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Casino accessibility and suicide: A county-level study of 50 US states, 2000 to 2016

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Abstract

Background and Aims: Suicide is the tenth leading cause of death in the United States (US). Research over many decades identifies that its etiology is complex, with risk factors operating in multiple domains. One such risk factor is gambling. Over the past three decades, exposure to gambling has increased dramatically in the US. The aim of this study was to measure the magnitude of the association between casino density and absolute risk of suicide in US counties.

Design, Setting, Cases: This spatial panel analysis used data for 3,131 counties from 50 US states from 2000 to 2016, for an overall sample of 53,227 county-year units. Using Bayesian conditional autoregressive Poisson models, we measured incidence rate ratios and credible intervals for the association between the density per population of casinos and other gambling outlets and the incidence of suicide.

Measurements: The outcome of interest was counts of suicides. The main exposures of interest were casinos and other gambling outlets.

Findings: A total of 527,401 suicides occurred during the study period. On average, there was a mean of 1.3 casinos (standard deviation [SD] = 9.1) and 1.4 other gambling venues (SD = 5.9) in each county-year. After controlling for confounding, the incidence rate ratio for casinos was 1.016, and the credible interval was between 1.010 and 1.023.

Conclusions: The density of casinos and other gambling venue is positively associated with suicide mortality in the United States.

Keywords

gambling; casinos; suicide; spatial analysis; addiction

DECLARATIONS OF COMPETING INTERESTS: The authors declare that they have no competing interests.

INTRODUCTION

Suicide was the fifth leading cause of life-years lost due to premature mortality in the United States (US) between 1990 and 2016 and was the second leading cause of death among those aged 10–34 years in 2016.[1] While suicide is an important public health problem, its etiology is complex. Research over many decades identifies risk factors operating in multiple domains, ranging from the individual (e.g., psychiatric disorders) to the environment (e.g., social conditions, economic policy).[2–4] One such risk factor is gambling. Over the past three decades, exposure to gambling has increased dramatically in the US. Whereas casinos were only permitted in Nevada and Atlantic City in 1989, by 2017 casinos were legal in forty states.[5] Over that period, the volume of casino gambling increased fourfold, with mean losses at casinos rising in real terms from $77 per US resident to $312 per US resident.[6]

Availability theory, borrowed from alcohol studies,[7] provides a plausible mechanism linking increased casino density to increased suicide mortality, on the basis of three assumptions. First, increased physical availability of casinos and other gambling venues is likely to lead to increased gambling participation and increased gambling losses.[8] Second, problematic gambling behavior or gambling disorder may develop with increased gambling participation, especially among those with risk factors in addition to participation.[9–11] Problem gambling refers to those who gamble despite problems in their lives caused by gambling.[12] Approximately 2 to 3 percent of the US adult population fit in this category.[13] Gambling disorder, previously classified as ‘pathological gambling’, is considered the most harmful form of gambling involvement and is thought to comprise 0.6 percent of the general population in the US.[14] It is recognized as a mental health disorder characterized by a pattern of continued gambling despite adverse consequences.[15] Finally, increased rates of harmful gambling are likely to lead to an increased incidence of suicide attempts and suicide death.[16]

There is clear evidence that gambling is linked to suicide, although studies on the topic remain sparse, especially with respect to suicide mortality.[16] For example, a national registry-based study of around 2000 Swedish adults diagnosed with gambling disorder found that suicide mortality among this cohort was over 15 times greater than in the general population.[17] Cross-sectional survey data from the United Kingdom suggests that rates of suicide ideation and/or attempts among problem gamblers were 2.9 times higher than among those with no signs of problem gambling.[18] A nationally-representative study from the United States found that suicide attempts were 2.4 times and 2.8 times more likely among problem gamblers and individuals with gambling disorder respectively compared to non-gamblers.[19] In Canada, nationally representative survey data suggest that problem gamblers were 3.4 times more likely to attempt suicide than the rest of the adult population.[20] Further, previous research has indicated a strong association between problem gambling and various comorbid disorders such as anxiety and mood disorders, substance use and personality disorders, as well as psychotic spectrum disorders.[21,22] Studies have shown that co-morbidity exacerbates gambling disorder and associated outcomes, including suicide, regardless of the type of comorbid disorder.[23]

Despite the link between gambling and suicide, and the increase in exposure to casinos over the last three decades, relatively little research has examined the relationship between casino accessibility and suicide. To date, no national study of casino legalization and suicide mortality has been published. The results of the current literature remain mixed. One of the first ecological studies examining this relationship analyzed both visitor and resident suicide mortality in Las Vegas, Reno, and Atlantic City, compared to other metro areas.[24] They found elevated suicide rates for both locations and among visitors and residents. In contrast to these findings, a study comparing the change in suicide rates before and after casinos were legalized in casino and control counties found no significant differences between casinos and controls.[25] Further research exploring the longitudinal effects of the increase in casinos and gambling outlet availability is needed to fully understand its relationship with suicide.

In this study, we conducted a longitudinal spatial ecological study to estimate the association between exposure to casinos and suicide mortality at the county level in the US, adjusting for theoretically relevant covariates. Our aim was to estimate the association between casino density and suicide incidence.

METHODS

Study Sample

This spatial panel analysis used data for 3,131 US counties from 50 US states over 17 years (2000 to 2016), for an overall sample of 53,227 county-year units.

Data

The outcome of interest was counts of suicides. We accessed Compressed Mortality Files from the Centers for Disease Control and Prevention for county-years from 2000 to 2016. Suicides were deaths classified as *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)* codes X60-X84 (intentional self-harm), U03 (terrorism involving intentional self-harm), and Y87.0 (late effects of intentional self-harm).

The main exposures were casinos and other gambling outlets. Other gambling outlets comprised establishments primarily engaged in operating gambling facilities or providing gambling services that are not casinos or casino hotels. Examples include but are not limited to bingo halls, off-track betting shops, slot machine parlors, and card rooms.[26] Using County Business Patterns data from the US Census Bureau, which documents the number of businesses present per county-year according to North American Industry Classification System (NAICS) codes, we calculated counts of casinos (NAICS codes 721120, 72112/, 731210, 73121/, and 71322//) and other gambling outlets (codes 713290 and 7132//). Consistent with previous analyses,[27] we denominated these count variables by county-year populations to generate measures of casino density, expressed in terms of venues per 100,000 population. These measures were heavily positively skewed (e.g., casinos: mean = 0.6, SD = 7.2, skewness = 39.0; kurtosis = 1191.4). Due to concerns that county-years with large numbers of casinos (e.g. Clark County, Nevada) would inordinately affect the

estimated associations and many other county-years had zero casinos or other gambling outlets, we square root transformed both measures.

Many county-year characteristics may be associated with the presence of casinos and other gambling outlets, causally related to suicide incidence, and do not lie on the causal path between the two.[28–30] These characteristics may therefore confound relationships between the main exposures and the outcome.[31] County Characteristics Intercensal Population Estimates from the US Census Bureau provided estimates of population composition within categories of sex, age, and race/ethnicity. We calculated proportions that were male, aged 0 to 24, aged 25 to 44, aged 45 to 64, aged 65+, non-Hispanic Black, non-Hispanic White, Hispanic, and Native American. Similarly, the US Census Bureau's Small Area Income and Poverty Estimates program estimated the annual median household income. From the Bureau of Labor Statistics, Local Area Unemployment Statistics described the proportion of the population aged > 16 years who were unemployed, and the Quarterly Census of Employment and Wages described the local workforce according to employment within industry categories. We calculated the proportion of the workforce employed in agriculture and mining, leisure and hospitality, financial services, and other industries. Finally, we calculated time-invariant measures of land area (square miles, which can be interpreted as a measure of population density because the model offset was population) and 2010 classifications of Rural-Urban Continuum Codes from the US Department of Agriculture, separated into metropolitan (RUCC: 1 to 3), urban (RUCC: 4 to 6) and rural (RUCC: 7 to 9).

Statistical Analysis

Bayesian conditional autoregressive Poisson models related casinos and other gambling outlets to counts of suicides within the 53,227 space-time units. Models were specified as:

$$Y_{i,t} \mid \mu_{i,t} \sim Poisson(E_{i,t}\exp(\mu_{i,t}))$$

where $Y_{i,t}$ is the observed count of suicides within county i in year t, and $E_{i,t}$ is the expected number of suicides based on county-year populations. The parameter $\mu_{i,t}$ therefore estimates the incidence rate ratio of suicides within county i in year t. We modelled the log of the incidence rate ratio linearly:

$$\mu_{i,t} = \beta_{00} + \beta_{01} + \lambda t + X\hat{}_{i,t}\beta_1 + \omega_t + \theta_i + \varphi_i$$

where β_{00} is the overall intercept term, β_{01} is the random intercept for state, and λ is a global linear time trend estimating the annual proportional change in suicide incidence over the 17 years. $X\hat{}$ is a matrix of independent variables, including the measures of casino and other gambling venue density, and the included covariates. β_1 is a vector of fixed-effects estimating the relationships between these variables and suicide incidence. The random effect ω captures residual variance in suicide incidence across years. The parameter θ_i is a time-invariant random effect that estimates the spatially unstructured error for counties and accounts for over-dispersion of the dependent variable. A time-invariant conditional autoregressive (CAR) random effect, φ_i, captures the spatially structured error. In doing so, it controls for the loss of unit independence due to spatial autocorrelation and addresses

the small area problem by borrowing strength from adjacent counties. The CAR random effects were identified using a binary matrix of adjacent counties with queen's contiguity. Models were estimated using R-INLA, which calculates the Integrated Network Laplace Approximation of a fully Bayesian model.[34–36]

In addition to the main analysis, in which the exposures of interest were the square root of casinos and other gambling outlets per 100,000 population, we conducted several sensitivity analyses to limit the possibility that our results were artifacts of our model specification or variable construction. Specifically, we conducted 5 sensitivity analyses. The first (S1) included an interaction term between casinos per 100,000 population (square root) and other gambling venues per 100,00 population (square root). The second (S2) replaced the main exposures with casinos and other gambling outlets per 100,000 population (i.e., not square root transformed). The third (S3) replaced the main exposures with unadjusted counts of casinos and other gambling outlets. The fourth (S4) replaced the main exposures with dummy variables indicating the presence of 0, 1, 2 or 3, or 4+ casinos and other gambling outlets. Lastly, the final sensitivity analysis (S5) removed Nevada counties.

RESULTS

A total of 527,401 people died by suicide in the 3,131 US counties from 2000 to 2016. On average, there was a mean of 1.3 casinos (SD = 9.1) and 1.4 other gambling venues (SD = 5.9) in each county-year. Casinos and other gambling venues were heavily concentrated in Nevada. Specifically, there were 13,173 (24.7%) county-years that had at least 1 casino nation-wide. In comparison, 235 of the 289 (81.3 %) county-years in Nevada had at least 1 casino. County-year characteristics are presented in Table 1.

Statistical Analysis

Table 2 shows the results of the main Bayesian conditional autoregressive Poisson model relating the square root of casinos and other gambling outlets per 100,000 population to suicides. After controlling for confounding, the incidence rate ratio for casinos was 1.016, and the credible interval was between 1.010 and 1.023, which means that each square root increase in the number of casinos per 100,000 population was associated with a 1.6% increase in suicides per population and that the range for this estimate was between 1.0% and 2.3% increase (95% CrI: 1.010, 1.023). Other gambling outlets were positively associated with suicides after controlling for confounding, with an estimated association slightly weaker than that for casinos and including the null value of 1.000 (IRR = 1.003; 95% CrI: 0.997, 1.009).

Results of the sensitivity analyses were generally consistent with the results of the main model (see Supplemental Table 1). Model S1, which included an interaction term, found no significant interaction between the square root of casinos per 100,000 population and the square root of other gambling venues per 100,000 population. In Model S2, the number of casinos per 100,00 population was associated with a 1% increase in suicides per population (95% CrI: 1.000, 1.002) and the number of other gambling outlets was associated with a 3% increase in suicides per population (95% CrI: 1.001, 1.004) after controlling for confounding. Not adjusting for population in Model S3 yielded null results. When including

the exposure as a categorical variable in Model S4, counties with four or more casinos had the largest increase in suicides per population compared to counties with no casinos, after controlling for confounding (IRR = 1.048, CrI: 1.028, 1.068). Other gambling outlets yielded null results. Finally, excluding Nevada in Model S5 demonstrated that each square root increase in the number of casinos per 100,000 population was associated with a 1.4% increase in suicides per population (95% CrI: 1.008, 1.021). The results for other gambling outlets were not statistically significant.

DISCUSSION

This spatial panel analysis of county-level data found that exposure to casinos was associated with an increased risk of suicide mortality. Estimates produced in sensitivity analyses were comparable to the main findings. With the rapid increase in casinos and gambling outlets over the past decade, these results, though small in effect size, may suggest that the increased density of these venues could be an important contributor to suicide risk.

Findings from the current study are consistent with the literature that suggests a positive association between casinos and suicide. In a cross-sectional analysis, McCleary et al. found that casino presence was related to modest elevations in suicide rates in metropolitan areas.[37] However, the same study also conducted a time series analysis of gaming and non-gaming counties and found that no changes in suicide could be attributed to casino operation. Of note, the time series analysis included counties from 1970 to 1995. Casinos and gambling outlets have experienced explosive growth since then which may explain the disparate results. Nevertheless, the small size of our identified association may explain why some earlier studies identified gambling as a risk factor for suicide[24,37] while others did not.[25,38]

Our findings are consistent with availability theory, which predicts that an individual's likelihood of gambling is linked to convenience. According to this mechanism, gambling will increase as casinos and other gambling outlets become more available. Our results may support this theory due to the observation of an increased incidence rate of suicide. However, competing explanations pertaining to adaptation exist. Adaption theory, proposed by Huxley in 1942[39] from a biological perspective, refers to an organism's ability to adapt to changes in its environment and ability to adjust over time. Applied to the gambling literature, adaption theory posits that people and communities adapt to the risks of gambling.[40] As individuals and societies increase their awareness of gambling-related harms, they may develop adaptations to the gambling environment, and thus become less prone to gambling and related harms.[41] As we are unable to provide evidence regarding the existence of any adaptation effect in the US, future research may be needed to consider these mechanisms.

Strengths and limitations

This study has several strengths which distinguish it from the limited literature on this topic to date. It is the first study to estimate the relationship between casinos and other gambling venue density and suicide mortality on the national scale. Previous studies have compared carefully selected casino locations with control locations at a variety of spatial scales, employing methods like cluster analysis or matching to match cases to

controls.[24,25,37,42] Second, it is the first longitudinal study of the relationship between casino density and suicide. Our spatial panel design compared associations both within and between counties over time and controlled for spatio-temporal autocorrelation, thereby providing more scientifically robust estimates than a cross-sectional ecological analysis. Future studies may consider a time series analysis, which could help with confounding but would only consider within-county comparisons. Finally, this study undertook sensitivity analyses to ensure that its findings were not the result of outliers like Clark County and other Nevada counties biasing national results, or that the findings were not reliant on idiosyncratic model specifications.

Nevertheless, the study is subject to various limitations. Data were not available for some important variables, some of which may confound the relationship of interest. For example, the presence of online gambling, knowledge of an individual's co-morbidities (i.e., substance abuse[43,44]), or alcohol availability at a casino or other gambling outlet all may increase or decrease the risk of suicide. It is possible that these unmeasured variables resulted in an overestimation of our estimates. However, we included controls for key socio-economic and geographic variables which are the most substantial known drivers of geographic variation in suicide. As such, any bias is likely minimal. In addition, we were limited to counties for our unit of analysis as the County Business Patterns database documents the number of businesses present per county-year. Counties represent artificial administrative boundaries, and it is likely that the impact of new casinos and other gambling outlets will span multiple geo-administrative areas. Further, the county-level casino counts exclude race-course casinos, or 'racinos'. According to industry statistics, racinos accounted for 5.3% of all casinos in the US in 2017. The proportion was higher in specific states like Ohio where seven of the state's eleven casinos are at race tracks.[5] The external validity of the County Business Patterns database for other types of casinos has yet to be studied. Next, suicide data are subject to under-reporting. If under-reporting rates are associated with casino density, then our results could be biased towards the null. Finally, we made no attempt to model potential spatial or temporal non-stationarity of the relationship between casino density and suicide mortality. Given the variety of regulatory structures in the US, it is likely that this relationship will vary to some degree from place to place and indeed may vary over time as predicted by adaptation theory. Yet, due to an inability to sufficiently control for this non-stationarity, we have estimated the average relationship across all county years.

Conclusions

Casino and other gambling venue densities are both associated with suicide mortality in the US between 2000 and 2016. While quasi-experimental and other more rigorous study designs will better support causal inference, this preliminary evidence is consistent with clear theoretical mechanisms linking casinos and suicides. Potential impacts on suicide should be considered when legalizing casinos and other gambling venues.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Descriptive statistics for 3,131 US counties over 17 years (n = 53,227)

Variable	Mean	SD	Min	Max
Outcome				
Suicides	11.6	30.7	0.0	843.0
Exposures				
Casinos per 100,000 population	2.9	22.2	0.0	1370.4
Other gambling outlets per 100,000 population	2.7	12.8	0.0	358.9
Demographics				
% Male	49.9	2.2	0.0	78.5
% Aged 0 to 14 years	19.5	3.0	0.0	39.1
% Aged 15 to 24 years	13.4	3.5	0.0	60.4
% Aged 25 to 44 years	24.6	3.5	0.0	47.4
% Aged 45 to 64 years	26.7	3.4	0.0	46.4
% Aged 65+ years	14.7	4.8	0.0	53.0
% Black	8.9	14.5	0.0	86.3
% Hispanic	7.8	12.9	0.0	99.0
% Native American	0.3	7.0	0.0	95.1
% White	79.3	19.6	2.1	99.6
Employment and income				
Annual median household income (USD)	42070.0	11654.4	0.0	134610.0
% Living in poverty	13.6	7.7	0.0	62.0
Unemployment rate (%)	6.3	2.7	0.0	28.9
% Employed in agriculture and mining	3.7	6.0	0.0	91.7
% Employed in construction	4.2	3.2	0.0	69.5
% Employed in manufacturing	11.9	10.6	0.0	75.0
% Employed in trades	17.8	5.8	0.0	64.9
% Employed in information services	1.0	1.1	0.0	21.0
% Employed in financial services	3.5	2.0	0.0	34.0
% Employed in professional services	5.5	4.6	0.0	91.6
% Employed in education and health	11.3	5.8	0.0	59.1
% Employed in leisure and hospitality	8.6	5.6	0.0	88.4
% Employed in others	2.3	1.4	0.0	19.5
Population density				
Land area (square km)	2904.0	9363.3	51.0	376855.9
RUCC - metro	0.4	0.5	0.0	1.0
RUCC - rural	0.2	0.4	0.0	1.0
RUCC - urban	0.3	0.5	0.0	1.0

Table 2.

Bayesian conditional autoregressive Poisson model for counts of suicide within 3,131 US counties over 17 years (n = 53,227)

	IRR	95% CrI	
Casinos per 100,000 population (square root)	**1.016**	**1.010**	**1.023**
Other gambling outlets per 100,000 population (square root)	1.003	0.997	1.009
Demographics			
% Male	**1.906**	**1.234**	**2.942**
% Aged 0 to 14 years	1.362	0.960	1.933
% Aged 15 to 24 years	REF		
% Aged 25 to 44 years	1.525	1.107	2.100
% Aged 45 to 64 years	**9.116**	**6.753**	**12.293**
% Aged 65+ years	**3.480**	**2.716**	**4.455**
% Black	**0.470**	**0.432**	**0.511**
% Hispanic	**0.519**	**0.463**	**0.582**
% Native American	**1.754**	**1.557**	**1.976**
% White	REF		
Employment and income			
Annual median household income (USD)	**0.966**	**0.959**	**0.973**
% Living in poverty	**1.001**	**1.000**	**1.003**
Unemployment rate (%)	**1.005**	**1.003**	**1.008**
% Employed in agriculture and mining	**0.835**	**0.711**	**0.980**
% Employed in construction	0.948	0.764	1.176
% Employed in manufacturing	0.943	0.862	1.030
% Employed in trades	0.907	0.788	1.043
% Employed in information services	0.795	0.481	1.313
% Employed in financial services	0.936	0.690	1.270
% Employed in professional services	0.951	0.819	1.105
% Employed in education and health	1.006	0.887	1.142
% Employed in leisure and hospitality	**0.846**	**0.727**	**0.985**
% Employed in others	REF		
Population density			
Land area (square km)	**1.034**	**1.026**	**1.041**
RUCC - metro	REF	REF	REF
RUCC - rural	0.979	0.955	1.005
RUCC - urban	0.999	0.984	1.013

Bolded values are statistically significant at an alpha of 0.05