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RESEARCH ARTICLE

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Longitudinal gambling risk transitions: evidence from a nationally representative Australian sample

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ABSTRACT

Aims: Problem gambling has downstream consequences on individuals, families and the community. While a strong research base now exists on predictors and outcomes of problem gambling risk and severity, few studies have examined the transitions in gambling risk status over time, and factors associated with these transitions.

Methods: The current study addresses this knowledge gap by examining gambling transitions using two waves of longitudinal, population-representative Australian data ($N = 12,364$) collected in 2015 and 2018. Focal to our approach is the assessment of predictors of gambling risk status including demographics, and key psychosocial factors that might attenuate the risk of transition into more severe gambling.

Results: The results show significant stability in gambling risk over time, particularly among individuals who reported no or low gambling risk. Gambling risk transitions were more likely to occur toward less severe than more severe levels of gambling. Furthermore, gambling problems tended to persist in more severe levels of gambling risk. Financial hardship, younger age, male gender, experience of hardship, lower levels of educational attainment, chronic health conditions, risky levels of alcohol consumption, living in low SES areas, and low sense of mastery were associated with transitions from low to more severe gambling over the three-year period. There were no significant predictors of transitions to lower levels of gambling risk in the current data.

Conclusions: Our findings can help inform public health interventions by better targeting individuals at elevated risk for more severe gambling over time, and we outline a method for analyzing transitions in longitudinal datasets that can be applied in future studies in addiction.

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Problem gambling is a broad term that is used to describe patterns of excessive gambling behavior that causes harm to self, others, or the wider community (Delfabbro and King 2020). Problem gambling encompasses a continuum of severity including Gambling Disorder, and global population prevalence estimates for past year problem gambling range from 0.1% to 5.8% (Calado and Griffiths 2016) and in Australia from 0.7% to 1.0% (Delfabbro and King 2022). Problem gambling is identified as a major public health concern in Australia and internationally (Wardle et al. 2023).

Problem gambling risk is commonly assessed with the Problem Gambling Severity Index (PGSI) (Ferris et al. 2001); the most widely used contemporary population-measure of problem gambling (Holtgraves 2009; Orford et al. 2010). The PGSI items capture a combination of the common features of addiction drawn from DSM-5 criteria for problem gambling, and categorizes individuals into four groups according to their risk for problem gambling; *1.* non-problem gambling; *2.* low risk gambling; *3.* moderate risk gambling; and *4.* problem gambling (Ferris et al. 2001). The limited evidence examining repeated measurement of the PGSI over time suggests stability within non-problem gambling groups but fluidity between at-risk gambling groups (Abbot et al., 2014; El-Guebaly et al. 2015; Sleczka and Romild 2021). Other research shows, however, that problematic gambling is a relatively stable characteristic (with more and less problematic periods), similar to other behavioral addictions (Williams et al. 2014; ACIL Allen Consulting 2015; Billi et al. 2015).

Numerous demographic and psychosocial factors are associated with problematic gambling. including male gender, lower educational attainment, younger age, experience of stressful life events, and poor mental health and substance use disorders (Hodgins and El-Guebaly 2004; Scherrer et al. 2007; Abbott et al. 2014; Williams et al. 2014; Billi et al. 2015; El-Guebaly et al. 2015; Dowling et al. 2017). Similarly,

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factors associated with recovery from gambling problems include female gender, older age, less severe gambling problems, lower levels of alcohol use, being employed, low depressive symptomatology, and meaningful leisure activities (Hodgins and El-Guebaly 2000; Fröberg et al. 2015; Lubman et al. 2015; Merkouris et al. 2016; Samuelsson et al. 2018; Merkouris et al. 2020). These data are useful in shedding light on factors that might predict gambling risk transitions, but they are predominantly based on cross-sectional data, or small non-representative samples, with some exceptions. For example, a recent longitudinal examination of the Massachusetts Gambling Impact Cohort (MAGIC Research Team 2021) data shows that similar factors are related to both current and future gambling problems. In the MAGIC study, these factors were mainly associated with the gambling intensity (expenditure, frequency, number of gambling activities) but also impulsivity, lower levels of happiness, lower income, male gender, alcohol and drug abuse and personality disorders (MAGIC Research Team 2021). Taken together, both cross-sectional and limited longitudinal evidence supports the understanding that problem gambling is caused by a large number of different risk factors from different domains, and is consistent with the biopsychosocial understanding of the etiology of addictions more generally (Griffiths and Delfabbro 2001; Sharpe 2002; Skewes and Gonzalez 2013; MAGIC Research Team 2021). In addition, the dimensional psychopathology model where certain comorbidities tend to cluster together (See for example Suomi et al. 2014), suggests that having one condition is likely to accumulatively lead to having others. Given that current public health approaches are limited in their ability to reduce gambling harm at the population level in Australia, a understanding of the psychometric profiles of individuals who gamble, and a more complete picture of all risk factors related to gambling risk transitions will provide valuable information to help inform future prevention efforts.

High-quality epidemiological data is needed to build understanding of the demographic and psychosocial factors that influence change in problem gambling risk across time. We draw upon data from one of the few large-scale population-based longitudinal studies that assess problem gambling and collects information on relevant risk factors including income and labor market dynamics, educational participation, family circumstances, and social, health and economic wellbeing, namely, the Household, Income and Labor Dynamics in Australia (HILDA) Survey (Watson and Wooden 2012). Using this data, the current study sought to:

1. Quantify population transitions between gambling risk categories over time in Australia; and
2. Identify significant sociodemographic and psychosocial predictors of these transitions.

Method

Survey design and participants

This study used data from the HILDA Survey: a household panel survey that commenced in 2001 with annual waves of data collection that have sought to interview all household members aged 15 years and older (Watson and Wooden 2012). At each wave of the HILDA Survey there are three different measurement processes for each household. An initial household interview is conducted with the nominated household contact person to collect general information about the household. Personal interviews are conducted with each household member aged 15 years or older. Most interviews are conducted face-to-face, though a relatively small proportion of interviews (less than 10%) have also been conducted by telephone. Finally, each person interviewed also fills in a separate self-completion questionnaire (SCQ), which is collected by the interviewer or returned *via* mail. The HILDA Survey has received ethics approval each year from the Human Research Ethics Committee of the University of Melbourne (ID 1955879).

The current analysis draws upon data from wave 15 (2015), when the gambling questions were first included, and wave 18 when the gambling questions were repeated. The analysis is restricted to respondents who were aged 18 years or older at wave 15, had participated in both target waves of data collection, and had completed/returned the SCQ on both occasions (where the gambling questions were presented). The total sample size available for analysis was 12,364 individuals. Longitudinal weights generated by the HILDA team for this combination of waves adjust for selection and non-response and ensure the analysis sample reflects the characteristics of the target population (which is the Australian population in 2015 who remained in the population in 2018, excluding those who were living in institutions or very remote parts of Australia in 2015, and those who had died or moved abroad by 2018).

Measures

Key outcome variable: Problem gambling risk was measured by the 9-item Problem Gambling Severity Index (Ferris et al. 2001), a commonly used measure of at-risk behavior associated with problem gambling. The PGSI asks about the negative consequences and behavioral symptoms of gambling over the previous 12 months, e.g. 'Have you bet more than you could really afford to lose?' with response options ranging from 0 = never to 4 = often (alpha = 0.92). The risk thresholds used in the current study were consistent with previous guidelines (Currie et al. 2010): *1.* non-problem (PGSI score 0, including non-gamblers); *2.* low risk (PGSI score 1-2); *3.* moderate risk (PGSI score 3-7); and *4.* problem gambling (PGSI score 8+). Given the very low prevalence/sample size in the problem gambling category, and consistent with many other studies, the current analysis of transitions combines the problem and moderate risk gambling categories into a 'high risk' category (PGSI score 3 and above) and no/low risk group of participants with PGSI scores 0-2 for robust analysis (Crockford et al. 2008; Afifi et al. 2010). Additional support for lowering the PGSI cut point comes from a recent study which shows that while the PGSI 8+ cut point has a specificity of 99% (almost no false positives), it only identifies 49% of the problem gamblers

based on clinical ratings and therefore generated many false negatives (Williams and Volberg 2014).

Sociodemographic information included key socio-demographic measures (as at 2015) including gender (male/female), age (categorised as 18 to 24 years (reference), 25 to 39 years, 40 to 54 years, 55 to 69 years, or 70 years or older); relationship status (married or de facto relationship vs none), presence of dependent children within the household, highest level of educational attainment (incomplete high school, completed high school, diploma or certificate, or tertiary qualifications), employment status (employed or not employed), the experience of financial hardship (experience of any of seven binary questions reflecting objective indicators of hardship such as went without meals due to a shortage of money) (Crowe and Butterworth 2016), remoteness of location based on the Australian Bureau of Statistics (ABS) Remoteness Structure (major city, inner regional, or outer regional/remote combined) (Australian Bureau of Statistics, 2021), area-level socioeconomic conditions based on the ABS Index of Relative Socio-economic Advantage and Disadvantage (Australian Bureau of Statistics, 2018), contrasting those living in areas classified within the lowest (most disadvantaged), highest (most advantaged) or the three middle quintiles.

Health and psychosocial predictors of gambling risk transitions

A binary measure for the presence of psychological distress was derived from the MHI-5 mental health scale of the Short Form Health Survey questionnaire (SF-36), with scores of 52 or less as indicative of psychological distress (Ware 2000; Too et al. 2020). The physical functioning (PF) subscale from the SF-36 was used to assess the presence of a long-term physical health condition (Ware and Sherbourne 1992; Butterworth and Crosier 2004; Lins and Carvalho 2016). Participants with risky levels of alcohol consumption were those who reported they exceeded sex-based thresholds of alcohol consumption (5 standard drinks for women, 7 standard drinks for men) on any single occasion (Leggat et al. 2022). A measure of perceived social support was based on 10 questions (Crowe and Butterworth 2016; Butterworth et al. 2007). Locus of control was assessed using Pearlin's Mastery Scale (Pearlin and Schooler 1978), that measures the degree to which individuals believe their life is under their control (Crowe and Butterworth 2016). Lack of perceived control has previously been found to be associated with a range of mental health outcomes (Crowe and Butterworth 2016), as well as problem gambling using HILDA data (von der Heiden and Egloff 2021). Life satisfaction was assessed by a single item asking participants to rate on a 0-10 scale the degree to which they are 'completely dissatisfied' to 'completely satisfied' with their life, whereby 10 indicates 'completely satisfied' (Headey et al. 2010). The continuous scales (physical functioning, social support, life satisfaction, locus of control) were standardized such that a one-point increase represented a standard deviation difference. Total scale scores were estimated if respondents provided answers to at least half of all scale items.

Missing data

Overall, 5.5% of in-scope respondents (those who participated in the HILDA Survey and returned a SCQ in 2015 and 2018) had missing data on at least one of these key measures, with the overall level of missingness very low (only 0.4% of items were missing). The greatest level of missingness was evident for the following scales: financial hardship, problem gambling, physical functioning, and social support, that had between 222 and 606 individuals with missing data. Of the 12,364 respondents, 1.8% (2015) and 2.2% (2018) had some missing data on the PGSI scale. Of these, 25.7% and 18.3% (0.5% and 0.4% in total) had only a single missing item while 61.5% & 72.8% (1.1% and 1.6% of total) were missing data for all the PGSI items. However, there was little consistency in missingness over the 2 occasions: 83.5% of those with missing data on all PGSI items in wave 15 have no missing data on the PGSI items in wave 18.

Multiple imputation by chained equations was used to generate 18 imputed datasets. The imputation process was stratified by gender (given potential gendered differences in gambling status and associations amongst variables), based on the two-wave longitudinal dataset, and used ordinary least squares (OLS), logit or ordinal logistic regression to match the nature of each measure (continuous, binary, or ordered categories). The estimates generated using the imputed dataset showed little difference from those produced by complete-case analysis.

Analysis

After reporting descriptive statistics for the analysis sample, we examined the distribution of PGSI scores for those in the four baseline gambling categories (non-problem, low risk, moderate risk, and problem gambling) and transitions between PGSI categories between 2015 and 2018. To examine characteristics associated with change in gambling risk over the three year time period, we report negative binomial models (given overdispersion in the count model) to identify the baseline correlates of wave 18 PGSI scores. We stratified the analyses based on the four baseline (wave 15) PGSI risk categories, given that the level of PGSI risk in wave 15 influences the direction and degree of change in wave 18 PGSI scores, and the stratified models show that the effect of many covariates differs across prior gambling status. After reporting the results for a series of simple models (incidence rate ratios [IRR], standard errors and predicted mean scores) we built simplified multivariate models using a process of backwards elimination (Hosmer et al. 2013) that included all covariates with a p-value of 0.1 or less in initial models, along with age and gender, and sequentially eliminated the covariates with the highest p-value until a parsimonious model was achieved where all covariates had a p value $<=$ 0.1, while maintaining age and gender in all models. We adopted this approach given our expectation there may be moderate to strong correlations between the measures included in the analysis (e.g. mental health, life satisfaction, social support).

In the supplementary material we report results from generalized linear models (with log-link and reporting IRR) to identify characteristics associated with binary change between broader no/low risk and moderate/high risk categories (see Supplementary Material).

Results

Sample characteristics

A summary of the (unweighted) sample characteristics according to gambling risk category in the first timepoint (2015) is provided in Table 1 for individuals in non-problem gambling (NPG); low risk gambling (LR), moderate risk gambling (MR) and problem gambling (PG) categories.

Table 2 shows the median and mean PGSI scores in 2015 and 2018 for individuals who were classified in the four gambling risk categories (NPG, LR, MR, PG) in 2015. It shows a decline in both median and mean PGSI score from 2015 to 2018 for each group, except for the NPG group that, by design, is constrained to only include individuals who initially had a PGSI score of 0. Table 2 also shows that there was little change in the NPG and LR gambling PGSI score from 2015 to 2018 but a large decline in scores in both MR and PR groups, that also reflects the scoring of these categories.

Transitions between the four gambling risk groups are shown in Table 3. This provides the weighted estimate of the Australian population falling into each gambling risk category in 2015 and 2018. It shows that a larger number of individuals transitioned toward lower risk gambling groups between 2015 and 2018 relative to those who transitioned toward higher risk gambling groups over the same timeframe. This was driven by a larger number of individuals in the MR group transitioning to NPG and LR groups relative

Table 2. Mean and median PGSI scores in 2015 and 2018 based on wave 15 risk group.

	Wave 15		Wave 18	
	Median	Mean	Median	Mean
Non-Problem gambling	0	0	0	0.81
Low Risk gambling	1	1.32	0	1.13
Moderate Risk gambling	4	4.38	2	2.88
Problem gambling	10.5	12.25	3	5.92

Notes. Wave 15 was in 2015, Wave 18 in 2018.

Table 3. Change in gambling risk 2015-2018 in Australian population (weighted).

2015 Gambling	NPG	LR	MR	PG
N		2018 Gambling		
NPG ($n = 11,424$)	15,296,941	361,279	131,417	32,719
LR ($n = 517$)	427,970	171,854	83,038	20,393
MR ($n = 298$)	158,646	88,709	132,986	43,071
PG ($n = 125$)	66,594	20,733	37,820	64,682
%		2018 Gambling		
NPG	96.68%	2.28%	0.83%	0.21%
LR	60.86%	24.44%	11.81%	2.90%
MR	37.47%	20.95%	31.41%	10.17%
PG	35.08%	10.92%	19.92%	34.07%

Notes. Percentage is relative to 2015 status. NPG: Non-Problem Gambling; LR: Low Risk; MR: Moderate Risk; PG: Problem Gambling.

Table 1. Sample characteristics by gambling risk in 2015.

Characteristic	Level	NPG (%)	LR (%)	MR (%)	PG (%)
Problem gambling risk		92.29 $n = 11,424$	4.11 $n = 517$	2.48 $n = 298$	1.12 $n = 125$
Age	18 to 24	10.92	9.37	8.94	13.62
	25 to 39	25.73	26.41	21.38	22.58
	40 to 54	26.82	25.48	26.53	35.14
	55 to 69	24.19	23.89	30.36	23.47
	70 to max	12.35	14.85	12.79	5.19
Gender	Women	55.02	40.45	33.80	37.71
	Men	44.98	59.55	66.20	62.29
Education	Incomplete high school	22.53	28.34	30.60	43.12
	Complete high school	15.05	16.81	13.98	13.58
	Dip/Cert 3/4	33.40	38.00	41.50	32.88
	Tertiary qualifications	29.02	16.85	13.92	10.43
Area SES	Lowest	28.30	36.60	42.08	35.76
	Middle	38.73	37.46	35.86	32.03
	Highest	32.98	25.94	22.06	32.21
Employed	No	35.41	39.52	39.48	37.22
Partnered	Yes	69.36	61.50	59.18	45.79
Dependent children	Yes	34.27	24.96	23.56	23.16
Hardship	Yes	19.45	27.67	31.77	49.16
Health condition	Yes	28.46	33.29	37.08	38.02
Psychological distress	Yes	13.28	16.67	20.79	38.82
Risky drinking	Yes	15.38	30.00	37.21	38.55
Physical functioning	Mean	84.05	80.25	78.78	68.28
	SE	0.21	1.09	1.36	2.49
Life satisfaction	Mean	7.98	7.75	7.53	7.00
	SE	0.01	0.07	0.09	0.18
Social support	Mean	5.48	5.18	5.08	4.62
	SE	0.01	0.05	0.06	0.10
Mastery	Mean	18.92	17.80	17.21	15.84
	SE	0.04	0.21	0.28	0.43

Notes. Percentages refer to the 2015 population. Means are standardized. NPG: Non-Problem Gambling; LR: Low Risk; MR: Moderate Risk; PG: Problem Gambling.

Table 4. Simple negative binomial univariate regression models, stratified by each of the four baseline gambling risk groups, showing predictors of wave 18 PGSI score (and predicted wave 18 mean PGSI score).

	Non-Problem Gambling W15, $n = 11{,}424$		Low-Risk Gambling W15, $n = 517$		Moderate-Risk Gambling W15, $n = 298$		Problem Gambling W15, $n = 125$	
	IRR (SE)	Pred. Score	IRR (SE)	Pred. Score	IRR (SE)	Pred. Score	IRR (SE)	Pred. Score
Age								
18 to 24	base	0.13	base	1.11	base	3.15	base	4.44
25 to 39	0.87 (0.23)	0.11	1.11 (0.35)	1.24	0.64 (0.19)	2.03	1.40 (0.69)	6.19
40 to 54	*0.54 (0.14)	0.07	0.93 (0.30)	1.03	1.05 (0.30)	3.32	1.51 (0.69)	6.72
55 to 69	**0.44 (0.12)	0.06	1.11 (0.35)	1.23	0.85 (0.24)	2.69	1.23 (0.59)	5.45
70 to max	**0.36 (0.12)	0.05	0.85 (0.30)	0.94	1.17 (0.38)	3.69	1.16 (0.86)	5.17
Gender								
Female	base	0.07	base	1.04	base	3.22	base	4.50
Male	*1.35 (0.21)	0.09	1.15 (0.19)	1.19	0.84 (0.13)	2.71	1.50 (0.44)	6.74
Hardship								
No	base	0.06	base	1.09	base	3.08	base	4.93
Yes	**3.23 (0.58)	0.18	1.14 (0.21)	1.25	0.82 (0.14)	2.52	1.46 (0.40)	7.22
Education								
Incomplete HS	base	0.14	base	1.10	base	2.85	base	7.36
Complete HS	**0.52 (0.13)	0.07	1.13 (0.29)	1.24	1.06 (0.26)	3.02	0.82 (0.35)	6.06
Dip/Cert 3/4	**0.49 (0.10)	0.07	1.04 (0.21)	1.14	1.04 (0.19)	2.97	0.57 (0.18)	4.18
Tertiary qual.	**0.41 (0.09)	0.06	0.96 (0.24)	1.05	0.90 (0.22)	2.56	0.75 (0.36)	5.54
Partnered								
No	base	0.10	base	1.12	base	3.28	base	6.00
Yes	*0.69 (0.11)	0.07	.01 (0.17)	1.13	0.80 (0.12)	2.61	0.97 (0.27)	5.81
Dep. children								
No	base	0.08	base	1.08	base	3.04	base	6.10
Yes	1.06 (0.17)	0.08	1.18 (0.22)	1.28	0.78 (0.14)	2.39	0.87 (0.29)	5.30
Employed								
No	base	0.10	base	1.21	base	2.98	base	7.07
Yes	*0.68 (0.11)	0.07	0.89 (0.15)	1.08	0.95 (0.15)	2.82	0.75 (0.22)	5.27
Health Cond.								
No	base	0.07	base	1.10	base	3.05	base	5.12
Yes	**1.83 (0.30)	0.12	1.09 (0.19)	1.19	0.85 (0.14)	2.59	1.40 (0.40)	7.20
MH condition								
No	base	0.07	base	1.07	base	2.88	base	6.08
Yes	**2.28 (0.49)	0.16	1.31 (0.29)	1.41	1.00 (0.19)	2.89	0.90 (0.26)	5.46
Risky drinking								
No	base	0.07	base	1.08	base	2.86	base	5.10
Yes	**2.44 (0.49)	0.16	1.16 (0.21)	1.25	1.03 (0.16)	2.94	1.37 (0.40)	7.00
Area SES								
Lowest	base	0.12	base	1.40	base	2.68	base	5.65
Middle	**0.62 (0.11)	0.07	*0.69 (0.13)	0.97	1.04 (0.18)	2.78	1.17 (0.40)	6.59
Highest	**0.47 (0.09)	0.06	0.70 (0.15)	0.98	1.28 (0.26)	3.44	0.99 (0.33)	5.58
Physical Funct.	*0.85 (0.07)	0.08	0.94 (0.08)	1.12	1.05 (0.08)	2.90	1.04 (0.14)	5.83
Life satisfaction	**0.81 (0.06)	0.08	0.94 (0.08)	1.12	0.96 (0.06)	2.84	*0.82 (0.08)	4.91
Social Support	**0.67 (0.05)	0.08	0.99 (0.08)	1.13	1.01 (0.07)	2.90	0.95 (0.11)	5.72
Mastery	**0.76 (0.06)	0.08	1.01 (0.08)	1.14	1.08 (0.08)	2.97	0.92 (0.11)	5.62

Notes. *indicates $p < 0.05$; **indicates $p < .01$; base indicates the variable level used as the reference for the model. IRR: incidence rate ratio; SES: socioeconomic status; MH: mental health. Models initially included age, gender, and all covariates with a p-value of 0.1 or less and sequentially eliminated the covariate with the largest p-value until we achieved a parsimonious model where all covariates had a p-value of 0.1 or lower.

to LR group transitioning to MR or PG categories. Just 3.3% of NPGs moved into the higher risk LR, MR or PG categories between 2015 and 2018. 14.6% of LRs transitioned to higher risk MR or PG categories compared to 58.2% of MRs and 65.9% of PGs transitioned to lower-risk categories over the same timeframe. When focussing on the PGs in wave 18, it can be seen that 20.3% of the estimated 160,865 PGs were in the NPG group, 12.7% were in LR group, 26.8% were in the MR group, and 40.2% were in the PG group in 2015.

Predictors of gambling transitions 2015-2018

Table 4 reports on the characteristics associated with wave 18 PGSI scores, with separate models for each baseline gambling category (NPG, LR, MR, PG). For the large group of survey respondents classified as NPG in 2015 (score of 0), most of the demographic (age, gender, partner status), socioeconomic (education, hardship), health (chronic conditions, physical functioning) and psychological (life satisfaction, social support, mastery) variables were significantly associated with PGSI scores in 2018. However, the mean differences across the categories of these variables were modest when considering the 28-point range of the PGSI scale. In contrast, very few characteristics were significantly associated with wave 18 PGSI scores in analysis of the other three gambling groups, with only area-level differences showing a difference with $p < .1$ for the LR group, and only educational attainment and life satisfaction significant for those classified in the wave 15 PG group, but mean differences across the categories of these variables were larger.

The final multivariate models in Table 5 reinforce these results. The characteristics associated with higher wave 18 PGSI scores in the NPG category included younger age, male gender, experience of hardship, lower levels of educational attainment, the experience of chronic health

Table 5. Multivariate negative binomial multivariate regression models, stratified by each of the four baseline gambling risk groups, showing predictors of wave 18 PGSI scores (and predicted wave 18 PGSI mean score).

	Non-Problem Gambling W15, $n = 11{,}424$		Low-Risk Gambling W15, $n = 517$		Moderate-Risk Gambling W15, $n = 298$		Problem Gambling W15, $n = 125$	
	IRR (SE)	Pred. Score	IRR (SE)	Pred. Score	IRR (SE)	Pred. Score	IRR (SE)	Pred. Score
Age								
18 to 24	base	0.13	base	1.11	base	3.15	base	4.44
25 to 39	1.02 (0.28)	0.11	1.05 (0.33)	1.24	0.62 (0.19)	2.03	1.64 (0.78)	6.19
40 to 54	0.80 (0.23)	0.07	0.87 (0.28)	1.03	1.01 (0.29)	3.32	2.35 (1.07)	6.72
55 to 69	0.65 (0.19)	0.06	1.02 (0.33)	1.23	0.80 (0.23)	2.69	1.92 (0.94)	5.45
70 to max	*0.48 (0.17)	0.05	0.85 (0.30)	0.94	1.12 (0.37)	3.69	1.49 (1.05)	5.17
Gender								
Female	base	0.07	base	1.04	base	3.22	base	4.50
Male	**1.61 (0.25)	0.09	1.09 (0.19)	1.19	0.82 (0.13)	2.71	1.63 (0.47)	6.74
Hardship								
No	base	0.06						
Yes	**2.40 (0.45)	0.18						
Education								
Incomplete HS	base	0.14					base	7.36
Complete HS	**0.43 (0.11)	0.07					0.86 (0.36)	6.06
Dip/Cert 3/4	**0.51 (0.11)	0.07					0.55 (0.18)	4.18
Tertiary qual.	*0.64 (0.14)	0.06					0.54 (0.27)	5.54
Health Cond.								
No	base	0.07						
Yes	**1.66 (0.29)	0.12						
Risky drinking								
No	base	0.07						
Yes	**2.10 (0.42)	0.16						
Area SES								
Lowest	base	0.12	base	1.40				
Middle	0.77 (0.14)	0.07	0.70 (0.13)	0.97				
Highest	**0.58 (0.11)	0.06	0.70 (0.15)	0.98				
Life satisfaction							*0.80 (0.08)	4.91
Mastery	*0.83 (0.07)	0.08						

Notes. *indicates $p < 0.05$; **indicates $p < .01$; base indicates the variable level used as the reference for the model. IRR: incidence rate ratio; SES: socioeconomic status; MH: mental health.

conditions, at-risk levels of alcohol consumption, living in a more disadvantaged area, and reporting low levels of mastery. Across the other three models relating to those who reported at risk gambling in 2015, the only finding that reached the 0.05 levels of statistical significance indicated that, of individuals classified in the PG group, those with higher scores on the life satisfaction measure reported lower scores on the wave 18 PGSI scale.

Finally, the supplementary analysis (see Supplementary Materials) of the binary gambling risk variable collapsing the two high risk gambling groups and two no or low risk gambling groups showed similar pattern of results. The findings show a significant overlap in the co-variates predicting change from low to high risk gambling, although the models are more constrained. Similar to the main analysis, the supplementary analysis shows few factors associated with reduced risk.

Discussion

The current study drew upon unique longitudinal Australian data to examine transitions between higher and lower severity of problem gambling risk over time. The main findings show that the majority of Australians did not report any at-risk gambling at either timepoint, consistent with other population-based gambling studies (Delfabbro and King 2022; MAGIC Research Team 2021). Furthermore, the majority of Australians did not present with any gambling risk in either timepoint. There was also a high degree of stability in gambling risk as measured by the PGSI, with a majority individuals remaining within 1 or 2 PGSI scores of their original 2015 score three years later in 2018. A larger change in score was much more likely in the moderate risk and problem gambling groups with transitions more likely toward less severe than more severe levels of gambling, similar to previous longitudinal evidence (Billi et al. 2015; Abbott et al. 2018), notwithstanding problem gambling rates have remained relatively stable over time in Australia (Delfabbro and King 2022). The current data shows that while most Australians' gambling risk is stable over time, over half a million Australians experienced moderate-risk or problem gambling in 2018, and almost half of these people reported non-problem or low-risk gambling three years earlier, highlighting a critical need to better identify individuals who are at risk to develop more problematic gambling. These findings can be used to guide public health measures to better address gambling harm at the population level.

Previous research is scant on the stability between low, moderate risk and problem gambling categories. One study that collected data multiple times over a shorter time period, but relying on a small convenience sample (Luce et al. 2016) suggests stability in non-problem, low risk and problem gambling groups, but considerable movement in the moderate risk group over time. In contrast to this, our analysis of HILDA shows that low risk gamblers are the most unstable gambling risk group, with more stability in gambling risk levels at more severe levels of gambling (i.e. moderate risk and problem gambling), and the highest stability among the

non-problem gambling group. While our findings are limited by the three year lag between data collection points, it is also consistent with other similar studies (Williams et al. 2014; ACIL Allen Consulting 2015; Billi et al. 2015). Another methodological limitation of the current study is inherent to the construction of the PGSI categories using the PGSI score: only a small change is required to move in or out of the low risk category (PGSI score 1-2), while the score range for the more severe categories (moderate risk score 3-7; problem gambling score 8-27) is substantially wider, thus larger score change required to move in and out of the category. The design of the PGSI tool thus partly explains why moderate risk and problem gambling may appear more stable.

Predictors of gambling severity transitions

The current findings show that financial hardship, younger age, male gender, experience of hardship, lower levels of educational attainment, the experience of chronic health conditions, at-risk levels of alcohol consumption, living in a more socioeconomically disadvantaged area, and reporting low levels sense of mastery led to increased gambling risk for individuals who reported no gambling problems three years earlier. Higher life satisfaction was related to decreased gambling risk for individuals in the problem gambling category, but there were no other significant predictors of gambling transitions in the other gambling risk groups.

These findings are largely consistent with previous literature showing that lower levels of educational attainment and younger age, alongside a number of psychosocial factors are predictive of an increase in gambling severity (Hodgins and El-Guebaly 2004; Scherrer et al. 2007; Abbott et al. 2014; Williams et al. 2014; Billi et al. 2015; El-Guebaly et al. 2015; Dowling et al. 2017). Particularly young males with lower education are shown to be at risk for more problematic gambling, similar to the current data (i.e. Clarke et al. 2006; Bray et al. 2014).

The current study builds on cross-sectional evidence on high prevalence problem gambling in lower socioeconomic areas (Kristiansen and Lund 2022). In Australia and many jurisdictions in Europe and North America, a disproportionately high number of gambling venues and gaming machines are located in more disadvantaged geographical areas (Papineau et al. 2020). Coupled with low levels of help seeking in these low SES areas (Rosenberg and Hickie 2019), it follows that individuals living in more disadvantaged neighborhoods are vulnerable to developing more serious gambling problems. Such findings also point to the need for targeted gambling support services, as well as primary and secondary prevention programs in the low SES areas, particularly with higher numbers of gambling venues. Critically, these findings can inform policy on improved regulation of the density of gaming machines, or gambling advertising in disadvantaged areas.

The findings related to other co-morbidities, risky drinking and chronic health conditions also point to the vulnerabilities to gambling harm and support a dimensional psychopathology framework whereby having one disorder increases the likelihood of having several others (Suomi et al. 2014). The current findings specifically extend previous cross-sectional research on mastery, or 'sense of control' and gambling severity, showing that individuals who feel more in control of their lives are less likely to transition to higher levels of problem gambling risk, compared to individuals who feel less in control of their lives (von der Heiden, 2021; Shumlich et al. 2017). Higher perceived control, and related concepts such as self-efficacy, are also related to gambling abstinence, as well as treatment success for problem gambling (Hodgins et al. 2019), and are known to be associated with better mental health and wellbeing overall (Reisenhofer et al. 2019). While locus of control orientation is considered to be relatively stable over time (Tyler, Heffernan, & Fortune, 2020), clinical evidence suggests there is a dynamic quality to this construct, in that it is responsive to a range of interventions and in fact can be reoriented (Page and Scalora, 2004). Given it was one of few modifiable characteristics significant in the final model, this construct is potentially important as an intervention opportunity.

Limitations and future directions

The current analysis identified broad patterns in gambling risk transitions in the Australian population, although some limitations should be considered in interpreting these findings. First, the use of self-report data is known to result in underreporting of gambling severity, expenditure and other negative consequences of gambling (Wood and Williams 2007). It is likely that the gambling risk estimates reported in the current study are much higher, and that individuals who transitioned to higher gambling risk were already experiencing harms in 2015 but simply downplayed, or did not report them in the survey. Alternative methodologies to self-report data include the use of actual gambling expenditure or behavioral data collected by the financial or gambling industry (see for recent examples Auer and Griffiths 2023; Muggleton et al. 2021). Obtaining independent access to industry data can however be difficult to navigate (Louderback et al. 2021). In addition to the limitations inherent to the PGSI scoring discussed in the previous section, another limitation of the HILDA gambling data is that gambling severity data is not captured within the same time frame with gambling participation. Therefore, the current analysis did not differentiate between those who gambled and did not gamble in the past year. Further research that can distinguish non-gamblers from non-problem gamblers is needed to replicate the current analysis, to account for the differences between the two groups who do not experience gambling harm. Further, the three-year lag between the two timepoints analyzed in our data were unable to capture short-term transitions in gambling risk. It is possible that the individuals experienced multiple transitions over time, similar to other addictions (Koenig et al. 2020; Bondy et al. 2013). Other challenges using the HILDA data include balancing the loss of power in the relatively small sample of 'at risk' gambling categories, particularly in the problem

gambling category, with the loss of sensitivity in combining the higher risk categories, like other research has done (Crockford et al. 2008; Afifi et al. 2010). This issue is similar with other low prevalence conditions in large population-based data, but nonetheless important to investigate. The alternative analysis reported in the Supplementary Materials collapsing the two lower gambling risk and two higher gambling risk categories show similar patterns about predictors of gambling risk, and could be a considered a valid approach to analysis where statistical power is in issue, with limitations. Finally, the focus of the current paper was on understanding on stability and change in gambling risk, however only two waves of data used in the current paper is limited in capturing a complete picture of these transitions. With more gambling data available within the HILDA dataset, future investigations can extent the current, first level analysis to examine transitions using more sophisticated longitudinal approaches.

The current study adds to a growing body of research examining gambling outcomes with the HILDA dataset (Gong and Zhu 2019; Churchill and Farrell 2020a; 2020b; Farrell and Fry 2021; von der Heiden and Egloff 2021; Koomson et al. 2022; Suomi et al. 2022; Tulloch et al. 2023), and extends the few studies that have examined HILDA using prospective methods. We identified three studies on HILDA gambling data that used longitudinal analysis showing that problem gambling is associated with lower subjective wellbeing, and a range of negative psychosocial outcomes, including crime victimization and offending, divorce, financial hardship, and hazardous alcohol use (Churchill and Farrell 2020a; Farrell and Fry 2021). Similarly, a range of psychosocial and health outcomes have been previously found to precede gambling problems in the HILDA data (Paterson et al. 2020).

One possible further extension of this line of research could be to examine transitions across multiple types of behavioral addictions including hazardous levels of alcohol and/or tobacco consumption (and vice versa). Previous research has already demonstrated the power of the HILDA dataset for investigating trajectories of alcohol (Leggat et al. 2022; Livingston et al. 2022) and tobacco (Brown and Adams 2013; Livingston et al. 2022) consumption across the life course, with identification of mediating factors such as household income and expenditure (Bentley et al. 2021), and substance use in adolescents and young adults (Callinan et al. 2020). Examining patterns in co-morbid addictions over time provides further insight into addiction and substance use at a population-level, the findings of which can inform population health practice and policy for targeted harm prevention efforts in a more nuanced way.

Conclusion

This current study is one of the few examining gambling risk transitions on a population level. It provides new insights into the size of gambling risk in the general population, the perseverance of this risk, as well as demographic and psychosocial factors that may increase an individual's problem gambling risk over time; such as younger age, lower education, living in disadvantaged neighborhoods, and a sense of lacking control over one's life. Given that public health interventions have yet to successfully address gambling harm in Australia and indeed the global community, the current findings are useful in pointing to several opportunities for prevention on both a population and individual level. Our findings also provide the methodological basis for further research in the area, focusing on the more nuanced psychosocial profiles of vulnerable populations at risk for gambling harm, as well as methods that can be applied to better understand transitions within and across unique behavioral addictions in future studies.

Ethical statement

The research in this paper does not require ethics board approval.

Disclosure statement

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