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Changes in some health and lifestyle behaviours are significantly associated with changes in gambling behaviours: Findings from a longitudinal New Zealand population study

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ABSTRACT

Although a large number of studies have investigated associations between risky gambling behaviours and health, lifestyle and social factors, research has not focused on *changes* in these factors and associations with *changes* in gambling risk level. This study utilised existing data from the four waves of the longitudinal New Zealand National Gambling Study to examine associations between changes in substance use, mental and physical health, and quality of life and deprivation with changes in gambling risk level over time. A Markov chain transition model was used to perform these analyses using data from participants who had completed all four waves (11,080 data transitions). Although changes in various covariates were associated with changes in all gambling risk levels, the highest number of significant factors was for transitioning into risky gambling from non-problematic gambling, including development, or continuation, of several negative health and lifestyle factors that may possibly be alleviated by transitioning out of risky gambling. These findings highlight the importance of screening for gambling behaviours when assisting people with substance use, health issues, or social situations or conditions in order to provide appropriate and effective social, health and treatment supports for people whose gambling behaviour increases over time.

1. Introduction

Most adults worldwide report having gambled at least once in the prior year (Calado & Griffiths, 2016), and while a majority do not experience negative consequences, a substantial minority gamble in a risky manner with associated harms. The last population representative gambling study to be conducted in New Zealand, the NZ National Gambling Study (NZ NGS), found that prevalence of current (past year) risky gambling amongst adults was 7.5% (Abbott et al., 2014), identified via the Problem Gambling Severity Index (PGSI) as low risk, moderate risk and problem gamblers. Although this prevalence was slightly lower at 4.5% in the 2018 NZ Health and Lifestyles Survey (the last time population level gambling data were collected in a wider health survey) (Te Hiringa Hauora & Kupe, 2018) the prevalence remained within the range identified in other countries such as Australia (Paterson et al., 2019, p.42), Canada (Williams et al., 2021), Finland (Salonen et al., 2018), Greece (Economou et al., 2019), Iceland (Olason et al., 2015), Sweden (Abbott et al., 2018b), and the United Kingdom (Gambling Commission, 2019), and in a recent *meta*-analysis of 23 prevalence studies conducted from 2016 to 2022 (Gabellini et al., 2023), although the studies are not directly comparable due to the use of different methods and gambling screens across studies. Longitudinal studies have shown that gambling behaviour is fluid, with at-risk adults transitioning into and out of periods of risky gambling (Abbott et al., 2018a, p.56; Bilevicius et al., 2019; Billi et al., 2014; Luce et al., 2016; Mutti-Packer et al., 2017; Samuelsson et al., 2018; Williams et al., 2015).

A plethora of research studies over the years have investigated and found associations between problematic or risky gambling and various comorbidities, risky behaviours, and negative health effects. Some of these, which have relevance to the present study, are detailed below.

1.1. Risky gambling and associations with substance use

Almost 40 years ago, Ramirez et al. (1983) identified a high prevalence of alcohol and drug abuse amongst a sample of treatment-seeking gamblers. A subsequent review of studies (from 1998 to 2010) of

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comorbidities in problem and pathological (severe problem) gamblers identified that the highest prevalence was for nicotine dependence (60.1%), followed by substance use disorder (57.5%) (Lorains et al., 2011). More recent reviews and studies have not only identified high rates of comorbidity between risky gambling and substance use disorders but have suggested that there may be common risk factors (Barnes et al., 2015; Cowlishaw et al., 2014; Rash et al., 2016) despite the differences between the various substances. The NZ NGS found that adults who gambled at a risky level were more likely to drink alcohol hazardously, smoke tobacco, and use cannabis, compared with people who gambled at a non-risky level (Abbott et al., 2014). However, the prevalence of comorbidity may be dependent on the initial disorder with a Norwegian study indicating a high level of substance use disorder (22.5%) amongst people initially diagnosed with gambling disorder, but a much lower comorbid prevalence of gambling disorder (0.7%) in people diagnosed initially with substance use disorder (Leino et al., 2023).

1.2. Risky gambling and associations with mental and physical health

A strong association between risky gambling and mental health issues has been reported in general, clinical and vulnerable populations. The most common co-existing mental health issues have been identified as general psychological distress, anxiety and depressive disorders (Churchill & Farrell, 2018; Rockloff et al., 2020; Rodriguez-Monguio et al., 2017; Sharman et al., 2019). The NZ NGS also identified high levels of these mental health issues among problem gamblers compared with non-problem gamblers (Abbott et al., 2014). A systematic review and *meta*-analysis of 36 studies of gambling treatment seekers also identified several other co-existing mental health issues including social phobia, panic disorder, post-traumatic stress disorder, attention-deficit hyperactivity disorder, adjustment disorder, bipolar disorder and obsessive–compulsive disorder (Dowling et al., 2015). A higher risk of depression may be associated with online gambling compared with land-based gambling due to the private nature of online gambling (Churchill & Farrell, 2018).

Several clinical and epidemiological studies have also reported a relationship between risky gambling and adverse physical health effects in general and clinical populations, although the evidence base is limited and inconclusive. Generally, poor physical health has been attributed to socio-economic or lifestyle factors associated with excessive gambling, such as sedentary behaviour or continual stress (Cowlishaw & Kessler, 2016). These can manifest as poor general health or stress-related symptomatology such as migraines, heart problems, high blood pressure and stomach ulcers (Hing et al., 2016; Williams et al., 2015). Other physical health effects can be associated with higher levels of substance use noted amongst problem gamblers, such as liver and lung diseases (Hing et al., 2016).

1.3. Risky gambling and associations with quality of life and deprivation

A person's quality of life relates to their perception of life within the culture and social norms in which they live, that are influenced by personal factors including physical and mental health, social relationships and their immediate environment (WHOQoL Group, 1995, p. 1405). It follows, therefore, that if a person experiences harms from their gambling, that this could affect their quality of life.

Several research studies have identified a relationship between risky gambling and poorer quality of life (Black et al., 2013; Browne et al., 2017a; Kohler, 2014; Mythily et al., 2017), with problem gamblers reporting reduced functioning in major quality of life measures such as mental health, physical and social functioning, and vitality (Black et al., 2013). This was also found in the NZ NGS with a majority of problem and moderate risk gamblers reporting overall quality of life below the median score for the study sample (Abbott et al., 2014); a finding that was consistent across each of the four years of the study (Abbott et al., 2018a).

Research examining relationships between risky gambling and deprivation is limited; however, risky gambling has been found to be associated with high levels of socio-economic deprivation and poverty (Hahmann et al., 2021; van der Maas, 2016). Partly this is due to a disproportionately high density of gambling venues (especially electronic gaming machine venues) in areas of high socio-economic deprivation (Macdonald et al., 2018; Raisamo et al., 2019; Wardle et al., 2014) providing increased availability and accessibility to a gambling activity that is one of the most harmful and, to a fiscally constrained population who have little opportunities to increase finances via other means, gambling may appear an attractive option to gain money (Welte et al., 2017). In NZ, half of people seeking professional help for their own gambling problems in 2021/22 cited community based electronic gaming machines as their primary problematic activity (Ministry of Health. 2023). Socio-economic status has also been found to moderate the association between gambling risk and some mental health issues (specifically anxiety disorders) (van der Maas, 2016), indicating the complex nature of these associations and the necessity of taking such associations into consideration in terms of treatment and public health approaches to reduce gambling harms.

1.4. Current study

Despite the many studies that have shown risky gambling behaviours to be associated with a plethora of negative health, lifestyle and social factors, attention has, to date, not focused on whether *changes* in gambling risk level are associated with *changes* in these factors. This is pertinent when considering that risky gambling behaviour is not a fixed state, with people transitioning in and out of the various gambling risk levels over time. The aim of the current study was, therefore, to identify whether changes in various health and social covariates were associated with changes in gambling risk level over time. We hypothesised that changes in substance use, mental and physical health, and quality of life and deprivation would have a significant association with changes in gambling risk levels.

2. Methods

2.1. Participants

This study was a secondary analysis of data collected from the four data collection years (annually from 2012 to 2015) of the population representative NZ NGS. In 2012, baseline data were collected from 6,251 participants. In 2015, 2,770 participants remained in the study. Data from participants who had been assessed at all four time points were used in the analyses.

2.2. Procedure

The design and methods of the NZ NGS are published separately (Abbott et al., 2017). In brief, data were collected from adults aged 18 years and older via face-to-face structured Computer Assisted Personal Interviews conducted in respondents' homes. Participants were recruited from around New Zealand.

2.3. Measures

2.3.1. Gambling risk level

The nine-item Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001) measured current (past year) gambling risk level. The PGSI is robust and reliable in the NZ population (Devlin & Walton, 2012) with high internal reliability (minimum Cronbach's alpha of 0.86). Participants are categorised as non-gambler, non-problem gambler (score 0; have not experienced any adverse consequences of gambling), low risk gambler (score 1 or 2, may be at risk but likely have not

experienced severe adverse consequences), moderate risk gambler (score 3 to 7, may be at risk and may have experienced some adverse consequences), or problem gambler (score 8 to 27, have experienced severe adverse consequences) (Browne et al., 2021; Ferris & Wynne, 2001).

2.3.2. Substance use covariates

Hazardous alcohol use was measured using the three-item AUDIT-C, developed from the 10-item Alcohol Use Disorders Identification Test (Saunders et al., 1993). The AUDIT-C has been shown to be accurate when compared with the full AUDIT (Reinert & Allen, 2002). Individual questions asked about tobacco and cannabis use.

2.3.3. Health covariates

Individual questions asked about anxiety and depression, overall general health, chronic health conditions (e.g. cancer and diabetes), obesity, disability and past trauma. Quality of life in the prior two weeks was measured using the eight-item EUROHIS-QOL 8. This short measure is psychometrically robust, and overall performance strongly correlates with scores from the original WHOQoL instrument (Schmidt et al., 2005). Scores range from 0 to 32.

2.3.4. Socio-economic covariates

Number of major life events experienced in the prior year was collected from a list of 15 events (e.g. death of someone close, divorce, having a baby) plus an 'other' category. Current (past year) level of individual deprivation was measured using the eight-item New Zealand Index of Socio-economic Deprivation for Individuals (Salmond et al., 2006), which has good statistical reliability (Cronbach's alpha 0.81). The more items that are scored positive, the greater the level of deprivation. Social engagement was measured via four questions relating to living in a neighbourhood/community (e.g. Can you get help from family, friends or neighbours when you need it? Are you a member of an organised group such as a sports or church group or another community group including those over the internet?).

2.3.5. Socio-demographic data

Gender, age, ethnicity, household size, highest educational level attained, employment status, annual personal income and location of residence data were collected at baseline.

2.4. Statistical analysis

Transitions in gambling risk level were described by changes in PGSI risk levels. The low risk, moderate risk and problem gambler categories comprised only a small proportion (8.2%) of the population; therefore, these categories were combined into one category termed 'risky gambler'. As there were few transitions from non-gambler to risky gambler (and vice versa), to remove model estimation issues and difficulties in the estimation of coefficients, these two transitions were removed from the data. This resulted in 75 transitions (60 participants) being removed, equating to removal of 0.68% of the total of 11,080 transitions available in the data.

A Multi-State Markov chain transition model was used to examine associations between *changes* in variables and *changes* in gambling risk levels. Due to the structure of the data set (longitudinal data; $t = 1,\ldots, 4$), it was possible to model changes as a Markov chain, defined by a matrix of transition: probabilities to transition from an initial state (at time t) to another (at time $t + 1$), with the initial state being known (Jackson, 2011). In this study, the states of gambling risk level were known and defined by the PGSI. The outcome of interest was defined by a matrix of transition, with the model estimating the associations with gambling risk level transitions and time-varying and transitioning covariates.

Markov models are particularly useful when the probability of transitioning from one state to another depends only on the current state and not on any previous states, known as the Markov property. The chosen Markov cohort model is a commonly used form of decision-analytic models. Markov models have previously been used in the study of chronic physical diseases and recently were developed to examine changes in state over time, specifically for addictions (Cai et al., 2018; de Haan-Rietdijk et al., 2017; Song et al., 2017; Yeh et al., 2012).

Descriptive statistics were first produced to examine time varying characteristics to identify variables that changed sufficiently over the whole study to be examined as a changing state variable. Initial models were developed to examine the change in gambling risk levels over time. The confounding effect of baseline characteristics was examined in the final model. Each of the following time-varying factors was examined for their addition to the model accounting for their time-varying effects: tobacco-use, recreational drug-use, hazardous alcohol-use, mental health status, life events and socio-economic status. As some of these factors had complex reciprocal relationships with gambling risk levels, several models were investigated and examined for the best fit. Four PGSI transitions were modelled (Fig. 1).

- Starting gambling (i.e. non-gambler becoming non-problem gambler)
- Stopping gambling (i.e. non-problem gambler becoming non-gambler)
- Transitioning to risky gambling (i.e. non-problem gambler becoming risky gambler)
- Transitioning out of risky gambling (i.e. risky gambler becoming non-problem gambler).

Conditional probabilities of transition from one gambling risk level to another are shown in Table 1. There is a 32% probability of non-gamblers (at year t) starting gambling the following year ($t + 1$). The probabilities of transitions between risk levels are the average values observed for the overall study period (2012 to 2015).

Covariates were considered as sets of categorical variables (each covariate was defined by a set of dummy variables). The initial step examined associations with covariates separately with a bivariate Multi-State Markov Model. A covariate had significant impact in the model if at least one dummy variable had a significant impact on at least one transition. Three separate covariate domains were used (i.e. substance-use, health-related and socio-economic). Coefficients were only estimated when covariates were significantly associated with a specific transition. The final model estimation included all significant covariates. Demographic variables were adjusted for as confounders in the final model. Hazard Ratios (HR) are presented along with 95% confidence intervals. The Bonferroni correction was used to counteract the multiple comparisons problem to reduce the chances of obtaining false-positive results (type I errors) by dividing the original alpha value (0.05) by the number of comparisons being made (80).

Sensitivity analysis assessed the robustness of the final model using a subset of the first two years of data ($N = 3{,}745$) and a subset of the first three years ($N = 3{,}115$). These subsets were then fitted with the final model to examine significance of the coefficients. There was little difference, thus, the final model was used.

Ethical approval

Ethical approval was not required as the study was a secondary analysis of existing anonymised data.

3. Results

3.1. Participant characteristics

Table 2 details participant characteristics at baseline. Participants were 57.8% female, aged 18 years and older, with the lowest percentage of participants (5.7%) in the 18 to 24-year age group. Almost two-thirds were of NZ European/Other ethnicity (61.4%), with Māori (NZ's

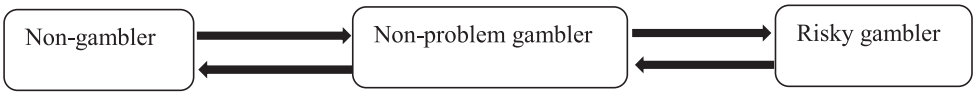

Fig. 1. PGSI transitions used in the Markov Modelling.

Table 1
Percentage distribution of PGSI transitions.

Transition	Non-gambler	Non-problem gambler	Risky gambler
Non-gambler	68	32	–
Non-problem gambler	11	83	6
Risky gambler	–	49	51

Table 2
Participant demographics.

Demographic variable	Description	n	%
Gender	Male	1170	42.2
	Female	1600	57.8
Age group (years)	18–24	158	5.7
	25–34	390	14.1
	35–44	577	20.8
	45–54	587	21.2
	55–64	460	16.6
	65+	597	21.6
Ethnic group	Māori	473	17.1
	Pacific	287	10.4
	Asian	282	10.2
	NZ European/Other	1702	61.4
	Not reported	26	0.9
Highest educational level	No formal qualification	458	16.5
	Secondary school qualification	616	22.2
	Vocational or trade qualification	624	22.5
	University degree or higher	1072	38.7
Labour force status	Employed	1722	62.2
	Unemployed/Beneficiary	268	9.7
	Student/Homemaker/Retired	736	26.6
	Other	18	0.6
Household size	1–2	1395	50.4
	3–4	937	33.8
	5+	438	15.8
Annual personal income (NZ$)	Up to 20,000	699	25.2
	20,001–40,000	829	29.9
	40,001–60,000	505	18.2
	60,001–80,000	329	11.9
	80,001–100,000	163	5.9
	Over 100,000	175	6.3
Location of residence	Auckland	880	31.8
	Wellington	308	11.1
	Christchurch	179	6.5
	Rest of NZ	1403	50.6

N = 2,770; Data collected at baseline.

indigenous population) comprising 17.1%, and Pacific and Asian populations each comprising about 10%. This was a slight deviation from ethnic percentages detailed in the 2013 national Census (Stats NZ website, nd), which indicated 14.1% Māori, 7.0% Pacific, 11.1% Asian and 67.8% NZ European/Other. Most participants had some level of education and 62.2% were in paid employment. Half lived alone or with one other person, and almost one-third lived in NZ's largest city of Auckland. One-quarter of participants were in the lowest annual personal income group of up to NZ $20,000.

3.2. Associations between changes in substance use, health and socio-economic covariates and changes in gambling risk level transitions

All gambling risk level transitions were statistically associated with some changes in the substance use domain, and some gambling risk level transitions were statistically associated with changes in some covariates in the health-related and socio-economic domains. Table 3 shows results for all covariates where there was a significant association with a gambling risk level transition.

Transitioning out of hazardous alcohol consumption (HR 1.52, 95% CI 1.09–2.12) and continuing hazardous alcohol consumption (HR 1.37, 95% CI 1.06–1.78) were both statistically associated with higher likelihood of *starting gambling*, compared with never drinking alcohol hazardously. Stopping tobacco smoking was also statistically associated with higher likelihood of *starting gambling*, compared with never smoking tobacco (HR 1.67, 95% CI 1.10–2.53). Developing a chronic illness was statistically associated with higher likelihood of *starting gambling*, compared with never having such an illness (HR 1.37, 95% CI 1.01–1.87).

Continuing to experience deprivation was statistically associated with higher likelihood of *stopping gambling*, compared with not experiencing deprivation (HR 1.37, 95% CI 1.12–1.67). Continuing hazardous alcohol consumption (HR 0.69, 95% CI 0.55–0.85), continuing to have a chronic illness (HR 0.78, 95% CI 0.64–0.96) and developing chronic illness (HR 0.58, 95% CI 0.39–0.89) all were statistically associated with lower likelihood of *stopping gambling*.

Continuing to smoke tobacco (HR 1.38, 95% CI 1.04–1.83), starting cannabis use (HR 1.95, 95% CI 1.12–3.38) and continuing to use cannabis (HR 2.18, 95% CI 1.50–3.38), continuing to have a low quality of life (HR 1.41, 95% CI 1.03–1.93), continuing to experience at least one major life event in the prior year (HR 1.89, 95% CI 1.25–2.85), starting to experience deprivation (HR 1.86, 95% CI 1.31–2.63), and stopping membership of organised groups (HR 1.50, 95% CI 1.06–2.13) were all statistically associated with higher likelihood of *transitioning to risky gambling*.

No changes in covariates were statistically associated with *transitioning out of risky gambling*. However, continuing hazardous alcohol consumption (HR 0.60, 95% CI 0.46–0.78) and continuing to have a low quality of life (HR 0.70, 95% CI 0.53–0.94), were both statistically associated with lower likelihood of transitioning out of risky gambling.

4. Discussion

Despite long-standing knowledge that risky gambling behaviours are significantly associated with a variety of negative behavioural, health and social factors, associations between changes in risky gambling behaviours and changes in such factors have not been well researched. This study aimed to identify associations between changes in gambling risk level and changes in various health and social covariates. The hypothesis was that there would be some significant associations between these transition states.

4.1. Associations between changes in substance use and changes in gambling risk level

Changing or continuing hazardous alcohol consumption, tobacco and cannabis use over time were statistically associated with changes in gambling risk levels. Stopping hazardous alcohol consumption was statistically associated with higher likelihood of starting gambling. Continued hazardous alcohol consumption was also statistically associated with higher likelihood of starting gambling, and lower likelihood of stopping gambling and transitioning out of risky gambling. These

Table 3
Associations between changes in substance use, health-related and socio-economic covariates and changes in PGSI transitions.

Domain	Covariate	Gambling transition	Covariate transition	No. of observations	Hazard Ratio	[95% CI]
Substance use	Tobacco	Starting gambling	Ref: No to No	401	1.00	–
			No to Yes	20	1.44	[0.92–2.26]
			Yes to No	**25**	**1.67**	**[1.10–2.53]**
			Yes to Yes	70	1.22	[0.93–1.59]
		Transitioning to risky gambling	Ref: No to No	206	1.00	–
			No to Yes	16	1.25	[0.74–2.12]
			Yes to No	17	1.35	[0.81–2.24]
			Yes to Yes	**86**	**1.38**	**[1.04–1.83]**
	Hazardous alcohol	Starting gambling	Ref: No to No	345	1.00	–
			No to Yes	30	1.34	[0.89–2.00]
			Yes to No	**49**	**1.52**	**[1.09–2.12]**
			Yes to Yes	**92**	**1.37**	**[1.06–1.78]**
		Stopping gambling	Ref: No to No	431	1.00	–
			No to Yes	48	0.92	[0.66–1.28]
			Yes to No	62	1.02	[0.76–1.38]
			Yes to Yes	**123**	**0.69**	**[0.55–0.85]**
		Transitioning out of risky gambling	Ref: No to No	171	1.00	–
			No to Yes	17	0.65	[0.40–1.06]
			Yes to No	26	0.71	[0.47–1.08]
			Yes to Yes	**92**	**0.60**	**[0.46–0.78]**
	Cannabis	Transitioning to risky gambling	Ref: No to No	260	1.00	–
			No to Yes	**15**	**1.95**	**[1.12–3.38]**
			Yes to No	9	0.96	[0.49–1.90]
			Yes to Yes	**41**	**2.18**	**[1.50–3.18]**
Health related	Chronic illness	Starting gambling	Ref: No to No	289	1.00	–
			No to Yes	**55**	**1.37**	**[1.01–1.87]**
			Yes to No	29	0.97	[0.64–1.45]
			Yes to Yes	**143**	**0.82**	**[0.67–1.02]**
		Stopping gambling	Ref: No to No	391	1.00	–
			No to Yes	**27**	**0.58**	**[0.39–0.89]**
			Yes to No	53	1.15	[0.84–1.58]
			Yes to Yes	**195**	**0.78**	**[0.64–0.96]**
	Quality of life	Transitioning to risky gambling	**Below Median to Below Median**	**142**	**1.41**	**[1.03–1.93]**
			Below Median to Median or above	51	1.27	[0.86–1.87]
			Median or above to Below Median	34	0.88	[0.57–1.36]
			Ref: Median or above to Median or above	98	1.00	–
		Transitioning out of risky gambling	**Below Median to Below Median**	**128**	**0.70**	**[0.53–0.94]**
			Below Median to Median or above	35	0.70	[0.46–1.06]
			Median or above to Below Median	41	0.74	[0.50–1.10]
			Ref: Median or above to Median or above	102	1.00	–
Socio-economic	Deprivation	Stopping gambling	Ref: 0 to 0	294	1.00	–
			0 to 1+	66	1.20	[0.92–1.58]
			1 + to 0	93	1.18	[0.93–1.50]
			1 + to 1+	**213**	**1.37**	**[1.12–1.67]**
		Transitioning to risky gambling	Ref: 0 to 0	109	1.00	–
			0 to 1+	**52**	**1.86**	**[1.31–2.63]**
			1 + to 0	36	0.97	[0.66–1.42]
			1 + to 1+	128	1.27	[0.94–1.71]
	Number of life events	Transitioning to risky gambling	Ref: 0 to 0	27	1.00	–
			0 to 1+	42	1.29	[0.79–2.10]
			1 + to 0	32	0.91	[0.54–1.53]
			1 + to 1+	**224**	**1.89**	**[1.25–2.85]**
	Member of an organised group	Transitioning to risky gambling	No to No	119	1.14	[0.88–1.49]
			No to Yes	34	0.99	[0.67–1.45]
			Yes to No	**45**	**1.50**	**[1.06–2.13]**
			Ref: Yes to Yes	127	1.00	–

Bold font shows significance at the 0.05 level and adjusted with the Bonferroni correction method.
Adjusted for age, ethnicity, employment status and highest educational level.
Table key:
No to No - there was no change in the covariate over time, e.g. for tobacco, a participant never smoked. This was always the reference group.
No to Yes - there was a transition from not doing/having the covariate to doing/having it, e.g. for tobacco a participant started smoking.
Yes to No - there was a transition from doing/having the covariate to not doing/having it, e.g. for tobacco a participant stopped smoking.
Yes to Yes - there was no change in the covariate over time, e.g. for tobacco, a participant continued smoking.

findings indicate that the relationship between hazardous alcohol consumption and gambling risk level transitions is complex and is likely to be influenced by other factors such as personality and risk-taking behaviours (Mishra et al., 2010; Samuelsson et al., 2018), and environmental factors (e.g. electronic gaming machines located in venues that provide alcohol, such as pubs, clubs and casinos). Although our study controlled for socio-demographic confounders, personality and environmental factors were not examined as those data had not been collected in the original data sets. Nonetheless, the co-location of alcohol with gambling opportunities is an important public health consideration, as there could be unintended consequences, such as perpetuating hazardous alcohol consumption or potentially initiating gambling

behaviour in some people, although our study was not able to discern the temporal direction of the association. In other words, while our study identified a significant statistical association between changes in hazardous alcohol consumption over time and changes in gambling risk level, it cannot identify cause and effect.

Continued tobacco smoking over time was statistically associated with higher likelihood of transitioning into risky gambling behaviours. This is an interesting finding in the context of stopping smoking being statistically associated with higher likelihood of starting gambling. Although the direction of the relationship between smoking and gambling remains unknown, it is possible that this finding indicates that adults who are regular smokers may have a higher risk of increasing their gambling to a potentially harmful level as previous cross-sectional studies that have shown problematic gambling is associated with smoking along with other unhealthy behaviours (Jiménez-Murcia et al., 2021; McGrath & Barrett, 2009). However, other explanations are also possible, and this finding needs to be replicated in future studies before any definitive conclusions can be drawn. Our finding of starting to use cannabis and continued cannabis use over time being statistically associated with higher likelihood of transitioning into risky gambling requires further study to understand the relationship. Although cannabis is an illegal recreational drug in NZ, it is accessed by a substantial minority of the adult population, with 14.7% reporting cannabis use in 2021/22 (Ministry of Health, 2022).

4.2. Associations between changes in health and wellbeing and changes in gambling risk level

Continuing to have a chronic illness and developing a chronic illness were both statistically associated with lower likelihood of stopping gambling, while developing a chronic illness was associated with higher likelihood of starting gambling. These findings may be related to the generally incapacitating nature of chronic illnesses affecting active pursuits and the fact that some gambling behaviours can easily be undertaken without physical exertion. However, other explanations are again possible and to elucidate the full nature and direction of this relationship requires further study.

Continuing to have a low quality of life (i.e. below median level) was statistically associated with higher likelihood of transitioning into risky gambling, and lower likelihood of transitioning out of risky gambling. These findings were expected as several cross-sectional studies have reported an association between problem gambling and low quality of life (e.g. Black et al., 2013; Mythily et al., 2017). Adults who gamble in a risky manner experience various levels of harm from their gambling (Browne et al., 2017a; Rawat et al., 2018), which can negatively affect quality of life (Browne et al., 2017a; Langham et al., 2016; Lin et al., 2011). Browne et al. (2017b), using a Health-Related Quality of Life approach to measure Disability Weights, identified that quality of life is negatively affected by any level of risky gambling.

Although many cross-sectional and qualitative research studies have identified associations between problematic gambling and mental health issues (e.g. depression and anxiety), general health and wellbeing, and physical health issues (Mutti-Packer et al., 2017), and cross-lagged path modelling in Australian and Hungarian studies showed mental health issues in one year were found to have associations with the development of risky gambling a year later (Dowling et al., 2019; Horváth et al., 2023), our study did not identify any statistical associations between *changes* in these factors and concurrent *changes* in gambling risk levels. This suggests complex coexistence between health issues and risky gambling behaviours. It may be that *changes* in health conditions are not associated with *changes* in gambling behaviour, or that unexamined confounders affected the relationship.

4.3. Associations between changes in major life events experienced, deprivation and social connectedness and changes in gambling risk level

Some people, especially women, gamble to escape from stressful situations or events (Buchanan, et al., 2020; Nuske et al., 2017). Our study found that continuing to experience at least one major life event in the prior year was statistically associated with higher likelihood of transitioning into risky gambling. Russell et al's study (2022) identified stressful life events precede gambling problems. This together with our findings indicates a public health importance, as the provision of appropriate and easily accessible support systems for people who experience stressful situations could help to reduce or prevent the development of risky gambling behaviours.

Problematic gambling is known to be associated with deprivation, partly related to a disproportionately high availability of gambling venues in areas of high deprivation (Abbott et al., 2018a). Financial problems are the most common harm experienced by risky gamblers (Browne et al., 2016; Langham et al., 2016), and prolonged financial deprivation usually leads to poverty. It was expected, therefore, that starting to experience levels of individual deprivation would be statistically associated with higher likelihood of transitioning into risky gambling, as found in the current study. Counterintuitively, however, continuing to experience deprivation was also statistically associated with higher likelihood of stopping gambling. It is possible that continued deprivation may have meant that there was no money with which to gamble (as the transition was from non-problem gambling to no gambling) and the behaviour stopped. However, as mentioned previously, our study was not able to discern the temporal direction of the association, other explanations are possible, and this finding needs to be replicated in future studies before any definitive conclusions can be drawn.

Change in only one social connectedness factor was statistically associated with a gambling transition, with stopping membership of organised group/s associated with higher likelihood of transitioning into risky gambling. A possible explanation for this finding is that people who gamble in a risky manner may no longer have the time or desire to be socially or community-oriented because their leisure time is taken up by the increased gambling behaviour (Browne et al., 2017a). Although our study cannot identify the direction of the association, an earlier Australian study reported that problem gamblers were significantly less likely to take part in community activities than non-problem gamblers (Billi et al., 2014). The current study adds to the Australian research by identifying that the reduction in social activities was associated with the transition to risky gambling behaviour.

4.4. Limitations

The main limitation of this study is that the analyses were restricted by the available data, as the study was a secondary analysis of existing data sets. A further limitation is that due to the small sample size of low risk, moderate risk and problem gamblers, these were combined into one category of risky gambler. Whilst recent research has identified that all levels of risky gambling are associated with harm (Browne & Rockloff, 2018), harms from low-risk gambling are generally of a low intensity. Thus, a combined 'risky gambler' category may mean that some associations with transitions to more severe levels of gambling have not been identified. Furthermore, the sample sizes in our study (i.e. number of transitions from one state to another) were quite small in some cases and this may have masked or exacerbated the statistical associations that were seen. Finally, it is also likely that there were some transitional lag effects that could not be identified because the study could only focus on changes across the four years of the study and any effects that might only become apparent after a longer period remain unknown.

5. Conclusion

Changes in various health and lifestyle factors were statistically associated with higher or lower likelihood of changes in gambling risk levels over a four-year period. The highest number of associated factors was found with transitioning into risky gambling, including continued or development of several negative health and lifestyle factors. However, the direction of the associations (or causality) cannot be ascertained from our study, and due to small sample sizes in some cases, the findings should be replicated in a future study before definitive conclusions can be drawn. Nonetheless, the data analysed for this study were sourced from a population level study and, as the prevalence of risky gambling in New Zealand is similar to that of other countries with gambling opportunities, the findings from this study have global relevance. This knowledge is useful in the context of providing appropriate social, health and treatment supports for people whose gambling behaviour increases over time, and underscores the importance of screening for gambling behaviours when assisting people with substance use, health issues, or social situations or conditions.

CRediT authorship contribution statement

Maria E. Bellringer: Writing – original draft, Funding acquisition. **Stéphane Janicot:** Methodology, Formal analysis, Writing – review & editing. **Takayoshi Ikeda:** Methodology, Formal analysis, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

This secondary analysis was of data publicly available to researchers in New Zealand on application to Statistics New Zealand.

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