Casino proximity, visit frequency, and gambling problems

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Abstract

The geospatial impact of casinos on gambling problems is poorly understood, despite its importance to policy decisions. In this study, we propose a conceptual model to describe how access relates to gambling problems and we test whether access convenience increases risk. We collect a large sample of Canadian gamblers (n=6,234) and geolocate each individual relative to domestic casino locations (N=110), using their home addresses. Our analysis suggests that nearby casinos increase risk for residents. We further find that frequency of play mediates the relationship, implying an indirect link between access convenience and gambling problems. The results are robust to several estimation strategies that address endogeneity issues found in the empirical literature.

Keywords: casino; gambling exposure; access convenience; travel time; adaptation; gambling disorder

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INTRODUCTION

The prospect of a new casino in a community is often a source of controversy for nearby residents. Economic benefits of casino expansion, including tax revenue, local employment, and tourism activity are typically welcomed by an array of stakeholders (Eadington, 1998, 1999; Henderson, 2006; Ishihara, 2017; Philander et al., 2015). Conversely, social costs are often the focus of parties opposed to gambling. Categories of perceived costs are numerous, including a loss of community values, increased risk of crime, and increased traffic congestion, but the most cited concern is typically the harms from gambling-related addiction (Ishizaka et al., 2013; Korn et al., 2003; C. K. Lee et al., 2010; C. K. Lee & Back, 2003, 2006; Philander et al., 2017; Wan, 2012).

Some of the smallest and largest casino projects involve debates about gambling-related addiction in the local population. For example, Japan's casino resorts, which are expected to involve capital investments in excess of $10 billion per property, have generated considerable debate about future gambling problems (Murase, 2018; Philander et al., 2017; Roberts & Johnson, 2016). Resident attitudes about casinos are closely shaped by the direct and indirect impacts of gambling addiction on the community (C. K. Lee et al., 2010; Vong, 2009; Wu & Chen, 2015) and policy makers therefore attempt to minimize the former and maximize the latter by geographically restricting property locations to island or border communities, in an attempt to concentrate consumption among out-of-jurisdiction visitors (Eadington, 1999).

Despite the importance of understanding casino impacts on nearby residents, the influence of access convenience on gambling problems remains an open question. There was a significant expansion of legal gambling in the late-20th and early-21st centuries, but the prevalence of problem gambling in related populations has tended to remain unchanged (M. W. Abbott et al., 2014; Welte et al., 2015). This seemingly paradoxical phenomenon has led to conflicting narratives about the influence of access by residents. Some research posited that expansion of gambling increases risk for local populations (Korn, 2000b), while other research proposes that individuals will adapt to the risks after an adjustment period (LaPlante & Shaffer, 2007; Prentice & Zeng, 2018). To thoughtfully develop host community plans for casinos, a more rigorous understanding of how casino access will contribute to the local populations' addiction risk is needed.

In the current study, we develop a conceptual model of casino patronage that helps explain the conflicting narratives about the casino access and local gambling problems. Using a large sample (n=6,234) of active gamblers from Canada, we then test our hypothesized pathway using geolocation coordinates for each of the survey respondents' homes, which is merged into a database containing the location and age of every casino in Canada. We address potential biases in our identification strategy by also providing robustness tests in the form of an instrumental variable model, which we used to test assumptions important to the underlying validity of our approach.

LITERATURE

There is a well-developed literature on the mechanisms by which casinos can contribute to local economies (Eadington, 1998). Empirical evidence suggests that casinos positively contributed to economic output in Macau (Zheng & Hung, 2012), Korea (C. K. Lee & Kwon, 1997), Australia (T. J. Lee, 2011), and a diverse range of U.S. jurisdictions (Evans & Topoleski, 2002; Walker & Jackson, 2007). Studies of resident perceptions find that locals recognize positive tourism-based impacts of casinos, but have mixed attitudes to casinos overall due to the perceived social harms (Giacopassi et al., 1999; C. K. Lee et al., 2010; Nichols et al., 2002; Vong, 2009; Wu & Chen, 2015).

The most salient casino-related cost is problem gambling (e.g. Tan et al., 2017). Problem gambling is a behavioral addiction, characterized by continued gambling despite negative personal, social, and/or financial outcomes (Hodgins et al., 2011). Among other criteria, impacted individuals are preoccupied with gambling, have unsuccessful efforts to control or stop gambling, and return to gambling another day to recoup losses (Potenza, 2014). Individuals tend to have excessive involvement in gambling, and this may manifest as a significant amount of time and/or money spent at gambling outlets, and/or participation in many different forms of gambling (LaPlante et al., 2014).

According to the Pathways Model, a prominent theory about the etiology of gambling problems (Blaszczynski & Nower, 2002; Milosevic & Ledgerwood, 2010; Moon et al., 2017; Nower & Blaszczynski, 2017), increased availability and accessibility of gambling is a factor in the development of gambling related problems. It is proposed in the model that access for individuals will enable increased frequency of play, which subsequently can lead to behavioral conditioning and development of problems (Blaszczynski & Nower, 2002).

Empirical studies of population-wide prevalence rates fail to align with the intuition provided by the Pathways Model. In general, prevalence studies find that rates of gambling disorders tend stay level or fall after a casino is introduced in a community, despite the implied increase in availability (M. W. Abbott et al., 2014; Welte et al., 2015). Many scholars propose that this phenomenon occurs because the influence of exposure on gambling disorders can be reduced through adaptive processes, whereby individuals change their behavior to mitigate risk (M. Abbott, 2006; LaPlante & Shaffer, 2007; Prentice & Zeng, 2018). However, these proposed mechanisms are propositional or explanatory. It is unclear if there is an “exposure effect” which can then be followed by individual “adaptation”. Resolving the nature of this relationship is important, as it will provide clarity as to the appropriate policy decisions that can be made about casino availability, expansion, and harm mitigation.

Some empirical work has attempted to provide clarity, but these studies have been affected by different endogeneity issues. In a meta-analysis of problem gambling prevalence surveys from Australia and New Zealand, Storer et al. (2009) found that higher density of electronic gambling machines is correlated with higher rates of gambling problems. Philander (2019) found similar effects in a large representative sample of Canadians, but both studies were based on cross-sectional data sets. Two noteworthy papers by Jacques and colleagues (Jacques et al., 2000; Jacques & Ladouceur, 2006) compared rates of disordered gambling from a survey conducted before and after a casino opening with rates in a similar control municipality without expansion. Both municipalities had a decrease in prevalence rates, but the control municipality had a greater drop. Although this appeared to be a useful natural experiment to inform policy, because of the length of time required for effects to emerge, the difference-in-difference approach may have been biased by the opening of a new casino less than 20 miles from the original casino, and a U.S. tribal resort-casino opened less than 75 miles away (Morrison, 2019). A bias in sample attrition may also explain the results, as gamblers with problems are more likely to leave longitudinal research studies (Wohl & Sztainert, 2011).

In addition to methodological challenges observed in the empirical literature, a gap in understanding relates to an absence of generalizable mechanisms that would explain the connection between the nearby presence of a casino and development of gambling problems. It seems likely that a behavioral response must occur. In the Pathways Model, consumption changes are proposed to result from access changes (Nower & Blaszczynski, 2004).

Intuitively, frequency of visit appears to be the most likely mechanism. Increased frequency of consumption due to closer access aligns with retail management theory. That literature suggests convenience of access is a determining factor in purchase behavior (Beauchamp & Ponder, 2010; Jiang et al., 2013; Seiders et al., 2007). Berry et al., (2002) describes access convenience as consumers' perceived expenditures of time and effort to initiate consumption behavior, and this seems particularly important for inseparable services like casino gambling, which must be consumed while they are produced.

A growing number of observational studies suggest that gambling frequency is positively correlated with risk of developing a gambling problem (Binde et al., 2017; Gainsbury, 2015; LaPlante et al., 2011, 2014). Most applicable to our study, an examination resort casino customers found that frequency of play, rather than any game or set of games played during their casino visits, predicted a history of gambling-related problems (LaPlante et al., 2013). However, the authors note that their modeling approach is non-causal. Although the Pathways Model proposes a causal role for behaviorally conditioned gamblers who develop habits and subsequent gambling problems (Blaszczynski & Nower, 2002; Nower & Blaszczynski, 2017), reverse causality also seems plausible, considering one of the defining characteristics of gambling problems is returning to ‘chase losses’ on a subsequent day (Potenza, 2014).

Overall, we reconcile casino access literature with the retail access literature, in a conceptual model that explain observed and hypothesized phenomena (see Figure 1). We propose that increased access convenience to casino locations is associated with an increase in the prevalence of gambling disorder, and that this increase is indirect. Specifically, we hypothesize that increased proximity of casino outlets is positively associated with frequency of play, which in turn, is positively associated with gambling disorder. In addition, individual risk-factors such as age, gender, and income levels (Johansson et al., 2009), or consumption of other forms of gambling may influence both visit frequency and disorder risk.

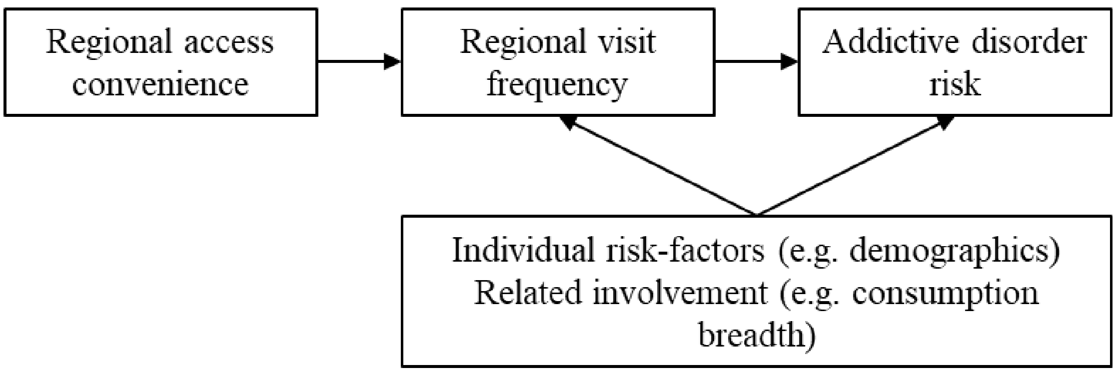

Figure 1 – Proposed model of the indirect role of access convenience in impacting addictive disorder risk. The hypothesized relationship between casino access and gambling disorder risk is mediated by frequency of visits to casinos. Individual factors contribute to both visit frequency and personal vulnerabilities to developing a gambling disorder. Other risk-factors or measures of involvement in gambling contribute visit frequency and risk of developing a gambling disorder.

Although this is a straightforward linking of ideas from consumer behavior and problem gambling etiology, a similar conceptual model has not been articulated (or tested) in the tourism or broader gambling literatures. Validating this conceptual framework provides substantial clarity to policy discussions. In our first hypothesis, we contend that there is behavioral response, whereby closer casino access leads to increased frequency of consumption.

H_1: Frequency of casino play is positively related to increased casino access convenience

We next operationalize potential for behavioral conditioning described by the Pathways Model, and test for the role of frequency of play in contributing to gambling-related problems.

H_2: Gambling disorders are positively related to frequency of casino play

We anticipate that findings provide evidence of the pathway from casino access convenience to gambling problems via frequency of play, as well as related effect sizes, which leads to the final hypothesis:

H_3: Frequency of casino play mediates an indirect relationship from casino access convenience to gambling disorders

We hypothesized that in addition to the direct relation described in H_1 and H_2, we would observe an indirect relation that connects casino access convenience to risk of developing a gambling disorder. We further test whether there is a direct effect of access on risk.

EMPIRICAL APPROACH

Mediation model

We estimated a mediation model like that shown in Figure 1, to test whether greater casino proximity predicts greater gambling disorder risk indirectly via greater visit frequency. We followed the procedure outlined by Zhao et al. (2010), and tested for the presence of an indirect-only mediation effect using a bootstrap test (Preacher & Hayes, 2008). We used average travel time from respondents' home to their nearest casino as our proxy of access convenience. In a meta-study of retail patronage, Pan & Zinkhan (2006) concluded that location convenience is an important determinant for consumers, noting that distance and drive time meaningfully impact shopping decisions. All models were estimated using the generalized structural equation model (gsem) in StataMP 15 (StataCorp LLC, 2017).

Instrumental variable model

As mentioned previously, there are potential endogeneity issues in the mediation model, as individuals at higher risk of gambling problems may choose to locate nearer casinos, leading to potential reverse causality. To further support the validity of our findings, we estimated a set of instrumental variable models that provided a stronger framework for inferring causality between visit frequency and gambling disorder risk (Angrist et al., 1996; Angrist & Imbens, 1995; Baiocchi et al., 2014; Rassen et al., 2009). We also used this approach to perform a Hausman test (Hausman, 2006) on our travel time variables, to support our claim that they are not directly related to gambling disorder risk and are indirectly related through visit frequency. We used a two-stage least squares (2SLS) approach that estimated the reduced form equations:

$$(1) \quad DG = f(CF, OG, DE, \varepsilon)$$

$$(2) \quad CF = f(T, OG, DE, \mu)$$

Where *DG* is disordered gambling risk; *CF* is casino gambling frequency; *T* is travel time to the nearest casino; *OG* is other gambling variables including duration of casino presence (Shaffer et al., 2004), number of other gambling formats played (LaPlante et al., 2014), highest frequency of non-casino play (LaPlante et al., 2014); *DE* are demographic controls, and ε and μ are respective error terms. We estimated linear and ordinal versions of equation (2). We report standard errors that account for clustering of observations by forward sortation area (discussed in the next section) because that location is implicated in the "assignment" of estimated travel time (Abadie et al., 2017). Individuals living in the same forward sortation area have the same estimated travel distance to their nearest casino.

Data

Respondents

This study was determined to be exempt from review by the first author's Institutional Review Board. We conducted a secondary analysis of a sample of active gamblers from Canada (Tabri et al., 2020). Casinos were not legal in Canada until 1985 (Korn, 2000a), but expanded to 110 by the time of data collection. We exploited the variation in casino locations by geocoding each respondent and each casino through postal code information, and computing travel times to each property for each respondent.

Since gambling disorders often afflict no more than 1-2% of the adult population at a given time, a large sample is needed (Welte et al., 2015). The data set includes 7,980 Canadians recruited by a third-party survey company in 2018 from their established online panel of 500,000 people. Participants were compensated with points that were redeemable for gift cards. Roughly 1,000 participants were recruited from each of the managed casino regions in Canada: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, and a set of provinces that jointly manage some gambling-related operations (New Brunswick, Prince Edwards Island, and Newfoundland and Labrador). The firm contacted potential participants and ended recruitment once the requisite number of individuals were recruited.

Within each gambling jurisdiction, quota sampling was used to recruit an equal number of men and women. Age groups were sampled to be representative of each province. Participants were adults aged 18 years or older who gambled in the last year, and we subjectively determined that 80% must have gambled in the last month. Surveying only gamblers increases the power of the study, as our estimated effects are not impacted by attenuation bias from non-gamblers. In a representative survey of four Canadian provinces, 49% of individuals aged 18 or older reported gambling during the past year (*Canadian Community Health Survey - Annual Component Study Documentation*, 2017). Although the non-representative sample may create concerns that we are omitting part of the demand curve, the sample included non-casino gamblers. Such participants are likely to be the marginal consumers who may participate in casino gambling if a property is sufficiently close. That is, it is unlikely that a potential casino gambler is a non-gambler altogether, and as our sampling strategy only excludes non-gamblers, it seems likely that our approach captures consumers on the margin. Consistent with best practices, participants who failed one or more attention check questions (*n* =1,317) were removed (Abbey & Meloy, 2017), as were those who had relevant data missing (*n* = 360).

Of the remaining respondents, 48.4% identified as male (*n* = 3,049), 51.5% identified as female (*n* = 3,248), and 0.1% provided an alternative gender response (*n* = 6). Participants ranged in reported age from 18 to 99 years (*M* = 47.80, *SD* = 14.94). Reported household income ranges were (in Canadian dollars) 'under $25,000' (6.87%), '$25,000 to under $40,000' (12.47%), '$40,000 to under $60,000' (16.02%), '$60,000 to under $80,000' (16.48%), '$80,000 to under $100,000' (14.25%), '$100,000 to under $150,000' (17.02%), '$150,000 or more' (7.89%), and 9.00% stated they were not comfortable providing income information. In terms of highest level of completed education, 25.56% completed high school, 36.77% received some post-secondary, 14.96% completed an undergraduate degree, 21.21% completed graduate-level education. Reported marital status were 'married' (48.26%), 'never married' (21.56%), 'married but separated' (2.81%), 'divorced' (8.01%), 'widowed' (3.06%), 'common-law' (15.48%), and 0.81% declined to provide a response.

Problem gambling severity index scores are used to measure gambling disorders (Ferris & Wynne, 2001). The problem gambling severity index is a nine-question scale used for measuring the severity of gambling problems in the general population. Scores vary from 0 to 27, and there are four classification categories based on that scale (Currie et al., 2013): non-gambler/non-problem gambler (0); low-risk gambler (1-4); moderate-risk gambler (5-7); and problem gambler (8-27).

Respondents were asked about their participation in casino and other forms of offline and online gambling. Gambling frequency variables were measured on a seven-point ordinal scale including: ‘never’ (never), ‘once a year’ (once yearly), ‘more than once a year but less than once a month’ (less than monthly), ‘more than once a month but less than once a week’ (monthly), ‘once a week’ (weekly), ‘most days’ (most days), and ‘everyday’ (everyday). Two variables for gambling involvement were computed, because these behaviors are believed to be implicated in gambling risk (LaPlante et al., 2014). The first was the highest frequency of non-casino gambling (depth), which ranged from 1 to 7 (M = 3.07, SD = 1.57). The second was the count of the number of gambling formats in which the individual participated (breadth), which ranged from 0 to 6 (M = 1.84, SD = 1.57). Other demographic variables were measured, including age, gender identity, income level, educational level, and marriage status, as these have been identified as risk factors among Canadian gamblers (Afifi et al., 2010). Summary statistics for variables used in the analysis are provided in Table 1.

Table 1: Summary Statistics

	Count	Mean	Std. dev.	Min.	Max.
Problem gambling severity index	6,277	1.81	3.94	0	27
Casino visit frequency	6,299	2.15	1.14	1	7
Travel time (hours)	6,262	1.24	2.90	.02	15.27
Travel time^2	6,262	9.93	42.16	.0005	233.04
Highest freq. non-casino (depth)	6,303	3.07	1.57	1	7
Count of gambling formats (breadth)	6,303	1.84	1.57	0	6
Log of years with casino	6,303	2.83	0.44	1.10	3.47
Age cat.	6,303	3.79	1.47	1	6
Gender cat.	6,303	1.52	0.50	1	3
Income cat.	6,303	4.46	2.01	1	8
Education cat.	6,303	3.89	1.66	1	8

Access convenience

Access convenience was estimated as the travel time between respondents’ homes and their nearest casino. Casino location and opening date information was obtained using data from the Alberta Gambling Research Institute (2018), provincial records (*Local Government Share of Provincial Casino and Community Gaming Centre Revenue*, 2018), and individual property searches. All locations were cross-validated in Google Earth (Gorelick et al., 2017). In total, there were 110 properties across Canada. Respondents were asked for the first three digits of their postal code, which is also known as the forward sortation area. Forward sortation areas are geographically contiguous areas containing an average of 8,000 households, but can include over 60,000 households depending on density (Graebner, 2018). Forward sortation areas were turned into geolocations by averaging the latitudes and longitudes of all six-digit postal codes in the area.

Euclidian distances were computed for every casino and forward sortation area, and travel times in hours by car to the nearest casino were then computed for each respondent that provided a forward sortation area, using the *georoute* module in Stata (Weber & Péclat, 2019). In Figure 2, we illustrate an example of geographic relationships appearing in this study, using a market with multiple casinos, the Vancouver metropolitan area (*ArcGIS Online*, 2020). In that market, casinos appear in many of the high-density population areas, and we illustrate that a large proportion of the population is within a ten minute drive of one or more casinos.

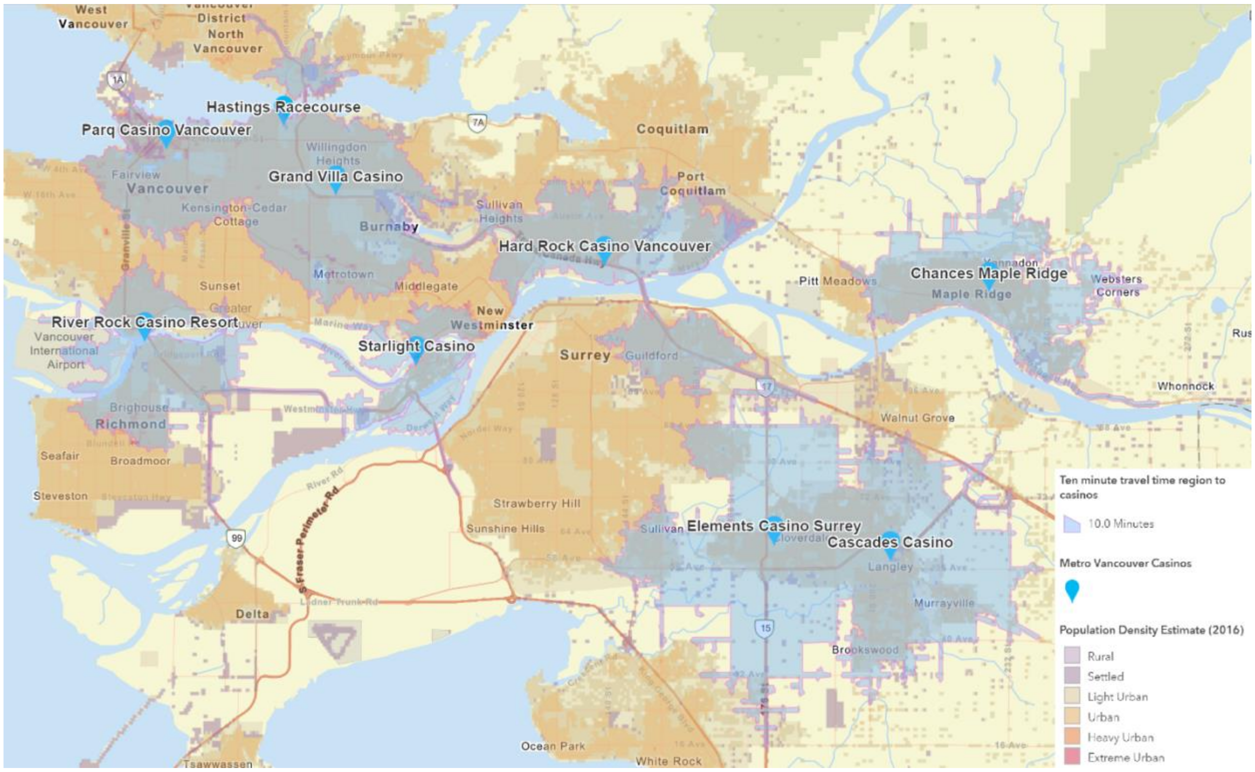

*Figure 2 – Sample illustration of geographic relationships appearing in this study: Metro Vancouver area casino locations, overlaid on population density plots and sub-ten minute travel time to casino regions by car (*ArcGIS Online*, 2020).*

The age of the nearest casino has also been proposed as a potentially important exposure variable (Shaffer et al., 2004), and therefore that value was computed and converted using the natural logarithm as a measure of the duration of exposure (log of years with casino). We model travel time using a quadratic functional form, which is consistent with prior models of retail demand conveying a negative first-order and positive second-order effect of distance on patronage (Barrow & Borges, 2014; Converse, 1950; Reilly, 1932).

RESULTS

Mediation model

We estimate standard errors using a bootstrap approach, but note that the use of bias-corrected confidence intervals do not change our findings (Hayes & Scharkow, 2013). We attempted 5,000 replications and all but nine converged. As shown in Figure 2, travel time has a statistically significant effect on casino visit frequency, with a negative first-order effect, β = -0.146, z = -7.18, $p < .001$, and a positive second-order effect, β = 0.006, z = 5.07, $p < .001$, supporting H_1. Casino visit frequency has a statistically significant effect on problem gambling severity index scores, β = 0.758, z = 13.20, $p < .001$, supporting H_2. The indirect effects of the linear, β = -0.111, z = -6.19, p<.001, and squared, β = 0.005, z = 4.62, p <.001, travel time terms are statistically significant, supporting H_3.

As a robustness check, we tested whether the non-linear travel time terms varied across a meaningful range. To do so, we calculated the marginal indirect effects of travel time, combining both linear and squared effects of travel time at the 25th percentile = 0.202 hours, and 75th percentile = 0.817 hours. At the 25th percentile, the marginal indirect effect of travel time was -0.109, p<0.001, and at the 75th percentile, the marginal indirect effect of travel time was -0.103, p<0.001, two similar results. These estimates suggest that within common travel times, the linear term tends to dominate effect sizes.

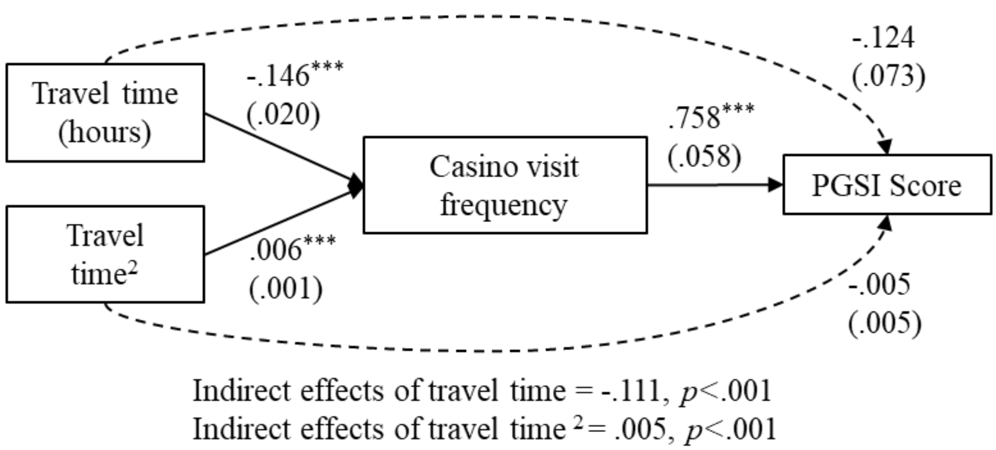

Figure 3 – Mediation model results. Bootstrap standard errors from 5,000 replication attempts and 4,991 replications shown in brackets; dotted lines indicate non-significant effects; PGSI = problem gambling severity index.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The significant indirect effect estimate in our model implies that frequency mediates the impact of access on problem gambling. Some authors would suggest that the absence of a direct effect is consistent with a fully mediated effect (Zhao et al., 2010), although others suggest that focus should remain on magnitude and significance of indirect effects (Rucker et al., 2011). In either case, our findings are consistent with our proposed mediation model. The related Hausman test following the process outline by Antonakis et al. (2010) required the exclusion of the demographic variables in order to enable the model estimator to converge, but despite that restriction, still supports the mediator as being exogenous: cov($u_{frequency}$, e_{pgsi}) = -.317, p=0.073). A Hausman test using a linear regression model and using all variables also supports exogeneity: $\chi^2(40) = 5.75$, p=1.000). Despite this empirical evidence, we relaxed the assumption of exogeneity in the next section as a robustness test.

Instrumental variable model

To provide a baseline understanding of effects, Table 2 first presents a series of ordinary least squares (OLS) models estimating the impacts of casino visit frequency on problem gambling severity index scores. Models 1-6 all show relatively stable effect sizes, estimating that a one unit increase in visit frequency along our 7-point scale is related to an average increase of 0.7 to 1.1 in problem gambling severity index score. As we noted, it is possible that these OLS effect sizes are endogenous, due to reverse causality or omitted variable bias. The estimated effects of other variables are as expected. Respondents' depth and breadth of gambling are both positively related to problem gambling severity index scores, with large effect sizes. For example, according to our estimate in Model 3, a person that participates in all six forms of gambling that compose our breadth variable would be projected to have a 3-point higher problem gambling severity index score on average than a person with no participation. The inclusion of demographic and province of residence control variables is indicated. Their addition causes our casino age variable to cease being statistically significant. As expected, our travel time variables (Models 4-6) were not statistically significant predictors of problem gambling severity index score.

Table 2: OLS models (Dependent variable: Problem gambling severity index score)

	(1)	(2)	(3)	(4)	(5)	(6)
Casino visit freq.	1.082***	0.714***	0.757***	1.107***	0.694***	0.758***
	(0.059)	(0.058)	(0.061)	(0.060)	(0.061)	(0.061)
Depth		0.330***	0.310***		0.331***	0.316***
		(0.043)	(0.043)		(0.043)	(0.043)
Breadth		0.497***	0.456***		0.516***	0.455***
		(0.050)	(0.052)		(0.052)	(0.053)
Log casino age		0.344***	0.193		0.385***	0.160
		(0.096)	(0.099)		(0.098)	(0.100)
Travel time (hours)				0.068	-0.013	-0.124
				(0.078)	(0.069)	(0.068)
Travel time^2				-0.002	-0.001	0.005
				(0.005)	(0.005)	(0.006)
Province	No	No	Yes	No	No	Yes
Sex	No	No	Yes	No	No	Yes
Age	No	No	Yes	No	No	Yes
Income	No	No	Yes	No	No	Yes
Education	No	No	Yes	No	No	Yes
Marital status	No	No	Yes	No	No	Yes
Observations	6,274	6,274	6,274	6,234	6,234	6,234
Adjusted R^2	0.098	0.176	0.207	0.099	0.177	0.207

Robust standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In Table 3, we provide reduced-form models using a 2SLS approach. Our instruments appear to be valid. Both travel time variables were significant in all three models, showing first and second order effects. The joint weak identification F-statistics are all above recommended values of 10 (Baum et al., 2018; Staiger & Stock, 1997) and also exceed the computed 10% maximal IV size (19.93) of weak instruments (Stock & Yogo, 2005). These results support H_1, suggesting frequency of casino play is positively related to convenience. Also, the Hansen-J tests support the use of our instruments, failing to reject their exclusion from the second-stage equation and further supporting the results of our Hausman tests (Baum et al., 2018; Hansen, 1982).

Importantly, the Hansen-J tests imply that casino proximity did not exert a direct effect on problem gambling severity index scores in our sample, but more likely influenced gambling risk indirectly, through frequency of visit. The estimate of the effect of casino visit frequency in our full model (3) was larger than the equivalent OLS model, but both support *H2.* The fully specified 2SLS model suggests a one unit increase in reported casino frequency was associated with a 1.6-point increase in problem gambling severity index score.

Table 3: Two-stage least squares models (First stage dependent variable: Casino visit frequency; second stage dependent variable: Problem gambling severity index score)

	Model 1		Model 2		Model 3	
	Casino Freq.	PGSI Score	Casino Freq.	PGSI Score	Casino Freq.	PGSI Score
Travel time (hours)	-0.238***		-0.241***		-0.146***	
	(0.028)		(0.022)		(0.022)	
Travel time^2	0.012***		0.011***		0.006***	
	(0.002)		(0.002)		(0.001)	
Casino visit freq.		0.598**		1.003***		1.620***
		(0.230)		(0.169)		(0.472)
Depth			-0.015	0.337***	-0.015	0.329***
			(0.011)	(0.044)	(0.011)	(0.045)
Breadth			0.308***	0.418***	0.312***	0.186
			(0.011)	(0.066)	(0.011)	(0.159)
Log casino age			0.037	0.350***	0.064*	0.105
			(0.034)	(0.097)	(0.031)	(0.109)
Province	No	No	No	No	Yes	Yes
Sex	No	No	No	No	Yes	Yes
Age	No	No	No	No	Yes	Yes
Income	No	No	No	No	Yes	Yes
Education	No	No	No	No	Yes	Yes
Marital status	No	No	No	No	Yes	Yes
Weak ID. (F-stat)		126.89		241.68		22.74
Hansen J-stat		0.81		1.10		0.00

Hansen J p-value		0.37		0.29		0.94
Adj. R-Squared		0.08		0.17		0.16
Observations	6,234	6,234	6,234	6,234	6,234	6,234

Robust standard errors in parentheses; PGSI = problem gambling severity index
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Although the models in Table 3 provide several diagnostic tests about the suitability of our instruments, they assume that the casino visit frequency variable is linear. In Table 4, we relaxed that assumption, and estimated an ordered probit model in the first stage. Ordered probit models fit onto regression models with ordinal dependent variables. Larger fitted values correspond to higher outcomes. The results were consistent with our other findings. Travel time decreased frequency of visits at a decreasing rate, and higher visit frequencies were associated with higher risk of a gambling disorder.[1]

Table 4: Linear regression model with ordered endogenous variable (First stage dependent variable: Casino visit frequency; second stage dependent variable: Problem gambling severity index score)

	Model 1		Model 2		Model 3	
	Casino Freq.	PGSI Score	Casino Freq.	PGSI Score	Casino Freq.	PGSI Score
Travel time (hours)	-0.253***		-0.285***		-0.186***	
	(0.033)		(0.031)		(0.028)	
Travel time^2	0.012***		0.013***		0.008***	
	(0.002)		(0.002)		(0.002)	
Casino visit freq. (Base: Never)						
Once yearly		0.479**		0.531***		0.347**
		(0.164)		(0.152)		(0.133)
Less than monthly		0.842***		1.114***		0.876***
		(0.228)		(0.220)		(0.177)
Monthly		3.418***		3.398***		2.985***
		(0.394)		(0.373)		(0.331)
Weekly		4.967***		5.030***		4.400***
		(0.620)		(0.599)		(0.565)

[1] We thank a reviewer for identifying that one of the PGSI questions is related to increased visitation and may produce some recursive results, "did you go back another day to try to in back the money you lost?" We re-estimated Table 4 without that question contributing to the PGSI score and produced similar results (not shown but available upon request).

Most days/Everyday		9.309***		9.291***		8.262***
		(1.419)		(1.362)		(1.320)
Depth			-0.014	0.282***	-0.012	0.265***
			(0.012)	(0.043)	(0.013)	(0.042)
Breadth			0.314***	0.433***	0.323***	0.435***
			(0.011)	(0.054)	(0.012)	(0.054)
Log casino age			0.023	0.333***	0.061	0.173
			(0.037)	(0.096)	(0.035)	(0.099)
Province	No	No	No	No	Yes	Yes
Sex	No	No	No	No	Yes	Yes
Age	No	No	No	No	Yes	Yes
Income	No	No	No	No	Yes	Yes
Education	No	No	No	No	Yes	Yes
Marital status	No	No	No	No	Yes	Yes
Observations	6,234	6,234	6,234	6,234	6,234	6,234

Robust standard errors in parentheses; PGSI = problem gambling severity index
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

To illustrate the risk from higher visitation, we plotted the marginal effects of travel time on visit frequency, and the influence of visit frequency on problem gambling severity index scores (see Figure 4). As predicted, increased travel time was related to reductions in frequency of play, while gambling disorder risk and standard errors increased with higher visitation. Risk increased more quickly above a monthly frequency. At a frequency of ‘most days/everyday’, estimated problem gambling severity index scores were roughly eight points higher than with no casino gambling. An eight point score is a meaningful difference, as it is sufficient to be classified as a ‘problem gambler’ on the index (Ferris & Wynne, 2001).

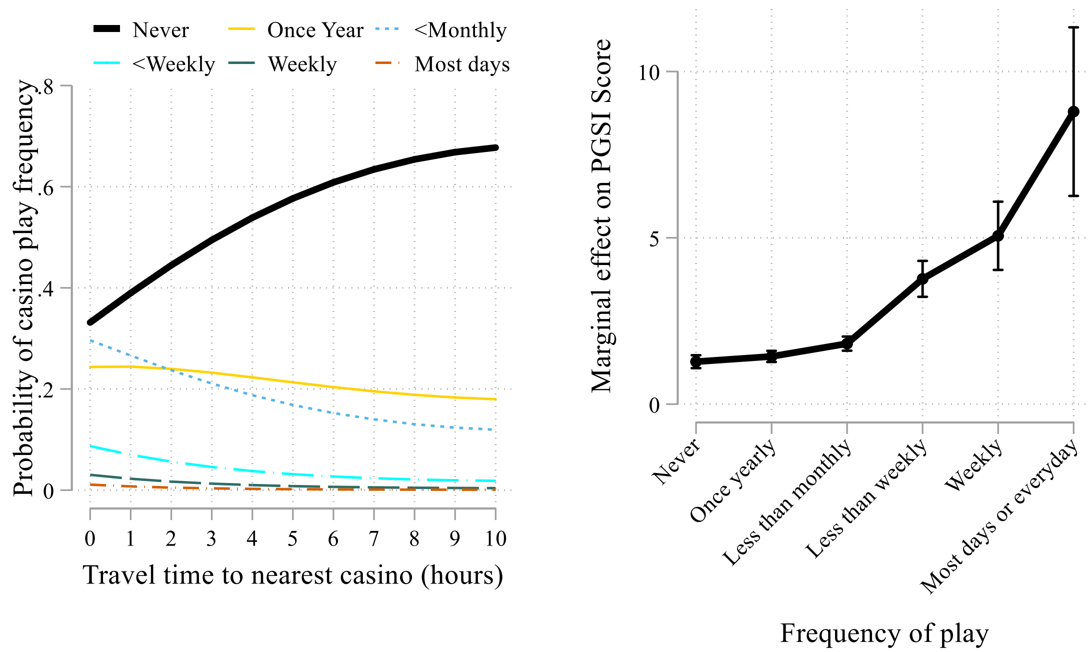

Figure 4 – Estimated impact of travel time on reported casino visit frequency category (left – "Probability of casino play frequency") and estimated impact of casino visit frequency on problem gambling severity index scores, with vertical bars indicating standard errors (right – "Marginal effect on PGSI Score"). Increases in travel time lead to a higher probability of reporting 'never' as a casino play frequency (left). Higher frequency of play leads to higher PGSI score estimates, with notable rises from 'less than monthly' to 'less than weekly' and 'weekly' to 'Most days or everyday'.

DISCUSSION

Casino gambling can make substantial contributions to regional economies by drawing in visitors, but negative perceptions of casinos are shaped by potential increases in local gambling problems (Eadington, 1998, 1999). Confounding these worthwhile debates is a set of empirical findings on the impact of increased access convenience on problem gambling, whose mixed results are generally unreliable due to methodological limitations. This study used a novel empirical approach to demonstrate reliable relations among casino proximity, casino gambling, and problem gambling risk levels, in a large data set from multiple Canadian jurisdictions. We observed that after controlling for other gambling behavior, demographics, and selection effects, risk of gambling problems increases for individuals who live closer to casinos. This increase in risk was mediated by frequency of visit, and the results further suggest that access convenience does not exert a direct effect on risk.

These findings provide substantially improved clarity to a policy area with frequent disagreement. Our identification strategy enabled us to provide a stronger argument of a link between high frequency casino gambling and risk of developing a gambling disorder. Because of the challenges posed by uncontrollable covariates, past efforts to establish such relations have been susceptible to statistical bias, and even natural experiments are vulnerable to bias due to the complexity of contributing environmental factors to gambling disorders. By examining responses from gamblers using an instrumental variable approach, we were able to estimate effects with less of a concern about confounding variables. Although we use a cross-sectional survey to collect respondent data, our variable of interest (travel time) is not identified through subjective survey responses, but rather location data that has had an impact that precedes our collected responses.

Noteworthy in interpreting these findings is that gambling disorder prevalence rates in Canada fell between 2002 and 2014, despite the expansion of casino gambling locations (Philander, 2019). Accordingly, there is reason to believe that prevention and adaptation strategies by individuals and organizations, were effective at reducing population-level prevalence of gambling addiction. Casinos may increase risk to nearby residents, but individual, public, or industrial mitigation strategies to reduce disorder prevalence may have had a greater aggregate effect. Our observation that risk rises more sharply above monthly frequencies of play may assist managers and public health advocates in targeting interventions that can reduce the probability of developing a gambling disorder by focusing interventions on higher frequency players. For example, many casinos have introduced entry fees for local residents (Philander, 2017), and the schedule of payments for entrance can be tiered around frequency levels noted to be related to higher risks.

More broadly, our findings provide an empirical basis for considering alternative location policies in the placement of casinos. Placing casinos in "tourism zones" that have relatively few nearby residents may be optimal, depending on policymaker goals. Where residents are impacted, regional exposure effects should be weighed against positive social outcomes (e.g. jobs and development) and policymakers should consider interventions that can mitigate harms from excessive consumption. For instance, strategies such as in-venue responsible gambling messaging, limit setting features, and employee interventions have all shown some merits in reducing harms (Ladouceur et al., 2017; Tanner et al., 2017).

Limitations and Future Work

The current research examined a large sample of individuals who gambled, and all were residents of the same country. The findings may not be generalizable to other cultures, and the findings do not provide intuition about how non-gamblers may convert to casino gambling. Similar work in other regions and with other goods would add to our broader understanding of access convenience and public health risks. Future work should also consider the policy implications of our findings more thoroughly. For example, research examining how to manage risks by developing interventions that reduce access convenience for high frequency groups, or research that assesses differentiated impacts to specific demographic groups.

There is ongoing opportunity to explore with greater detail how access convenience is implicated in local risk. For example, it remains unclear if population-wide adaptation is related to spontaneous recovery by individuals, or whether specific policies and programs meaningfully contribute to protection efforts. Like many jurisdictions, regulated Canadian casino, lottery, and online operators spend between 0.4% and 1.6% of their gross revenue from gambling on responsible gambling programs (Canadian Partnership For Responsible Gambling & Responsible Gambling Council, 2018), but it is unknown how this leads to adaptive effects, if at all (Ladouceur et al., 2017).

There may be proximity related effects that are unrelated to access convenience. For instance, increased saliency of the gambling product may occur if the casino venue is in the individual's neighbourhood, which may prompt increase visitation that is not directly related to ease of travel. Future studies could accommodate these effects with instruments that capture salience-related interventions, such as mail advertisements that are sent to specific postal codes.

Conclusion

Our findings about the mechanism implicated in problem gambling risk provide clarity to an area of the literature that has received substantial debate, and that has important policy implications for casino stakeholders. Casinos can have substantial positive impacts on local economies by way of tourism, but as managers, policymakers, and other stakeholders consider access in their communities, they should examine how residents' travel times will change, particularly among those that may have other risk-factors. To offset potential harms from increases in gambling frequency, policymakers should consider interventions, including prevention and treatment programs, if casinos are placed in close proximity to their constituents.

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