Addiction
RESEARCH REPORT
doi:10.1111/add.12595

Gambling expenditure predicts harm: evidence from a venue-level study

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ABSTRACT

Background and Aims The Total Consumption Theory of gambling suggests that gambling expenditure is positively associated with gambling-related harm. We test the hypothesis that electronic gaming machine (EGM) expenditure predicts gambling-related harm at the level of the EGM venue. **Design** Cross-sectional analysis of survey and administrative data. **Setting** General urban adult population of the Northern Territory of Australia. **Participants** The sample consisted of 7049 respondents to a mail-survey about venue visitation and gambling behaviour across 62 EGM venues. **Measurements** Gambling-related harm was defined as the endorsement of two or more items on the Problem Gambling Severity Index. We obtained venue-level EGM expenditure data from the local licensing authority for all venues in the study area. We compared the prevalence of gambling-related harm among patrons aggregated at the venue level with the estimated mean EGM expenditure for each adult resident in the venue's service area using a Huff model, correlation analysis and multivariate binomial regression. **Findings** Aggregated to the venue level ($n = 62$), per-capita EGM expenditure was correlated significantly with rates of gambling-related harm ($r = 0.27$, $n = 62$, $P = 0.03$). After adjusting for venue type and number of EGMs, an increase in mean per-capita monthly EGM expenditure from $AU10 to $AU150 was associated with a doubling in the prevalence of gambling-related harm from 9% (95% CI = 6–12%) to 18% (95% CI = 13–23%). **Conclusions** As suggested by the Total Consumption Theory of gambling, aggregate patron electronic gaming machine expenditure predicts the prevalence of gambling-related harm at the venue level.

Keywords Electronic gaming machines, gambling expenditure, gambling-related harm, slot machines, Total Consumption Theory, gambling venues.

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Submitted 17 January 2014; initial review completed 5 March 2014; final version accepted 20 April 2014

INTRODUCTION

Estimates of gambling-related harm, particularly via problem gambling prevalence surveys, are costly and time-consuming to produce. Prevalence surveys, because they are based on self-reported behaviour, also tend to underestimate both gambling expenditure [1,2] and rates of problem gambling [1,3]. Furthermore, prevalence studies tend to adopt different methods, making comparisons problematic even within the same jurisdiction over time [4]. They also tend to be of insufficient statistical power to detect small changes over time or to investigate the spatial distribution of harms across small areas [5].

In contrast, detailed gambling expenditure data at the venue level are collected routinely in all developed countries that levy gambling-specific taxes. For example, the Victorian Government, Australia, publically release data on all gambling venues within the state, including annual electronic gaming machine (EGM) expenditure, venue location and administrative classification [6]. These administrative data provide an accurate, complete and consistent longitudinal measure of commercial gambling behaviour at the venue level.

However, in the absence of a demonstrated link between gambling expenditure and the prevalence of gambling-related harm, researchers and regulators have been unable to draw inferences about the distribution of

harm using gambling expenditure data. If a definite relationship between expenditure and harm can be established, the extant expenditure data may potentially be used to estimate changes in gambling-related harm over time, and at a fine geographical scale, without the need for expensive and ultimately unreliable prevalence studies.

Literature review

The Total Consumption Theory of gambling, borrowed from the single distribution theory of alcohol studies [7,8], implies that the number of people experiencing severe gambling-related harm is correlated with the mean population consumption of gambling [9,10]. At the individual venue level, this suggests that the proportion of patrons experiencing severe gambling-related harm is correlated with aggregate gambling expenditure. Similarly, venues with relatively high levels of gambling expenditure per patron will also have relatively high levels of harm. If this proposition is correct, researchers and regulators alike may be justified in using measures of gambling expenditure as a proxy for gambling-related harm within gambling venues.

Most studies examining gambling harm and expenditure have focused most frequently on the individual as the unit of analysis. For example, a nationally representative study of Canadian adults that specifically examined the relationship between expenditure and harm found gambling expenditure to be a strong predictor of harm [11]. Unsurprisingly, significant relationships between problem or pathological gambling and gambling expenditure are also found consistently in nationally representative surveys, for example in the United States, Great Britain, Australia and Sweden [1,12–14].

These correlations at the level of the individual aside, Total Consumption Theory is more concerned with the behaviour of populations. At the regional scale of analysis, a case study of the introduction of the UK national lottery found the mean level of gambling expenditure to be correlated with the number of households spending an excessive proportion of their income on gambling [10]. Williams & Wood used secondary data collected in eight Canadian provinces to estimate that problem gamblers (4.2% of the population) accounted for 23.1% of total gambling expenditure [15]. Similarly, Livingstone & Woolley presented data demonstrating that the within-session expenditure of problem gamblers in Victoria was three times that of non-problem gamblers [16]. Hansen & Rossow, in a study of 11 637 adolescents across 73 Norwegian schools, found that the school-level prevalence of problem gambling was associated with the mean gambling expenditure among students [17]. Room *et al.* found that both the mean level of gambling expenditure and the prevalence of gambling problems increased in the local community after the opening of a casino at Niagara Falls [18].

With the jurisdiction as the unit of analysis, the Australian Productivity Commission compared rates of problem gambling with EGM expenditure and demonstrated a positive correlation between EGM expenditure and rates of problem gambling in eight Australian states and territories [1]. Similarly, a meta-analysis of 34 problem gambling surveys conducted in Australia and New Zealand since 1991 found a strong, positive relationship between problem gambling prevalence and the per-capita density of EGMs, although expenditure was not examined specifically in this analysis [19].

However, a number of studies have failed to produce clear evidence of a correlation between gambling expenditure and gambling-related harm. As noted by Abbott [20], the results of a large, national general population survey in the United States were not consistent with the hypothesized relationship between expenditure and gambling harm at the regional level [12]. Similarly, in several countries, most notably New Zealand, population problem gambling prevalence as estimated by successive surveys has not risen, while aggregate gambling expenditure over the same period has increased substantially [20].

No study to date has explicitly examined the relationship between gambling expenditure and the prevalence of gambling-related harm at the venue level. There are two reasons why the gambling venue level is a particularly important scale for the analysis of gambling-related harm. First, as the site at which most gambling actually occurs in developed countries, regulated gambling venues provide arguably the most important location at which harm minimization interventions can be targeted. Levels of harm among patrons vary between venues [21,22], suggesting that venue-specific factors may play a substantial role in mediating the riskiness of gambling. Secondly, an emerging body of literature has documented a relationship between heightened problem gambling risk and residential distance to gambling venues at the level of the individual gambler [23–25]. However, the causal mechanism which generates an association between proximity to gambling venues and gambling-related harm remains unclear.

If a link can be established between gambling expenditure and gambling-related harm at the venue level, it may advance our understanding of the spatial patterning of gambling-related harm. This study is the first to test the hypothesis that EGM expenditure is correlated with gambling-related harm at the venue level. Furthermore, it describes the strength of that relationship in order to gauge the potential use of per-capita EGM expenditure as a predictor of gambling-related harm.

METHODS

Data

To investigate the relationship between gambling expenditure and the prevalence of gambling-related harm at the EGM venue level, three independent sets of data are required: (i) estimates of the prevalence of gambling-related harm among patrons of individual venues, (ii) venue-specific EGM expenditure data and (iii) estimates of the number of adults in the service area of each venue, to use as the denominator for estimating per-capita EGM expenditure.

Gambling-related harm

We obtained venue-level estimates of gambling-related harm by conducting a postal survey. Using the Australian geocoded national address file (G-NAF) [26] as a sample frame, we mailed a questionnaire to all 46 263 households in the urban centres of the Northern Territory to which Australia Post would deliver unsolicited mail and which were zoned residential. To extend our spatial coverage, we selected 2300 addresses across the peri-urban fringes of the two largest urban centres (to which Australia Post does not deliver mail) for hand delivery of questionnaires. The questionnaires were mailed out once to each address between April and August 2010 and hand-delivered in July and September 2010. Any household member aged 18 years or older was eligible to respond, and return of the survey implied consent. The Human Research Ethics Committee of Charles Darwin University granted approval to conduct the study (protocol no. H09048).

To mitigate survey non-response bias we weighted responses using post-stratification. We used raking to estimate weights across the follow strata: gender, age bracket (18–29, 30–44, 45–64, ≥65 years), town and delivery method (postal or hand delivery). We derived strata populations from the profiles of those who were present in the study area on census night during the 2011 Census of Population and Housing.

The questionnaire elicited information about which gambling venues the respondent had visited in the last month. Respondents selected their most frequently visited venue from a list of all EGM venues in, or proximate to, their town of residence. Participants were asked to report whether they participated in EGM gambling on their last visit to this venue and to complete the Problem Gambling Severity Index (PGSI) [27] for the last 12 months. Following Currie *et al*. [11], we coded those respondents who endorsed two of the nine questions in the PGSI as 'sometimes', 'most of the time' or 'almost always' as experiencing gambling-related harm (note that a subsequent analysis of the same data set using the more conventional categorization of those scoring 8 or more on the PGSI as the outcome variable yielded similar results in terms of significance, but with a larger estimated coefficient for per adult expenditure). The Currie *et al*. measure of gambling harm was selected in order to capture 'gambling-related harm' more accurately, which is conceptually broader than the pathological gambling construct upon which the conventional PGSI 8+ threshold is based [11].

We estimated the prevalence of gambling-related harm for each venue in the study by allocating individual respondents to the venue they had visited most frequently in the previous month. Respondents who did not visit a venue in the last month or who did not complete the PGSI ($n = 2102$) were excluded from the analysis.

EGM expenditure

We obtained EGM expenditure data for each venue in the study from the state regulatory authority, the NT Department of Justice. This data set contained nominal monthly EGM expenditure, the number of EGMs operational at the end of each month, the street address and the licensing category (i.e. hotel, club or casino) for each venue in the study. Rather than directly use monthly figures for expenditure and operational EGMs, we adjusted the expenditure series for inflation into September 2010 Australian dollars ($AU) and calculated the mean for both of these series over the period of the survey (April–September 2010).

Estimated service-area adult population

We estimated the service-area population of each gambling venue using the Huff model, a probabilistic method for calculating trading areas and their populations [28]. We parameterized the Huff model using coefficients derived from a previous analysis of EGM gamblers' visitation patterns based on the postal survey [29]. We used G-NAF dwellings as origin points, weighted according to the adult (aged 18+) population distribution at the Statistical Area 1 level, as counted in the 2011 census. To capture EGM use by non-residents, we used the place of enumeration census data set, which counts the number of people who were present in a location on census night, as our weighting datum. The study area was defined as all dwellings within 40 km of venues in the study, on the basis that journeys of 40 km or more are generally categorized as irregular rather than commuter trips in Australia [30]. The Huff model used took the following form:

$$servicePop_i = \sum_j 0.95 \cdot o_j^{1.01} \cdot \frac{a_i \cdot d_{ij}^{-1.18}}{\sum_i [a_i \cdot d_{ij}^{-1.18}]}$$

where $servicePop_i$ is the census-night population of the service area of venue i, o_j is the estimated population of

Table 1 Selected medians for gambling venues in the study. Median absolute deviations are reported in parentheses.

	Hotels (n = 35)	*Clubs (n = 25)*	*Casinos (n = 2)*
Respondents per venue (unweighted)	28 (25)	62 (65)	533 (406)
Respondents per venue (population weighted)	500 (507)	968 (1085)	7803 (5910)
Number of EGMs	10 (0)	22 (18)	531 (354)
Monthly EGM expenditure in AUD	43 253 (23 526)	62 799 (87 370)	3 581 380 (2 557 500)
Harm rate[a]	8.3% (4.7%)	14.6% (5.6%)	19.6% (3.5%)
Service population	444 (78)	1884 (1677)	30 812 (26 824)
Monthly EGM expenditure per adult	96 (31)	40 (34)	127 (28)

As most variables are not normally distributed, medians and median absolute deviations are reported instead of means and standard deviations. [a]The harm rate is the weighted mean of the harm rates of all venues. The weightings were derived from the post-stratification estimates of the number of people in the sample frame who visit that venue most frequently. AUD = Australian dollars; EGM = electronic gaming machine.

dwelling j, d_{ij} is the Euclidian distance between dwelling j and venue i, and a_i is an index of the relative attractiveness of venue i, defined as:

$$a_i = numEGMs_i^{1.17} \cdot isCasino_i^{-0.23} \cdot isClub_i^{0.12} \cdot \ln supermarketDist_i^{-0.31} \cdot \ln gpoDist_i^{0.26} \cdot ocean_i^{0.2} \cdot innerCity_i^{-0.18}$$

For details regarding these measures, the derivation of their weightings, and more information regarding the service-area model for gambling, see Markham *et al.* [29].

Descriptive statistics for EGM venues are reported in Table 1.

Statistical analysis

We first calculated the Pearson's product–moment correlation between per-capita EGM expenditure and the prevalence of gambling-related harm, weighted by the number of responses per venue. We then calculated the association between per-capita EGM expenditure and the prevalence of gambling-related harm using a binomial rate regression, an extension of the logistic regression model which analyses the result of multiple Bernoulli trials for each unit (in this case, EGM venues) as the outcome variable. Binomial rate regression was selected as it weights each venue in the analysis according to the number of post-stratification weighted responses, thereby ameliorating the small number problem where rates of gambling-related harm in venues with few survey responses have a much greater variance than those with many responses. As we suspected non-constant variance in regression residuals, we calculated all reported standard errors and confidence intervals (CI) using MacKinnon & White's heteroskedasticity-correcting estimator [31]. We calculated the predictor variable of interest, per-capita EGM expenditure, by dividing EGM expenditure by the estimated adult service population for each venue. We included other licensing variables, such as venue type (i.e. hotel, club or casino) and the number of operational EGMs, as covariates as previous studies have shown these to be associated with rates of gambling-related harm [21]. All statistical analyses were determined prior to commencing analysis except for post-stratification weighting, which was conducted following the suggestion of an anonymous reviewer.

Table 2 Demographic composition of sample.

	Sample	*Population*
Sex		
Female	4300 (62%)	54 351 (50%)
Male	2652 (38%)	54 476 (50%)
Age (years)		
18–2	656 (10%)	26 656 (24%)
30–44	1914 (28%)	33 852 (31%)
45–64	3304 (48%)	36 767 (34%)
65 or older	971 (14%)	11 552 (11%)
Education level		
School	2409 (34%)	34 826 (40%)
Tech	1298 (19%)	29 438 (33%)
University	3301 (47%)	23 629 (27%)
Employment status		
Self-employed	582 (8%)	8,171 (9%)
Employee	4827 (69%)	62 441 (66%)
Not in labour force	1294 (19%)	20 966 (22%)
Unemployed	273 (4%)	2 413 (3%)

RESULTS

We received 7049 completed questionnaires, constituting a response rate of 14.5%. As Table 2 demonstrates, respondents were older (Wilcoxon's rank sum test: $W = 53976961$, $P < 0.001$), more likely to be female ($\chi^2 = 370.4$, d.f. = 1, $P < 0.001$) and better educated ($\chi^2 = 1429.8$, d.f. = 2, $P < 0.001$) than the general population (see Table 2).

Monthly EGM expenditure per capita and the prevalence of gambling-related harm were correlated

significantly at the venue level ($r = 0.27$, $n = 62$, $P = 0.03$) in a bivariate comparison. After fitting the multivariate binomial regression model that controls for the number of EGMs in the venue and the licensing category of the venue (i.e. hotel, club or casino), there was still strong evidence for this correlation (see Table 3), a result strengthened by changes to the venue weighting scheme (see Supporting information, Table S1).

The prevalence of gambling-related harm at a club with the median 22 EGMs is estimated to increase from 9% (95% CI = 6–12%) to 18% (95% CI = 13–23%), as the monthly EGM expenditure per adult rises from $AU10 to $AU150 (see Fig. 1). In other words, within this range of expenditure (which includes 89% of the venues in the study and 92% of the respondents who visited a venue), each $AU20 increase in monthly EGM expenditure per adult is associated with an estimated average 1.7% increase in the prevalence of gambling harm. Compared to a null model, approximately 25% of the deviance in the rates of gambling-related harm among patrons was explained by the multivariate binomial regression model. The mean respondent-weighted absolute value of venue residuals was 4.6% [standard deviation (SD) = 4.0%].

Table 3 Predictors of the prevalence of gambling-harm in electronic gaming machine (EGM) venues.

	Coefficient estimate (95% confidence interval)	*P-value*
Intercept	−3.15 (−3.98, −2.32)	<0.0001
Monthly expenditure per adult, 100s AUD	0.58 (0.10, 1.05)	0.0172
Venue type		
Casino	0.00 (ref. group)	
Club	0.74 (0.28, 1.20)	0.0016
Hotel	0.33 (−0.09, 0.74)	0.1287
Number of EGMs, 10s	0.01 (0.01, 0.02)	<0.0001

$n = 62$. Deviance explained = 25%. Coefficients are expressed on the logit scale. *P*-values and confidence intervals have been corrected for heteroskedasticity. Venues were weighted by the population-weighted number of respondents who visited that venue most frequently. There was no interaction between the number of EGMs and venue type fitted in this model. AUD = Australian dollars.

DISCUSSION

The level of gambling-related harm varied substantially among venues, both between venues of different types (i.e. hotels, clubs and casinos) and within those categories. The prevalence of gambling-related harm at the venue level is correlated significantly with estimated monthly EGM expenditure per adult in both bivariate linear and multivariate binomial models. Holding all other variables constant, for a typical venue in our study area, each $AU20 increase in monthly EGM expenditure per adult is associated with an estimated 1.7% increase in the prevalence of gambling harm for a club with 22 EGMs.

These data are consistent with the hypothesis that EGM expenditure predicts the rate of gambling-related harm. While this is the first study of its kind, and thus replication in other geographic contexts is needed, we cautiously suggest that the use of per-capita EGM expenditure as a proxy for gambling-related harm may be justified. Furthermore, our findings are consistent with the prediction of the Total Consumption Theory, lending further support to its application in the domain of gambling.

We expect that the finding of a significant relationship between EGM expenditure and the prevalence of gambling-related harm at EGM venues is generalizable to other settings (and to other modes of gambling), wherever those experiencing gambling-related harm account for a substantial proportion of aggregate gambling expenditure. However, the precise magnitude of the relationship between expenditure and rates of harm is likely to vary between jurisdictions (and within the same

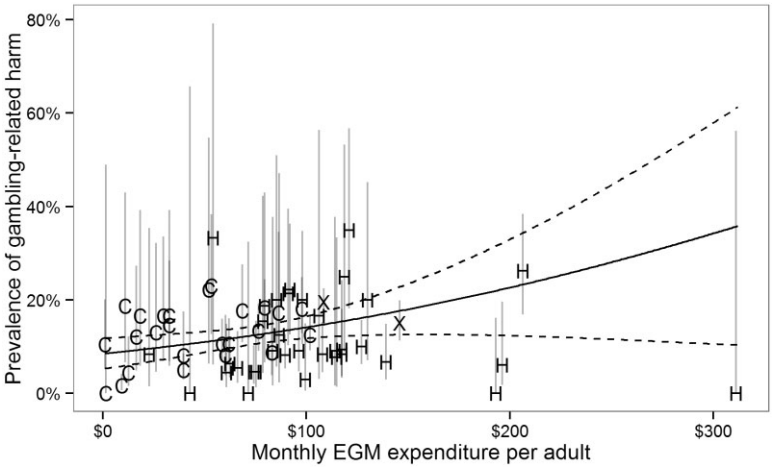

Figure 1 Predicted prevalence of gambling-related harm for a hypothetical club with the median number of electronic gaming machines (EGMs) (22). The solid black line shows the fitted regression line, and the dashed black lines outline the 95% confidence intervals. Points indicate actual venues in the study. Symbols X, C and H indicate venues of type casino, club and hotel, respectively. The intersecting vertical grey lines showing the 95% confidence interval for the prevalence of gambling-related harm at that venue, calculated using Wilson's method. Wilson's confidence intervals are asymmetric except when $P = 0.5$

jurisdiction over time) due to environmental, regulatory and social differences. Therefore, direct calculation of the proportion of EGM gamblers experiencing harm made from the coefficients estimated in this study should be undertaken with caution.

Although this cross-sectional study does not demonstrate a causal relationship between gambling expenditure and gambling-related harm, the correlation between EGM expenditure and gambling related-harm is important. We are not advancing a simplistic single-causal model in which visiting high expenditure venues causes disordered gambling pathology (although we do not rule out this possibility). Instead, we suggest that excessive gambling expenditure is conceptually and empirically inseparable from gambling-related harm because expenditure of money is the proximate source of many of the negative consequences associated with harmful gambling. Therefore, the money lost at EGM venues constitutes a harm in itself for some gamblers, and this is detectable in aggregate gambling expenditure data.

Limitations

The relatively low response rate threatens internal validity in two ways. First, the sample composition is older, better educated and more likely to be female than the general population, meaning that the findings may be specific to this particular population subgroup. However, previous studies [10,17] and the Total Consumption Theory of gambling suggest that the relationship between gambling expenditure and gambling harm should be present in all population subgroups, even if harm rates vary among these groups. If this is the case, then the relationship between expenditure and harm should be robust to response bias. To investigate this proposition we re-analysed our data on seven large subpopulations of respondents, and found little evidence to suggest the absence of a relationship between expenditure and harm in a population subgroup (see Supporting information, Fig. S1 and Table S2). Therefore, we suggest that the substantive result of an association between expenditure and harm is not invalidated by this study's low response rate.

Secondly, the use of a mail survey and the recruitment method whereby any household member was eligible to reply to the questionnaire are all likely to skew the sample in favour of gamblers when compared to a telephone survey [3]. This selection bias is likely to increase the estimated rates of gambling-related harm, because gambling participation is the most important predictor of gambling-related harm. Indeed, our estimate of the rate of PGSI 8+ problem gambling in this study is several times that found in the last state-wide prevalence telephone survey in the same jurisdiction [32]. As such, our coefficient estimates for the association between expenditure and harm rates are probably biased upwards. Nevertheless, our finding of a strong positive relationship between expenditure and harm at the venue level is still likely to be valid unless selection bias affects venues differentially. This means that relative harm rates of gambling venues estimated on the basis of expenditure are unlikely to be affected by bias.

There are several other possible sources of non-sampling error. First, our measures of service populations are estimates only. Secondly, the populations served by venues are likely to differ non-randomly in terms of household income. It is reasonable to expect that lower-income individuals will tend to experience gambling-related harms at lower levels of expenditure, thus biasing the magnitude of the estimated relationship downwards. Thirdly, although this study included a venue with an estimated monthly EGM expenditure per adult of more than $AU300, 98% of respondents who visited venues estimated expenditure of less than $AU150. Three of the four outlier venues are located in the extreme peri-urban fringe of Darwin, suggesting that gambling behaviour may differ in the peri-urban hinterlands or that the Huff model may be underestimating the service-area populations of peri-urban venues. Consequently, the shape of the expenditure/harm curve when expenditure levels are exceeds $AU150 is open to question. While exploratory modelling suggests that a slight lessening of the expenditure–harm relationship may exist above $AU150 (see Supporting information, Fig. S2), further data collection is required to test this. Finally, visitors in non-residential accommodation are likely to be under-represented in the study and may have different venue choice behaviour, decreasing the precision of parameter estimates.

CONCLUSIONS

Our finding of a measurable correlation between gambling-related harm and EGM expenditure, as predicted by Total Consumption Theory, has the potential to reduce the data collection required to research and regulate EGM gambling within a jurisdiction. These resources could be redirected usefully to other research or harm minimization initiatives. If replication studies in other jurisdictions confirm our finding, we see little reason for those seeking to investigate the spatial patterning of gambling-related harm to continue to collect survey data on this topic. Rather, studies in this domain may reasonably rely on per-capita gambling expenditure estimates, and research effort currently employed to describe aggregate gambler behaviour could be re-deployed in an effort to explain the patterns we see in gambling expenditure data.

Declaration of interests

None of the authors have any connection with the gambling industry, nor have any of the authors ever received funds for any purpose from the gambling industry.

Acknowledgements

The first author was supported by an Australian Postgraduate Award. Data collection was funded by the Community Benefit Fund of the Northern Territory Government and the Australian Research Council Project LP0990584. We thank the Northern Territory Department of Justice for the provision of EGM expenditure data.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Figure S1 Coefficient estimates (on the logit scale) and heteroskedasticity corrected 95% confidence intervals for the association between mean monthly electronic gaming machine (EGM) expenditure per adult and rates of gambling-related harm among important subpopulations in our study. Coefficients were estimated by multivariate binomial regression. For the details of the full models, see Supporting information, Table S2

Figure S2 Predicted prevalence of gambling-related harm for a hypothetical club with the median number of electronic gaming machines (EGMs) (22), estimated using a semi-parametric spline in a generalized additive model. The solid black line shows the fitted regression line, and the dashed black lines outline the 95% confidence intervals. Points indicate actual venues in the study. Symbols X, C and H indicate venues of type casino, club and hotel, respectively. The intersecting vertical grey lines showing the 95% confidence interval for the prevalence of gambling-related harm at that venue, calculated using Wilson's method. Wilson's confidence intervals are asymmetric except when $P = 0.5$

Table S1 Predictors of the prevalence of gambling-harm in electronic gaming machine (EGM) venues, weighted by raw respondent count and weighted by EGM count.

Table S2 Predictors of the prevalence of gambling-harm in electronic gaming machine (EGM) venues for population subgroups.