WHAT'S THE HARM? PREDICTING THE RISK OF FUTURE GAMBLING PROBLEMS

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ABSTRACT

Problem gambling (PG) and gambling-related harm (GRH) are strongly associated with heavier gambling involvement in terms of the amount of time and money spent gambling as well as the number of gambling formats participated in. This association has been the focus of public health initiatives aimed at the prevention of GRH and PG, most notably the "Lower Risk Gambling Guidelines". However, it has also been demonstrated that heavier gambling involvement is only one feature relevant to the development of either outcome. In order to better identify cases in which gambling problems may emerge, a secondary analysis of data from the Alberta Gambling Research Institute's National Project Online Panel Survey was conducted. In the first study, it was shown that while breadth of gambling involvement is a stronger concurrent and future predictor of gambling problems than involvement in any particular type, involvement in certain types of gambling (electronic gambling machines in particular, and casino table games to a lesser extent) does confer additional risk. In the second study a more comprehensive examination of the factors that predict GRH or PG onset was undertaken as part of an initiative to update the 'at-risk' category of the Problem and Pathological Gambling Measure (PPGM). The analysis showed that five items pertaining to breadth of gambling involvement, largest single day gambling loss, perception of gambling problems, rated importance of gambling as a leisure activity, and overall level of PG symptomatology demonstrated superior prediction accuracy relative to previously utilized operationalizations of 'at-risk' gambling. Taken together, these two studies a) more conclusively demonstrate that certain types of gambling do confer additional risk; b) provide a substantially improved 'at-risk' assessment to a well-validated problem gambling assessment instrument; and c) provide a more complete understanding of the risk factors associated with GRH and PG.

CONTRIBUTION OF AUTHORS

A version of Chapter 2 has been accepted for publication in the *Journal of Gambling Studies* (Gooding & Williams, in press). Nolan Gooding was responsible for conducting statistical analyses, writing the original manuscript, editing, and was the corresponding author during the peer review process. Robert Williams was responsible for the conceptualization of the manuscript and editing.

A version of Chapter 3 is under review at *International Gambling Studies* (Gooding, Williams, & Volberg, under review). Nolan Gooding was responsible for statistical analyses, writing the original manuscript, editing, and had an equal role in the conceptualization of the manuscript. Robert Williams was responsible for editing the manuscript and had an equal role in its conceptualization. Rachel Volberg edited the manuscript and had an equal role in its conceptualization.

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LIST OF ABBREVIATIONS

AGRI	Alberta Gambling Research Institute
ANP	AGRI National Project
APA	American Psychiatric Association
AUC	Area under the curve
EGM	Electronic gambling machine
GPI	Gambling Participation Instrument
GRH	Gambling-related harm
LEO	Leger Opinion
LRGG	Lower Risk Gambling Guidelines
MAGIC	Massachusetts Gambling Impact Cohort Study
PG	Problem gambling
PGSI	Problem Gambling Severity Index
PPGM	Problem and Pathological Gambling Measure
PPGM-R	Problem and Pathological Gambling Measure – Revised
NODS	NORC DSM Screen for Gambling Problems

CHAPTER 1: INTRODUCTION

There has been an unprecedented global expansion of legal gambling opportunities over the past 35 years. While the social and economic impacts of this expansion are mixed (Williams et al., 2011), it is clear that greater access to gambling increases the likelihood that a portion of the population will experience gambling-related harm (GRH) or problem gambling (PG). As a result, efforts have been dedicated to conceptualizing gambling harms (Langham et al., 2016) and their antecedents (Abbott et al., 2018); evaluating the association between gambling participation, GRH, and PG (Binde et al., 2017; Hodgins et al., 2022; Mazar et al., 2020; Young et al., 2021, 2022); and modelling the etiology of PG (e.g., Blaszczynski & Nower, 2002; Williams et al., 2022).

Problem gambling is "characterized by difficulties in limiting money and/or time spent gambling which leads to adverse consequences for the gambler, others, or for the community" (Neal, Delfabbro, & O'Neill, 2005, pp. i). While the definition of PG is well established and generally agreed upon (Williams & Volberg, 2014), the adverse consequences associated with it (i.e., GRH) are less well defined. This is due, in part, to the subjectivity of the concept of harm. However, Langham et al., (2016) propose the following functional definition of GRH: "Any initial or exacerbated adverse consequence due to an engagement with gambling that leads to a decrement to the health or wellbeing of an individual, family unit, community, or population." (pp. 4). This definition treats harm as an outcome and not a cause or symptom of harmful gambling. It also allows for the experience of harm to occur over various temporal windows and to affect those beyond the individual gambler. While this definition demonstrates strong progress in the field, some concerns have been raised over GRH research, including the conflation of opportunity costs and harm, the validity of additive methods for measure the extent of GRH, and inappropriate anchors for assessing the severity of harm (Delfabbro & King, 2019).

Despite these concerns, GRH has recently received increased attention in research and public health. This attentional shift is due, in large part, to the relative rarity of PG in the population (Williams et al., 2021a), an increasing recognition that GRH occurs even among low risk gamblers (Browne & Rockloff, 2018; Browne et al., 2020), and that GRH can extend beyond the individual who gambles (Langham et al., 2016). Along with their definition of GRH, Langham et al. (2016) developed a comprehensive taxonomy of GRH with the intention of establishing an internationally agreed upon conceptualization of gambling harm. The Conceptual Framework of Gambling Related Harm (Langham et al., 2016) identifies seven harm domains: financial harms; relationship disruptions; emotional or psychological distress; decrements to health; cultural harm; reduced school or work performance; and criminal activity. Moreover, they recognize that some harms may occur at a temporal point of significance (i.e., crisis harms) and can promote treatment seeking or behavioural change, while others are more persistent and can continue to occur even after cessation of gambling (i.e., legacy harms).

A related, but distinct approach has been to consider the set of factors the contribute to the risk of harmful gambling. The Conceptual Framework of Harmful Gambling (Abbott et al., 2018; Hilbrecht et al., 2020) posits two sets of factors associated with the risk of experiencing gambling harm: general factors (i.e., cultural, social, psychological, biological) and specific factors (i.e., gambling environment, exposure, gambling types, treatment resources). The general factors associated with GRH and PG are well-supported in the literature and include younger age, male gender, lower socioeconomic status, novelty seeking, and psychological comorbidities (Abbott et al., 2004; Black et al., 2015; Dowling et al., 2015; Williams et al., 2015). However, a recent meta-analysis indicated that the strongest correlates of problem gambling are not sociodemographic or psychological, but are specific to gambling participation (Allami et al., 2021). This is consistent

with recent etiological research indicating that intensive gambling involvement is the immediate antecedent to gambling problems (Williams et al., 2022). This is also, in part, why the Conceptual Framework for Harmful Gambling (Abbott et al., 2018) draws a distinction between harmful and non-harmful gambling, as opposed to problem and recreational gambling. Although PG and GRH are not directly the same, both are associated with harmful gambling behaviour.

The association between gambling participation and PG has received much attention. Population surveys provide consistent evidence that PG is greater among individuals participating in certain gambling formats relative to others (Binde, 2011; Williams et al., 2022; Williams, Volberg, & Stevens, 2012, Appendix G). These formats include electronic gambling machines (EGMs) and casino table games and their stronger association with PG is thought to result from their ability to facilitate continuous play and provide a high frequency of reinforcement (Haw, 2008; Leino et al., 2015; Linnet et al., 2010; Parke & Griffiths, 2007). However, game-specific associations with PG are limited by the fact that many gamblers do not restrict their participation to a single format. This is particularly true of individuals experiencing gambling problems (Holtgraves, 2009; Wardle et al., 2011; Williams et al., 2021b).

The number of gambling formats that an individual participates in is referred to as their *breadth of gambling involvement.* When controlling for frequency and breadth of gambling involvement, some studies (e.g., Laplante, Afifi, & Shaffer,2013; Philander & MacKay, 2014) have found no association between participation in specific formats and PG. However, other studies have found that while breadth of involvement is strongly associated with PG, certain formats do confer an additional risk. Participation in EGMs posed an additional risk of gambling problems among Swedish adults (Binde, Romild, & Volberg, 2017); participation in casino table games conferred additional risk among Massachusetts adults (Mazar et al., 2020) and young

Americans aged 14-21 (Welte, Barnes et al., 2009); and live action sports betting posed additional risk to European patrons of the bwin.com online gambling website (Laplante, Nelson, & Gray, 2014). Importantly, this issue has not been addressed in a Canadian context in over two decades (Afifi et al., 2013).

Intensive gambling involvement can also confer risk for GRH and is the foundation of the newly developed Lower Risk Gambling Guidelines (LRGG; Hodgins et al., 2022; Young et al., 2021, 2022). The LRGGs were developed on data aggregated from 11 studies consisting of roughly 60,000 participants and advise individuals to gamble no more than four days a month, on no more than two different types of gambling, and with no more than 1% of their household income. The LRGG follow the recent trend of focusing on harm rather than PG and represent an important milestone for harm reduction and responsible gambling initiatives. However, as described in the Conceptual Framework for Harmful Gambling, participation is only one relevant antecedent of gambling problems and may therefore be limited in its ability to predict future problems.

The contention that gambling participation is insufficient to predict future gambling problems is supported by recent etiological research. In a study of Canadian adults, Williams et al. (2022) found that in addition to gambling participation, an individual's largest single day gambling loss, their rated importance of gambling as a leisure activity, the proportion of their social group with gambling problems, and their susceptibility to gambling fallacies explain additional variance in future PG status. Each of these factors appear to promote continued and intensified gambling participation, providing a potential explanation for their etiological effect on PG.

Etiological models are vital in public health research because they inform efforts aimed at prevention and early detection. In addition to Williams et al. (2022), six other large scale longitudinal studies have investigated the etiology of PG (Abbott, Bellringer, et al., 2018; Abbott,

Romild, et al., 2018; Billi et al., 2014; el-Guebaly et al., 2015; MAGIC Research Team, 2021; Williams et al., 2015). While some findings are jurisdictionally and time-period specific, these studies are generally in agreement with Williams et al. (2022) in that: (1) gambling-related variables are the strongest predictors of PG; and (2) these variables do not pertain exclusively to gambling participation. However, despite consistent empirical support for the role of gambling-related variables in the etiology of PG, there is an absence of research attempting to operationalize these findings. As a result, there is little means of practically and reliably assessing the risk of future GRH or PG.

It is commonplace for PG assessment instruments, such as the Problem and Pathological Gambling Measure (PPGM; Williams & Volberg, 2010, 2014) or the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001) to classify individuals with levels of symptomatology below the PG threshold as 'at-risk'. The implication of this title is that there is a prospective risk of more serious problems. However, none of these instruments provide empirical support for this convention. While it is theoretically possible that low levels of gambling symptomatology may become progressively more serious over time, it is also the case that many gamblers who experience impaired control or negative consequences from gambling consider this a 'wake-up' call to limit their gambling involvement. Moreover, PG appears to be relatively unstable over time (Gooding, Williams, & Williams, 2022) and many gamblers in remission experience low levels of residual symptomatology.

Given that intensive gambling involvement can lead to GRH and PG (Hodgins et al., 2022; Young et al., 2021, 2022; Williams et al., 2022), it is important that this association receives special attention. However, it is evident that any effort to predict GRH or PG status concurrently or prospectively is incomplete on the basis of participation alone (el-Guebaly et al., 2015; MAGIC

Research Team, 2021; Williams et al., 2015). While operationalizations of 'at-risk' gambling do exist (e.g., levels of symptomatology below the PG threshold), the nature and extent of that risk is not empirically supported and does not take into account the broad set of factors that contribute to GRH and PG. Despite the breadth of existing research pertaining to the conceptualization of gambling harms and their antecedents, little attention has been dedicated to developing a practical tool that can aid in the early detection of GRH and PG. As such, there are two broad objectives guiding the present research:

1. Analyze a large Canadian dataset to evaluate whether certain types of gambling confer additional risk for PG while controlling for breadth of gambling involvement.
2. Use this same Canadian dataset to undertake a more comprehensive examination of the factors that predict future GRH and PG as part of an initiative to update the 'at-risk' category of the Problem and Pathological Gambling Measure.

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CHAPTER 2: ARE THERE RISKIER FORMS OF GAMBLING? EVIDENCE FROM THE CANADIAN NATIONAL STUDY

(GOODING & WILLIAMS, UNDER REVIEW WITH THE JOURNAL OF GAMBLING STUDIES)

ABSTRACT

Gambling-related harm is a public health issue requiring market regulation and efforts aimed at prevention and treatment. An important consideration for the regulation of gambling is whether certain types of gambling are intrinsically more harmful than others. The present study was a comprehensive investigation of this issue in a nationwide sample of 10,199 Canadian adult gamblers that included 1,346 problem gamblers. We investigated (a) the univariate cross-sectional association between individual types of gambling and problem gambling; (b) the cross-sectional association between individual gambling types and problem gambling when controlling for breadth of gambling involvement; (c) the prospective/lagged relationship between participation in different gambling types and future problem gambling; and (d) the self-reports of people with gambling problems concerning the types and modalities they consider to be most problematic. Our collective results indicate that breadth of gambling involvement is a stronger predictor of gambling problems than involvement in any particular type, but that involvement in certain types (electronic gambling machines in particular, and casino table games and online gambling to a lesser extent) does confer additional risk.

Contribution of Authors: Nolan Gooding was responsible for conducting statistical analyses, manuscript preparation, editing, and correspondence during peer review. Robert Williams was responsible for the conceptualization of the manuscript and editing.

2.1 INTRODUCTION

Gambling-related harm is widely recognized as a public health issue and as such, requires market regulation and initiatives for prevention and treatment (Volberg, 1994; Korn & Shaffer, 1999; Gainsbury et al., 2014). Though only a small minority of Canadians meet criteria for problem gambling (Williams et al., 2021) a large amount of gambling-related harm occurs in people who are below the clinical threshold (Browne, Volberg, Rockloff, & Salonen, 2020). An important consideration for mitigating gambling-related harm is whether certain types and modalities of gambling have a greater contribution to the risk of gambling harm than others.

2.1.1 Univariate associations between certain gambling types/modalities and problem gambling status

Population surveys provide consistent evidence that gambling-related harm is higher among individuals participating in certain types of gambling compared to other types (Allami et al., 2021; Binde, 2011; Williams et al., 2022; Williams, Volberg, & Stevens, 2012, Appendix G). More specifically, electronic gambling machines (EGMs) and casino table games consistently have had the strongest associations with problem gambling (PG), while types such as lotteries, tend to have weak associations. The basis for this association is thought to be because EGMs and casino table games are 'continuous' types of gambling that can be repeatedly engaged in and provide a high frequency of reinforcement (Haw, 2008; Leino et al., 2015; Linnet et al., 2010; Parke & Griffiths, 2007). The use of multi-line EGMs further increases the rate of reinforcement (Harrigan et al., 2011; Templeton et al., 2015) as do 'losses disguised as wins' where the amount 'won' is less than the amount wagered, but nonetheless trigger winning sounds (Dixon et al., 2010; Dixon, Graydon et al., 2014).

Population surveys have also provided strong evidence that gambling-related harm is higher among individuals accessing gambling via an online modality (Allami et al. 2021; Binde, 2011; Wood, Williams, & Parke, 2012; Welte et al., 2009). The basis for this association is thought to be because of its 24-hour accessibility, the ability to play while intoxicated, enhanced anonymity, and the online provision of continuous types of gambling (Griffiths, 2003; Wood, Williams, and Parke, 2012; Wood & Williams, 2009).

2.1.2 Confound with intensity of gambling involvement

An important confound with the above results is that people who engage in EGMs, casino table games, and access gambling online do not restrict their involvement to these specific types or modalities. Indeed, most gamblers participate in more than one type of gambling, with people having gambling problems being especially likely to participate in a wider variety of types and modalities relative to people without gambling problems (Holtgraves, 2009; Phillips et al., 2013; Williams et al., 2021; Wardle et al., 2011).

Thus, LaPlante, Afifi & Shaffer (2013) found that after controlling for both frequency and breadth of involvement there were no specific types of gambling with a significant association to problem gambling among Las Vegas casino patrons. Similarly, an analysis by Philander & MacKay (2014) found after controlling for level of involvement that online gambling was associated with a *lower* risk of problem gambling in British adults as well as Ontario online panelists. However, most other studies have found that while breadth and/or frequency of involvement has a stronger association with problem gambling, certain types do confer some additional risk. For example, a study of Swedish adults found EGMs to pose additional risk when controlling for breadth of involvement (Binde, Romild & Volberg, 2017). Similarly, casino gambling was found to confer additional risk both in a study of Massachusetts adults (Mazar et al.,

2020) as well as in a study on U.S. young adults (14-21) (Welte, Barnes et al., 2009). LaPlante et al. (2011) found that online EGMs posed additional risk among British adults. Afifi et al. (2013) also found EGMs and casino gambling to pose additional risk in Canadians aged 15+ in 2002, along with instant win lottery tickets, bingo, card and/or board games, horse racing, sports lotteries, and games of skill. Finally, LaPlante, Nelson & Gray (2014) found that live action sports betting posed additional risk among European patrons of the bwin.com online gambling website.

2.1.3 Longitudinal research

The above research has established that the association between gambling-related harm and certain types and modalities of gambling is due to people with gambling-related problems having a greater breadth of involvement, but that involvement in certain types of gambling does pose additional risk. However, a limitation of the above results is that they are cross-sectional in nature. While it may be the case that engagement in certain types or modalities is associated with some additional *concurrent* risk, it does not a) identify the directional nature of this relationship (i.e., it is possible these additional types/modalities are sought out after gambling problems have developed); or b) speak to whether engagement in certain types/modalities are more or less likely to subsequently lead to future gambling problems. Longitudinal research that examines the relationship between current participation in different types/modalities and *future* problem gambling can shed light on this issue.

The large majority of longitudinal studies have only looked at the concurrent relationship between types of gambling and problem gambling over time. However, three studies have also conducted a lagged/prospective analysis. In the Quinte Longitudinal study in Ontario (QLS; Williams et al., 2015) multivariate prediction of next year PG status was associated with previous year participation in EGMs, online gambling, and instant lottery tickets (in addition to level and

breadth of gambling involvement). In the Leisure, Lifestyle, and Lifecycle Project in Alberta (LLLP; el-Guebaly et al., 2015), multivariate prediction of next year PG was associated with previous year participation in EGMs, casino table games, bingo, and sports betting (in addition to breadth of gambling involvement). In the Massachusetts Gambling Cohort Study (MAGIC; MAGIC Research Team, 2021), multivariate prediction of next year PG was associated with previous year online gambling, daily lottery games, out-of-state casino participation, traditional lottery games, and instant lottery participation (note that within-state EGMs and casino table games had very limited availability during the course of this Massachusetts study).

2.1.4 Self-report

A final consideration is whether people with gambling problems self-report there to be particularly problematic types or modalities of gambling. Across different jurisdictions and periods of time, EGMs are the type of gambling that treatment seekers and helpline callers most often indicate as being problematic (Stea, Hodgins, & Fung, 2015; Potenza, Steinberg, & Wu, 2005; Ledgerwood et al., 2005; Hodgins & e-Guebaly, 2000). While these results are informative, they are somewhat limited by the fact that individuals seeking help are a non-representative minority of people with gambling problems.

Another source of data are self-reports of problem gamblers collected in the context of population surveys. In six population surveys in Ontario (2), Alberta, Massachusetts, Canada, and internationally (primarily U.S.) all individuals identified as problem gamblers were asked whether they were particular types of gambling that have contributed to their problems more than others, and if so, to identify the specific one(s) (el-Guebaly et al., 2015; MAGIC Research Team, 2021; Williams, Belanger & Arthur, 2011; Williams & Volberg, 2013; Williams et al., 2015; Wood & Williams, 2009). The percentage reporting there to be a particular problematic type averaged 45%

across studies (ranging from 29.8% (Ontario) to 58.3% (Canada)). When specifying which one(s) those were, EGMs were identified as the most problematic type in all of these studies, with instant lottery tickets being identified as problematic in two of these studies.

2.1.5 The present study

Converging lines of evidence indicate that certain types of gambling do confer additional risk of harm relative to other types. However, these findings may be somewhat jurisdictionally and time-period specific. Thus, the purpose of the present paper is to re-examine this issue in the national study of gambling and problem gambling that was recently conducted in Canada. More specifically, the present investigation will examine individual types and modalities of gambling with respect to their:

a) univariate cross-sectional association with problem gambling
b) cross-sectional association with problem gambling after controlling for breadth of gambling involvement
c) prospective/lagged relationship with future problem gambling in a multivariate analysis
d) identification as problematic types/modalities in the self-reports of people with gambling problems

2.2 METHODS

2.2.1 Sampling and recruitment

The present investigation is a secondary analysis of data from the online panel survey that was part of the Alberta Gambling Research Institute's (AGRI) National Project (ANP). The Baseline Online Panel Survey was administered to 10,199 Canadians by Leger Opinion (LEO) between August 16 and October 10, 2018. LEO is Canada's largest online panel, consisting of over 400,000 active members who receive financial compensation for completing online surveys.

The email solicitation to panelists was nonspecific and simply indicated that it was "a very important academic study." However, eligibility to complete the survey was restricted to people who completed an initial screening question indicating they had gambled on one or more types of gambling once a month or more in the past year. Repeated email solicitations were sent out until a sample of at least 10,000 with an equal number from each province or region was achieved (i.e., 1,400 each from the provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and 1,400 from the four Atlantic provinces combined).

Between Aug 20 and Nov 30, 2019, people who had completed the Baseline Survey were re-contacted and asked to take the Follow-Up Survey. A total of 4,707 complied, representing 82.5% of those who had agreed to be re-contacted, and 46.2% of all Baseline participants.

2.2.2 Questionnaire

The survey was available in both English and French and took an average of 19.5 minutes to complete. The primary focus of the survey was on gambling (i.e., attitudes, past year participation, motivation, fallacies, social exposure, responsible gambling, family history, problem gambling), but comprehensive information was also collected on demographics, mental health, substance use, and personality. Pertinent to the present investigation were the following instruments and questions:

The Gambling Participation Instrument. The Gambling Participation Instrument (GPI; Williams et al., 2017) assesses all dimensions of gambling participation in a past year time frame: types of gambling engaged in, gambling provider, means of access, frequency of gambling, time spent gambling, and gambling expenditure. Eight specific types of gambling are assessed: lottery and raffle tickets, instant games, electronic gambling machines (EGM), casino table games, sports betting, bingo, 'other' types of gambling, and speculative financial market activity. (Note that

'other' types and speculative financial activities are not included in the present analysis). If the person engaged in any type via online access they were identified as an online gambler. Four aggregate measures of overall gambling involvement are derived: total number of different types engaged in; total gambling frequency; total time spent gambling; and total gambling expenditure. Depending on the specific domain, the test-retest coefficients of the GPI are fair to excellent (0.46 – 0.84), and the validity coefficients are good to excellent (0.60 – 0.91) (Williams et al., 2017).

Problem and Pathological Gambling Measure. Problem gambling was assessed with the Problem and Pathological Gambling Measure (PPGM; Williams & Volberg, 2010, 2014), which classifies individuals into four main categories of non-gambler, recreational gambler, at-risk gambler, and problem/pathological gambler using a past 12-month time frame. To be classified as PG, the PPGM usually requires an individual to endorse symptoms indicative of both impaired control and significant negative consequences resulting from this impairment. However, the PPGM attempts to limit false negatives (problem gamblers in denial) by (a) allowing individuals to be classified as PGs if they have any pattern of problem gambling symptomatology combined with a gambling frequency or expenditure equivalent to unambiguously identified problem gamblers; and (b) allowing for others to identify the presence of harms and/or impaired control (i.e., the person is asked whether other people would indicate harm or impaired control had occurred, independent of whether they believed it themselves).

The PPGM has good internal consistency (Cronbach's alpha = 0.76-0.81) as well as one month test-retest reliability (r = 0.78) (Williams & Volberg, 2010, 2014). It has superior construct validity (Christensen et al., 2019), as well as better sensitivity, positive predictive power, diagnostic efficiency, and overall classification accuracy in the population assessment of PG

compared to instruments such as the DSM-IV and Problem Gambling Severity Index (Williams & Volberg, 2010, 2014).

Self-reported contribution of gambling types/modalities to problems. All participants identified as a problem gambler were asked "Are their particular types of gambling that have contributed to your problems more than others?" If they responded "yes" then they were asked "Which types of gambling have contributed to your problem?" with the instruction to "check all that apply". They were then asked whether their problems were mostly with land-based gambling, online gambling, or both.

2.2.3 Analysis

To test the univariate cross-sectional association between types of gambling and PG, we calculated the prevalence of problem gambling for people participating in each type of gambling on a monthly or more frequent basis.

To evaluate the cross-sectional association between monthly or more participation in each gambling type and problem gambling after controlling for breadth of gambling involvement, the prevalence of PG was plotted for each type of gambling across increasing breadth of involvement to determine whether any individual plot line(s) showed consistently higher problem gambling prevalence rates compared to other plot lines.

The prospective/lagged association between engagement in different individual types of gambling and future PG was reported by Williams et al. (2022) in a previously published analysis of the AGRI National Project's Online Panel Survey. It is re-reported for the present study.

Finally, the proportion of problem gamblers who indicated that a specific type and/or modality of gambling contributed to their gambling problems is reported along with the specific type/modality identified.

All analyses were conducted in SPSS version 27.0 and corresponding figures were produced via the R package *ggplot2* (Wickham, 2016).

2.3 RESULTS

Among the 10,199 participants, 145 (1.4%) were classified as Non-Gamblers[1], 7320 (71.9%) were Recreational Gamblers, 1388 (13.6%) were At-Risk Gamblers, and 1346 (13.2%) were Problem/Pathological Gamblers.

2.3.1 Univariate cross-sectional association between individual types of gambling and problem gambling

Figure 1 shows the percentage of people who participated in each type of gambling as well as the portion of participants who also met criteria for problem gambling. The percentage of people who participated monthly or more in each type of gambling was 80.0% for lotteries and raffles, 37.6% for instant games, 21.7% for online gambling, 17.7% for EGMs, 7.4% for bingo, 6.7% for sports betting, and 6.6% for casino table games. The proportion of people who participated in each type monthly or more who were problem gamblers was 12.1% for lotteries, 21.3% for instant lotteries, 32.7% for online gambling, 44.0% for EGMs, 48.6% for bingo, 41.8% for sports betting, and 60.6% for casino table games.

What Figure 1 also illustrates is that the problem gambling rate for each type of gambling has a strong, negative associated with the overall participation rate for each type (r = -.88), with the most patronized types having the lowest proportion of problem gamblers and the least patronized types of gambling having the highest proportion. The implication of this finding is that less popular types of gambling will always tend to have higher rates of problem gambling

[1] These were people who reported no involvement for any type of gambling, despite having indicated being a monthly gambler on the initial screening question.

independent of their inherent risk profile simply because problem gamblers have a greater breadth of involvement.

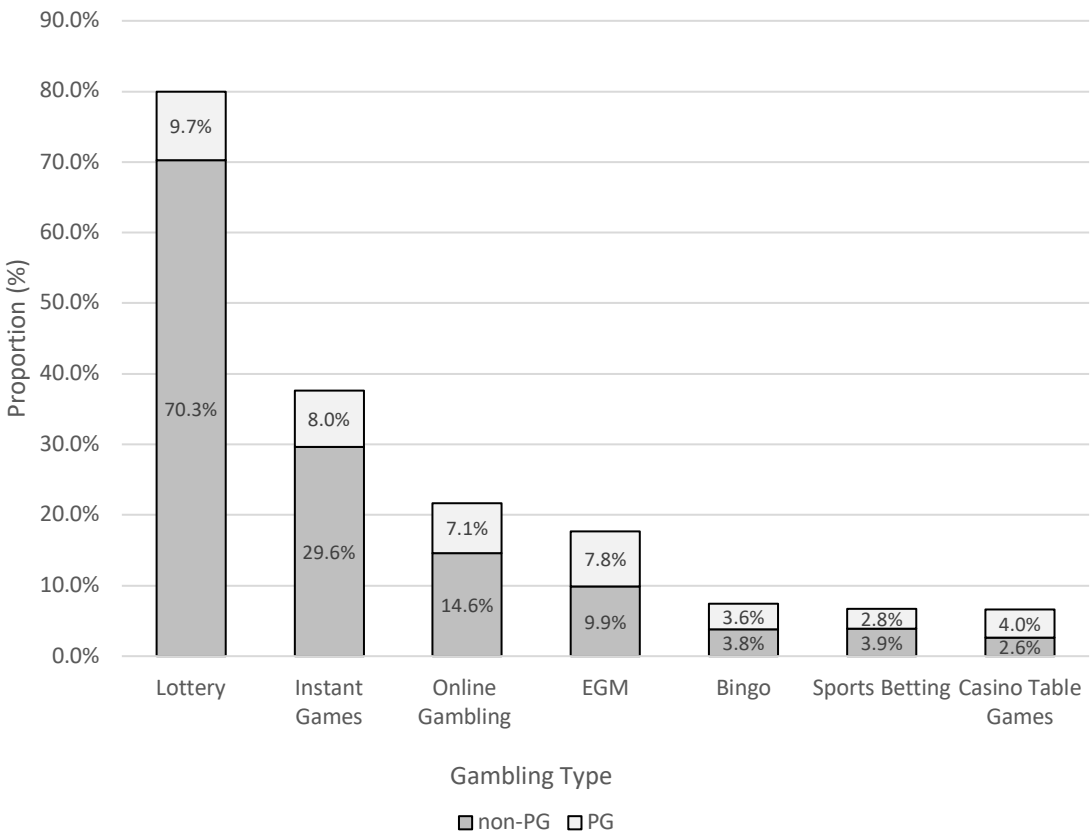

Figure 2.1. Univariate cross-sectional relationships between problem gambling and monthly or more participation in each type of gambling.

2.3.2 Breadth of gambling involvement mediates the relationship between types and problem gambling

The mean number of gambling types engaged in for all participants was 1.8 compared to 3.2 for people meeting criteria for problem gambling. The association between breadth involvement and PPGM category was statistically significant (r = .576; p < .01). The strong association between breadth of involvement and problem gambling likely has to do with a) problem gamblers being intrinsically more interested in a wider variety of gambling types, and b)

a greater breadth of gambling involvement normally entailing greater overall frequency, time and expenditure, which increases the risk of gambling-related harm. As an illustration of this latter point, Table 1 shows a robust association between breadth of involvement and all aggregate measures of gambling intensity (r = .271 for expenditure; r = .400 for time; r = .785 for frequency).

Table 2.1. association between breadth of gambling involvement, intensity of gambling involvement and problem gambling

	# Types	Total Frequency	Total Time	Expenditure	PPGM Category
# Types	1.00	.785**	.400**	.271**	.576**
Total Frequency	.785**	1.00	.446**	.312**	.585**
Total Time	.400**	.446**	1.00	.286**	.405**
Expenditure	.271**	.312**	.286**	1.00	.348**
PPGM Category	.576**	.585**	.405**	.348**	1.00

**$p < .01$

Figure 2 shows the problem gambling rate for each type of gambling as a function of breadth of gambling involvement. Each line represents a different type of gambling, and changes along the x-axis indicate an increasing breadth of involvement. For example, the first point on the EGM line represents the proportion of PGs who gambled exclusively on EGMs, the second point on the line represents the proportion of PGs who participated in EGMs and one other type of gambling, and so on. As a result, the lines are not independent beyond the first level, and the same participant may be represented at different points (e.g., someone who participated in EGMs + bingo is represented both in the EGM line at 2 types of involvement and the bingo line at 2 types of involvement). What Figure 2 illustrates is that both breadth of gambling involvement and specific type of gambling involvement are related to problem gambling. As seen, problem gambling rates steadily go up as breadth of gambling involvement increases, with the majority of

people who participate in four or more types of gambling being problem gamblers. However, it is also evident that certain types of gambling have consistently higher rates of problem gambling at almost all levels of involvement. More specifically, EGMs and casino table games have the highest proportion of problem gamblers when participating in either one, two, or three types of gambling.

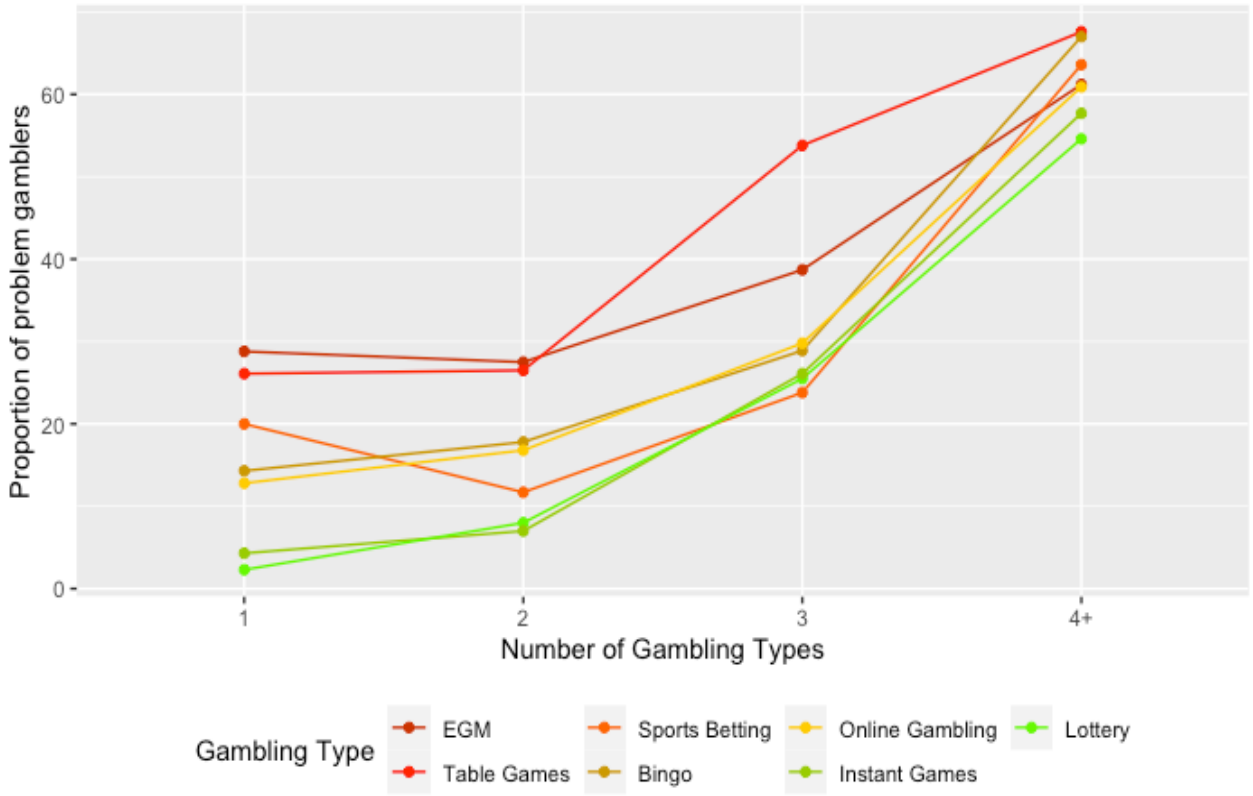

Figure 2.2. Proportion of problem gamblers relative to participation in each gambling type and breadth of gambling involvement

Among individuals who participated in only one type of gambling, a chi-square test revealed significant difference in the proportion of PGs engaged in each type ($\chi^2 = 386.06, p <$ .0001). Follow-up comparisons indicated that: (1) a greater proportion of individuals participating in EGMs, casino table games, sports betting, and online gambling met criteria for problem gambling relative to those participating in lottery/raffle tickets and instant games; (2) a greater proportion of EGM gamblers met criteria for problem gambling relative to online gamblers; and

(3) a greater proportion of individuals participating in bingo met PG criteria relative to individuals participating in lottery or raffle tickets.

2.3.3 Lagged/prospective relationship between engagement in different gambling types at baseline and future problem gambling

A total of 108 independent variables (IVs) were available for this lagged/prospective analysis, including participation in each of the different types of gambling, being an online gambler, and the four aggregate measures of overall gambling involvement. The bivariate relationship between each of the 108 IVs at Baseline and problem gambling categorization at Follow-Up was examined with chi-square tests utilized for categorical variables and t-tests for continuous variables. All IVs with a significant ($p < .01$) future relationship were subsequently entered into a stepwise binomial logistic regression predicting future problem or non-problem gambling status (for more details, see Williams et al., 2022).

As seen in Table 2, a total of fourteen demographic, psychological, and gambling-related variables were included in the final model. As expected, two of these were aggregate measures of gambling involvement: total gambling losses and total frequency of gambling. The strongest predictor, largest gambling loss in a single day, is also an indirect measure of overall gambling intensity. However, it is notable that two individual types of gambling participation also provided additive predictive power beyond gambling intensity: past year EGM participation (OR = 2.01, $p < .001$) and illegal online gambling (OR = 1.73, $p = .001$). (Note: illegal online gambling is when the person indicated they gambled on an out-of-province website).

Table 2.2. Stepwise Logistic Regression of Baseline Variables Predicting Problem Gambling One Year Later (n = 4,611).

	B	Wald	*p*	Odds Ratio	95% C.I.	
Largest Gambling Loss in Single Day (past 12 mo)	.48	60.57	.00000000	1.62	1.43	1.83
Impulsivity Score	.09	44.23	.00000000	1.09	1.06	1.12
Household Income	-.19	28.96	.00000007	.82	.77	.88
EGM Participation (past 12 mo)	**.70**	**27.56**	**.00000015**	**2.01**	**1.55**	**2.62**
Total Gambling Losses (past 12 mo)	*.07*	*21.10*	*.00000435*	*1.07*	*1.04*	*1.10*
History of Problem Gambling Prior to Past 12 mo	1.19	17.72	.00002552	3.28	1.89	5.69
Total Frequency of Gambling (past 12 mo)	*.06*	*17.29*	*.00003211*	*1.06*	*1.03*	*1.09*
Age	-.18	16.65	.00004499	.84	.77	.91
Family History of Problem Gambling	.37	13.66	.00021956	1.45	1.19	1.76
Gambling Fallacies Measure	-.11	12.58	.00038932	.89	.84	.95
Portion of Social Group with Gambling Problems	.27	12.23	.00046957	1.31	1.13	1.53
Importance of Gambling as a Leisure Activity	.26	11.66	.00063814	1.30	1.12	1.51
Illegal Online Gambling (past 12 mo)	**.55**	**10.42**	**.00125006**	**1.73**	**1.24**	**2.42**
Tobacco or E-Cigarette Frequency (past 12 mo)	.06	8.05	.00455012	1.06	1.02	1.10

2.3.4 Self-report of types contributing to gambling problems

Among respondents meeting criteria for problem gambling at Baseline, only 37.3% indicated that there were particular types of gambling that contributed to their problems more than others. For those that did say yes, 61.7% identified EGMs; 29.1% lottery or raffle tickets; 23.6% instant lotteries; 13.1% casino table games (other than poker); 12.6% sports betting; and 11.3% poker. In terms of modality, 51.8% said their problems were mostly with land-based gambling, 31.1% said online gambling, and 17.1% said their problems were with both land-based and online modalities.

2.4 DISCUSSION

The present study comprehensively investigated the relationship between different types of gambling and problem gambling in the context of the AGRI National Project's online panel survey. We investigated (a) the univariate cross-sectional association between individual types of

gambling and problem gambling; (b) the cross-sectional association between individual gambling types and problem gambling when controlling for breadth of gambling involvement; (c) the prospective/lagged relationship between participation in different gambling types and future problem gambling; and (d) the self-reports of people with gambling problems concerning the types and modalities they consider to be most problematic.

Results showed that breadth and intensity of gambling involvement to be a much stronger predictor of problem gambling than involvement in any specific type. Plotting problem gambling rates as a function of individual type and total number of types engaged in illustrated that engaging in three or more types of gambling was associated with considerably more risk than engagement in any individual type. In addition, lagged multivariate analysis showed 'largest gambling loss in a single day' (an indirect measure of gambling intensity) to be the strongest individual predictor of future problem gambling among 108 variables. Finally, when asking problem gamblers directly (who averaged 3.2 types of gambling engagement), 62.7% indicated that no specific type of gambling contributed to their problems more than any other type.

The strong relationship between breadth and intensity of involvement and problem gambling is very consistent with the prior literature (Holtgraves, 2009; Phillips et al., 2013; Williams et al., 2021; Wardle et al., 2011). People with a keen interest in gambling tend to engage in a wider variety of gambling types. This broader engagement, in turn, normally entails a greater overall frequency of engagement, more time spent, and more money spent. Higher levels of gambling involvement, in turn, are associated with greater risk of gambling-related harm. Indeed, level of gambling involvement is the basis of the newly developed Canadian Lower Risk Gambling Guidelines, which were derived from an extensive analysis of all international longitudinal and cross-sectional data sets (Young et al., 2021, 2022). These guidelines provide recommended limits

for an individual's breadth of gambling involvement (i.e., no more than two formats on a monthly basis), their gambling frequency (i.e., less than four days a month), and their gambling expenditure (i.e., no more than 1% of monthly income).

Results also showed that despite level of involvement having the strongest relationship to problem gambling, engaging in certain types and modalities of gambling did confer additional risk. It was found that EGMs and casino table games have the highest proportion of problem gamblers when participating in either one, two, or three types of gambling. In addition, lagged multivariate analysis showed that EGM participation and illegal online gambling were the only individual types of gambling associated with the future development of problem gambling. Finally, for the 37.3% of problem gamblers who did indicate there was a particularly problematic type, a) EGMs were identified to a much greater extent (by 61.7%) compared to any other type, and b) online gambling was implicated to some extent, with 31.1% saying their problems were associated with online gambling and 17.1% indicating their problems were with both online and land-based gambling.

These above results are also very consistent with the prior literature, which has identified EGMs, casino table games, and online gambling to be most problematic. The relationship between EGMs, table games, and problem gambling is likely due to their ability to facilitate rapid play and provide a high frequency of reinforcement (Haw, 2008; Leino et al., 2015; Linnet et al., 2010; Parke & Griffiths, 2007). This is analogous to drug addiction, where the speed of the effect (e.g., injection or inhalation versus ingestion) and drug half-life are potent determinants of the dependency-forming potential of different substances (Nutt et al., 2007). Other features contributing to the association between EGMs problem gambling may be their wide availability (Meyer et al., 2011) and ability to produce dissociative states (Dixon et al., 2014). The relationship between problem gambling and online gambling is due to its 24-hour accessibility, the ability to

play while intoxicated, enhanced anonymity, and the online provision of continuous types of gambling (Griffiths, 2003; Wood, Williams, and Parke, 2012; Wood & Williams, 2009). The specific relationship with illegal out-of-province online gambling is likely related to the fact that in 2018 two provinces (Alberta and Saskatchewan) did not offer any provincially-operated online gambling as well as the fact that that only British Columbia, Manitoba, Ontario, and Quebec offered online EGMs and casino table games.

The present investigation has some limitations. First, our analysis was limited to Canadian adults in 2018. There are features of the gambling context, such as availability and treatment access, that vary by country and time period and may therefore limit generalizability to other jurisdictions and other time periods. However, the concordance between the results of the present investigation and those of the broader literature increases confidence in the findings. Second, respondents were not randomly assigned to participate in specific formats and as such, we cannot determine whether EGMs and table games were directly conferring risk or whether individuals with particular vulnerabilities were attracted to these formats. The presence of EGM participation in table 2.2, however, supports the former, given it remained strongly related to future PG in the presence of other relevant variables. Relatedly, our results do not speak to whether there are certain combinations of gambling types that create greater risk than other combinations. Given that gambling formats vary in their structural characteristics, and that these variations provide different motivation for gambling participation (Binde, 2013), it would be valuable to understand the risk associated with the various different combinations.

2.4.1 Conclusion

The present study was a comprehensive investigation of the relationship between gambling formats and problem gambling in a large sample of Canadian adult (18+) gamblers. Our results

demonstrate that there is a strong association between problem gambling and breadth of gambling involvement, due, in part to the association between breadth of involvement and level of involvement. Despite this association, converging evidence indicates that certain types and modalities of gambling do confer additional risk. More specifically, EGMs were robustly associated with problem gambling in all of our analyses, with casino table games and online gambling being implicated to a somewhat lesser extent. These findings provide valuable insight for the provision and regulation of gambling, and for public health initiatives aimed at prevention and treatment.

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CHAPTER 3: THE PROBLEM AND PATHOLOGICAL GAMBLING MEASURE – REVISED: AN UPDATE OF CHRONIC AND AT-RISK GAMBLING (GOODING, WILLIAMS, & VOLBERG, UNDER REVIEW WITH INTERNATIONAL GAMBLING STUDIES)

ABSTRACT

Most problem gambling (PG) assessment instruments classify individuals with subthreshold levels of gambling symptomatology as 'at-risk'. However, this convention lacks empirical support. The present study aimed to develop an empirically supported revision of the Problem and Pathological Gambling Measure (PPGM-R) that (1) assesses the risk of future gambling-related harm (GRH) and problem gambling (PG) and (2) predicts cases in which PG will persist. Data from the Alberta Gambling Research Institute's National Project Baseline and Follow-up Online Panel Surveys (*n*=4707) were used to identify gambling-related predictors of future GRH or PG. Five variables maximized prediction power: PPGM total score, problem perception, rated importance of gambling as a leisure activity, largest single day gambling loss, and breadth of monthly gambling involvement. A 13-point scale was produced based on the relative risk of each outcome and Receiver Operating Characteristic (ROC) analyses found that scores of 1, 3, and 5 best captured a gradient of risk for future GRH/PG. A PPGM-R score of 6+ was found to be most predictive of chronic PG. The PPGM-R and its risk assessment improve upon existing assessment instruments by (1) assessing the risk of both future GRH and PG and (2) doing so across a gradient of risk.

Contribution of Authors: Nolan Gooding was responsible for statistical analyses, manuscript preparation, editing, and had an equal role in the manuscript's conceptualization. Robert Williams was responsible for editing and had an equal role in conceptualization. Rachel Volberg edited the manuscript and had an equal role in its conceptualization.

3.1 INTRODUCTION

The past 35 years has seen an unprecedented worldwide expansion of legalized gambling. While the social and economic effects of this expansion are mixed (Williams et al., 2011), it is clear that greater access to gambling increases the likelihood that a minority of individuals will experience gambling-related harm (GRH) and/or meet criteria for problem gambling (PG). Indeed, variables pertaining to gambling involvement tend to be the strongest correlates of current (Allami et al., 2021) and future PG (Williams et al., 2022).

The rate of past year PG varies between 0.1% and 5.8%, with the average in most western jurisdictions being around 2% (Calado & Griffiths, 2016; Williams, Volberg, & Stevens, 2012). Part of this variation can be attributed to the use of different assessment instruments (Williams et al., 2012). The three most widely used instruments for assessing PG in the general population are the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001), various operationalizations of the DSM criteria such as the NORC DSM-IV Screen for Gambling Problems (NODS; Gerstein et al., 1999), and the Problem and Pathological Gambling Measure (PPGM; Williams & Volberg, 2010, 2014). The few studies that have directly compared these instruments within the same sample generally favour the PPGM. Relative to other instruments, the PPGM varies less as a function of gender, age, and ethnicity (Williams & Volberg, 2010, 2014), has better classification accuracy (Williams & Volberg, 2014), is better suited to capture the multidimensional nature of PG (Christensen et al., 2019), and is better able to differentiate between levels of severity in both general populations and in clinical contexts (Molander & Wennberg, 2022).

The unique scoring system of the PPGM is part of the reason behind its better performance. Unlike the PGSI or the NODS, which simply use a total score threshold to designate PG status, the PPGM requires a particular pattern of item endorsement. Specifically, individuals

must report experiencing both impaired control and harm to receive a PG designation. Individuals who meet these criteria and have a score of five or more are sub-designated as 'pathological gamblers', indicating greater severity and associated chronicity. Moreover, the PPGM attempts to limit false positives and false negatives. The former is accomplished by requiring individuals to gamble monthly or more often in the past year to receive a past-year PG designation. The latter is accomplished by classifying individuals as having PG if they report some PG symptomatology and have a frequency and expenditure that is equivalent to individuals unambiguously identified as having PG, and/or if other people have indicated the person has both impaired control and harm deriving from this impaired control.

However, one of the limitations of the PPGM, which also applies to other assessment instruments (e.g., the PGSI, Ferris & Wynne, 2001), is that individuals with levels of symptomatology below the PG threshold are automatically placed in an 'at-risk' category. The term 'at-risk' implies a prospective risk for more serious problems. However, none of these instruments provide empirical support for this convention. While it is theoretically plausible that having a few symptoms may portend even more problems in the future, it is also the case that a significant portion of people who develop impaired control or negative consequences from their gambling find this to be a 'wake-up call' to reduce their involvement. Furthermore, PG tends to be unstable over time (Gooding et al., 2022) and it is not uncommon for some people in remission to still experience low levels of residual symptomatology.

A related issue concerns what exactly the person is at risk for. Historically, PG has been the outcome of interest, and this is the likely outcome implied in these at-risk categories. However, the field has begun to shift its attention more broadly towards GRH (e.g., Langham et al., 2016). This is primarily because PG is too narrow a focus, as people with a designation of PG constitute

a small portion of the total number of people harmed by gambling (Browne & Rockloff, 2018). In fact, studies indicate that while individuals with PG personally experience higher levels of harm, the majority of harm in the population occurs in lower-risk groups (Browne, Volberg, Rockloff, & Salonen, 2020; Canale, Vieno, & Griffiths, 2016; Raisamo et al., 2015; Volberg et al., 2021). Barring theoretical concerns around how GRH is operationalized (e.g., Delfabbro & King, 2017), these findings represent a shift away from a strictly addiction-based model towards a public health model emphasizing a continuum of gambling harms/problems (Korn & Shaffer, 1999). The changed focus toward GRH is also evidenced by the newly developed Lower Risk Gambling Guidelines (LRGG; Young et al., 2021, 2022; Hodgins et al., 2022), which identify risk factors for GRH rather than PG.

Thus, the primary purpose of the present study is to re-examine and potentially revise the at-risk category within the PPGM so that it is shown to empirically predict both future GRH and PG. A secondary aim is to re-evaluate the ability of the pathological gambling category to predict PG chronicity. A final aim is to reassess the overall reliability and validity of the revised PPGM.

3.2 METHODS

3.2.1 Sampling and recruitment

The present investigation is a secondary analysis of the Alberta Gambling Research Institute's (AGRI) National Project (ANP) online panel survey. The Baseline Online Panel Survey was administered to 10,199 Canadians by Leger Opinion (LEO) between August 16 and October 10, 2018. LEO is Canada's largest online panel, consisting of over 400,000 active members who receive financial compensation for completing online surveys. The email solicitation to panelists did not specify the purpose of the study beyond that it was "a very important academic study." However, eligibility to complete the survey was restricted to people who completed an initial

screening question indicating they had gambled on one or more types of gambling once a month or more in the past year. Repeated email solicitations were sent out until a sample of at least 10,000 was achieved, with an equal number from each province or region (i.e., 1,400 each from the provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and 1,400 from the four Atlantic provinces combined).

Between Aug 20 and Nov 30, 2019, people who had completed the Baseline survey were re-contacted and asked to take the Follow-up survey. A total of 4,707 complied, representing 82.5% of those who had agreed to be re-contacted, and 46.2% of all Baseline participants. More information regarding attrition in the ANP online panel survey is reported by Williams et al. (2022). Briefly, participants with less involvement in gambling and fewer gambling problems were less likely to complete the Follow-up survey, probably due to the survey's focus on gambling.

Ethics approval for the online panel survey was obtained on June 19, 2018 from the University of Lethbridge Human Subjects Review Committee (approval number: 2018-063).

3.2.2 Questionnaire

The survey was self-administered and took an average of 19.5 minutes to complete. The questionnaire captured comprehensive information pertaining to demographics, substance use, mental health problems, and certain aspects of personality. In addition, relevant to the present investigation, gambling-related information was collected in the following areas:

Gambling Participation. Gambling participation was assessed using the Gambling Participation Instrument (GPI; Williams et al., 2017) which assesses all dimensions of gambling participation in a past year time frame: types of gambling engaged in, gambling provider, means of access, frequency of gambling, time spent gambling, and gambling expenditure. Eight specific types of gambling are assessed: lottery and raffle tickets, instant games, electronic gambling

machines (EGM), casino table games, sports betting, bingo, 'other' types of gambling, and speculative financial market activity. Four aggregate measures of overall gambling involvement are derived: total number of different types engaged in; total gambling frequency; total time spent gambling; and total gambling expenditure. Depending on the specific domain, the test-retest coefficients of the GPI are fair to excellent (0.46 – 0.84), and the validity coefficients are good to excellent (0.60 – 0.91) (Williams et al., 2017).

In addition to the above variables, the three dichotomous Lower Risk Gambling Guidelines variables (Young et al., 2021, 2022; Hodgins et al., 2022) were also derived from these data: engaging in more than two types of gambling, gambling more than four days a month, and spending more than 1% of household income on gambling.

Gambling Motivation. Gambling motivation was assessed with a single item that asked about the person's main reason(s) for gambling. The response options were excitement/enjoyment/fun; to win money; to develop my skills; to compete or for the challenge; to socialize; to support a worthy cause; to escape, relax, or relieve stress; it makes me feel good about myself; and other. In addition, respondents were asked about the importance of gambling as a leisure or recreational activity, and the importance of money, with four response options ranging from "not important at all" to "very important".

Gambling Exposure. Four questions were asked regarding respondents' exposure to gambling from family when growing up; portion of regular social group who are regular gamblers, portion of regular social group who are PGs; and opportunities to gamble at work/school.

History of Problem Gambling. Respondents were asked, "Have you or anyone in your family ever had a gambling problem? (i.e., had difficulty controlling their gambling to the extent that it caused significant problems)". If respondents indicated 'yes', they were asked to specify

which family member had gambling problems and whether it was in the past 12 months or earlier. For the present investigation, two variables were included: (1) any family history of problem gambling and (2) personal history of problem gambling prior to the past 12 months.

Problem Gambling. Problem gambling was assessed with the Problem and Pathological Gambling Measure (PPGM; Williams & Volberg, 2010, 2014), which is a 14-item instrument that classifies individuals as non-gambler, recreational gambler, at-risk gambler, problem gambler, or pathological gambler using a past 12-month time frame. The PPGM has a Harm scale consisting of seven items asking about whether the person has experienced significant harm in the areas of finances, mental health, relationships, physical health, work/school, and illegal activity. Anyone scoring one or higher is identified as having GRH. The PPGM also has an Impaired Control scale consisting of four items asking about difficulty controlling and/or limiting gambling and an Other Issues scale that includes three items asking about preoccupation, tolerance, and withdrawal. To be classified as PG, the PPGM typically requires a score of one or higher on the Harm scale and one or higher on the Impaired Control scale. The PPGM has good internal consistency (Cronbach's alpha = 0.76-0.81) as well as one month test-retest reliability (r = 0.78) (Williams & Volberg, 2010, 2014). The PPGM also has excellent construct validity (Christensen et al., 2019), sensitivity, specificity, and overall classification accuracy (Williams & Volberg, 2010, 2014), and is better able to differentiate between levels of severity (Molander & Wennberg, 2022).

Perception of Gambling Problems. The Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001) was also administered. Using a past 12-month time frame, the fifth item of the PGSI asks, "Have you felt you might have a problem with gambling?" with four response options: Never, sometimes, most of the time, and all the time. For the present study, the response options for this question were collapsed to two categories: never and sometimes or more.

3.2.3 At-risk analysis

While wishing to cast a wide net to identify variables empirically predictive of future GRH and PG, there are some logistical constraints to take into account. For one, the final set of at-risk variables must be operationalizable and easily administered. For another, it would be most efficient if the variables could predict both future GRH and PG. The variables chosen should also be things that would be routinely included as part of a survey on gambling involvement. Finally, although a multivariate analysis was employed, it was important that each variable had a strong *bivariate* relationship with GRH and PG (i.e., not just a multivariate relationship) for situations where not all of the variables are available and/or assessed.

Hence, a decision was made to limit the number of at-risk variables to no more than five that were predictive of both future GRH and PG. A decision was also made to restrict the variables to ones that were gambling-related, as a) initial analyses established that substance use, mental health, personality, and demographic variables were much weaker predictors of GRH and PG (in line with the findings of Allami et al. (2021) and Williams et al. (2022)) and b) because many of these types of variables would not routinely be assessed in the context of gambling participation or PG assessments. Finally, variables were entered into a multivariate model sequentially with their order of entry being determined by the strength of their bivariate relationship with GRH and PG.

An additional consideration is that because the present investigation was primarily concerned with the *onset* of either GRH *or* PG, the analysis predicting future GRH was limited to respondents who scored zero on the PPGM Harm subscale at Baseline and the analysis predicting future PG was limited to respondents who were not classified as PGs at Baseline. However, in

order to confirm that the final set of at-risk variables can also predict *continuing* GRH and PG from Baseline to Follow-up the analyses were re-run with all participants included.

For the final set of five variables, points were assigned to response options that reflect increased *relative* risk. Specifically, one point was assigned to a response that reflects a two to three fold increase in the relative risk of developing GRH or PG; two points allocated for a four to five fold risk; and three points for a six-fold or more risk. Points for each variable were summed together to produce a total risk score. Receiver operating characteristic (ROC) analyses were conducted to calculate the area under the curve (AUC) with 95% confidence intervals and identify a set of thresholds for predicting GRH and PG across a gradient of severity. AUC is a general index of prediction accuracy and similar investigations (e.g., Currie et al., 2017) indicate that an AUC between 0.5 and 0.7 reflects low accuracy, an AUC between 0.7 and 0.9 reflects moderate accuracy, and an AUC greater than 0.9 reflects high accuracy. Sensitivity, specificity, and positive prediction power, and overall classification accuracy for each level of the risk score were also calculated.

3.2.4 Pathological gambling analysis

The total score cut-off for pathological gambling was evaluated for its ability to predict PG chronicity. Thus, sensitivity, specificity, positive prediction power, and overall classification accuracy were calculated for various cut-offs to determine the threshold that best identified chronic cases (i.e., PG cases that persisted from Baseline to Follow-up).

3.2.5 Reliability and validity

Finally, the PPGM-R was re-evaluated for reliability and validity. Reliability was assessed by the internal consistency of the items (Cronbach's alpha). Concurrent validity was assessed by means of a Kendall tau correlation between each of the PPGM-R categories and concurrent

aggregate gambling expenditure, frequency, and time spent gambling. Construct validity was assessed by means of the Kendall's tau correlation between PPGM-R categories and PGSI total score. Predictive validity was established by virtue of the above-described at-risk and pathological gambling analyses predicting future behaviour.

3.3 RESULTS

A total of 4,707 respondents completed both the Baseline and the Follow-up survey. Of this group, 51.3% were female, 74.4% were over the age of 45, 63.4% were married or living in common law, 76.4% had at least some post-secondary education, and 49.5% had an annual household income greater than or equal to $60,000. Of the 4,707 Baseline respondents who completed the Follow-up survey, a total of 3,980 (84.6%) did not report Baseline GRH and 4,208 (89.4%) were not classified as PG at Baseline. At Follow-up, a total of 765 respondents reported GRH and 531 were classified as PGs.

3.3.1 Baseline predictors of future GRH and PG

The bivariate relationship between each of the 44 Baseline independent variables and GRH and PG at Follow-up was determined by their Rao score statistics, which are automatically calculated in an SPSS binary logistic regression before any variables enter the model ('step 0'). The Rao test calculates the chi-square improvement in model fit when the variable is added to a constant-only model.

Rao score statistics associated with GRH had a strong association with Rao score statistics associated with PG, as evidenced by a significant Kendall's tau correlation between the rankings ($\tau = .573$, $p < .001$, $n = 44$ pairs). The ten variables with the highest average score statistic ranking across both analyses were selected for inclusion in the binary logistic regression. The score statistics for each of these 10 variables are displayed in Table 1.

Table 3.1. Rao Score Statistics for variables predicting future harm and problem gambling (PG)

	Score Statistic (rank)	
Variable	GRH (n = 3980)	PG (n = 4208)
PPGM total score	112.79 (1)	387.20 (1)
Importance of gambling for leisure	81.72 (2)	100.60 (6)
Problem perception	69.86 (3)	286.10 (2)
Largest single day loss	59.54 (4)	172.49 (4)
Monthly or more table game participation	40.92 (5)	128.19 (5)
Breadth of monthly involvement	36.03 (6)	185.15 (3)
Exceeding LRGG for # types engaged in (i.e., 2)	30.80 (7)	70.32 (9)
Monthly or more EGM participation	27.17 (8)	92.79 (8)
Portion of social group being PGs	24.73 (10)	99.99 (7)
Monthly or more participation in 'other' gambling	55.32 (12)	24.33 (12)

A binary logistic regression was then conducted to predict future GRH, with people having GRH at Baseline excluded from the analysis (n = 3,980). Variables were entered into the model sequentially, with entry order determined by the size of the score statistic. As shown in Table 2, four variables accounted for the majority of changes in model fit and explained variance: PPGM total score, rated importance of gambling as a leisure activity, perception of possible gambling problems, and largest reported single day gambling loss in the past 12 months. However, as a whole, the model accounted for only a modest portion of the variance, with Nagelkerke R^2 = 9.9%. When the entire sample was included in the analysis (i.e., people who already experienced GRH at Baseline), Nagelkerke R^2 increased to 44.2% (n = 4,707).

Table 3.2. Sequential hierarchical logistic regression predicting future GRH (excluding people with GRH at Baseline) (n = 3980)

Variable	Block χ^2	p	Model χ^2	p	Nagelkerke R^2
1. PPGM total score	68.56	<.001	68.56	<.001	4.3%
2. Importance of gambling for leisure	45.58	<.001	114.14	<.001	7.2%
3. Problem perception	11.40	<.001	125.54	<.001	7.9%
4. Largest single day loss	10.56	.001	136.10	<.001	8.5%
5. Monthly or more table game participation	6.24	.013	142.33	<.001	8.9%
6. Breadth of monthly involvement	0.72	.397	143.05	<.001	9.0%
7. Exceeding LRGG for # types engaged in (i.e., 2)	2.99	.084	146.04	<.001	9.1%
8. Monthly or more EGM participation	0.04	.841	146.08	<.001	9.1%
9. Portion of social group being PGs	7.41	.006	153.49	<.001	9.6%
10. Monthly or more participation in 'other' gambling	5.31	.021	158.80	<.001	9.9%

Note: Nagelkerke R^2 was 44.2% when including people with GRH at Baseline.

A similar binary logistic regression was also conducted to predict future PG, with people classified as PGs at Baseline excluded (n = 4,208). As shown in Table 3, four variables accounted for the majority of changes in model fit and explained variance: PPGM total score, problem perception, breadth of monthly involvement (i.e., number of formats engaged in on a monthly basis), and largest reported single day loss. As a whole, the model accounted for a moderate proportion of the variance, with Nagelkerke R^2 = 22.1%. However, when the entire sample was included in the analysis (i.e., people who were already PG at Baseline), Nagelkerke R^2 increased to 47.7% (n = 4,707).

Table 3.3. Sequential hierarchical logistic regression predicting future PG (excluding people with PG at Baseline) (n = 4208)

Variable	Block χ^2	p	Model χ^2	p	Nagelkerke R^2
1. PPGM total score	186.52	<.001	186.52	<.001	12.8%
2. Problem perception	34.70	<.001	221.22	<.001	15.1%
3. Breadth of monthly involvement	65.28	<.001	286.50	<.001	19.4%
4. Largest single day loss	18.30	<.001	304.80	<.001	20.6%
5. Monthly or more table game participation	1.56	.211	306.36	<.001	20.7%
6. Importance of gambling for leisure	7.29	.007	313.66	<.001	21.2%
7. Portion of social group being PGs	7.97	.005	321.63	<.001	21.7%
8. Monthly or more EGM participation	0.68	.794	321.70	<.001	21.7%
9. Exceeding LRGG for # types engaged in (i.e., 2)	2.55	.111	324.24	<.001	21.9%
10. Monthly or more participation in 'other' gambling	4.53	.033	328.77	<.001	22.1%

Note: Nagelkerke R^2 was 47.7% when including people with PG at Baseline.

Three of the four variables that maximized model fit were shared between each analysis, resulting in a subset of five variables that could be used for predicting both GRH and PG. These five variables were selected for the PPGM's at-risk assessment. Relative risk ratios were calculated for the response options of each variable and points were assigned to responses that reflected increases in the average relative risk of PG and GRH. The resulting scale ranges from zero to 13. For each response option, the proportion of respondents who developed GRH or PG and the points that were assigned are shown in Table 4.

Table 3.4. At-risk assessment for GRH and PG

Variable	Response option	Proportion who developed GRH (n = 3980)	Proportion who developed PG (n = 4208)	Points
PPGM Total Score	0	5.7%	2.8%	0
	1-2	22.6%	18.1%	2
	3+	31.8%	38.9%	3
Problem Perception	Never	6.5%	3.8%	0
	Sometimes or more often	24.3%	28.3%	2
Breadth of Regular Involvement	0 – 2	6.5%	3.9%	0
	3 – 4	11.5%	12.4%	1
	5+	29.0%	49.1%	3
Largest Single Day Gambling Loss	<$200	6.5%	4.0%	0
	$200 – $499	13.1%	15.2%	1
	$500 – $999	26.9%	29.9%	2
	≥$1,000	30.8%	38.5%	3
Importance of Gambling as a Leisure Activity	Not at all important	4.9%	3.1%	0
	Somewhat important	11.0%	8.6%	1
	Quite/very important	18.1%	15.2%	2
Points Total				**13**

3.3.2 Performance of the at-risk assessment

ROC analyses were conducted to assess the prediction accuracy of the risk assessment. Consistent with the logistic regression analyses, prediction accuracy was greater for PG onset (AUC = .804, 95% CI, .770, .837) than it was for onset of GRH (AUC = .704, 95% CI, .670, .739). A second set of analyses evaluated the prediction accuracy when including the entire sample (i.e., including people who experienced GRH and/or PG at Baseline). Prediction accuracy increased for both future PG (AUC = .890, 95% CI, .872, .907) and future GRH (AUC = .857, 95% CI, .840, .874).

The sensitivity, specificity, positive prediction power, and overall classification accuracy of different relative risk scores for future GRH are shown in Table 5. As seen, a score of one

correctly identified 69.9% of people who subsequently reported GRH for the first time and 88.1% of people who reported GRH at Follow-up regardless of whether they also reported GRH at Baseline. However, a score of one is also associated with a high false positive rate, as only 12.6% - 30.0% of people with a risk score of one actually had GRH at Follow-up (i.e., positive predictive power). For comparison purposes, the historically used PPGM At-Risk classification only identified 27.9% of people who subsequently reported GRH, although the positive predictive power was higher at 23.4%.

Table 3.5. At-Risk scores predicting future GRH

Relative risk Score	Future GRH Onset (n = 3980) (excluding people with GRH at Baseline)				Future GRH (n = 4707) (full sample)			
	Sensitivity	Specificity	PPP	CA	Sensitivity	Specificity	PPP	CA
1	69.9%	63.5%	12.6%	63.9%	88.1%	60.2%	30.0%	64.7%
2	49.1%	82.6%	17.6%	80.3%	80.5%	78.2%	41.7%	78.6%
3	32.3%	91.1%	21.5%	87.0%	73.1%	87.1%	52.4%	84.8%
4	21.5%	95.2%	25.4%	90.1%	65.5%	91.6%	60.1%	87.3%
5	12.5%	97.3%	25.9%	91.4%	58.3%	94.1%	65.9%	88.3%
6	7.9%	98.6%	29.7%	92.2%	50.5%	96.3%	72.4%	88.8%
7	5.0%	99.3%	35.0%	92.7%	42.2%	97.6%	77.3%	88.6%
8	1.8%	99.5%	21.7%	92.7%	31.8%	98.4%	79.7%	87.6%
9	1.4%	99.8%	33.3%	92.9%	24.2%	99.1%	84.1%	86.9%
10	0%	99.9%	0%	92.9%	17.5%	99.5%	87.0%	86.2%
11	0%	100%	0%	93.0%	11.6%	99.8%	91.8%	85.5%
12	-	-	-	-	5.9%	100%	97.8%	84.7%
13	-	-	-	-	2.1%	100%	100%	84.1%

Sensitivity (# predicted to have future GRH divided by # who actually did have future GRH)
Specificity (# predicted not to have future GRH divided by # who actually did not have future GRH)
PPP = Positive predictive power (# with future GRH divided by # predicted to have future GRH)
CA = Classification accuracy (# correctly predicted to have future GRH and correctly predicted not to have future GRH divided by the total sample size)

The sensitivity, specificity, positive prediction power, and overall classification accuracy of different relative risk scores for future PG are shown in Table 6. As seen, a score of one correctly identified 83.4% of people who subsequently reported PG for the first time and 92.3% of people who reported PG at Follow-up regardless of whether they also reported PG at Baseline. However, a score of one is also associated with a high false positive rate, as only 10.5% - 21.8% of people

with a risk score of one actually had PG at Follow-up. For comparison purposes, the historically used PPGM At-Risk classification only identified 54.3% of people who subsequently became PGs, although the positive predictive power was higher at 21.7%.

Table 3.6. At-Risk scores predicting future PG

Relative risk Score	Future PG Onset (n = 4208) (excluding people with PG at Baseline)				Future PG (n = 4707) (full sample)			
	Sensitivity	Specificity	PPP	CA	Sensitivity	Specificity	PPP	CA
1	83.4%	60.1%	10.5%	61.4%	92.3%	58.0%	21.8%	61.9%
2	70.9%	78.7%	15.7%	78.3%	87.0%	75.7%	31.3%	77.0%
3	59.2%	88.2%	21.9%	86.6%	81.7%	84.8%	40.7%	84.5%
4	47.1%	93.1%	27.6%	90.6%	76.1%	89.7%	48.5%	88.2%
5	35.4%	95.8%	32.0%	92.6%	69.3%	92.6%	54.4%	90.0%
6	27.4%	97.8%	40.7%	94.0%	62.3%	95.2%	62.1%	91.5%
7	19.7%	98.8%	48.4%	94.6%	52.7%	96.7%	67.0%	91.7%
8	12.6%	99.4%	52.8%	94.8%	41.1%	97.9%	71.5%	91.5%
9	9.0%	99.7%	64.5%	94.9%	31.1%	98.7%	75.0%	91.1%
10	5.8%	99.9%	76.5%	94.9%	22.6%	99.2%	77.9%	90.5%
11	3.6%	100%	80.0%	94.8%	14.9%	99.6%	81.4%	90.0%
12	2.7%	100%	100%	94.8%	7.9%	99.9%	91.3%	89.5%
13	0.9%	100%	100%	94.7%	2.8%	100%	93.8%	89.0%

Sensitivity (# predicted to have future PG divided by # who actually did have future PG)
Specificity (# predicted not to have future PG divided by # who actually did not have future PG)
PPP = Positive predictive power (# with future PG divided by # predicted to have future PG)
CA = Classification accuracy (# correctly predicted to have future PG and correctly predicted not to have future PG divided by the total sample size)

The sensitivity, specificity, and positive predictive power for future onset of *either* GRH or PG are shown in Table 7. For the purposes of the revised PPGM-R At-Risk category, a relative risk score of 1+ will be described as moderate relative risk, 3+ as high relative risk, and 5+ as very high relative risk.

Table 3.7. At-Risk scores predicting future onset of either GRH or PG

Risk Score	Sensitivity	Specificity	PPP
1+	79.0%	61.7%	17.8%
3+	50.7%	89.5%	33.6%
5+	26.5%	94.3%	42.9%

3.3.3 Problem Gambling Chronicity

The PPGM total scores of individuals with PG at Baseline (n = 468) were examined to identify the total score threshold most predictive of continued PG at Follow-up. A total of 304 individuals had PG during both time periods. As seen in Table 8 a **total score of six** was found to be the demarcation that best balanced and maximized sensitivity plus specificity (Youden's index). Table 8 shows the sensitivity, specificity, and positive prediction power, and overall classification accuracy for predicting PG chronicity at various total score thresholds.

Table 3.8. Cut-offs for pathological gambling (n = 468)

PPGM Total Score	Sensitivity	Specificity	Positive Predictive Power	Classification Accuracy
3	94.6%	17.1%	68.3%	66.2%
4	87.2%	34.1%	71.0%	68.8%
5	76.6%	55.5%	76.1%	69.4%
6	66.4%	67.1%	78.9%	69.7%
7	58.2%	75.6%	81.6%	69.0%

Sensitivity (# PGs predicted to have future PG divided by # who actually did have future PG)
Specificity (# PGs predicted not to have future PG divided by # who actually did not have future PG)
PPP = Positive predictive power (# PGs with future PG divided by # predicted to have future PG)
CA = Classification accuracy (# PGs correctly predicted to have future PG and # PGs correctly predicted not to have future PG divided by the total sample size)

3.3.4 Reliability and validity of the revised Problem and Pathological Gambling Measure

The revised Problem and Pathological Gambling Measure (PPGM-R) is a 15-item instrument that classifies individuals into five main gambling categories: non-gambler (0), recreational gambling (1), at-risk gambling (with 3 sublevels) (2), problem gambling (3), and pathological gambling (4). The PPGM-R includes all of the 14 original items plus one new problem perception item from the current analysis which asks, "In the past 12 months, have you ever felt you had a problem with gambling?" In addition, the at-risk category has been revised to more precisely measure and predict the level of future risk of GRH and/or PG. The revised instrument and scoring system are included in Appendix A.

The new 15-item PPGM-R displayed excellent internal consistency, as evidenced by a Cronbach's alpha of .928 (n = 10054). Construct validity was established by a significant Kendall's tau association between the PPGM-R categories and PGSI total score (τ = .691, p <.001, pairs = 10054). Reasonable concurrent validity was established by virtue of significant Kendall's tau associations between the four PPGM-R categories and total gambling frequency (τ = .455, p <.001, pairs = 10199), time spent gambling (τ = .426, p <.001, pairs = 10199), and total gambling losses (τ = .144, p <.001, pairs = 10196).

3.4 DISCUSSION

The primary objective of the present study was to use data from the Alberta Gambling Research Institute's National Project (ANP) to revise the at-risk category within the PPGM so that it robustly empirically predicts both future GRH and future PG. Secondary objectives were to re-evaluate the ability of the PPGM pathological gambling category to predict PG chronicity as well as reassess the overall reliability and validity of the revised PPGM.

Five strong predictors of future GRH and PG were identified. The strongest one for predicting both GRH and PG was PPGM total score, which is a measure of subclinical problem gambling symptomatology that was historically utilized by the PPGM to identify people in the at-risk category. In the case of predicting future GRH, this would be people endorsing items on the Impaired Control or Other Issues scales but not the Harm scale. In the case of predicting future PG, this would be people endorsing items from either the Harm, Impaired Control, or Other Issues scale but not items from both the Harm and Impaired Control scales. While important, PPGM total score is not a sufficient predictor on its own as it only identified 27.9% of people who subsequently reported GRH and 54.3% who subsequently became PGs compared to the 69.9% and 83.4% respectively identified by the new five item at-risk measure. Nonetheless, it confirms that having

any level of problem gambling symptomatology is reliably associated with an increased likelihood of having even more symptomatology in the future.

Perception of potential problems with gambling was the next strongest predictor. Prior research has established that problem perception is associated with a lower likelihood of remission among problem gamblers, primarily due to this perception having an association with higher levels of harm and impaired control (Gooding et al., 2023). The present investigation extends these findings to individuals with sub-threshold levels of symptomatology and indicates that subjective problem perception is robustly associated with future GRH and PG status at all levels of symptomatology.

Rating gambling as an important leisure or recreational activity was a particularly strong predictor of future GRH and a weaker predictor of PG. Its strong association with GRH is likely because it indicates the person is somewhat enamoured with gambling and tends to spend a significant amount of time engaged in it. This, in turn, could lead to preoccupation and over-involvement which increases the likelihood of experiencing GRH or PG (Binde et al., 2017; Holtgraves, 2009; Mazar et al., 2020; Phillips et al., 2013).

Finally, there were two predictive variables that are reflective of higher levels of actual gambling involvement: breadth of monthly gambling involvement and highest reported single day gambling loss in the past 12 months. This is consistent with the recognition that intensive gambling involvement is the immediate antecedent to GRH and PG (Hodgins et al., 2022; Williams et al., 2022). Largest gambling loss in a single day was in fact the strongest individual predictor of future PG and breadth of gambling involvement was a strong predictor of concurrent PG in the etiological investigation of problem gambling in Canada recently conducted by Williams et al. (2022). The present results differ in other respects from this etiological investigation in that the Williams et al.

(2022) study focused exclusively on PG; endeavoured to identify variables that were both concurrent and future predictors of PG; included demographic, personality, substance use, and mental health variables; and used a multivariate approach that allowed variables with weaker bivariate relationships to enter the model if they added significant overall predictive power.

Higher levels of gambling involvement are also the primary focus of the Lower Risk Gambling Guidelines (Hodgins et al., 2022; Young et al., 2021, 2022). Breadth of gambling involvement is in fact one of the three LRGG criteria. Gambling expenditure is also one of the LRGG criteria (i.e., spending no more than 1% of income on gambling), but this was not found to be a strong predictor of either GRH or PG in the present analysis. While excessive gambling expenditure is one of the primary causes of GRH and PG, *self-reported* gambling expenditure tends to be unreliable (Williams et al., 2017; Wood & Williams, 2007) and the present results would suggest that asking about greatest single day loss may provide a more reliable marker of expenditure. The third LRGG criteria of not gambling more than four days a month was also not a strong predictor of GRH or PG in the present study although frequent participation in EGMs and table games were found to have strong bivariate relationships to GRH and PG. Some of the differences between the present results and the LRGG are due to the fact that the LRGG were developed based on both *concurrent and future harm* and are derived from several international data sets from several different time periods, whereas the present results predict *future harm and problem gambling* among Canadians in 2019. Another difference is that the LRGG used certain PGSI questions as a measure of harm whereas the present results used the Harm scale from the PPGM. Also, the LRGG focused on gambling involvement variables, whereas the present results considered a wider range of gambling-related variables for inclusion.

When the five risk factors identified above are operationalized into an at-risk rating scale they were found to do a fairly good job of predicting future GRH and PG (and significantly better than the prior PPGM at-risk criteria). More specifically, a risk score of one correctly identified 69.9% of people who subsequently reported the onset of GRH and 83.4% of people who were subsequently identified as PGs, with these percentages being much higher when including people who had already experience GRH or PG at Baseline. That said, a score of one has low positive predictive power, with only 12.6% and 10.5% of people with this score actually having GRH or PG respectively one year later. Thus, in the revised PPGM this level of relative risk, associated with a score of one or higher, is characterized as 'moderate'. Higher risk scores are associated with lower sensitivity but progressively higher positive predictive power. For instance, a risk score of 3 or higher has a sensitivity of 50.7% and positive predictive power of 33.6%, which is characterized as 'high relative risk' when predicting GRH or PG. A risk score of 5 or higher has a sensitivity of 26.5% but a positive predictive power of 42.9%, which is characterized as 'very high relative risk'.

Another advantage of the current risk assessment over the prior one is that it classifies individuals according to a gradient of risk. For example, being at moderate relative risk (i.e., a score of 1-2) may be phenomenologically similar to gambling recreationally because it is not necessarily associated with adverse consequences and may only reflect greater gambling involvement. As such, interventions with this group may be as simple as providing information about lower risk gambling limits (Hodgins et al., 2022; Young et al., 2021, 2022) or using pop-up messages on electronic formats (Bjørseth et al., 2021; Mutti-Packer et al., 2022). Alternatively, high relative risk (i.e., 3-4 points) and very high relative risk (i.e., 5+ points) gambling is more likely to be associated with greater gambling involvement and some problem gambling

symptomatology. Individuals in these categories may therefore benefit from more resource-intensive interventions to reduce gambling behaviour, such as motivational interviewing (Yakovenko et al., 2015).

Of final note, the present analysis determined that a PPGM total score of six was a better demarcation for predicting chronicity of problem gambling compared to the previous total score of five. The present analysis also confirmed the new 15-item PPGM-R to have a) excellent internal consistency (Cronbach's alpha of .928); b) good construct validity by virtue of a Kendall tau association of .691 between the PPGM-R categories and PGSI total score; and c) reasonable concurrent validity by virtue of significant Kendall's tau associations between the four PPGM-R categories and total gambling frequency (τ = .455), time spent gambling (τ = .426), and total gambling losses (τ = .144).

The present investigation should be considered in light of the following limitations. First, the investigation was limited to Canadian adults (18+) in 2018 – 2019. Thus, while all variables considered in this study were theoretically cross-jurisdictional, the PPGM-R should be tested and validated in other populations and in other time periods. Second, only about half of respondents completed both the Baseline and Follow-up surveys. However, attrition is only a problem when it is associated with extreme loss of data at the high or low end of a variable, as longitudinal analysis essentially looks at the strength of the relationship between independent variables (IV) and the dependent variable (DV). Thus, it is important that the IVs and DV retain their *range*, as the strength of the association is largely unaffected by sample size at each point on the range. In the present situation, there is little reason for concern as attrition analysis found relatively little difference in completers versus non-completers, but with a slight tendency for greater attrition in groups that were already the most well represented in the dataset (i.e., less involved gamblers and

people without comorbidities) (Williams et al., 2022). It is also important to note that the relative risk ratios calculated in the present study are contingent on the base rate of PG in the sample. In the ANP online panel survey, the rate of PG was roughly 13%, which is much higher than the 0.6% of Canadians who are classified as having PG (Williams et al., 2021). As such, the validity of these ratios in a general population sample remains unclear. Other limitations concern the fact that a) all variables were based on self-report; b) the GRH results are specific to the PPGM Harm scale, which may not apply to other analogous measures of harm; and c) the results are limited to a 12 month time frame, with predictors of future GRH and/or PG potentially being different when considering shorter or longer time periods.

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CHAPTER 4: DISCUSSION

The research presented herein was guided by two broad objectives. First, the association between participation in specific gambling formats and problem gambling was evaluated in a sample of Canadian adult (18+) gamblers while controlling for their breadth of gambling involvement. Second, a more comprehensive examination of the factors that contribute to the future GRH/PG was undertaken as part of an initiative to update the 'at-risk' category of the Problem and Pathological Gambling Measure. Taken together, the present research provides a more complete understanding of the risk factors associated with GRH and PG.

The association between intensive gambling involvement and gambling problems has been the subject of much prior research (Afifi et al., 2013; Binde et al., 2017; Holtgraves, 2009; LaPlante et al., 2013; Mazar et al., 2020; Wardle et al., 2011) and is the foundation of many responsible gambling initiatives including the newly developed Lower Risk Gambling Guidelines (Hodgins et al., 2022; Young et al., 2021, 2022). However, given the jurisdictional and temporal specificity of gambling opportunities, it is important that this association is re-evaluated in different samples at different times. Specifically, such an investigation has not been undertaken in Canada in over 20 years (Afifi et al., 2013). Consistency between studies that differ with respect to their methodology, sample, or the period in which they were conducted can increase confidence in the findings. In this regard, the results presented herein were highly consistent with previous research.

One of the most important consistencies between the present study and prior studies was the association between breadth of gambling involvement and PG. Some studies have shown that after controlling for breadth of involvement, all game-specific associations with PG are rendered non-significant (Laplante et al., 2013; Philander & McKay, 2014) while others have shown that formats like EGMs (Afifi et al., 2013; Binde et al., 2017; LaPlante et al., 2011), casino table games

(Afifi et al., 2013; Mazar et al., 2020; Welte, Barnes et al., 2009) and live action sports betting (LaPlante et al., 2014) confer additional risk. The results presented in chapter 2 indicate that among respondents in the AGRI National Project's Online Panel Survey, breadth of involvement was more strongly associated with PG than participation in any specific format, but that certain formats (e.g., EGMs, casino table games) are associated with consistently higher rates of PG than others. However, because respondents were not randomly assigned to participate in specific formats, the direction of game-specific associations with problem gambling are unclear. While these games may put individuals at risk, it is equally plausible that individuals with certain vulnerabilities are particularly attracted to these formats. The presence of EGM participation in table 2.2 does, however, provide evidence for the risk conferred by EGMs, as participation in this format was still strongly related to future PG in the presence of relevant controls. When individuals experiencing PG were asked about the formats contributing most to their problems, over 60% indicated that no specific format was to blame. This finding supports the notion that it is typically gambling in general, and not any specific gambling format, that contributes to gambling harm/problems for a subset of gamblers.

The association between breadth of gambling involvement and PG is best explained by associated increases in gambling intensity. As shown in table 2.1, there are moderate to strong correlations between breadth of gambling involvement and gambling intensity, as measured by gambling frequency, expenditure, and time spent gambling. This means that individuals who participate in a wider array of gambling activities tend to gamble more regularly, for longer, and with more money. The more widely and intensely one gambles, the greater their risk of experiencing harm or PG becomes. The association between intensive involvement and GRH specifically is the foundation of the LRGGs, which advise individuals to gamble on no more than

two types of gambling regularly, no more than four days a month, with no more than 1% of their household income (Hodgins et al., 2022; Young et al., 2021, 2022). Exceeding these limits increases the likelihood of experiencing big losses, which tend to be the first consequences of gambling to emerge, and which can contribute to further order harm, such as relationship disruptions or emotional disturbances (Langham et al., 2016). Interestingly, figure 2.1 appears to corroborate the breadth of gambling involvement limit for PG (in addition to GRH), given the large increase in PG rates observed between the second and third level of involvement for all gambling formats.

Despite the apparent validity of at least some of the LRGGs in predicting PG, participation is only one relevant factor in the development of PG. As shown in table 2.2, there are a series of factors separate from one's breadth and intensity of gambling involvement that predict subsequent gambling problems, including higher impulsivity, a personal or family history of PG, endorsing more fallacious beliefs about gambling, having a larger number of individuals with PG in your social group, and the rated importance of gambling as a leisure activity. While intensified gambling tends to immediately precede PG (Williams et al., 2022), these other factors may act as antecedents to intensified gambling itself. For example, socializing with a larger number of individuals with PG likely distorts one's perception of normative gambling behaviour. Similarly, the rated importance of gambling as a leisure activity likely speaks to one's unwillingness to cease or reduce their gambling.

Given the wide array of factors that contribute to PG, the second objective of the present research was to conduct a comprehensive examination of the factors predicting future PG *and* GRH as part of an initiative to update the 'at-risk' category of the PPGM. To increase the feasibility and validity of this objective, a series of *a priori* decisions were made, including: (1) limiting

potential predictors to those that are gambling-related; (2) excluding validated instruments from the list of potential predictors; and (3) identifying variables that were strong bivariate *and* multivariate predictors of both GRH *and* PG. These criteria were selected (1) based on previous research indicating that gambling-related variables are more strongly associated with PG than psychological or demographic variables (Allami et al., 2021; Williams et al., 2022), (2) to facilitate the brevity and validity of the assessment, and (3) to maintain consistency with the field's recent interest in GRH.

There was a large degree of concordance between the relative strength of bivariate predictors for GRH and PG, as evidenced by a significant Kendall's Tau correlation of the rank order of Rao score statistics for each outcome ($\tau = .573$, $p < .001$, $n = 44$ pairs). A similar pattern was found in the multivariate logistic regression analyses, with the separate models sharing three of the four variables that maximized model fit, including PPGM total score, perception of gambling problems, and largest single day gambling loss. However, the PG model explained over twice as much variance as the GRH model, indicating that there is more uncertainty in the prediction of GRH relative to PG. One potential explanation of this discrepancy is the subjectivity of GRH. Specifically, the harm subscale of the PPGM asks about 'significant' or 'serious' harms, the experience of which likely varies depending on factors such as household income and level of social support. Some researchers have utilized a more fine-grained measure of harms consisting of 72-items to more closely evaluate the types of harm being experienced (Langham et al., 2016; Li et al., 2016). However, this approach has been criticized for conflating opportunity costs with GRH and not adequately differentiating between gambling behaviour and GRH (Delfabbro & King, 2019). While there is serious value in understanding GRH as its own construct, it is important that

these methodological limitations be addressed before research findings are used to implement policy and regulatory changes.

Notwithstanding these limitations, our results indicate that that an individual's total score on the PPGM was the strongest predictor of GRH and PG onset, with over a fourfold increase in the relative risk of either outcome for those who endorse even one criterion. Given that the existing operationalization of 'at-risk' gambling provided by many assessment instruments is sub-threshold levels of gambling symptomatology (e.g., Williams & Volberg, 2010, 2014), the strong relationship between PPGM total score, GRH, and PG onset indicates that this former operationalization is indeed valid. However, the PPGM 'at-risk' gambling designation demonstrates poorer sensitivity than the assessment developed here and is specific to PG but not GRH.

The two other variables that were strongly predictive of both outcomes were problem perception and largest single day gambling loss. Problem perception has been demonstrated to be associated with next year PG among individuals already experiencing PG (Gooding et al., 2023), but the findings presented in chapter 3 indicate that it is also associated with the onset of GRH and PG. The implication of this finding is that early concerns regarding over-involvement in gambling should receive due attention, even in the absence of harm or other symptomatology. The association between the onset of gambling problems and largest single day gambling loss, but not overall expenditure, indicates that large losses may be more reliable markers of intensified gambling than typical expenditure or percent of household income spent gambling. Self-reported gambling expenditure tends to be unreliable (Williams et al., 2017; Wood & Williams, 2007), but large losses on a single occasion are likely very salient and may even represent other harmful gambling practices, such as chasing losses.

Relative to previous operationalizations of at-risk gambling, the main advantage of the risk assessment developed in chapter 3 is its ability to evaluate individuals across a gradient of relative risk. Nearly 80% of individuals who subsequently develop GRH or PG were correctly identified as being at risk (i.e., sensitivity) according to the new assessment, with the positive prediction power increasing substantially for those with a risk score of 3+ (i.e., high relative risk) and a risk score of 5+ (i.e., very high relative risk). One disadvantage of the new risk assessment is the high false positive rate associated with moderate risk gambling (i.e., risk score of 1-2). However, a graded risk assessment allows researchers and health care officials to maximize the detection of potential future cases while also maximizing the utility of the prevention and intervention efforts being employed. As outlined in section 3.4, moderate risk gambling may be phenomenologically similar to recreational gambling and reflect heavier involvement but no serious impairments otherwise. As such, the provision of lower-risk gambling advice (Hodgins et al., 2022; Young et al., 2021, 2022) or the use of pop-up messages and normative feedback (Auer & Griffiths, 2015; Bjørseth et al., 2021; Mutti-Packer et al., 2022) may be entirely sufficient to deter more harmful gambling. On the other hand, high or very high relative risk gambling may require more resource intensive interventions to reduce gambling behaviour and encourage behavioral change. A graded assessment of relative risk allows researchers and health care providers to discern between gamblers who require different levels of help.

The research presented herein is subject to a few broad limitations. First, the data came from the online panel, Leger Opinion (LEO). While LEO's online panel is structured to be demographically and geographically representative of the Canadian population, panelists may not be representative of the population in a variety of ways. Specifically, panelists of LEO opt-in to the panel itself, as well as the surveys they complete. Opt-in panels/surveys may yield less accurate

estimates than probability samples (Bruggen et al., 2016; Pickering & Blaszczynski, 2021) and are impossible to calculate response rates for. Moreover, the proportion of panelists with problem gambling or other pathologies is typically much larger than what is expected in the general population (Lee et al., 2015; Williams & Volberg, 2012). A related limitation concerns the fact that data were exclusively Canadian, limiting cross-jurisdictional generalizability. This may be particularly true of the results presented in chapter 2. The temporal and jurisdictional specificity of gambling opportunities limits the generalizability of the results regarding specific gambling formats and their association with problem gambling. Regarding temporal specificity, bill C-218 came into effect in 2021, which allows Canadians to bet on single sporting events, as opposed to the former parlay system. Legislative changes such as this can increase the level of sports betting participation in the population and may affect the relative rate of problem gambling for different formats. However, the general agreement between our study and those conducted previously increases confidence in the findings. Another limitation of the present work is that the risk assessment developed in chapter three was not subject to independent validation. This is due, in part, to the complexity of the analytic plan used, as well as the breadth of the data available. Given the large number of individuals who developed GRH and/or PG in the AGRI National Project's Online Panel Survey, the data provided a unique opportunity to conduct a thorough and high-powered analysis. However, the results and design of the risk assessment should be considered preliminary until they can be validated in independent samples.

Conclusion

Two intersecting lines of research have been presented. First, the association between involvement in specific gambling formats and problem gambling was evaluated while controlling for breadth of gambling involvement. It was shown that breadth of involvement was more strongly

associated with problem gambling than participation in any specific format, but that certain formats (e.g., EGMs, casino table games) do confer additional risk. However, as shown by Williams et al. (2022), participation is incomplete in and of itself to predict future problem gambling. As such, the second line of research aimed to more comprehensively evaluate the factors contributing to the risk of future PG *and* GRH as part of an initiative to update the 'at-risk' category of the Problem and Pathological Gambling Measure. In addition to breadth of gambling involvement and large single day gambling losses, the level of gambling symptomatology one experiences, their rated importance of gambling as a leisure activity, and their subjective perception of gambling problems increase the accuracy of predicting subsequent GRH and PG. Furthermore, a graded assessment of relative risk allows researchers and health care providers to tailor prevention efforts to the specific needs of individuals depending on their level of risk.

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APPENDIX A

PROBLEM & PATHOLOGICAL GAMBLING MEASURE (PPGM) – REVISED

(Gooding, Williams, & Volberg, 2023)

1. Has your involvement in gambling caused significant **financial problems** for you or someone close to you in the past 12 months (Yes=1; No=0).

2. Has your involvement in gambling caused significant **mental stress** in the form of guilt, anxiety, or depression for you or someone close to you in the past 12 months? (Yes=1; No=0).

3. Has your involvement in gambling caused serious problems in your **relationship with your spouse/partner, important friends or family, or caused you to repeatedly neglect your children** in the past 12 months? (Note: Family is whomever the person themselves defines as "family") (Yes=1; No=0).

4. Has your involvement in gambling resulted in significant **health problems** or injury for you or someone close to you in the past 12 months? (Yes=1; No=0).

5. Has your involvement in gambling caused significant **work or school problems** for you or someone close to you in the past 12 months or caused you to miss a significant amount of time off work or school? (Yes=1; No=0).

6. Has your involvement in gambling caused you or someone close to you to write bad cheques, take money that didn't belong to you or commit other **illegal acts** to support your gambling in the past 12 months? (Yes=1; No=0).

7. Is there anyone else who would say that your involvement in gambling in the past 12 months has caused any significant problems regardless of whether you agree with them or not? (Yes=1; No=0).

HARM SCORE	**/7**

8. In the past 12 months, have you often gambled longer, with more money or more frequently than you intended to? (Yes=1; No=0).

9. In the past 12 months, have you often gone back to try and win back the money you lost? (Yes=1; No=0).

10. In the past 12 months, have you made any unsuccessful attempts to reduce, control or stop your gambling? (Yes=1; No=0).

11. In the past 12 months, is there anyone else who would say that you have had difficulty controlling your gambling, regardless of whether you agreed with them or not? (Yes=1; No=0).

IMPAIRED CONTROL SCORE	**/4**

12. In the past 12 months, would you say you have been preoccupied with gambling? (Yes=1; No=0).

13. In the past 12 months, did you find you needed to gamble with larger and larger amounts of money to achieve the same level of excitement? (Yes=1; No=0).

14. In the past 12 months, when you were not gambling did you often experience irritability, restlessness, or strong cravings for it? (Yes=1; No=0).

15. In the past 12 months, have you ever felt like you might have a problem with gambling? (Yes=1; No=0).

OTHER ISSUES SCORE	**/4**

TOTAL SCORE	**/15**

PPGM-REVISED SCORING & CLASSIFICATIONS

PATHOLOGICAL GAMBLER (4)
1. Harm Score of 1 or higher, plus
2. Impaired Control Score of 1 or higher, plus
3. Total Score of 6 or higher
4. Reported gambling frequency of at least once a month on some form of gambling, unless person reports a lifetime history of problem gambling.

PROBLEM GAMBLER (3)
1. Harm Score of 1 or higher, plus
2. Impaired Control Score of 1 or higher, plus
3. Total Score of 2 to 5, plus
4. Reported gambling frequency of at least once a month on some form of gambling, unless person reports a lifetime history of problem gambling.

OR
1. Total Score of 3 or higher, plus
2. Frequency of gambling[2] AND average reported gambling loss[3] $\geq$ median for unambiguously identified Problem and Pathological Gamblers in the population (i.e., as established by the most recent population prevalence survey).

[2] Simplest way of establishing this is by using the highest frequency of gambling reported for any individual form in the past year.

[3] Sometimes gambling expenditure is collected by asking about both losses on gambling and winning on gambling. In this situation it is best to use the reported losses figure rather than *net* losses figure, as it tends to be a more accurate estimate of true losses, especially among problem gamblers. Note also that the scorer may choose not to apply the gambling loss criteria so as to designate someone as an 'At-risk Gambler' or 'Problem Gambler' in situations where the person's income and/or net worth is very high relative to the general population.

AT-RISK GAMBLER (2) (this category also includes people who may be problem gamblers in denial)

1. Does not meet criteria for Problem or Pathological gambling
2. Has a risk assessment score of 1 or higher (scores ranging from 0 to 13):
    a. Total PPGM score: 0 = 0; 1-2 = 2; 3+=3
    b. Score on PPGM15: 0=0; 1=2
    c. Number of Different Types of Gambling engaged in monthly in past 12 months (using the 8 GPI categories of lotteries or raffles; instant games; EGMs; casino Table games; sports betting; bingo; financial speculation; and 'other'): 0-2=0; 3-4=1; 5+=3
    d. Largest amount of money lost to gambling in a single day in past 12 months: <$200=0; $200-$499=1; $500-$999=2; $1000+=3
    e. Rated importance of gambling as a recreational or leisure activity: not very important=0; somewhat important=1; important=2
    - Three subcategories of At-Risk:
        - Score of 1+: moderate (17.8% chance of future gambling-related harm or problem gambling in the next 12 months)
        - Score of 3+: high (33.6% change of future gambling-related harm or problem gambling in the next 12 months)
        - Score of 5+: very high (42.9% chance of future gambling-related harm or problem gambling in the next 12 months)

RECREATIONAL GAMBLER (1)

- Gambler who does not meet criteria for Pathological, Problem or At-Risk gambler.

NONGAMBLER (0)

- No reported gambling on any form in past year.