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FULL-LENGTH REPORT

Unambiguous evidence that over half of gambling problems in Australia are caused by electronic gambling machines: Results from a large-scale composite population study

MATTHEW BROWNE[1]*, PAUL DELFABBRO[2], HANNAH B. THORNE[1], CATHERINE TULLOCH[1], MATTHEW J. ROCKLOFF[1], NERILEE HING[1], NICKI A DOWLING[3] and MATTHEW STEVENS[4]

[1] Experimental Gambling Research Laboratory, School of Human, Medical, and Applied Sciences, CQUniversity, Bundaberg, Australia

[2] School of Psychology, University of Adelaide, Adelaide, Australia

[3] School of Psychology, Deakin University, Geelong, Australia

[4] STRS Consultants, Australia

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ABSTRACT

Background and aims: It is well understood that engagement with some forms of gambling, like EGMs, is riskier than other forms. However, while reports of associations are common, few studies have attempted to evaluate and compare the relative risk of all available forms, and none have estimated the relative contribution of each form to the total burden of gambling problems (GP) in a population. *Methods:* Using an aggregated dataset of national and state-based prevalence studies in Australia ($N = 71{,}103$), we estimated prevalence and unique effects of frequency of engagement on each form on GP. Two alternative numerical methods were then applied to infer the relative contribution of each form to the total amount of GP. *Results:* EGMs are responsible for 51%–57% of gambling problems in Australia, and 90% of gambling problems are attributable to EGMs, casino, race, and sports betting. Casino table games and EGMs are equally risky at the individual level, but the former contribute far less to problems due to low participation. Bingo and lottery play show no statistically detectable risk for GP. *Discussion and conclusion:* The results illustrate which forms present the greatest population burden and illuminate the reasons why. EGMs have an outsized impact. EGM uniquely combines high risk conditional on play, with a high participation rate and a high frequency of play among participants. This is in contrast to risky but less commonly played casino games, and prevalent but non-risky forms like lotteries. We conclude that EGM regulation should be a primary focus of policy action in Australia. More innovative policy ideas relating to EGMs should be tested due to the disproportionate impact of this product type.

KEYWORDS

gambling, gambling problems, gambling harm, electronic gaming machines, gambling policy, harm minimisation

*Corresponding author.
University Drive, Bundaberg, QLD 4670, Australia.
E-mail: m.browne@cqu.edu.au

INTRODUCTION

Gambling takes many forms in Australia, including lottery tickets, sports betting, and electronic gambling machines (EGMs). With the partial exception of Western Australia, liberalisation of gambling opportunities since the 1990s has occurred relatively homogeneously across the country, with opportunities to gamble becoming ubiquitous and pervasive.

Gambling has been privatised in Australia and many forms, such as EGMs, Keno, and sports and race betting, are available at pubs, clubs, and hotels (Markham & Young, 2015). Online race and sports betting through registered operators is also legal in Australia (ACMA [Australian Communications and Media Authority], 2022). Partially due to these factors, Australia has a far higher annual per capita gambling expenditure than any other nation, averaging AUD$1,277 per adult (QGSO [Queensland Government Statistician's Office], 2021). However, gambling participation, frequency and expenditure per player vary widely. The highest participation rates, i.e., past-year participation, are for lotteries (42%), race betting (17%), EGMs (16%), and instant scratch tickets (16%) (Hing et al., 2021). Although draw-based lotteries are the most commonly played activity on a weekly basis, they represent only a small proportion of the overall net revenue earned from gambling (QGSO, 2021). By far the greatest expenditure is on EGMs, which alone accounts for 51% of total gambling revenue (QGSO, 2021). The relative contribution of each of the gambling forms to the population burden of gambling problems is of key policy interest. However, it is not straight-forward to infer this contribution from simple prevalence or average expenditure (Markham, Young, & Doran, 2014).

Although most gamblers play relatively rarely, frequent engagement with some products, such as EGMs, is known to increase the risk of harm. These harms can include financial distress (Sundqvist & Wennberg, 2022; Swanton & Gainsbury, 2020), self-harm (Gray, Edson, Nelson, Grossman, & LaPlante, 2021), and suicidality (Andreeva, Audette-Chapdelaine, & Brodeur, 2022; Wardle & McManus, 2021). Harm occurs when people spend excessive time and money gambling which is why harmful gambling is recognised as a behavioural condition associated with repetitive behaviour, impaired control, pre-occupation, and chasing losses (Browne & Rockloff, 2020; Neal, Delfabbro, & O'Neil, 2005). The core element of all gambling forms is the same: "stacking money or something of material value on an event having an uncertain outcome in the hope of winning additional money and/or material goods" (Williams, Volberg, Stevens, Williams, & Arthur, 2017, p. 11), although 'wagering' activities are generally distinguished from more mathematically prescribed gaming activities such as lottery products, slots and most casino games.

Importance of structural and situational characteristics

Structural and situational differences between forms of gambling contribute to differences in the risk of problems developing (Parke, Parke, & Blaszczynski, 2016). For example, forms of gambling characterised by high event frequency and continuous play are thought to promote gambling problems (Blanco et al., 2013; Dowling, Smith, & Thomas, 2005; Livingstone & Woolley, 2008). This fast bet speed contrasts with other forms of gambling, such as lotteries, in which the outcome of a bet may not be known for days or weeks. More generally, electronic games, including electronic versions of casino table games, also provide for the implementation of a myriad of structural features that can promote a sense of 'flow' that increases the dopaminergic response and promotes excessive time and spend on the device. These features include tokenisation, jackpots, a mix of large and small payoffs (often implemented through occasional free-spins or bonus games), and audiovisual feedback (Delfabbro, Falzon, & Imgram, 2005; Donaldson, Langham, Rockloff, & Browne, 2016; Dowling et al., 2005; Goodwin, Thorne, Langham, & Moskovsky, 2017; Landon et al., 2018; Li, Rockloff, Browne, & Donaldson, 2015; Nower & Blaszczynski, 2010; Rockloff & Hing, 2013). Most, if not all, of these features tend to be absent in more traditional forms, such as scratch tickets or bingo (Delfabbro, King, Browne, & Dowling, 2020; Dowling et al., 2005; Goodwin et al., 2017; Schüll, 2012).

Variable risk for promoting gambling problems that exist across forms may also be attributed to the degree to which they are attractive and accessible to vulnerable players (e.g., young people), or may promote maladaptive cognitions and beliefs. Betting on racing, sports, and some table games involve an element of skill. However, genuine expertise on 'skilled' gambling forms, such as sports and race betting, is rare (Browne, Rockloff, Blaszcynski, Allcock, & Windross, 2015; Ladouceur, Giroux, & Jacques, 1998) compared to more established skill games, such as poker (Levitt & Miles, 2014). Few gamblers can reliably make money gambling on skilled forms (Browne et al., 2015), and for many, they can foster illusions of control or 'delusions of expertise' (Cantinotti, Ladouceur, & Jacques, 2004; MacKay, Bard, Bowling, & Hodgins, 2014; Myrseth, Brunborg, & Eidem, 2010), given the technical difficulty in tracking whether one is genuinely doing better than chance (Browne et al., 2015). Sports betting is particularly attractive to young men, a demographic that appears to possess both biological and subcultural vulnerabilities to excessive betting (Clark et al., 2012; Hing, Russell, Vitartas, & Lamont, 2016; Lamont & Hing, 2020; Russell, Hing, & Browne, 2019). Geographic availability may also play a role in increasing the risk of particular gambling forms. For example, while casino table games are often only available in the central business district of major cities, EGMs are typically far more pervasive throughout suburban and regional areas in Australia, with some evidence of greater concentration in lower SES areas (Kristiansen & Lund, 2022; Rintoul & Deblaquiere, 2019; Rintoul, Livingstone, Mellor, & Jolley, 2013; Young, Markham, & Doran, 2012). In general, one would expect that forms that are available at more times and more places foster excessive gambling, with mobile/internet betting perhaps being the penultimate example of accessibility (Young et al., 2012).

Since gambling problems are understood to arise largely from excessive money and time spent on gambling (Neal et al., 2005), and given their structural characteristics and relative popularity compared to other continuous forms, one might well expect that EGM gambling is responsible for the greatest quantum of gambling problems in Australia (Dowling et al., 2005). As outlined by Delfabbro et al. (2020),

the available evidence appears to support this conclusion. A high proportion of help-seekers nominate EGMs as the principal source of their problems (Jackson, Thomas, Holt, & Thomason, 2005; Rodda & Lubman, 2014; Ronzitti et al., 2016), and population prevalence surveys typically find strong associations of EGMs with problems (along with race betting, sports betting, and casino table games) (Browne, Hing, Russell, Thomas, & Jenkinson, 2019; Rockloff, Browne, Greer, Armstrong, & Thorne, 2020,b; Woods, Sproston, Brook, Delfabbro, & O'Neil, 2018). However, this evidence is limited in several respects. First, these correlations reflect risk of problems conditional on engagement with the form at an individual level, and do not describe the proportion of gambling problems attributable to the form at the population level. That is, these correlations do not account for varying participation rates amongst gambling forms, which affect how much each contributes to gambling problems in the population. For example, casino table games are strongly associated with problems but if only a small percentage of the population gambles on casino table games, this form would contribute a relatively small amount to population level problems. Finally, bivariate associations between an innocuous form and problems may be spurious and simply because a gambler who gambles on a dangerous form is also more likely to gamble on an innocuous form. For example, if the risk of gambling on EGMs was high, and the risk of gambling on Keno was nil, but EGM players were also more likely to play Keno, then we would observe an association between Keno play and gambling problems.

These methodological issues can be resolved by taking advantage of the following: (a) that gambling problems necessarily arise from engagement with some forms of gambling, (b) population prevalence surveys routinely conduct comprehensive assessment of engagement with all forms, as well as gambling problems, and (c) although engagement across forms display moderate correlations, these appear to be low enough so as to present no difficulties with multicollinearity (Delfabbro et al., 2020). In essence, the data available presents an ideal use-case scenario for multiple regression to estimate direct associations, with no unmeasured 'third variables' (as is typically the case) that might pose a problem for inference of a direct causal association, and straight-forward extension from sample to population. Similar analyses have been conducted on earlier collated prevalence data (Delfabbro et al., 2020), and on recent individual prevalence surveys in several Australian states and territories (cited in the Methods section below). Although EGMs were identified as the most problematic form in all of these studies, differences in methodology somewhat obscure the relative contribution of each gambling form. Importantly, comorbidities and sociodemographic variables should *not* be included in such an analysis, despite this routinely being done in the literature. This is because 'distal' causal effects are more properly conceived as risk factors for the complex of *both* increasing gambling engagement and gambling problems. As an illustrative example, to include gender (male) as a covariate along with engagement on forms is to propose that being male can cause problems uniquely, independently, and even in the total absence of engagement with gambling. This is theoretically implausible. Rather, known gender effects on gambling problems are plausibly due to increased rates of high engagement with problematic forms, such as sports betting (i.e., the effect is mediated by engagement); or, less plausibly, a differential rate of problems given a similar degree of engagement (i.e., an interaction effect).

Aim

In the current study, we aimed to examine the relationship between the frequency of engagement in different forms of gambling and gambling problems to determine the relative contribution of each form to population-level gambling problems in Australia. This aim requires a multivariate estimation of the degree of individual-level gambling problems conditional on frequency of participation, as well as the frequencies of participation across the population.

METHOD

We conducted a secondary analysis of a pooled analysis of population representative datasets. These were collected via gambling prevalence surveys conducted across six Australian states and territories: Victoria (VIC) (Rockloff, Browne, Greer, et al., 2020a,b), Tasmania (TAS) (ACIL Allen Consulting et al., 2018), South Australia (SA) (Woods et al., 2018), the Australian Capital Territory (ACT) (Paterson, Leslie, & Taylor, 2019), New South Wales (NSW) (Browne, Hing, et al., 2019) and the Northern Territory (NT) (Stevens, 2017). Together, these surveys provide almost full coverage of each Australian state and territory; except for Queensland where we faced challenges in accessing recent data, and Western Australia where EGMs are highly restricted (i.e., they are available only in the one casino located in the capital city). Accordingly, we also incorporated data from a national survey (Hing et al., 2021), excluding WA respondents. Each of these surveys involved telephone interviews obtained via random digit dialling, with multiple re-contact attempts. Although the precise methodology varied somewhat between studies, such as in the way that participation was assessed and the inclusion of novel gambling forms, they were nevertheless relatively homogenous in methodology and individually aimed to achieve a representative sample within each jurisdiction.

Participants

The aggregated dataset contained 71,103 cases, of which 40,268 had gambled in the previous year (inclusive of lottery-only gamblers). For convenience, all cases (including non-gamblers) were included in the analysis, as these individuals provide a baseline (zero participation, zero problems) for estimating conditional effects of participation across forms.

Measures

The seven datasets all included measures of basic demographics, from which we extracted age and gender. When age was elicited via an age range (e.g., "18–24"), we imputed the midpoint for that category. Gambling problems were measured consistently using the Problem Gambling Severity Index (PGSI) (Ferris & Wynne, 2001). Some surveys (NSW, VIC, TAS) coded for missing values in the PGSI (e.g., "unknown/refused") and we treated these as zeros. Individuals who did not endorse any past year gambling participation were coded as zero on the PGSI. Along with non-gambling (no past-year gambling participation), PGSI scores were classified as: non-gambling (NG), Non-problem gambling (0, NPG), low-risk gambling (1–2, LR), moderate-risk gambling (3–7, MR) and problem gambling (8+, PG). Descriptive statistics for these variables for each jurisdiction are given in Table 1.

Although participation in various gambling forms was assessed slightly differently in each jurisdiction, they generally followed a very similar approach. First, a binary participation screening question was asked, e.g., "In the last 12 months, have you spent any money betting on eSports?" (VIC). Positive endorsement of past-year participation for each gambling form then followed by eliciting frequency on that form: "In the past 12 months, how often did you take part?". Respondents could provide responses on a weekly, monthly, or yearly basis (e.g., "Twice a week"). Responses were then coded in terms of a common base of frequency per annum. This approach naturally leads to a preponderance of round numbers for each base. For instance, in the final aggregated dataset we observed 1,170 cases of "12 times

Table 1. Summary of demographics, PGSI status, and participation in gambling forms for each jurisdiction

	Sample						
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
	TAS	ACT	NT	SA	VIC	NSW	NAT+
N	5,000	9,965	5,000	20,017	10,638	10,012	10,471
Gender (Male)	2,464	4,624	2,326	8,907	4,888	5,076	5,573
	(49.3%)	(46.4%)	(46.5%)	(44.5%)	(45.9%)	(50.7%)	(53.22%)
Mean Age	57.1	50.9	49.6	55.3	53.0	50.7	46.03
PGSI status							
NG	2,127	4,114	1,257	7,052	3,007	4,559	5,791
	(42.5%)	(41.3%)	(25.1%)	(35.2%)	(28.3%)	(45.5%)	(64.4%)
NPG	2,601	5,039	3,229	11,722	6,655	4,463	3,601
	(52.0%)	(50.6%)	(64.6%)	(58.6%)	(62.6%)	(44.6%)	(55.3%)
LR	188	568	342	753	683	634	611
	(3.8%)	(5.7%)	(6.8%)	(3.8%)	(6.4%)	(6.3%)	(34.4%)
MR	61	179	131	369	223	269	335
	(1.2%)	(1.8%)	(2.6%)	(1.8%)	(2.1%)	(2.7%)	(5.8%)
PG	23	65	41	121	70	87	133
	(0.5%)	(0.7%)	(0.8%)	(0.6%)	(0.7%)	(0.9%)	(3.2%)
Gambling form participation prevalence							
EGM	780	1,667	858	3,477	1,572	1,525	1,482
	(15.6%)	(16.7%)	(17.2%)	(17.4%)	(14.8%)	(15.2%)	(14.2%)
Race	450	1,366	845	2,148	2,039	1,269	1,574
	(9.0%)	(13.7%)	(16.9%)	(10.7%)	(19.2%)	(12.7%)	(15.0%)
Scratch tickets	897	2,045	691	-*	1,160	1,334	1,283
	(17.9%)	(20.5%)	(13.8%)		(10.9%)	(13.3%)	(12.3%)
Keno	1,078	421	1,159	1,298	313	976	769
	(21.6%)	(4.2%)	(23.2%)	(6.5%)	(2.9%)	(9.7%)	(7.3%)
Bingo	75	177	86	585	183	213	186
	(1.5%)	(1.8%)	(1.7%)	(2.9%)	(1.7%)	(2.1%)	(1.8%)
Casino	156	400	335	755	453	462	697
	(3.1%)	(4.0%)	(6.7%)	(3.8%)	(4.3%)	(4.6%)	(6.7%)
Sports	113	686	274	887	447	546	1,027
	(2.3%)	(6.9%)	(5.5%)	(4.4%)	(4.2%)	(5.5%)	(9.8%)
Lotteries	2,068	4,436	2,639	9,980*	5,109	3,886	3,447
	(41.4%)	(44.5%)	(52.8%)	(49.9%)	(48.0%)	(38.8%)	(32.9%)
Other	94	255	171	483	416	387	577
	(1.9%)	(2.6%)	(3.4%)	(2.4%)	(3.9%)	(3.9%)	(5.5%)

Notes: + National survey data excludes WA respondents. * SA measured frequency of scratch tickets and lottery purchases in the same question. NG: Non-gambler, NPG: Non-problem gambler, LR: low risk gambling problems, MR: moderate-risk gambling problems, PG: Problem gambler. EGM: Electronic gambling machines.

per annum" for EGMs, and only 7 cases of "13 times per annum".

Each study assessed frequency separately for each form of gambling. The categorisation scheme differed somewhat between jurisdictions. However, the nomination and wording for the major categories (EGMs, race betting, sports betting, Keno, bingo, casino table games, instant scratch tickets, and lotteries) was highly consistent. The exception to this was the SA survey, in which instant scratch tickets and lotteries were combined into a single question. Since lottery participation is far greater than instant scratch tickets, we treated this item as lotteries for the main analysis. In the NSW survey, items included both "Keno" and "Keno/lottery via lottoland", the responses to which were combined into lotteries for the main analysis.

Minor and novel forms of gambling were assessed variably (if at all) across prevalence surveys. These included online social casino games, esports betting, fantasy sports betting, betting on non-sporting events, betting at home/informal games, phone-in competitions, private card games and novelty events. Because of this inconsistency, separate categorisation of these forms was therefore of marginal utility in a combined analysis. However, for the purpose of estimating the unique effects of mainstream forms, we adopted the principle that an ambiguous and composite measure of minor forms as a covariate was better than excluding them entirely. Accordingly, we collapsed the frequency of participation in all these activities under an 'Other' category. As shown in Table 1, the highest participation rate for these forms was 3.9% (VIC and NSW). However, we caution against interpretation of this category since estimates will be affected by the variable composition of this measurement across jurisdictions. In addition, these "other" forms of gambling are relatively low prevalence, which makes these estimates less reliable than those made for major gambling forms (i.e., EGMs, casino games).

Procedure

Population weights were available for each of the constituent datasets in this analysis. If we had intended to obtain a nationally representative estimate of the prevalence of gambling problems in Australia (excluding WA), we could have re-weighted these by state and territory population sizes. However, weighting comes at a cost: it reduces the effective degrees of freedom (or information) in a dataset and makes some cases more influential in a non-transparent manner. Given our objective was to assess the relative contribution of gambling forms to gambling problems, the consistent use of random digit dialling in the surveys, and the relatively high degree of homogeneity across the contributing jurisdictions, we opted not to weight the data. Since the sample sizes and the state populations also vary, the dataset should be thought of as an aggregate of representative jurisdiction surveys, rather than strictly representative of the Australian population. Nevertheless, inference from this sample to the population remains fairly strong due to the high degree of homogeneity across jurisdictions and relatively good match of sample demographics to the Australian population.

Statistical analysis

For convenience of subsequent calculations, we employed OLS regression and treated both PGSI and frequency of play on each form as continuous score variables. Both frequency of play and PGSI scores tend to be overdispersed; that is, they are subject to positive skew in scores, and a unit change at higher scores provides less information (i.e., it is subject to more error) than a unit change at lower scores. It is conventional to treat PGSI scores using $\log(x+1)$ transformation to stabilise the error variance (see e.g. Jeffrey et al., 2019, Rockloff etl al, 2020a,b). We treated frequency of play using the same transformation, thus preserving a linear model link, but yielding a model that stabilises the error variance for very high scores. Multiple regression yields beta coefficients β_j that describe the expected change in the outcome conditional on a unit change on the independent variable. If the sample is approximately representative, then one method of estimating the relative importance of gambling form *j*'s contribution to gambling problems in the population is via

$$Imp_j = \sum_i X_{i,j}\beta_j \quad [1]$$

where $X_{i,j}$ is frequency of play on the *j*th form by respondent *i*. In other words, each respondent's gambling frequency profile is converted to an implied risk attributable to each form. Rather than summing these over forms to yield estimates of risk per participant (as is done when creating linear regression estimates), they are summed over participants, to yield an attributable contribution per form. Another approach to assess relative importance is based on a method of partitioning the total model R^2. The approach by Lindeman, Merenda, and Gold (1980), termed *'lmg'*, is recommended by Johnson and Lebreton (2004) and Groemping (2006), who describe an implementation in their *relaimpo* R package. In short, *lmg* addresses the difficulty that the incremental R^2 attributable to each predictor is dependent on the order in which it is included: any common explanatory covariance is allocated to the predictors already in the model. This metric averages attributable R^2 over all possible combinations of covariates, ranging from none to all, making it invariant to order of variable entry. We checked for method variance by implementing both approaches.

All analyses were conducted in the R statistical environment (R Core Team, 2013). Analysis scripts are available on request. However, since the contributing datasets remain the property of the commissioning agencies, we are unable to supply the dataset itself without their approval.

Ethics

This study was conducted in accordance with the Declaration of Helsinki. Approval to access non-identifiable raw data was obtained from each of the data custodians, and

ethical approval was granted by the Central Queensland Human Research Ethics Committee (#22365).

RESULTS

Table 2 shows Spearman bivariate correlations among frequency of play on gambling forms, PGSI, age and gender. The largest correlations between forms were between race betting frequency and sports betting frequency (0.36) and keno frequency and EGM frequency (0.33). EGM frequency (0.36), followed by sports betting (0.27), had the strongest bivariate associations with gambling problems. Age and gender associations with forms were quite small, though sports betting was more frequent among men (0.17); and sports betting (0.18) and casino betting (0.18) were more frequent among younger people. We re-ran these correlations excluding non-gamblers, but these are not reported because this yielded an almost identical correlation matrix to that shown in Table 2.

Given the moderately low correlations between frequency of play on gambling forms, there was little cause for concern regarding multicollinearity. In line with this, the determinant of the design matrix was reasonably large at 0.615, and the maximum variance inflation factor (VIF) for each coefficient was low at 1.25.

Table 3 summarises the OLS regression model predicting ln (PGSI+1) from similarly transformed frequency of gambling on each form. Risk of gambling problems increased most quickly with increasing EGM (β = 0.147) and casino (β = 0.136) gambling frequency. Sports betting presented about half the risk of casino gambling (β = 0.068) as a function of frequency, whereas race betting was about half again (β = 0.038), and scratch and bingo gambling about a further half of race betting. Nevertheless, a significant unique association was detected for all forms, except bingo and lotteries, with these two forms appearing to have virtually nil unique association with gambling problems. Overall, the form/frequency model accounted for 25% of the variance in gambling problems.

Table 3 also summarises the sample prevalence of (any) participation in each gambling form over the last 12 months, and the mean frequency of gambling (p/a) among those who gambled at all on that form. Lottery gambling was the most prevalent (40.1% of respondents), followed by EGM gambling (13.3%) and scratch tickets (8.3%). Notably, race

Table 2. Spearman correlation matrix of gender, age, PGSI and frequency of play on gambling forms

Age	−0.05										
PGSI	0.09	−0.10									
EGM	0.03	−0.03	0.36								
Race	0.10	−0.05	0.24	0.24							
Scratch	−0.03	−0.05	0.16	0.19	0.13						
Keno	0.05	−0.03	0.22	0.33	0.23	0.18					
Bingo	−0.07	0.00	0.07	0.14	0.05	0.06	0.09				
Casino	0.12	−0.18	0.25	0.24	0.22	0.09	0.16	0.05			
Sport	0.17	−0.18	0.27	0.18	0.36	0.09	0.15	0.03	0.31		
Lotteries	0.04	0.14	0.17	0.24	0.21	0.21	0.23	0.07	0.07	0.09	
Other	0.08	−0.12	0.17	0.11	0.13	0.07	0.09	0.04	0.18	0.19	0.05
	Male	Age	PGSI	EGM	Race	Scratch	Keno	Bingo	Casino	Sports	Lott.

Table 3. Regression of frequency of play on gambling forms on gambling problems, prevalence, frequency and relative importance of each form

							Relative Imp.	
term	*B*	*SE(B)*	*t*	*P*	Prev.	Freq.| Part. #p/a	(A)	(B)
EGM	0.147	(0.0023)	64.3	0.000	16.0%	17.6	56.6%	51.8%
Casino	0.136	(0.0055)	24.7	0.000	4.6%	9.7	9.4%	14.2%
Sports	0.068	(0.0033)	20.3	0.000	5.6%	30.5	9.2%	11.4%
Race	0.038	(0.0025)	15.2	0.000	13.6%	41.3	9.8%	9.0%
Keno	0.023	(0.0030)	7.7	0.000	8.5%	17.1	3.9%	6.0%
Other	0.079	(0.0045)	17.3	0.000	3.4%	24.0	5.2%	5.3%
Scratch	0.028	(0.0031)	9.1	0.000	10.4%	9.9	4.9%	1.9%
Bingo	0.000	(0.0052)	0.0	0.977	2.1%	26.4	0.0%	0.2%
Lotteries	0.001	(0.0016)	0.6	0.560	44.4%	24.6	1.0%	0.1%
[Intercept]	0.021	-(0.0044)	4.9	<0.001			100%	100%
Adj. R^2: 0.2476, F (942,389) = 1,550, P < 0.001								

Notes: Prev.: Population participation prevalence. Freq.| Part. (#p/a): Frequency of play (number of time per annum) conditional on participation; i.e. among participants who played at least once in the last year. (A), (B): Relative importance in explaining population gambling problems calculated via Equation [1] (A) or the *lmg* measure (B).

betting tended to be about twice as prevalent as sports betting; this relationship being the inverse of the increased risk of sports betting conditional on frequency of engagement. Race bettors tended to gamble the most frequently, followed by sports bettors. However, it is important to keep in mind that this reflects frequency of sessions over the year, rather than the number of bets placed within sessions.

We then calculated the implied unique association of each form with gambling problems (A) and standardised the results to 100%. Importantly, this involved case-wise multiplication of (log) frequency with each beta coefficient, followed by summation. Thus, the calculation takes into account the entire distribution of frequencies, not just the mean frequency that is also reported in Table 3. We compare these results to the *lmg* relative importance metric (B). A reasonably consistent pattern of results was found for both approaches. EGMs accounted for the largest proportion of gambling problems by a wide margin (A: 56.6%, B: 51.8%). Casino, sports, and race betting together accounted for a further third of the total burden of gambling problems, with the remainder (about 10%) associated with other forms.

DISCUSSION

The headline result of this analysis was to confirm something that has been shown previously with restricted datasets: EGMs are the single largest contributor to gambling problems in Australia. Due to the large dataset and the analytical methods employed, this is the first study to estimate the precise proportion of problems attributable to each of the gambling forms available in Australia. The only similar combined analysis was conducted by Delfabbro et al. (2020), who collated summary statistics rather than raw data across earlier Australian prevalence studies, and considered only EGMs, casino, and race betting. As financial losses are likely to be the primary driver of gambling problems, it is unsurprising that our estimates of the relative contribution of forms to problems tend to mirror their relative contribution to gambling revenue. EGMs, for instance, account for 51% of gambling revenue in Australia (Livingstone, 2017; QGSO, 2021), and we estimate a similar attributable portion of problems to this form. A notable exception to this rule is lotteries/lotto, which comprise about 10% of total gambling revenue (QGSO, 2021), but contribute negligibly to population gambling problems. This can be explained by the very high participation rate (40.1%), which entails that the aggregate expenditure is distributed over a very large number of gamblers, who typically buy a low-cost lottery ticket once every two weeks. In contrast, the AUD$4.9b of revenue derived from casino gambling (compared to AUD$2.4b for lotteries/lotto) is drawn from just 2.7% of the population, illustrating the opposite effect of a low participation rate but high relative expenditure. Since the modal or typical gambler does not experience gambling problems, in principle the mean expenditure per player should be less important than the degree to which the form has a 'long tail' of very high spending players. However, in practice it would appear that gambling forms that promote high average spend tend to be the same forms that promote excessive expenditure among a minority of players.

By far, EGM and casino gambling present the greatest risk to players given exposure to the product. As continuous forms of betting, one session can involve placing many bets and involve structural, environmental, social, and audiovisual features that promote both persistence and behavioural dependence. Our results are consistent with those of Delfabbro et al. (2020), who found that EGMs were the riskiest form of gambling. However, the present analysis highlights that at an individual level, casino gambling is quite similar to EGMs in terms of risk and far riskier than race betting, given a similar degree of engagement. This may be due to the more discontinuous nature of race betting relative to casino and EGM gambling. These findings do, however, need to be qualified in that casino table games tend to attract a very small proportion of the population and have a lower conversion rate than EGMs (e.g., the proportion of casino table game players who gamble regularly as a function of total participation is lower). For this reason, the absolute number of people negatively affected by racing and who seek help for gambling problems may still be higher than for casino table games. This model shows that casino table games could present a far larger absolute risk if they were more widely available, e.g., through online gambling. International studies show that online casino games are one of the highest risk activities, which is consistent with the model estimated here (e.g., Binde, Romild, & Volberg, 2017; Casteén et al., 2018).

It is notable that, despite the high level of power derived from the present dataset, bingo and lottery frequency displayed a non-significant unique association with gambling problems. We, therefore, retain the null hypothesis that these forms do not meaningfully contribute to gambling problems in Australia. It has been proposed that associations between less common forms and gambling problems may reflect the tendency of people with gambling problems to gamble on more forms, rather than being due to the characteristics of the form itself (Brosowski, Olason, Turowski, & Hayer, 2021; Delfabbro et al., 2020; Gainsbury, 2012). However, bingo showed no association with gambling problems, despite being the least prevalent form (1.4%). In contrast, casino gambling is only slightly more prevalent (2.7%) but showed a very strong unique relationship with problems. This is inconsistent with the hypothesis that unique associations of gambling problems with forms are being partially driven by problem gamblers desiring to gamble on many forms. Rather, these results suggest that it is the characteristics of the various forms that drive these observed effects; either in attracting vulnerable players and/or fostering excessive engagement in players who do choose to participate.

Sports and race betting share similar structural features. Yet, interestingly, risk conditional on frequency of play for sports (0.068) is almost double that of race betting (0.038). This may reflect the younger and less experienced demographic who are

attracted to sports betting (Hing et al., 2016; Seal et al., 2022), social and cultural differences (Nyemcsok, Pitt, Kremer, & Thomas, 2022; Raymen & Smith, 2020), and/or the intense marketing and incentives currently associated with sports betting (Browne, Rockloff, et al., 2019; Hing, Russell, Thomas, & Jenkinson, 2019; Rockloff, Browne, Russell, Hing, & Greer, 2019) contributing to more intensive gambling on sports. However, the prevalence of race betting is about double that of sports betting, giving rise to a similar degree of impact at the population level.

Limitations

Several limitations need to be considered when interpreting these findings. First, the results are based on only one country and product market so the results may not be generalisable to other countries or areas (e.g., Europe) where online gambling is more widely available. Conversely, there may be places where EGMs are less available, in which case, other forms may constitute higher risk (inclusive of Western Australia, which was not part of our dataset). Second, the results are based on self-report data, which may not reflect the accurate frequency of gambling. Third, it is likely that many high-spending gamblers did not respond to the surveys. People with a gambling problem and very high-spending gamblers may be less likely to participate in population gambling surveys (Productivity Commission, 1999). The lack of consistency in measurement of participation in minor and exotic forms was a clear limitation, although the degree to which these activities contribute to total gambling problems in Australia is small. Likewise, the inconsistency of the South Australian dataset in combining lotteries and instant scratch tickets is undesirable.

The form/frequency model accounted for only 21% of the variance in (log) gambling problems, which might be considered 'low' given that, theoretically, these two constructs are highly coupled. However, this was not surprising given that both measures are likely subject to a moderately high degree of measurement error, which acts to reduce observed associations. Furthermore, although frequency of play is probably the best practicable proxy for intensity of engagement with gambling, it is not a direct measure. For example, two players reporting an EGM session once a week could spend very different amounts of money during that session, and/or play for a very different amount of time. Finally, the experience of gambling problems might be moderated by a differing degree of resources to support the activity, or a differing degree of vulnerability (or willingness to acknowledge) the effects of gambling in different population settings (e.g., lower socioeconomic populations). We see little reason to believe that this lack of precision in estimating the impact of forms at the individual level would markedly impact our estimates of the relative contributions of each form at the population level.

Conclusions

In our view, the principal contribution of this work is to provide a straightforward guide to which forms of gambling are principally responsible for gambling problems in Australia. EGMs, casino games, sports and race betting are the "Big 4", together accounting for about 90% of gambling problems. However, even in this set, EGMs stand out as being both especially high-risk, with frequent play being popular among a relatively large segment of the gambling population. Unlike casino gambling, EGM availability is ubiquitous in suburbs and towns across Australia. By virtue of being a unique combination of high-risk and high-prevalence, EGMs are responsible for the majority of gambling problems in the country. Regardless, calls to reduce availability, restrict their more addictive structural features, or implement other features that might interrupt excessive spending, all appear to have been ignored (Livingstone & Woolley, 2007; Stevens & Livingstone, 2019). Gambling forms like EGMs that are responsible for the greatest share of problems also contribute the largest revenue stream for government and commercial stakeholders (Livingstone & Adams, 2011). While this presents an understandable structural obstacle to reforms to provision of these products, it is to be hoped that Australian policy might eventually be influenced by unambiguous and unequivocal evidence of their negative impacts. EGM regulation should be the first priority for reducing gambling harm in Australia, with casino, sports and race betting being important secondary priorities.

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