Exploring the substance and behavioural addiction nexus among people who gamble

by

Catherine Sarginson

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Carleton University
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Catherine Sarginson
Abstract

Adverse consequences of problem gambling, addictive substance use, and addictive behaviours are palpable. High co-occurrence rates amongst these behaviours suggest a common etiology. Yet, most research examines addictions in isolation. The current study is a secondary data analysis of the Alberta Gambling Research Institute’s National Project to examine the co-occurrence of addictive behaviours in people who gamble. Data from 10,199 Canadian adults were entered into a mixture model to identify subgroups defined by engagement in addictive behaviours. The Pathways Model of Disordered Gambling was used as a framework. We hypothesized that at least four classes would emerge—one without problems and three or more that aligned with the model. A seven-class model emerged. The classes were generally consistent with the model regarding emotional vulnerability and impulsivity, but demonstrated unique patterns of substance use and addictive behaviours. These findings underscore the need to examine patterns of co-occurrence for addictions.
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Exploring the substance and behavioural addiction nexus among people who gamble

Many Canadians gamble, with approximately two-thirds (64.5%) aged 15 and above reporting gambling within a year of taking part in the Canadian Community Health Survey (CCHS; Rotermann & Gilmour, 2022). In fact, Canada ranks fourth in countries with the highest gambling loss per adult (Blau et al., 2019). Gambling can be defined as an activity where the outcome of the event involves an element of chance or randomness, and where something of value (e.g., money) is wagered on that chance outcome (Hodgins et al., 2011; Potenza, 2013).

Although over half of Canadians engage in gambling, only a minority of Canadians (1.6%) are at a moderate-to-severe risk for problem gambling. As well, this means that nearly two percent of Canadians, who are at risk for problem gambling, are also at risk for a variety of adverse consequences associated with gambling, such as difficulties with individual, interpersonal, and family functioning (Kourgiantakis et al., 2013). The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) defines disordered gambling as gambling behaviours that are persistent and repeated which lead to significant impairment or distress (American Psychiatric Association, 2013). Conversely, problem gambling refers to disordered gambling behaviours that do not quite meet the threshold for diagnosis (Ioannidis et al., 2019). Regardless of whether someone experiences disordered gambling or problem gambling, the consequences are palpable.

The consequences of problem gambling include mental health issues, financial hardship, employment problems, legal issues, interpersonal strains, and social isolation (Cook et al., 2015; Ferris & Wynne, 2001; Kourgiantakis et al., 2013). Furthermore, the negative consequences of problem gambling can extend beyond the individual. Specifically, problem gambling can create a ripple effect of negative consequences, whereby it affects spouses (Hodgins et al., 2007; Abbott
et al., 1995), children (Darbyshire et al., 2001; Abbott et al., 1995), and other family members (Kalischuk, 2010). Indeed, it is estimated that for every person with gambling problems, seven other people are adversely affected (Velleman et al., 2015). As such, problem gambling is an emergent public health issue (Shaffer & Korn, 2002).

Of note, people with gambling problems may experience other concurrent behaviour problems that have high addiction potential, including substance use problems and non-substance use behaviours such as video gaming problems (Sussman et al., 2011; Tiego et al., 2019; Yau & Potenza, 2015). In fact, it is more common that people with gambling problems have problems with other behaviours than solely having gambling problems. Indeed, a meta-analysis by Lorains and colleagues (2011) found that the rate of co-occurrence between disordered gambling and substance addiction was 57.5%. In other words, co-occurring addictions are more the norm than they are the exception. The moderate to high rates of co-occurrence of addictive behaviours suggests that they may have a common etiology.

**Gambling and co-occurring addictive behaviours**

People with gambling problems often engage in other behaviours that have high addiction potential. For instance, gambling problems tend to co-occur with alcohol (Tiego et al., 2019; Di Nicola et al., 2015; Lejoyeux et al., 2000; Martens et al., 2009; Barnes et al., 2011), shopping (Tiego et al., 2019), tobacco use (Barnes et al., 2011), and cannabis use (Barnes et al., 2011) problems. Interestingly, people who gamble are more likely to use alcohol and other substances than people that do not gamble (Hardoon et al., 2004; Ste-Marie et al., 2006). For instance, results from a systematic review and meta-analysis indicated a high prevalence rate of substance use disorder and nicotine dependence among people living with disordered gambling (Lorains et al., 2011). Likewise, results from another systematic review and meta-analysis found similar
results in a sample of people seeking treatment for disordered gambling (Dowling et al., 2015). Moreover, those with substance use disorder (SUD) have almost a three-fold higher likelihood of disordered gambling than those without (el-Guebaly et al., 2012). As evidenced, disordered gambling and other putative addictive behaviours rarely occur in isolation (Grant & Chamberlain, 2015; Tiego et al., 2019).

In addition to addictive behaviours co-occurring with one another, addictive behaviours also often co-occur with other mental health issues, such as anxiety and depression (Regier et al., 1990; Brady et al., 2007). Results from a systematic review and a meta-analysis indicate that people with disordered gambling also have high current and lifetime comorbidity rates with mood and anxiety disorders (Lorains et al., 2011; Dowling et al., 2015). Moreover, individuals who struggle with mood or anxiety disorders are at an increased risk for developing a gambling problem (el-Guebaly et al., 2006). This may suggest that these mood and anxiety factors may be acting as etiological catalysts for gambling problems. Moreover, a history of adverse childhood experiences (ACEs), or childhood trauma, has been shown to be highly co-morbid with gambling problems (Lotzin et al., 2018) and can lead to many physical health (Gilbert et al., 2015; Ross et al., 2020; Felitti et al., 1998) and mental health (Negriff, 2020; Afifi et al., 2014; Afifi et al., 2017) problems. Furthermore, ACEs have also been associated with substance use behaviours (Afifi et al., 2020; Moss et al., 2020) and other addictive behaviours, including overeating (Imperatori et al., 2016), internet use (Arslan, 2017), and sex (Kotera & Rhodes, 2019).

In the Syndrome Model of addiction (Shaffer et al., 2004), addiction is a collection of symptoms (i.e., a syndrome) with numerous opportunistic manifestations (e.g., gambling, drinking, or smoking). The assumption of the Syndrome Model is based on the view that various addictions share certain underlying etiological factors. Accordingly, one’s bio-psycho-social
background influences their likelihood of developing an addiction, however, how that addiction manifests varies as a product of an individual's relationship with an addiction object.

Scholars have proposed that people may engage in addictive behaviours as a means of coping with negative affect and life stressors (Estevez et al., 2019; Plante et al., 2019; Passanisi et al., 2020; Coelho et al., 2022; Nower et al., 2022). A recent systematic review found that severe depression is significantly associated with problem gambling and problem video gaming (Richard et al., 2020). The researchers posit that these addictive behaviours may be a means of emotional coping and dysregulation through negative reinforcement or relieving negative moods. Similarly, anxiety disorders commonly co-occur with SUDs (Grant et al., 2004; Kessler et al., 1997). Anxiety is also common with other behaviours with high addiction potential, such as gambling (van der Maas, 2016), internet use (Shaw & Black, 2008), video gaming (Loton et al., 2016), and smartphone use (Matar Boumosleh & Jaalouk, 2017). Furthermore, Barrault and colleagues (2019) assert that the strong correlations that they found between coping motives and depression and anxiety demonstrate that gambling can be used as a dysfunctional means of coping with negative affect. In this view, gambling provides temporary relief from psychiatric symptoms (i.e., depression and anxiety) while leading to negative consequences and worsening psychiatric symptoms in the long-term. Therefore, coping as a mechanism of negative reinforcement (e.g., providing temporary relief from negative emotions) appears to be a common factor in the development of addiction problems.

Coelho and colleagues (2022) used the Syndrome Model as a theoretical framework to examine the perceived causes of addictive behaviours from the perspective of those with lived experience. They found that coping was endorsed by those with lived experience as the most cited cause, whereby participants felt that they developed an addiction while using a substance or
a behaviour as a means of coping with negative affect, symptoms of mental health disorders, physical health problems, stressful life events, and major life changes. This suggests that these pre-morbid psychiatric symptoms predispose certain people to engage in addictive behaviours, like gambling, to cope with how they feel. In other words, the addictive behaviour creates temporary relief from their symptoms, thus providing them with a (dysfunctional) coping mechanism via negative reinforcement.

Coelho and colleagues (2022) also found that enhancement was commonly endorsed as a perceived cause of one’s gambling problems. Enhancement refers to deriving a sense of thrill and enjoyment from a substance or behaviour (Coelho et al., 2022). Enhancement was also cited as a more common cause of other addictive behaviours, but not substance use problems. Moreover, a study by Barrault and colleagues (2019) showed that enhancement, as well as financial motives and depression, significantly predicted problem gambling in a sample of people who gamble. As such, enhancement may be a common etiological factor, like coping, for gambling problems and other addictive behavioural issues.

In contrast with coping, which is largely driven by negative reinforcement, enhancement is largely driven by positive reinforcement (e.g., to increase positive emotions; Milosevic & Ledgerwood, 2010). Enhancement is quite prevalent among people who score high on measures of impulsivity, as they are motivated by excitement (Barrault et al., 2019). Impulsivity refers to actions initiated suddenly without consideration of potential consequences (Zorrilla & Koob, 2019). Impulsivity has been identified as a central risk factor for problem gambling (Secades-Villa et al., 2016; Koob & Le Moal, 2008), and has been linked to other addictive behaviours, such as alcohol and substance abuse (de Wit, 2009). Additionally, deficits in impulse control have been linked to anti-social personality disorder (Evenden, 1999).
People with gambling problems and who have a financially focused self-concept may also engage in other addictive behaviours. Coelho and colleagues (2022) found that the pursuit of money was an explanation for gambling problems provided by people with lived experience, however, people who pursue financial success as a central life goal may also turn to addictive behaviours as a means of coping and enhancement. Indeed, people who view financial success as more important to their self-concept often have mental health problems that make them vulnerable to negative affect compared to people who view financial success as less important to their self-concept. These vulnerabilities include perfectionism (Tabri et al., 2018, Tabri et al., 2021), neuroticism, low global self-esteem (Tabri et al., 2017), and low perceived self-efficacy to cope with adversity in life (Tabri et al., 2018). Likewise, people who view financial success as more important to their self-concept often have impulsive and anti-social personality traits that make them vulnerable to engage in risky behaviours compared to people who view financial success as less important to their self-concept (Glenn et al., 2017; Kasser & Ryan, 1993; Tabri, Salmon, & Wohl, 2022). As such, the extent to which people view financial success as important to their self-concept may be a crucial factor for understanding not only the development of gambling problems, but also addiction problems more generally and their co-occurrences.

Despite a plethora of evidence demonstrating the high rates of co-occurring addictive behaviours and substance addictions, little research has examined the etiological factors that may help explain these co-occurrences.

**The Pathways Model of Disordered Gambling**

The Pathways Model of disordered gambling (Blaszczynski & Nower, 2002) is the leading biopsychosocial framework that is used to explain the etiology and maintenance of disordered gambling. In the Pathways Model, people with gambling problems are viewed as a
heterogenous group in terms of etiology. In particular, there are three distinct etiological pathways to disordered gambling that are characterized by the presence or absence of specific premorbid psychopathological features, maladaptive personality traits, and motivations for gambling: (1) behaviourally conditioned; (2) emotionally vulnerable; and (3) anti-social risk-taking.

In the behaviourally conditioned pathway, people do not have any premorbid psychopathological features and they develop gambling problems due to classical and operant conditioning processes inherent in gambling. The conditioning processes help cultivate erroneous beliefs about gambling, namely the ability to win at gambling. These erroneous beliefs maintain gambling in the face of mounting financial losses. In the emotionally vulnerable pathway, people experience the same behavioural conditioning processes and subsequent erroneous beliefs about gambling that maintain their gambling activities. However, people in the emotionally vulnerable pathway have premorbid mood problems, poor coping and problem-solving skills, and stress in their lives, and so they turn to gambling primarily as a means for coping. In the anti-social risk-taking pathway, people possess psychosocial and biological vulnerabilities comparable to those in the emotionally vulnerable pathway. However, they also have a higher propensity towards risk-taking, as well as maladaptive anti-social and impulsive personality traits. In this light, people on the anti-social risk-taking pathway primarily turn to gambling as a means to enhance positive affect (e.g., excitement).

The Pathways Model (Blaszczynski & Nower, 2002) has been shown to have good empirical support (Gupta et al., 2013; Valleur et al., 2016; Black & Allen, 2022; Kurilla, 2021; Nower et al., 2021). For instance, Black and Allen (2022) conducted a latent class analysis (LCA) on a sample of people who struggle with problem gambling, and they identified four
classes, or subtypes. The authors note that their findings provide some support for the Pathways Model, as three of the four subtypes they identified aligned well with the Pathways Model subtypes. They described the fourth subtype that they identified as having combined features of the emotionally vulnerable pathway and the anti-social risk-taking pathway as defined in the Pathways Model. Furthermore, in a recent systematic review on the validity of the Pathways Model, Kurilla (2021) found that nine out of 14 (64%) of the studies reviewed provided evidence for the existence of the three gambling subtypes described in the Pathways Model, whereas the remaining five (46%) studies observed a different number of subtypes. However, they still coincided with the Pathways Model (Kurilla, 2021). Specifically, the studies that identified a different number of subtypes found that some aligned with those outlined in the Pathways Model, and some overlapped with more than one pathway (e.g., emotionally vulnerable and anti-social risk-taking). In sum, there is good evidence from research that supports the three etiological subtypes outlined in the Pathway Model.

Although the Pathways Model (Blaszczynski & Nower, 2002) was developed to help explain the etiology and maintenance of disordered gambling, it has been used to understand other addictive behaviours. For instance, the Pathways Model has been extended to explain the etiology and maintenance of video gaming addiction (Marchica et al., 2022), problematic smartphone use (Billieux, 2012), and pathological exercise in anorexia nervosa (Tabri & Wohl, 2022). Given these extensions of the Pathways Model and the high co-occurrence rates of addictive behaviours, I propose that the Pathways Model could be used to help understand the co-occurrence of gambling problems with other problematic behaviours that have high addiction potential. In particular, the co-occurrence of behaviours with high addiction potential are likely
to occur among people with gambling problems who are on the emotionally vulnerable pathway or the anti-social impulsive risk-taking pathway.

**The role of financial success in problem gambling**

Although it is generally accepted that the pursuit of financial success via gambling likely leads to gambling problems, the role of financial success or financial gambling motives in the etiology and maintenance of disordered gambling has been overlooked in the Pathways Model. This is a critical omission because recent meta-analytic research has shown that gambling motivated by the prospect of financial success was moderately associated with a greater involvement in gambling and with having more severe gambling problems (Tabri, Xuereb, Cringle & Clark, 2022). The positive meta-analytic associations were present even after controlling for shared variance with other motives (i.e., social, enhancement, coping). Together, the findings from meta-analytic research suggest that gambling for financial gain may contribute to the development and maintenance of gambling problems.

It has also been proposed that the extent to which people have a financially focused self-concept (i.e., overvaluing the importance of financial success for self-definition and self-worth) may help proliferate and maintain disordered gambling (Tabri et al., 2017). Several studies involving community samples of people who gamble have shown a moderate association with disordered gambling, as well as with lower responsible gambling beliefs and behaviours (for a review, see Tabri & Wohl, 2021). Financially focused self-concept has also been shown to have a unique association with disordered gambling even when statistically controlling for overlapping variance with various etiological factors of disordered gambling (e.g., Tabri et al., 2017).
More recent research has examined financially focused self-concept in the context of the Pathways Model. Using latent profile analyses (LPA), Tabri, Salmon, and Wohl (2022) observed three profiles that aligned with the three etiological subtypes outlined in the Pathways Model \((i.e., \text{behaviourally conditioned, emotionally vulnerable, and anti-social risk-taking})\) in a community sample of people with gambling problems. They also found that the average level of financially focused self-concept was elevated across the three subtypes and increased as the number of etiological factors per subtype increased. Another finding was that financially focused self-concept was correlated with erroneous gambling beliefs—the proposed key maintaining mechanism of gambling across the subtypes in the Pathways Model. Together, these findings support the notion that financially focused self-concept may play an integral role in the etiology and maintenance of gambling problems and that the Pathways Model may become more precise and comprehensive by integrating financially focused self-concept.

**Overview of the current research**

The purpose of the current research was to examine the co-occurrence of substance and non-substance addictive behaviours among people who gamble using the Pathways Model (Blaszczynski & Nower, 2002) as a conceptual framework. To that end, a secondary analysis of the Alberta Gambling Research Institute’s (AGRI) National Project dataset was conducted (Shaw, 2021). This dataset is publicly available for secondary analyses. It includes a large sample of Canadians who gamble that are demographically and geographically representative of the Canadian adult (18+) population. The data was collected between August and September 2018 online through the Leger Opinion’s (LEO) participant registration pool. Participants completed a large questionnaire battery, which included questionnaires assessing etiological factors of disordered gambling, gambling involvement, and engagement in behaviours that have
high addiction potential. It also included measures that assessed mood problems, or emotional vulnerability, personality factors, such as impulsivity, and the importance of money.

Akin to prior research that examined the Pathways Model, a mixture modelling approach was used to explore the patterns of co-occurrence of addictive behaviours. I hypothesized that at least four subgroups would be present in the data. Specifically, I anticipated that one subgroup without gambling problems would emerge, and three or more classes of people with gambling problems would emerge that coincide with the three pathways outlined in the Pathways Model. Although there are only three pathways outlined in the model, based on the findings of Kurilla’s (2021) systematic review, it is probable that more subgroups would emerge that coincide with the model but have overlapping features from more than one pathway. We also anticipated that people scoring high on emotional vulnerability, impulsivity, and financial focus would engage in one or more addictive behaviours, including substance and non-substance based behaviours. Because my thesis research used a secondary data analysis approach, the existing dataset did not include measures of anti-social traits or risk-taking. As such, these factors could not be explored.

**Method**

**Participants**

Ten-thousand one-hundred ninety-nine adults (53% females) aged 18+ residing in Canada took part in a National survey between August and September 2018 (Shaw, 2021). Participants were recruited from all 10 provinces and three territories. Eight-thousand six-hundred sixteen participants completed the survey in English and 1,583 completed it in French. Registered participants of LEO were sent an email with the screening question: “How often would you say you participate in any form of gambling?” The inclusion criteria for participation
in our study was a response of “Usually at least once a month”. As such, the sample consisted of
individuals that participated in some form of gambling. One hundred forty-five non-gamblers
were identified in the dataset. Given the nature of our research question (i.e., assessing co-
occurring addictive behaviours in people who gamble), the non-gamblers in the sample were
excluded from our analyses. Moreover, as the sample size was substantially large (i.e., 10,199
participants), non-gamblers made up only about 1% of the entire sample, which was not a large
enough proportion to warrant inclusion. As such, 10,054 participants were included in the
analysis.

**Procedures and Measures**

**Variables**

**Gambling.** The extent to which participants had disordered gambling symptoms was
assessed using the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001), which is a
standardized screening instrument for problem gambling. The PGSI includes nine items (see
Appendix A) that measure the extent of problem gambling behaviours (e.g., “Have you gone
back another day to try and win back the money you lost?”) and the consequences of engaging in
problem gambling behaviours (e.g., “Has your gambling caused any financial problems for you
or your household?”). Participants responded by indicating how frequently they engaged in
problem gambling behaviours and experienced consequences due to their gambling behaviour
over the last 12 months. Participants responded to each item using a response scale with
endpoints 0 (Never) and 3 (Almost always). A total score was computed with higher scores
corresponding to greater disordered gambling severity. The total score can be used to classify
participants into one of four risk categories. A score of zero indicates no gambling problems. A
score between one and two indicates low risk for gambling problems. A score between three and
seven indicates moderate risk for gambling problems. A score of eight or more indicates high likelihood that the participant has gambling problems.

The behaviourally conditioned pathway is one that does not involve pre-morbid psychopathological features, but rather is a function of the conditioning mechanisms at play with the development of addictions. However, as erroneous beliefs about gambling stem from these conditioning mechanisms and are a feature of this pathway, the variable gambling fallacies was included in the model as predictive of this pathway. This variable is taken from Leonard, Williams, and Vokey’s (2015) Gambling Fallacies measure, and is a total summative score out of 10 items that assess one’s resistance to a variety of gambling fallacies. As such, higher scores on this measure indicate greater resistance to gambling fallacies. Accordingly, we anticipated that those with gambling problems would have low gambling fallacies scores, thus indicating that they hold some erroneous beliefs about gambling. Of note, gambling fallacies were reverse-scored following analyses and re-labelled “erroneous gambling beliefs” for reader ease of understanding. As such, higher scores represent more erroneous beliefs about gambling.

As coping has been posited as the impetus for developing problems via the emotionally vulnerable pathway, a gambling motivation variable representative of coping was included in the model. This is a nominal variable whereby participants were asked to select from a checklist any reasons that they identify as main motivations for their gambling. Specifically, “[t]o escape, relax, or relieve stress” is the variable that will serve as the coping variable, as aspects of coping include escape and stress relief. The other motivations listed in the checklist included: “excitement/enjoyment/fun”; “to win money”; “to develop my skills”; “to compete or for the challenge”; “to socialize”; “to support worthy causes”; “it makes me feel good about myself”; and “other [specify]”. 
Additionally, as enhancement (e.g., excitement) has been identified as the primary motivator for the anti-social impulsive risk-taking pathway, a gambling motivation variable for enhancement was also included in the model. Like the coping variable, participants were asked to select from a checklist any reasons that they identify as main motivations for their gambling. The participant response for enhancement was “Excitement/ enjoyment/fun.”

**Substances.** Single-item frequency measures of engagement in substance use for e-cigarettes/tobacco use, alcohol use, cannabis use, and drugs not for medical use (i.e., cocaine, amphetamines, hallucinogens, heroin, opium, fentanyl, etc.) were collected in the study. These variables measure frequency of use over a 12-month period. More specifically, participants were asked “During the past 12 months, how often did you use [substance]?” An 8-point response scale was used with endpoints 1 (Not at all) to 8 (Every day). These items were developed by the AGRI researchers.

**Behaviours.** Single-item measures of engagement in overeating, sex or pornography, exercise, shopping, social media, video gaming, and internet use were collected in the study. Participants were first asked if they had problems with over-involvement with any of the behaviours listed in the past 12 months. If participants responded “Yes,” then they were asked “Which specific activities have you had problems with?” and were instructed to check all that apply. These items were developed by the AGRI researchers.

**Emotional Vulnerability.** The emotionally vulnerable pathway is characterized by stress and mood problems. As such, a variety of variables related to mood problems, a measure of life stress, and a measure of childhood trauma were included in the model. Specifically, the variables related to mood problems include depression, anxiety, post-traumatic stress disorder (PTSD), and panic. These scales reflect the fifth edition of the Diagnostic and Statistical Manual of Mental
Disorders’ (DSM-5) criteria for major depressive disorder (MDD), generalized anxiety disorder (GAD), PTSD, and panic disorder.

Stress was measured using the statement “Thinking about the amount of stress in our life, would you say that in the past 12 months most of your days are…” with response options that ranged from 0 (Not at all stressful) to 4 (Extremely stressful). As such, higher scores correspond to more stress in one’s life.

For depression, participants were first asked “In the past 12 months, was there ever a period of 2 weeks or longer where you had a depressed mood most of the day nearly every day and/or a loss of interest or pleasure in most activities?” If respondents answered “No,” they skipped over the remaining depression criteria and their score was categorized as “No.” The remaining criteria was in the form of a checklist whereby participants would check off any symptoms (that correspond to the DSM-5 criteria for MDD) that occurred during this time period. At least three out of seven criteria listed must have been selected for participants’ scores to be converted to “Yes.”

For anxiety, participants were screened by the questions “Would you describe yourself as chronically anxious?” and “Does this anxiety cause significant distress or impairment in your social functioning, employment, or other areas?” If respondents answered “No” to either of these questions, they skipped over the remaining anxiety criteria and their score was categorized as “No.” If they responded “Yes” to both screening questions, then they were asked to check off any symptoms that apply to them (that correspond to the DSM-5 criteria for GAD). At least three out of the six criteria listed must have been selected for participants’ scores to be converted to “Yes.”
For post-traumatic stress, participants were only asked to check off which intrusion symptoms (that correspond to PTSD’s criterion B in the DSM-5) had occurred for at least a month (criterion F in the DSM-5) if they endorsed at least one of 11 earlier qualifying items (criterion A in the DSM-5). The qualifying items asked about whether respondents had experienced a variety of traumatic life events, such as serious illness, injury, or death of someone close to them; being a victim of assault, robbery, or other crime; and/or causing, witnessing, or suffering a serious injury because of an accident. If participants endorsed one or more of the 11 qualifying items, they proceeded with items that asked about avoidance behaviours (criterion C in the DSM-5), negative alterations in cognitions and mood (criterion D in the DSM-5), and alterations in arousal and reactivity (criterion E in the DSM-5). If participants met all the criteria, their scores were converted to “Yes.”

For panic, participants were asked “In the past 12 months have you had recurrent unexpected panic attacks during which 4 or more of the following symptoms occur: pounding heart, sweating, trembling, shortness of breath, feelings of choking, chest pain, nausea, dizziness, chills or [heat sensations, paresthesia, derealization, fear of losing control, and/or fear of dying?]”. These symptoms correspond to criterion A for Panic Disorder in the DSM-5. As such, respondents that answered “No” skipped over the remaining panic criterion and their score was categorized as “No.” Otherwise, participants were asked “Have these attacks been followed by either a persistent worry about having additional attacks and/or avoidance of activities (e.g., exercise) or unfamiliar places?” (criterion B in the DSM-5), whereby endorsement for this item was then converted to “Yes” and non-endorsement was converted to “No.”

Lastly, childhood trauma is a dichotomous measure (Yes/No) in which participants responded to the following question: “Did you ever experience significant physical, sexual, or
emotional abuse or neglect as a child?” As such, the item was either endorsed or not endorsed, thereby providing a proportion of childhood trauma in the sample.

**Self.** For the anti-social impulsive risk-taking pathway, a comprehensive measure of impulsivity (Form S, Subfacet I) taken from the NEO Personality Inventory Revised (NEO-PI-R; Costa, 1992) was used. This measure includes eight questions underscoring aspects of impulsivity, such as “I have little difficulty resisting temptation,” with a 5-point Likert response scale ranging from “Strongly agree” to “Strongly disagree.” The scores for the eight items were then summed to get a total score for the facet impulsivity. Unfortunately, the AGRI National Project dataset does not include measures of anti-social or risk-taking traits. As such, these factors cannot be directly observed.

In the AGRI National Project dataset, one item was used to assess “How important is money to you?” Participants responded using a response scale with 4-points: “Not at all important”, “Somewhat important”, “Quite important”, and “Very important”. Because no other measures were used to assess the importance of financial success to the self, we used this item as a proxy for a financially focused self-concept (FFS).

**Data Analytic Approach**

A mixture modelling approach was used to identify subgroups of participants defined by engagement in various types of substance use, problematic engagement in different addictive behaviours, and disordered gambling symptoms. A mixture modelling approach is a data-driven statistical technique used to identify subgroups of people within a population based on similar patterns of responses on both discrete and continuous variables. All variables, including disordered gambling items, substance use items, behavioural addiction items, emotional
vulnerability items, and self items were used in the mixture modelling analyses. The analyses were carried out using Mplus version 8.2 (Muthén & Muthén, 1998-2017).

To reach a global maximum likelihood, 50,000 starts, or initial starting value sets, were commanded with the best 1,000 optimizations being retained. The global maximum likelihood refers to the method used to estimate the parameters of the model based on the observed data. The goal of this method is to maximize the likelihood that the most probable outcome (i.e., the model that best explains the dataset) will emerge under the assumed model. Each initial starting value “starts” a new iteration, whereby the algorithm attempts to classify and/or re-classify cases or group membership to find the best parameter estimates. As such, the algorithm ran 50,000 times and kept the top 1,000 “guesses” or optimizations. A total of 10 models were run wherein the number of subgroups, or classes, increased with each model run, starting with a one-class model, and increasing by increments of one (i.e., two-class model, three-class model, etc.). Each model included a different number of subgroups or classes.

I used several measures of fit to adjudicate the relative fit of the different models. These fit statistics included the Bayesian Information Criteria (BIC), Vuong-Lo-Mendell-Rubin (VLMR), size of the smallest profile, and entropy. Briefly, BIC values represent the amount of unexplained variation there is in the statistical outcome (i.e., the subgroups or classes). As such, lower values (as opposed to higher) indicate that the model provides a stronger fit for the data because the model can explain more of the variation in the outcome. VLMR values compare the probability ratios of adjacent models to identify whether the model with more subgroups or classes is better than the model with fewer subtypes by examining the size of disparity between the null ($H^0$) and alternative ($H^1$) distributions. If a given VLMR value is statistically significant (i.e., $p < .05$), then the model with more subgroups or classes (i.e., $k$) is favoured over the model
with fewer subgroups or classes (*i.e.*, *k*-1). Moreover, interpretability and precision checks of the model results were conducted. Specifically, the size of the smallest subtype or class should not have fewer than 50 cases (Muthén & Muthén, 2000) so as to ensure that the smallest class can still make sense conceptually and is not spurious (Hipp & Bauer, 2006). I also used entropy as measure of model fit. Entropy classification probability values closer to one indicate more similarities between variables within a subgroup or class. Therefore, entropy values closer to one indicate a greater ability to accurately classify variables and so indicate greater fit. Lastly, model residuals were examined to determine the fit. For the categorical items, standardized residuals were examined, whereby residuals > |2| indicate misfit. For the continuous items in the model, residuals > |.10| indicate misfit.

**Results**

**Model Fit**

The models with eight, nine, and 10 classes did not converge and so their model fit statistics were inadmissible. As such, results below are for the models one to seven. Of the remaining models (see Table 1), the model with seven classes demonstrated the best fit to the data. The 7-class model’s BIC value was the lowest compared to all other models. This suggests that the 7-class model explained the most variation in the variables. The statistically significant (*p* < .05) VLMR values demonstrated that the 7-class model fit better than the six-class model. Moreover, each class had more than 50 participants. Lastly, an entropy value close to one (*i.e.*, 0.960) indicated that the 7-class model was able to accurately classify the variables based on the similarities within each class.
Table 1. Model fit indices

<table>
<thead>
<tr>
<th>Classes</th>
<th>BIC</th>
<th>VLMR p-value</th>
<th>Smallest class size</th>
<th>Entropy</th>
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<tbody>
<tr>
<td>1</td>
<td>441633.717</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>422425.189</td>
<td>0.0000</td>
<td>2,660</td>
<td>0.994</td>
</tr>
<tr>
<td>3</td>
<td>412843.315</td>
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<td>1,755</td>
<td>0.927</td>
</tr>
<tr>
<td>4</td>
<td>405747.592</td>
<td>0.0000</td>
<td>636</td>
<td>0.943</td>
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<tr>
<td>5</td>
<td>400202.112</td>
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<td>632</td>
<td>0.937</td>
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<tr>
<td>6</td>
<td>394212.960</td>
<td>0.0000</td>
<td>417</td>
<td>0.953</td>
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<tr>
<td>7</td>
<td><strong>390410.615</strong></td>
<td><strong>0.0000</strong></td>
<td><strong>380</strong></td>
<td><strong>0.960</strong></td>
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</table>
### Classification

#### Table 2. Classification data

<table>
<thead>
<tr>
<th>Class</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
<th>Class 5</th>
<th>Class 6</th>
<th>Class 7</th>
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<tbody>
<tr>
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<td>$n=5153$</td>
<td>$n=1586$</td>
<td>$n=380$</td>
<td>$n=383$</td>
<td>$n=478$</td>
<td>$n=1406$</td>
<td>$n=668$</td>
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</table>

<table>
<thead>
<tr>
<th>Gambling</th>
<th>PGSI (0-27)</th>
<th>Erroneous beliefs (0-10)</th>
<th>Enhancement</th>
<th>Coping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.736</td>
<td>3.178</td>
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<tr>
<td></td>
<td>2.402</td>
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<td>2.014</td>
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</tr>
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<td>4.470</td>
<td>4.393</td>
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</table>

<table>
<thead>
<tr>
<th>Substances</th>
<th>Tobacco (0-7)</th>
<th>Alcohol (0-7)</th>
<th>Cannabis (0-7)</th>
<th>Illicit Drugs</th>
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<tr>
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<td>3.172</td>
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</tr>
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<td>6.893</td>
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<td></td>
<td>0.137</td>
<td>3.369</td>
<td>6.027</td>
<td>9.7%</td>
</tr>
<tr>
<td></td>
<td>4.592</td>
<td>3.999</td>
<td>1.725</td>
<td>14.2%</td>
</tr>
<tr>
<td></td>
<td>2.487</td>
<td>3.494</td>
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</tr>
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<td>0.120</td>
<td>2.818</td>
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<tr>
<td></td>
<td>6.813</td>
<td>4.027</td>
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<table>
<thead>
<tr>
<th>Behaviours</th>
<th>Overeating</th>
<th>Sex &amp; Porn</th>
<th>Exercise</th>
<th>Shopping</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1.1%</td>
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<td>0%</td>
<td>0.1%</td>
</tr>
<tr>
<td></td>
<td>7.7%</td>
<td>4.1%</td>
<td>1.4%</td>
<td>4.4%</td>
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<td>7.4%</td>
<td>3.1%</td>
<td>4.8%</td>
</tr>
<tr>
<td></td>
<td>11.9%</td>
<td>11.1%</td>
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<tr>
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<td>8.7%</td>
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<td>11.7%</td>
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</table>

<table>
<thead>
<tr>
<th>Emotional Vulnerability</th>
<th>Stress (0-4)</th>
<th>PTSD</th>
<th>Depression</th>
<th>Anxiety</th>
<th>Panic</th>
<th>Childhood Trauma</th>
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<tbody>
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<td></td>
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<tr>
<td></td>
<td>3.029</td>
<td>5.6%</td>
<td>19.4%</td>
<td>16.6%</td>
<td>15.2%</td>
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</tr>
<tr>
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<td>5.8%</td>
<td>25.1%</td>
<td>23.4%</td>
<td>21.6%</td>
<td>36.1%</td>
</tr>
<tr>
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<td>3.078</td>
<td>11.3%</td>
<td>18.3%</td>
<td>23.4%</td>
<td>21.6%</td>
<td>36.1%</td>
</tr>
<tr>
<td></td>
<td>2.999</td>
<td>12.4%</td>
<td>12.1%</td>
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<tr>
<td></td>
<td>3.584</td>
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<td>22.8%</td>
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</tr>
<tr>
<td></td>
<td>3.299</td>
<td>16.3%</td>
<td>27%</td>
<td>33.8%</td>
<td>29.6%</td>
<td>37.7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Self</th>
<th>Importance of money (0-3)</th>
<th>Impulsivity (0-32)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.763</td>
<td>13.021</td>
</tr>
<tr>
<td></td>
<td>1.957</td>
<td>14.759</td>
</tr>
<tr>
<td></td>
<td>1.915</td>
<td>16.047</td>
</tr>
<tr>
<td></td>
<td>1.965</td>
<td>15.431</td>
</tr>
<tr>
<td></td>
<td>1.873</td>
<td>16.240</td>
</tr>
<tr>
<td></td>
<td>2.191</td>
<td>18.476</td>
</tr>
<tr>
<td></td>
<td>2.042</td>
<td>15.963</td>
</tr>
</tbody>
</table>

*Note.* Decimals represent the placement on continuous variables. Continuous variable ranges are provided in left-most column in parentheses. Percentages represent the proportion of class members who endorsed said variable.
Class 1: Participants who do not have gambling problems and are relatively problem-free in terms of substance use, addictive behaviours, emotional vulnerability, financial focus, and impulsivity

Class 1 included just over half of the participants (51.3%) in the sample. Participants in Class 1 had the lowest absolute and relative levels of erroneous gambling beliefs and gambling problems. For instance, the PGSI score in Class 1 was less than the value of one, which corresponds to no or very little gambling problems among participants. Participants in Class 1 also had the lowest endorsement of both enhancement and coping as reasons for gambling—reasons which were outlined in the Pathways Model as being linked to the development of problem gambling—compared to participants in all other classes. As such, participants in Class 1 exhibited very little or no risk for gambling problems.

Regarding substance use, participants in Class 1 consumed alcohol three times a month or less. Their level of alcohol use was one of the lowest compared to participants in the other classes. Participants in Class 1 also almost never engaged in tobacco or cannabis use. As well, very few participants reported using illicit drugs (i.e., 0.5%), including cocaine, amphetamines, hallucinogens (such as LSD, mushrooms, or PCP), heroin, opium, fentanyl, or any other drugs not intended for medical use, compared to participants in the other classes. As such, participants reported overall low substance use.

As for addictive behaviours (i.e., overeating, sex and pornography, exercise, shopping, social media, video gaming, internet use), participants in Class 1 reported overall low levels of engagement. Indeed, as shown in Table 2, less than 1.2% reported engagement in addictive behaviours and these levels of engagement were the lowest compared to participants in the other classes. As such, participants reported overall low engagement in addictive behaviours.
In terms of emotional vulnerability, participants in Class 1 reported a bit to quite a bit of stress, but their level of stress was substantially lower than the stress levels reported by participants in the other classes (see Table 2). As well, very few participants in Class 1 endorsed having PTSD (0.5%), depression (2.5%), anxiety (0.6%), and panic (1.6%) in the past 12 months. As well, 9.8% of participants in Class 1 reported a history of childhood physical, sexual, or emotional abuse (i.e., childhood trauma), but this level of abuse was much lower than that of participants in the other classes. As such, participants in Class 1 reported the lowest levels of emotional vulnerability.

As for self factors, participants in Class 1 viewed money as somewhat to quite important (see Table 2). Yet, their reported level of importance of money was lower than that of participants in the other classes. Furthermore, participants in Class 1 had low levels of impulsivity, as their average score (i.e., 13.02) was below the midpoint of the total score range (i.e., total score ranges from 0-32). Moreover, Participants in Class 1 reported the lowest level of impulsivity relative to participants in the other classes (see Table 2). In short, participants in Class 1 were relatively free of psychopathology stemming from the over importance of money and impulsivity.

In sum, participants in class one include those who do not have gambling problems and relatively problem-free in terms of substance use, addictive behaviours, emotional vulnerability, financial focus, and impulsivity.

Class 2: Participants at low risk for gambling problems that frequently use tobacco and have some emotional vulnerability

Class 2 was the second largest class in the sample and included 1,586 participants, which was 15.8% of the total sample. Participants in Class 2 were at low risk for developing gambling
problems based on their PGSI score (see Table 2) and they had the second lowest level of erroneous gambling beliefs when compared to the other classes (see Table 2). In terms of gambling motives, just over half of the participants in Class 2 endorsed enhancement (50.9%) as a primary reason for engaging in gambling, whereas just over a quarter of the class endorsed coping (25.7%). The endorsement rate for enhancement was the third lowest when compared to the other classes (see Table 2). As well, the endorsement rate for coping was the second highest when compared to the other classes. These observations suggest that participants in Class 2 have some risk for developing gambling problems.

Participants in Class 2 also had the highest rate of tobacco use, whereby they would use tobacco products almost every day. Additionally, they consumed alcohol between 2-3 times a week and once a month (see Table 2). Class 2 rarely, if ever, used cannabis products. They also had the third lowest rate of illicit drug use (7.8%; e.g., cocaine, amphetamines, hallucinogens, heroin, opium, fentanyl) for the total sample (see Table 2). As such, participants in Class 2 were largely heavy users of tobacco in terms of substance use.

Aside from Class 1, Class 2 had the lowest rates of problems with over-involvement in terms of sex and pornography (4.1%), exercise (1.4%), video gaming (3.1%), shopping (4.4%), and social media use (4.3%). A somewhat large portion of participants in Class 2 reported problems with over-involvement related to internet use (7.2%) and overeating (7.7%). However, endorsement of problems of over-involvement with addictive behaviours was low. Thus, most participants in Class 2 did not have problems with addictive behaviours.

In terms of emotional vulnerability, participants in Class 2 had a higher level of stress compared to Class 1 who were relatively free from emotional vulnerability. Their average score on the response scale corresponded to “a bit stressful,” which was comparable to the stress scores
of participants in the other classes. Participants in Class 2 also had higher rates than those in
Class 1 in terms of PTSD (5.6%), depression (19.4%), anxiety (16.6%), and panic (15.2%) in the
past 12 months. Additionally, 23.8% had also experienced childhood trauma. These rates were
either similar or lower than those observed in the remaining classes (see Table 2). As such, a
substantial portion of participants in Class 2 have emotional vulnerability.

Regarding self factors, Class 2 was the second least impulsive, after Class 1 (see Table
2). Like Class 1, participants in Class 2 had low levels of impulsivity, where their average score
(i.e., 14.76) was below the midpoint of the total score range (i.e., total score ranges from 0-32).
Also, the degree to which money was important to participants in Class 2 was somewhat higher
than those in Class 1, but like those in the other remaining classes (see Table 2). Thus,
participants in Class 2, on average, viewed money as being quite important to them. Taken
together, participants in Class 2 tended to have some impulsivity and viewed money as quite
important.

In sum, participants in Class 2 were at low risk for gambling problems, but they
frequently used tobacco and had some emotional vulnerability.

Class 3: Participants at low risk for gambling problems that frequently use cannabis and that
have low-to-moderate emotional vulnerability and some impulsivity

There were 380 participants in Class 3, which included 3.7% of the total sample.
Participants in Class 3 were very similar to participants in Class 2 in terms of their PGSI and
erroneous gambling belief scores (see Table 2). Class 3 primarily engaged in gambling for
enhancement (55.3%) with the second highest endorsement compared to participants in other
classes, but some also engaged in gambling as a means of coping (22.5%). As such, participants
in Class 3 were at a low risk of developing gambling problems.
Regarding substance use, participants in Class 3, on average, did not use tobacco frequently \(i.e.,\) less than once per month) akin to participants in Class 1. However, they consumed alcohol a few times per month akin to participants in most other classes. Of note, participants in Class 3 reported the highest average score for cannabis use compared to the other classes (see Table 2). The average of 6.027 corresponds to using cannabis 4-6 times per week on the response scale. Furthermore, close to 10\% of participants in Class 3 (9.7\%) reported using illicit drugs, which was the median for the total sample.

In terms of problems with addictive behaviours, participants in Class 3 had endorsement rates that were comparable to those in Class 2, but higher than Class 1 (see Table 2). Problems with social media use (7.9\%) and internet use (10.2\%) were two problematic behaviours that received the greatest endorsements in Class 3. Because rates of problematic engagement in the addictive behaviours in Class 3 were akin to those in Class 2, they were not a defining aspect of Class 3.

Class 3 was somewhat emotionally vulnerable. Like much of the sample, participants in Class 3, on average, experienced quite a bit of stress in their lives (see Table 2). As well, although they had lower levels of PTSD (5.8\%), over a quarter had depression (25.1\%), anxiety (23.4\%), and childhood trauma (36.1\%). Their endorsement of childhood trauma was also the third highest in the sample at 36.1\% (see Table 2). As such Class 3 participants had moderate emotional vulnerability.

In term of the self variables, Class 3 participants were relatively more impulsive, as their average score fell above the midpoint of the total score range \(i.e.,\) total score ranges from 0-32). Their average impulsivity score was the third highest score across all seven classes (see Table 2). Class 3 also viewed money as somewhat-to-quite important to them, which was about the
median score when compared to all seven classes. As such, in average relative terms, participants in Class 3 were more impulsive, but did not view money as more important.

In sum, participants in Class 3 were at low risk for gambling problems. However, they frequently used cannabis and had low-to-moderate emotional vulnerability and impulsivity.

Class 4: Participants at moderate risk for gambling problems that use multiple substances at different frequencies and that have some emotional vulnerability

Class 4 included 3.8% of the total sample (n=383). Based on their average PGSI and erroneous gambling beliefs scores, participants in Class 4 were at a moderate risk for developing gambling problems (see Table 2). However, their rates of endorsement for enhancement (53.2%) and coping (22.4%) as primary reasons for gambling were similar to participants in the other classes—not particularly high nor low for the total sample.

In terms of substance use, participants in Class 4 used various substances at different frequencies. They used tobacco, on average, 1-3 times per week; consumed alcohol, on average, once per week; and used cannabis, on average, once a month or less. Furthermore, about 14% of participants in Class 4 reported using illicit drugs. Taken together, participants in Class 4 used multiple substances, with tobacco being the most common.

As for problems with over-involvement in behaviours, participants in Class 4 endorsed a range of problems, including exercise (7.2%), overeating (11.9%), shopping (7.2%), video gaming (6.5%), sex and pornography (11.1%), social media use (6.3%), and internet use (8%). The rate of endorsement in Class 4 was like Classes 3, 5, and 7, which were overall lower than 11.9% in each class. As such, problems with addictive behaviours were not particularly prevalent in Class 4.
Regarding emotional vulnerability, participants in Class 4 reported quite a bit of stress (see Table 2). This level of stress was similar to values observed in classes 2 and 3. As well, mental health problems (PTSD, depression, anxiety, panic, and childhood trauma) were somewhat prevalent among participants in Class 4, between 11% and 23%. Of note, however, is that the rates of mental health problems in Class 4 was similar to those in Classes 2, and 5.

Like the emotionally vulnerable factors, participants in Class 4 scored near the midpoint of the response distribution on both self factors (i.e., impulsivity and importance of money; see Table 2). For instance, their average impulsivity score (i.e., 15.431) was close to the midpoint of the total score range (i.e., total score ranges from 0-32). Likewise, their average score for the importance of money was 1.965, which is close to the midpoint of the response scale (i.e., 1-4). Also, a score of 2 on the response scale corresponds to “somewhat important.” Moreover, participants impulsivity and importance of money scores in Class 4 were similar to those in Classes, 2, 3, and 5. Taken together, participants’ impulsivity and importance of money scores were non-discriminant.

**Class 5: Participants at moderate-to-high risk for gambling problems that use multiple substances at different frequencies and that have some emotional vulnerability and impulsivity**

Class 5 included 478 participants, which was 4.8% of the total sample. Participants in Class 5 were at moderate-to-high risk for problem gambling based on their PGSI and erroneous gambling beliefs scores (see Table 2). As well, participants in Class 5 had the highest PGSI and erroneous gambling beliefs scores relative to participants in the other classes. Also, of note, close to half of the participants in Class 5 endorsed enhancement as a primary motivation for gambling – akin to enhancement endorsement rates in Classes 1-6. However, less than 15% of participants in Class 5 endorsed coping (14.2%), which was similar to participants in Class 1.
In terms of substance use frequency, participants in Class 5 used tobacco 1-3 times a month, on average. Participants in Class 5 also consumed alcohol 2-4 times a month, on average, akin to participants in Classes 2 and 3 (see Table 2). Moreover, they used cannabis approximately once per month or less, on average, akin to participants in Class 4 (see Table 2). Likewise, close 15% of participants in Class 5 used illicit drugs, which was akin to participants in Class 4 (see Table 2). Taken together, participants in Class 5 used multiple substances at low frequency.

As for problems with over-involvement in behaviours, less than 12% of participants in Class 5 endorsed a range of problems, with sex and pornography (11.9%) and overeating (11.4%) scoring the highest. The rate and pattern of endorsement of problems among participants in Class 5 resembled those of participants in Class 4. As such, given the low rate of problems with addictive behaviours in Class 5, they were not characteristic of most participants in Class 5.

Regarding emotional vulnerability, participants in Class 5 reported quite a bit of stress (see Table 2). This level of stress was similar to values observed in classes 2, 3, and 4. As well, mental health problems (PTSD, depression, anxiety, and panic) were somewhat prevalent among participants in Class 4, between 14% and 22.8%, which was similar to participants in Class 4. Of note, however, the prevalence of childhood trauma was 27.2%, which was more prevalent than that of participants in Class 4. As such, participants in Class 5 had some degree of emotional vulnerability.

As for self factors, participants in Class 5 scored just above the midpoint of the total score range (i.e., total score ranges from 0-32) for impulsivity (i.e., 16.24). Of note, participants in Class 5 had the second highest impulsivity score compared to participants in the classes 1-4, and Class 7 (see Table 2). Participants in Class 5 also viewed money as somewhat-to-quite
important, akin to participants in all the other classes (see Table 2). As such, in average relative terms, participants in Class 5 were more impulsive, but did not view money as more important.

In sum, participants in class 5 were at moderate-to-high risk for gambling problems, used multiple substances at different frequencies, and had some emotional vulnerability and impulsivity.

Class 6: Participants at low-to-moderate risk for gambling problems that engage in problematic overeating who are emotionally vulnerable and impulsive

Class 6 included 1,406 participants, which was 14% of the total sample. Based on their PGSI and erroneous gambling beliefs scores, participants in Class 6 were at a low-to-moderate risk for gambling problems (see Table 2). Just over half endorsed enhancement (53.2%) as a primary motive for gambling, which was similar to endorsement rates in classes 2, 3, and 4. Likewise, about a quarter endorsed coping (24.7%) as a primary motive for gambling, which was similar to endorsement rates in classes 2, 3, and 4.

Regarding substance use, participants in Class 6 did not use substances frequently. They had very low frequency of use for tobacco and cannabis. The average score for these substances was less than the value of 1 (1 corresponds to “less than once a month” on the response scale). However, they consumed alcohol 2-3 times a month. Moreover, only 5% of participants in Class 6 endorsed using illicit drugs (see Table 2). As such, most participants in Class 6 were not using addictive substances.

As for endorsing problems with over-involvement in behaviours that have addiction potential, participants in Class 6 reported the greatest endorsement for overeating (29%) followed by internet use (19.7%), shopping (13.9%), sex and pornography (13.8%), and social media use (12.7%). These rates of endorsement were the highest compared to all other classes.
The remaining behaviours (exercise and video gaming) were each less than 10% and comparable to rates for classes 4, 5, and 6 (see Table 2). As such, about one third of participants in Class 6 had problems with overeating, which is substantial.

In terms of emotional vulnerability, participants in Class 6 reported the most stress in their lives, on average, compared to all other classes (see Table 2). Class 6 also had the highest proportions of depression (42.8%), anxiety (33.8%), and panic (29.6%) compared to the other classes. As well, proportions of PTSD (12.9%) and childhood trauma (37.7%) were substantial and were the second highest compared to the other classes. As such, many participants in Class 6 were emotionally vulnerable.

Regarding the self factors, Class 6 was the most impulsive class with a score \( i.e., 18.47 \) above the midpoint of the total score range \( i.e., \) total score ranges from 0-32). Class 6 also had the highest value of the sample for the importance of money (see Table 2) and viewed money as quite important to them.

In sum, participants in Class 6 were at low-to-moderate risk for gambling problems, many had problems with addictive behaviours, especially overeating, and many were emotionally vulnerable and impulsive.

**Class 7: Participants at moderate risk for gambling problems, use addictive substances frequently, are emotionally vulnerable and have some impulsivity**

Class 7 included 668 participants, which was 6.6% of the total sample. Participants in Class 7 were at a moderate risk for gambling problems based on their PGSI and erroneous gambling beliefs scores (see Table 2). Also, close to 60% of participants in Class 7 endorsed enhancement (59.5%) as a primary reason for gambling. As well, close to 30% of participants in
Class 7 endorsed coping (27%) as a primary reason for engaging in gambling. The endorsement rates for enhancement and coping were the highest across all classes.

In terms of substance use, participants in Class 7 used tobacco almost every day, consumed alcohol approximately once per week (the highest rate of consumption across classes), used cannabis multiple times per week, and had the highest rate of illicit drug use (27.8%; see Table 2). As such, participants used multiple substances very frequently.

As for problematic over-involvement in behaviours with addiction potential, most participants did not have such problems. The only behaviours with which more than 10% of participants in Class 7 endorsed was problems with sex and pornography and overeating (see Table 2). The remaining behaviours each had less than 10% endorsement. As well, the pattern and rates of endorsement among participants in Class 7 were similar to those in classes 3 and 4. As such, most participants in Class 7 did not have problems with addictive behaviours.

Class 7 participants appeared quite emotionally vulnerable, as they experienced quite a bit of stress in their lives, with their stress being the second highest across the seven classes (see Table 2). They also had the highest rate of PTSD (16.3%) and childhood trauma (43.2%), in addition to over a quarter of the class experiencing depression (27%), anxiety (27.8%), and panic (27.7%). As such, many participants in Class 7 were emotionally vulnerable.

For self factors, participants in Class 7 viewed money as quite important like participants in classes 2, 3, and 6 (see Table 2). As for impulsivity, their average impulsivity score \( (i.e., 15.963) \) was very close to the midpoint of the total score range \( (i.e., \text{total score ranges from 0-32}) \). As such, importance of money and impulsivity were not discriminant.

In sum, participants in Class 7 were at moderate risk for gambling problems, used addictive substances frequently, and were emotionally vulnerable.
Discussion

The Pathways Model of disordered gambling (Blaszczynski & Nower, 2002) is the leading biopsychosocial framework for the etiology and maintenance of disordered gambling. In the Pathways Model, people with gambling problems are a heterogeneous group in terms of etiology. Three etiological subtypes are theorized to explain the pathways to disordered gambling, which include behaviorally conditioned, emotionally vulnerable, and anti-social impulsive risk-taking. Herein, I used the Pathways Model as a framework to understand the nexus between disordered gambling, substance use, and addictive behaviors. In doing so, I also examined their overlap with various forms of psychopathology linked to emotional vulnerability (stress, PTSD, depression, anxiety, panic, and childhood trauma), financial focus, and impulsivity. I used mixture modelling to identify subgroups of people defined by their degree of disordered gambling, substance use, problematic engagement in addictive behaviors, emotional vulnerability, financial focus, and impulsivity in a large nationally representative sample of Canadians who gamble.

A model that included seven subgroups or classes of participants provided the best fit to the data. As expected, a subgroup of participants that did not have gambling problems emerged in the data and comprised about half of the total sample. They also had the lowest endorsement rates for enhancement and coping gambling motives relative to the other six subgroups. As well, they had the lowest rates of substance use and problematic engagement in addictive behaviors, and were relatively free from psychopathology-related emotional vulnerability, financial focus, and impulsivity. In short, participants in the first subgroup were largely problem-free and comprised about half of the total sample. These observations are consistent with prior mixture
modeling research that also observed a problem-free group of community gamblers (e.g., Dowd et al., 2019; for a recent systematic review, see Kurilla, 2021).

For the remaining six subgroups of participants that I observed, all had gambling problems and erroneous gambling beliefs that varied by severity. Many participants in these six groups endorsed either enhancement or coping gambling motives, with most endorsing enhancement motives. Although the difference between the number of participants endorsing enhancement or coping gambling motives in the remaining six subgroups was similar, some of the subgroups had greater endorsement of both motives than others, which may be linked to the presence and absence of other factors in the model, such as emotional vulnerability.

Interestingly, participants in the remaining six subgroups all had emotional vulnerability that varied by degree but not by kind. That is, no single emotional vulnerability factor was a unique feature of a given subgroup. Although some emotional vulnerability factors were more common than others across the six subgroups (e.g., depression and childhood trauma), the pattern of prevalence differences between the emotional vulnerability factors were largely similar across the six subgroups. This is likely due, in part, to the high degree of comorbidity between the emotional vulnerability factors. For example, depression and anxiety (panic is a type of anxiety disorder) are often highly correlated in that people who meet diagnostic criteria for depression often meet diagnostic criteria for an anxiety disorder (e.g., Eysenck & Fajkowska, 2018). Also, people with PTSD often develop depression and anxiety disorders (Sphinxen et al., 2014). In addition, it is well-established that childhood adversity is a general risk factor for various forms of psychopathology, including depression, anxiety, and PTSD (e.g., Francis et al., 2023). Accordingly, the distinct types of emotional vulnerability did not help to differentiate between the six subgroups of participants that had gambling problems. Instead, the six subgroups
differed in terms of the number of participants with gambling problems that had emotional vulnerability. Two subgroups had the highest number of participants that had emotional vulnerability (classes 6 and 7). One subgroup (Class 3) had relatively fewer participants with emotional vulnerability, while the remaining three subgroups (classes 2, 4, and 5) displayed an even smaller proportion of participants with emotional vulnerability. As such, the presence of emotional vulnerability is important for understanding the etiology of disordered gambling, whereas the type of emotional vulnerability may not be as central.

Like emotional vulnerability, the degree of impulsivity helped to differentiate between the six subgroups of participants with gambling problems. Two subgroups (classes 2 and 4) had average impulsivity scores that were below the midpoint of the total score range, which I deemed as having little or no impulsivity. Three subgroups (classes 3, 5, and 7) had average impulsivity scores that were at the midpoint of the total score range, which I deemed as having some impulsivity. The remaining subgroup (Class 6) had an average impulsivity score that was above the midpoint of the total score range, which I labeled as “moderate” impulsivity. The relationship between impulsivity and the gambling variables among the six groups was complex. For instance, the subgroup of participants with the most impulsivity (Class 6) did not have the most severe gambling problems and erroneous gambling beliefs. Instead, one of the subgroups that had some impulsivity (Class 5) had the most severe gambling problems and erroneous gambling beliefs. Complicating matters further, another subgroup with some impulsivity (Class 3) had the lowest gambling severity and erroneous gambling beliefs of the six subgroups that had gambling problems. The third subgroup with some impulsivity (Class 7) had moderate gambling problems and erroneous gambling beliefs. As such, the link between impulsivity and gambling problems was not linear. These observations are consistent with Devos and colleagues’ (2020) results in
which they found that high levels of erroneous gambling beliefs were not present among all
gamblers with impulsivity.

Of importance, when intersecting emotional vulnerability and impulsivity, the six
subgroups of participants with gambling problems can be linked to the subtypes identified in the
Pathways Model. There were two subgroups (classes 2 and 4) that had the lowest emotional
vulnerability and impulsivity, which would map onto the behaviourally conditioned type. The
mapping of the remaining four subgroups onto the Pathways Model types was less clear because
two subgroups (classes 3 and 5) had some emotional vulnerability and impulsivity, one subgroup
had moderate emotional vulnerability, but some impulsivity (Class 7), and one subgroup had
both moderate emotional vulnerability and impulsivity (Class 6). These four subgroups are
generally consistent with the Pathways Model in that there are emotionally vulnerable and
impulsive types. However, my results suggest that more nuance in the Pathways Model may be
needed as emotional vulnerability and impulsivity vary in severity on a continuous scale (e.g.,
low, moderate, high) as opposed to on a categorical scale (absent vs. present). My suggestion is
consistent with Kurilla’s (2021) systematic review of research evaluating the Pathways Model in
which he concluded that an assessment of the severity of the etiological factors would further
advance our understanding of the etiology of disordered gambling.

Extending the results for disordered gambling, emotional vulnerability, and impulsivity, I
examined the extent to which participants used addictive substances and had problematic
engagement in addictive behaviours. Alcohol use was common among all the subgroups of
participants. Among the six subgroups of participants that had some degree of disordered
gambling, there were different patterns of substance use and problematic engagement in
addictive behaviours. There were two subgroups in which participants used a specific substance
at high frequency. Participants in one subgroup used tobacco everyday (Class 2), whereas participants in another subgroup used cannabis 4-6 times per week (Class 3). There was one subgroup that had relatively more problematic engagement in addictive behaviours, particularly overeating and social media use (Class 6). There were also two subgroups that used multiple substances frequently, as well as some illicit drug use (Classes 4 and 5). Lastly, there was one subgroup that used multiple substances at a relatively greater frequency (weekly and daily) and close to one third used illicit substances (Class 7).

When examining addictive substances and behaviours in unison with the etiological factors in the Pathways Model (emotional vulnerability and impulsivity), new insights emerge concerning the co-occurrence of disordered gambling and other addictions. In particular, of the two subgroups that coincide with the behaviourally conditioned pathway (classes 2 and 4), participants in one subgroup used tobacco frequently (Class 2) whereas participants in the other subgroup used multiple substances frequently, as well as some illicit drugs (Class 4). For the four remaining subgroups with differential levels of emotional vulnerability and impulsivity, there were two subgroups (classes 3 and 5) that had some emotional vulnerability and impulsivity, but participants in one subgroup used cannabis 4-6 times per week (Class 3) and participants in the other subgroup used multiple substances frequently, as well as some illicit drugs (classes 4 and 5). Among participants in the subgroup that had moderate emotional vulnerability, but some impulsivity (Class 7), they used multiple substances at a relatively greater frequency (weekly and daily) and close to one third used illicit substances. In the one subgroup that had both moderate emotional vulnerability and impulsivity (Class 6), they had relatively more problematic engagement in addictive behaviours, particularly overeating and social media use, and little or no substance use.
The findings from the analyses linking the etiological factors in the Pathways Model (emotional vulnerability and impulsivity) with substance use and problematic engagement in behaviours with high addiction potential are important for at least three reasons. First, they are consistent with a large body of correlational research demonstrating moderate and high rates of co-occurrence between disordered gambling, substance use problems, and problematic engagement in behaviours with high addiction potential (e.g., Dowling et al., 2015; el-Guebaly et al., 2012; Grant & Chamberlain, 2015; Lorains et al., 2011; Sussman et al., 2011; Tiego et al., 2019; Yau & Potenza, 2015). Second, the findings of the current research extend prior research by showing that there are various distinct patterns of co-occurrence. Third, knowledge about the distinct patterns of co-occurrence can be used to inform treatment interventions for people with co-occurring addictions with disordered gambling. For instance, interventions that target one addictive substance (e.g., tobacco) may not be efficacious if the client had problems with multiple substances (e.g., tobacco, cannabis, and cocaine). In short, my findings underscore the need to look for different patterns of co-occurrence between disordered gambling, addictive substances, and addictive behaviours as opposed to only examining linear associations.

Lastly, I examined the role of financial focus in relation to the different co-occurring patterns of disordered gambling, emotional vulnerability, impulsivity, substance use, and addictive behaviours. Financial focus was lowest amongst the subgroup of participants that did not have gambling problems (Class 1). However, financial focus was somewhat greater among participants with disordered gambling. All viewed money as quite important. This observation is consistent with prior research. More specifically, Tabri and colleagues (2021) showed that financial focus was lowest among people with no gambling problems but was elevated among participants with gambling problems. Tabri and colleagues (2021) also showed that financial
focus was moderately greater among disordered gamblers with more etiological factors compared to disordered gamblers with fewer etiological problems. I observed a similar pattern, but the differences tended to be smaller.

**Limitations and Future Directions**

There are several limitations of the current research that should be noted. First, a measure of anti-social personality traits was not included in the analyses. The reason is that anti-social personality traits were not included in the AGRI questionnaire battery. The omission of anti-social personality traits is important because it is an etiological factor in the Pathways Model, namely the anti-social impulsive risk-taking subtype. As such, it is unclear whether one or more subgroups of participants may fit better with the anti-social impulsive risk-taking subtype in the current research. That said, the subgroups of participants that had moderate emotional vulnerability, some impulsivity, and who used multiple substances weekly and daily, as well as illicit drugs (Class 7), may more closely resemble the anti-social impulsive risk-taking subtype as opposed to the emotionally vulnerable subtype. The reason is that using multiple addictive substances and illicit drugs is characteristic of anti-social impulsive risk-taking disordered gamblers. As such, it is important that future research replicate and extend the current research by including a measure of anti-social personality traits.

Another limitation of the current research is that the data was from a single time-point. This means that causal relationships could not be examined. As such, it is unclear whether the overlap of engagement with various substances and non-substance addictive behaviours preceded or followed from the development of gambling problems. It is also unclear from the current research whether participants were using the addictive substances while gambling. As such, future research should use a longitudinal research design to tease apart the temporal interplay
between gambling and substance use, and to better understand whether people are using addictive substances when gambling.

**Conclusion**

The present study explored the substance and behavioural addiction nexus among people who gamble. Overall, we observed that problem gamblers are a heterogeneous population, as evidenced by the identification of seven distinct subgroups. These subgroups were generally consistent with the Pathways Model in terms of emotional vulnerability and impulsivity. However, there were distinct patterns of co-occurring addictive substance use and problematic engagement in behaviours with high addiction potential. There were three distinct subgroups characterized by frequent use of a single substance (*e.g.*, tobacco or cannabis) or problematic engagement in one or two addictive behaviours (*e.g.*, overeating and social media use). As well, there were three subgroups characterized by frequent use of multiple substances. The findings underscore the need to examine and identify different patterns of co-occurrence between disordered gambling on the one hand and addictive substance use and problematic engagement in behaviours with high addiction potential on the other hand.


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## Appendix A

### Problem Gambling Severity Index (PSGI) Items

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>b_gp1</td>
<td>b_gp1 – PGSI1. Have you bet more than you could really afford to lose? (In the past 12 months, how often…)</td>
<td>Never, Sometimes, Most of the time, Almost Always</td>
</tr>
<tr>
<td>b_gp2</td>
<td>b_gp2 – PGSI2. Have you needed to gamble with larger amounts of money to get the same feeling of excitement? (In the past 12 months, how often…)</td>
<td>Never, Sometimes, Most of the time, Almost Always</td>
</tr>
<tr>
<td>b_gp3</td>
<td>b_gp3 – PGSI3. When you gambled, did you go back another day to try to win back the money you lost? (In the past 12 months, how often…)</td>
<td>Never, Sometimes, Most of the time, Almost Always</td>
</tr>
<tr>
<td>b_gp4</td>
<td>b_gp4 – PGSI4. Have you borrowed money or sold anything to get money to gamble? (In the past 12 months, how often…)</td>
<td>Never, Sometimes, Most of the time, Almost Always</td>
</tr>
<tr>
<td>b_gp5</td>
<td>b_gp5 – PGSI8. Has your gambling caused any financial problems for you or your household? (In the past 12 months, how often…)</td>
<td>Never, Sometimes, Most of the time, Almost Always</td>
</tr>
<tr>
<td>b_gp6</td>
<td>b_gp6 – PGSI5. Have you ever felt that you might have a problem with gambling? (In the past 12 months, how often…)</td>
<td>Never, Sometimes, Most of the time, Almost Always</td>
</tr>
<tr>
<td>b_gp7</td>
<td>b_gp7 – PGSI6. Has your gambling caused any health problems, including stress or anxiety? (In the past 12 months, how often…)</td>
<td>Never, Sometimes, Most of the time, Almost Always</td>
</tr>
<tr>
<td>b_gp8</td>
<td>b_gp8 – PGSI7. Have people criticized your betting or told you that you have a gambling problem, regardless of whether or not you thought it was true? (In the past 12 months, how often…)</td>
<td>Never, Sometimes, Most of the time, Almost Always</td>
</tr>
<tr>
<td>b_gp9</td>
<td>b_gp9 – PGSI9. Have you felt guilty about the way you gamble or what happens when you gamble? (In the past 12 months, how often…)</td>
<td>Never, Sometimes, Most of the time, Almost Always</td>
</tr>
</tbody>
</table>