking in all indoor areas, making it the only smoke-free casino on Las Vegas Boulevard (ie, the Las Vegas Strip).[14 15] The purpose of this study is to measure fine particulate matter with a diameter that is generally 2.5 µm and smaller (PM2.5) inside Las Vegas casinos that allow smoking and compare PM2.5 levels with those at the Park MGM. To our knowledge, this is the first study to assess PM2.5 levels in a smoke-free casino in Las Vegas.

METHODS

This cross-sectional study assessed PM2.5 in resort-style hotel casinos in Las Vegas, Nevada, USA, during a 3-day period in 2022. PM2.5 is a non-unique marker of SHS in indoor environments. The purposive sample of 8 out of approximately 30

casinos on Las Vegas Boulevard includes seven casinos that allow smoking and one smoke-free casino. Casinos were selected to be of similar type and in the same vicinity as the smoke-free casino. Data collection occurred after Nevada ended its COVID-19 mask mandate.

PM2.5 was measured using a SidePak AM520 Personal Aerosol Monitor (TSI, St Paul, Minnesota, USA). This instrument is commonly used for sampling of SHS and PM2.5 worldwide, including in casinos.[7 10 16 17] The SidePak was fitted with a PM2.5 size selecting inlet with an impactor disk prepared per manufacturer's specifications. The instrument was set to a flow rate of 1.7 L/min, and was zeroed using a 'zero cal filter', before each use. The data-logging interval was set to 1 min.

Each casino was visited twice over a Thursday, Friday and Saturday between approximately 13:00 and 23:30, and no casino was visited more than once on the same day. During each visit, indoor air was assessed in the smoking-permitted gaming areas and in areas where smoking is not otherwise permitted, such as a restaurant or sportsbook designated as non-smoking. Similar to previous studies, assessments occurred for at least 30 min in each area, for each visit.[8 10 17–19] For the smoke-free casino, PM2.5 was assessed on the gaming floor and in a restaurant and sportsbook as a comparison. Outdoor air was also assessed for 10 min outside each casino.

The SidePak was placed in a backpack with 1 m of Tygon tubing exposed to the environment at the level where a person breathes. Data were collected discreetly to avoid changing the behaviour of casino visitors and employees. The time when each area was entered and exited was recorded.

Direct puffs of tobacco smoke or electronic cigarette emission were avoided during data collection.[10] When outdoors, vehicle exhaust and tobacco smoke were also avoided.

Data were downloaded using TrakPro Data Analysis Software (V.5.0.0.24, TSI, St Paul, Minnesota, USA) and statistical analyses were conducted using R (V.4.1.0, Vienna, Austria). The first and last minute for each indoor area were excluded to ensure that data during transitions between areas were not analysed. A t-test was used to determine if differences in PM2.5 for areas within smoking-permitted casinos and the smoke-free casino were statistically significant, using a significance level of 0.05.

RESULTS

For the casino gaming areas, the mean PM2.5 concentration in casinos that permit smoking was 164.9 µg/m^3 (SD 155.98 µg/m^3) compared with 30.5 µg/m^3 (SD 29.7 µg/m^3) in the smoke-free casino (table 1). For areas of casinos where smoking is otherwise prohibited (ie, non-smoking areas), the mean was 83.2 µg/m^3 (SD 43.01 µg/m^3) in smoking-permitted casinos compared with 48.1 µg/m^3 (SD 14.84 µg/m^3) in comparable areas of the smoke-free casino. PM2.5 means for each casino gaming area where smoking was allowed ranged from 95.3 to 306.5 µg/m^3, while PM2.5 means for each 'non-smoking area' in these casinos ranged from 49.2 to 103.5 µg/m^3. Mean PM2.5 levels were significantly higher in casinos that permit smoking compared with the smoke-free casino, for both the casino gaming area (p=0.002) and in 'non-smoking areas' (p=0.003). Tobacco product use was not observed in any casino 'non-smoking areas' or in any areas of the smoke-free casino. Major differences were not observed for different days when casinos were visited. Further, log distributions and non-parametric measures were similar to arithmetic data; therefore, while means are presented to enable comparisons with previous studies, the table also include summary medians as a comparison.

Table 1 Average levels of PM2.5 in eight casinos, by sampled area—Las Vegas, Nevada, 2022

	Casino area mean PM2.5 (µg/m^3)			Non-smoking* area mean PM2.5 (µg/m^3)			Outdoor area mean PM2.5 (µg/m^3)		
Casino	Visit 1	Visit 2	Gaming area mean (median)	Visit 1	Visit 2	Non-smoking area mean (median)	Visit 1	Visit 2	Outdoor mean (median)
Casino 1	123.8 n=29	157.1 n=32	141.2 (109) n=61	110.4 n=32	87.7 n=34	98.7 (101) n=66	8.1 n=10	4.6 n=10	6.4 (7) n=20
Casino 2	371 n=30	244 n=31	306.5 (231) n=61	56.3 n=30	149.2 n=31	103.5 (113) n=61	6.5 n=10	9.4 n=10	8 (7) n=20
Casino 3	103 n=29	88.9 n=35	95.3 (94.5) n=64	28.5 n=31	71.4 n=29	49.2 (44) n=60	13.1 n=10	7.2 n=10	10.2 (10) n=20
Casino 4†	18 n=30	42.9 n=30	30.5 (20) n=60	53.9 n=30	42.1 n=29	48.1 (48) n=59	27.7 n=10	13.2 n=10	20.5 (18) n=20
Casino 5	166.7 n=30	114.8 n=31	140.3 (129) n=61	94 n=32	98.8 n=37	96.6 (86) n=69	10.4 n=10	6 n=10	8.2 (9) n=20
Casino 6	107.3 n=30	144.7 n=32	126.6 (101) n=62	27.9 n=29	110.6 n=29	69.1 (49) n=58	38 n=10	7.6 n=10	22.8 (16.5) n=20
Casino 7	168.9 n=31	131.1 n=30	150.3 (153) n=61	68.8 n=30	90.8 n=32	80.2 (80) n=62	16.4 n=10	14.8 n=10	15.6 (11) n=20
Casino 8	216.2 n=31	176.1 n=38	194.1 (170) n=69	68.7 n=31	93.2 n=30	80.7 (78) n=61	7.8 n=10	9.1 n=10	8.5 (7.5) n=20
Smoking casinos	180.3 n=210	150.7 n=229	164.9 (133) n=439	65.6 n=215	99.7 n=222	83.2 (79) n=437			
Smoke-free casino	18 n=30	42.9 n=30	30.5 (20) n=60	53.9 n=30	42.1 n=29	48.1 (48) n=59			
							All outdoor areas		
							16 n=80	9 n=80	12.5 (9.3) n=160

*Non-smoking areas are areas where smoking is prohibited either by the Nevada Clean Indoor Air Act or by the casino. The Nevada Clean Indoor Air Act exempts the casino gaming area from locations where smoking is prohibited.
†Casino 4 is smoke-free in all indoor areas.
n, minutes assessed, after excluding first and last minute; PM2.5, particulate matter with a diameter <2.5 µm.

DISCUSSION

This study finds that PM2.5 levels in casino gaming areas are 5.4 times higher in casinos that permit smoking than in the smoke-free casino. Additionally, PM2.5 levels in 'non-smoking areas' of casinos, such as restaurants and sportsbooks, are 72% higher than comparable areas in the smoke-free casino.

Allowing smoking indoors continues to pose an exposure risk to casino employees and visitors. These data can be useful to inform efforts to eliminate SHS in casinos. These findings can also be useful for casino employees and trade unions who want to understand current levels of PM2.5 and occupational risks of exposure to SHS in Las Vegas casinos. The number of people at risk of exposure to SHS in Las Vegas casinos is large. In 2019, there were 42.5 million visitors to Las Vegas and more than 96 000 casino employees on the Las Vegas Strip.[20 21]

The findings that there are elevated PM2.5 levels throughout casinos that allow smoking, and that average PM2.5 levels in these casinos are significantly higher than a smoke-free casino, are expected. However, these findings remain important because they document and illustrate the differences in PM2.5 levels in these casinos and show that casino employees and visitors remain at risk of exposure to high levels of SHS in Las Vegas casinos, despite claims that ventilation mitigates SHS.

Continuing to allow smoking indoors is counter to social norms and trends related to tobacco use. Most of the US population lives in a state or community with comprehensive smoke-free protections, and smoke-free casinos are becoming more common, with at least 12 states and territories prohibiting smoking in non-tribal casinos.[22] After COVID-19 pandemic-related business closures ended, over 200 casinos reopened smoke-free; these included many tribal casinos and temporarily included casinos in New Jersey.[23] In 2021, the Navajo Nation passed legislation prohibiting commercial tobacco use on all tribal land, including casinos.[24] Smoke-free policies that are voluntarily adopted by a business can be changed; and emergency orders that made casinos in locations such as New Jersey smoke-free were not permanent. In contrast, legislation that prohibits smoking, like smoke-free policies adopted by states and the policy adopted by the Navajo Nation, can result in sustained protections from SHS.

Previous research finds that the percentage of Nevada gamblers who smoke is similar to or less than that of the US population.[25] Additionally, a survey of US adults in 2017 found that 75% favoured smoke-free casino policies. Among those who visit casinos several times per year and at least once per month, the percentages favouring smoke-free casino policies were similar, 75.3% and 74.2%, respectively.[26] Together, those findings show that smoking in casinos is disfavoured by most adults, and that casinos are placing a majority of people, including casino employees, at an increased health risk to accommodate the relatively small and declining number of people who smoke.

This study has several limitations. First, factors other than smoke can impact PM2.5 levels; these include pollution, cooking, room size and ventilation. However, tobacco smoke is the main source of elevated indoor PM2.5 in areas where smoking is present.[1 7 27] Second, room volume could not be measured, and therefore smoke density was not estimated, though previous studies have documented that smoke density is the primary determinant of PM2.5 in casinos.[13] Third, due to differential responses with various particle types and because this instrument was not calibrated with a gravimetric measure of SHS, these data should be considered semiquantitative and may not be generalisable to other settings. Further, because the calibration factor (K) for SHS is expected to be less than 1, this would mean actual concentrations of PM2.5 are lower than measured, and this should be considered if comparing with other studies and taking into consideration the calibration, or lack thereof, used in those studies. However, these findings remain useful to compare differences in this cross-sectional setting. Finally, due to the proximity of some casinos to vehicle traffic, vehicle emissions may have impacted outdoor PM2.5 concentrations. However, these data reflect PM2.5 levels that individuals experience outside of casinos in Las Vegas.

This study also has strengths. First, this study used a monitor and method that are commonly used in these types of evaluations. Second, data collection occurred multiple times in each casino, with each casino being visited on different days and different times of the day, accounting for variability in exposure that could occur.

CONCLUSION

This study demonstrates that decisions by casinos to continue to allow smoking indoors result in PM2.5 levels that are substantially higher than in a casino that prohibits smoking. These casinos also place the health of non-smoking tourists and casino employees at unnecessary risk. The only way to protect people from involuntary exposure to SHS is to prohibit smoking in all indoor areas, including in casinos.[1 2]

Contributors MAT conceptualised the study. MAT, MAC and JRH designed the study. MAT collected the data, conducted the analysis and interpreted the data. MAC and JRH provided input on the analysis and interpretation of data. All authors contributed to editing manuscript drafts and MAT prepared the final manuscript. JRH provided supervision.

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REFERENCES

1 U.S. Department of Health and. *The health consequences of involuntary exposure to tobacco smoke: A report of the surgeon general*. Atlanta (GA), 2006.
2 U.S. Department of Health and. *The health consequences of smoking-50 years of progress: A report of the surgeon general*. Atlanta (GA), 2014.
3 Öberga M, Woodward A, Jaakkolac MS, *et al*. Global estimate of the burden of disease from second-hand smoke. 2010.
4 Institute of Medicine. *Secondhand smoke exposure and cardiovascular effects: making sense of the evidence*. Washington (DC), 2010.
5 American Nonsmokers Rights Foundation. Percent of U.S. State populations covered by 100% smokefree air laws 2022. Available: https://no-smoke.org/wp-content/uploads/pdf/percentstatepops.pdf [Accessed 5 Apr 2022].
6 Tynan MA, Holmes CB, Promoff G, *et al*. State and local comprehensive smoke-free laws for worksites, restaurants, and bars-United States, 2015. *MMWR Morb Mortal Wkly Rep* 2016;65:623–6.
7 Babb S, McNeil C, Kruger J, *et al*. Secondhand smoke and smoking restrictions in casinos: a review of the evidence. *Tob Control* 2015;24:11–7.
8 Repace J. Respirable particles and carcinogens in the air of Delaware hospitality venues before and after a smoking ban. *J Occup Environ Med* 2004;46:887–905.
9 Repace JL. Secondhand smoke in Pennsylvania casinos: a study of nonsmokers' exposure, dose, and risk. *Am J Public Health* 2009;99:1478–85.
10 York NL, Lee K. A baseline evaluation of casino air quality after enactment of Nevada's clean indoor air act. *Public Health Nurs* 2010;27:158–63.
11 Achutan C, West C, Mueller C, *et al*. Environmental tobacco smoke exposure among casino dealers. *J Occup Environ Med* 2011;53:346–51.

12 Jiang R-T, Cheng K-C, Acevedo-Bolton V, *et al*. Measurement of fine particles and smoking activity in a statewide survey of 36 California Indian casinos. *J Expo Sci Environ Epidemiol* 2011;21:31–41.
13 Repace JL, Jiang R-T, Acevedo-Bolton V, *et al*. Fine particle air pollution and secondhand smoke exposures and risks inside 66 us casinos. *Environ Res* 2011;111:473–84.
14 Jones J. Los angeles times. In: *Park MGM is first resort in Las Vegas to ban smoking* 16. September 2020.
15 MGM Park. Nomad las vegas reopen as the strip's first smoke-free casino resort press release. 2020. Available: https://investors.mgmresorts.com/investors/news-releases/press-release-details/2020/PARK-MGM--NOMAD-LAS-VEGAS-REOPEN-AS-THE-STRIPS-FIRST-SMOKE-FREE-CASINO-RESORT/default.aspx
16 Hahn EJ. Smokefree legislation: a review of health and economic outcomes research. *Am J Prev Med* 2010;39(6 Suppl 1):S66–76.
17 Hyland A, Travers MJ, Dresler C, *et al*. A 32-country comparison of tobacco smoke derived particle levels in indoor public places. *Tob Control* 2008;17:159–65.
18 Shamo F, Wilson T, Kiley J, *et al*. Assessing the effect of Michigan's smoke-free law on air quality inside restaurants and casinos: a before-and-after observational study. *BMJ Open* 2015;5:e007530.
19 Matt GE, Quintana PJE, Hoh E, *et al*. A casino goes smoke free: a longitudinal study of secondhand and thirdhand smoke pollution and exposure. *Tob Control* 2018;27:643–9.
20 Las vegas convention and visitors authority. Las vegas historic tourism statistics. 1970-2021. Available: http://res.cloudinary.com/simpleview/image/upload/v1646339932/clients/lasvegas/Las_Vegas_Historical_1970_to_2021_ed406c05-0e5d-4800-a39b-ddb7c9f6f6c0.pdf
21 University of Nevada Las Vegas. *Las vegas strip casino employment university of nevada las vegas*. Center for Gaming Research, 2022.
22 Centers for Disease Control and Prevention. STATE tobacco activities tracking and evaluation (STATE) system. n.d. Available: http://www.cdc.gov/tobacco/statesystem
23 American Nonsmokers Rights. Reopening casinos smokefree: the new normal 2022. Available: https://smokefreecasinos.org/reopening-casinos-smokefree-the-new-normal/ [Accessed 9 May 2022].
24 Kurtzleben D. Navajo nation bans indoor smoking in public places, including casinos. *National Public Radio* November 14, 2021. Available: https://www.npr.org/2021/11/14/1055640666/navajo-nation-bans-indoor-smoking-in-public-places-including-casinos
25 Pritsos CA, Pritsos KL, Spears KE. Smoking rates among gamblers at Nevada casinos mirror us smoking rate. *Tob Control* 2008;17:82–5.
26 Tynan MA, Wang TW, Marynak KL, *et al*. Attitudes toward smoke-free casino policies among US adults, 2017. *Public Health Rep* 2019;134:234–40.
27 Apelberg BJ, Hepp LM, Avila-Tang E, *et al*. Environmental monitoring of secondhand smoke exposure. *Tob Control* 2013;22:147–55.