Running head: Gambling and Brain Injury

Moderate to severe gambling problems and traumatic brain injury: A population-based study.

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Problem gambling and Traumatic Brain Injury: A population-based study

Abstract
Traumatic brain injury (TBI) is a common injury characterized by a change in brain function after an external blow to the head and is associated with substance abuse, psychological distress, risk-taking, and impulsivity. Convenience and clinical samples have also linked TBI to problem gambling, but have not ruled out confounding variables such as hazardous drinking and psychological distress. This study examines the relationship between TBI and moderate to severe problem gambling in a general population probability sample controlling for hazardous drinking and psychological distress. The data were obtained from a 2015-2016 cross-sectional general population telephone survey of adults ages 18+from Ontario, Canada (*N*=3,809). Using adjusted odds ratio (AOR), moderate and severe problem gambling was independently associated with a history of TBI after adjusting for potential confounders (AOR: 2.80), and had a statistically significant relationship with psychological distress (AOR = 2.74), hazardous drinking (AOR = 2.69), and lower educational levels (AOR = 0.37). This population-based finding confirms the link between TBI and moderate and severe problem gambling, however more research is needed to determine if there is a causal relationship or the potential implications for prevention and treatment.

Problem gambling and Traumatic Brain Injury: A population-based study

1. Introduction

Traumatic brain injury (TBI), including concussion, is a common form of injury, characterized by a change in brain function caused by a blow to the head by an external force, that can lead to serious long-term consequences (Centre for Disease Control and Prevention, 2010; Matteo et al., 2010; Menon et al., 2010). Recent research suggests that these injuries are more common than previously thought, with past-year prevalence estimates reaching 5% or higher among adolescents, and lifetime estimates reaching nearly 20% in adolescent and adult populations in Canada (Ilie et al., 2013; Ilie et al., 2014; Ilie et al., 2015b). Individuals reporting past TBI are also more likely to report substance misuse and mental health problems (Anstey et

al., 2004; Ilie et al., 2015a; Ilie et al., 2014). The purpose of the current study was to determine whether TBI is also linked to moderate to severe problem gambling.

In recent years, gambling has become a common pastime, with the majority of adults in most developed countries participating in one or more forms of gambling in the past year (Ialomiteanu et al., 2016; Korn and Shaffer, 1999). For most participants, gambling appears to be a relatively harmless recreational pastime (e.g., Hope and Havir, 2002). However approximately 1.9% of the population develop a problem with gambling, with about 0.6% developing a severe problem (Ialomiteanu et al., 2016; Williams and Volberg, 2013). Problem gambling can have a devastating impact on a person's financial, social, family and work life, and can result in bankruptcy, depression, suicide and many other adverse outcomes (Cook et al., 2015; Hodgins et al., 2011; Levens et al., 2005).

An understanding of the factors that increase an individual's likelihood of developing a gambling problem is necessary for preventing and treating this disorder. A variety of individual and social factors have been identified that affect risk of problem gambling. These include availability of opportunities to participate in gambling (van der Maas et al., 2017), erroneous beliefs about gambling (Turner et al., 2008; Turner et al., 2006), behavioral contingencies (Blaszczynski & Nower, 2002; Weatherly & Dixon, 2007), sociodemographic factors including being young and male (Holdsworth et al., 2012), problems related to alcohol and drug use (e.g., Rennert et al., 2014; Welte et al., 2004), and mental disorders such as depression, anxiety, and suicidality (Cook et al., 2015; Kerber et al., 2008; Turner et al., 2011; Turner et al., 2008). Nevertheless, much remains to be understood about the factors and pathways that may predispose individuals to gambling problems.

Given the relationship between TBI and tobacco, alcohol, and cannabis use (Ilie et al., 2015a; Ilie et al., 2013), and the comorbidity of problem gambling with substance use (Turner et al., 2011) and mental health problems (Cook et al., 2015; Kerber et al., 2008; Turner et al., 2008), it is reasonable to hypothesize that TBI may also be related to problem gambling. A review of the literature found a small number of studies that have reported a link between TBI and problem gambling. Hodgins and Hollub (2015) reported that in a community-derived sample of 104 problem gamblers, nearly half of their sample reported experiencing a TBI in their lifetime. Similarly, Whiting et al. (2016) observed that experiencing a TBI was a significant correlate of problem gambling in a sample of 738 American veterans. These observations suggest that experience of a TBI is associated with problem gambling, but there is insufficient evidence to determine if there is a causal relationship. Clinical observations have also suggested that gambling problems are associated with TBI (Guercio et al., 2012). Neurobiological research suggests that damage to multiple pathways by brain injury may result in increased risk taking and impaired performance on gambling-related tasks (Levine et al., 2005; MacPherson et al., 2009). Evidence suggests that problem gamblers may be characterized by increased aggressiveness, risk-taking and impulsivity in comparison to the general population (Korman et al., 2008; Loxton et al., 2008; Maccallum et al., 2007; Parke and Griffiths, 2005), which are characteristics that have been observed among those who have experienced TBI (Dooley et al., 2008; Ilie et al., 2015a; Ilie et al., 2017a; Ilie et al., 2017b; McAllister, 2008; Slomine et al., 2005; Williams et al., 2010). Thus, it is possible that increased aggressiveness, impulsivity and risk-taking that can result from TBI might predispose individuals to problem gambling. Neverthless, the available evidence for such a link suffers from reliance on opportunistic or small clinical samples. and to date no studies have assessed the association between experiencing TBI

and problem gambling in population-level representative samples. It is possible that any observed association between problem gambling and TBI may be confounded by the association of both of these measures with common demographic, substance-related and mental health measures.

In this article, we report on the association of TBI with problem gambling in a large, population-representative sample of adults (aged 18 and older) from Ontario, Canada. We control for the potential confounding effects of sociodemographic factors, hazardous drinking, and psychological distress.

2. Methods

2.1. Sample

Data were derived from the 2015 and 2016 cycles of the Centre for Addiction and Mental Health's (CAMH) Monitor, a continuously-fielded cross-sectional telephone survey of Ontario adults aged 18 years or older, administered by the Institute for Social Research at York University. Informed consent, confidentiality, and privacy was assured for all participants. The institutional research ethics committee at CAMH and York University approved the survey as protocol #305/2009-06, 2015. Excluded from selection were adults who were phoneless, institutionalized, and unable to speak English. The design employed a stratified, two-stage-probability sample drawn quarterly through random digit dialing of listed and unlisted landline and mobile telephone numbers. Each calendar year, the four quarterly non-overlapping samples

are combined to provide a single annual dataset. The analysis we present here is based on a random subsample of 4,016 respondents who were asked about their gambling behaviour and lifetime traumatic head injuries (response-rate was 41% and cooperation rate was 46% in both years)[1]; after listwise deletion the sample was reduced to 3,809 (Male = 47.5%). The data were weighted to adjust for varying selection probabilities, regional representation, and a final post-stratification adjustment to restore the age by sex distribution based on the most recently available census figures. The weighted sample is considered representative of the non-institutionalized Ontario adult population. A complete description of the survey and discussion of potential nonresponse bias is available on the *Monitor's* webpage (Ialomiteanu et al., 2016).

2.2. Variables

Problem gambling was measured by the Problem Gambling Severity Index (PGSI), a subscale of the Canadian Problem Gambling Index (CPGI) (Ferris and Wynne, 2001). This measure consists of 9 items that are scored from 0 (never) to 3 (almost always) and then a total score is derived that ranges from 0 to 27. Scores between 0 to 2 indicate no risk to low risk, scores between 3 to 7 indicate moderate risk, and scores above 8 indicate severe problem gamblers (Williams and Wood, 2007). In this data set there were too few severe problem gamblers, therefore the last two categories were combined in one: scores 3 and above being used to indicate moderate to severe risk for gambling problems (coded 1 = 3+; scores between 0 to 2

[1] We are using AAPORs (American Association of Public Opinion Research) eligibility-adjusted **response rate calculation #3** which includes an estimate of unknown eligible in the denominator (e.g., Completed/(Completed + Partial + Refused + Non-contact + Other + Estimated Eligibility * (Unknown Household + Unknown Other) and **cooperation rate calculation #1** which is Completed divided by (Completed + Partially Completed + Refused + Other). See Standard Definitions at http://www.AAPOR.org).

were coded 0). The PGSI is often coded this way (Blaszczynski and Nower, 2010; Crockford et al., 2008; Currie et al., 2013; Hodgins et al., 2010).

Demographic variables included sex, age, and education. The Alcohol Use Disorders Identification Test (AUDIT) (Babor et al., 2001; Saunders et al., 1993) was developed by the World Health Organization as a screening instrument to detect problem drinkers at the less severe end of the spectrum of alcohol problems. It was adopted by the current study to measure hazardous drinking. The AUDIT has been demonstrated to be a highly valid measure with strong internal consistency and test-retest reliability (Babor et al., 2001). The AUDIT consists of ten items asking about the frequency, volume, and pattern of alcohol consumption, indicators of dependence, and adverse consequences associated with drinking. The validated threshold score of 8 or more is used to designate a hazardous or harmful level of drinking. For the current analysis, responses were dichotomized into those respondents reporting hazardous or harmful drinking levels versus those not reporting such risky behaviour (coded 0 = no hazardous drinking, 1 = hazardous drinking).

The Kessler 6-Item Psychological Distress Scale (K6) is a simple measure of psychological distress that consists of 6 questions about the participant's emotional state. Each of the six questions began with the wording: *"In the past 30 days how often did you…"* and the following symptoms: *(1) feel nervous; (2) feel hopeless; (3) feel restless or fidgety; (4) feel so depressed nothing could cheer you up; (5) feel that everything was an effort; and (6) feel worthless.* The questions were scored from 0 (None of the time) to 4 (All of the time) and then a total score ranging from 0 to 24 was computed. According to Galeo et al., a score of less than 8 is a probable non-case, a score of 8 to 12 was classified as mild to moderate mental illness and above 13 was classified as probable serious mental illness (Galea et al., 2007). In this study, we

used a cut-off score of 8 or more on the Kessler K6 to indicate moderate to severe psychological distress(Galea et al., 2007). According to Galea et al., (2007) the K6 has very good sensitivity (1.0 for severe distress and 0.9 for moderate distress) and very good specificity (1.0). In the current study the alpha was 0.82, and a component analysis found only a single eigenvalue greater than 1, which suggests only a single component in the scale and this component accounted for 55% of the variance.

Traumatic brain injuries (TBI) sustained in one's lifetime were assessed by a single question prefaced as follows: "*We are interested in any head injuries that resulted in you being unconscious (knocked out) for at least 5 minutes, or you had to stay in the hospital for at least one night because of it".* Respondents were then asked: "*How many times, if ever in your life, have you had this type of head injury"?* Due to low frequencies, responses were recoded to create a binary reported lifetime TBI variable (coded 0 = no, 1 = yes).

2.3. Analysis

To test each variable, design-based analyses Rao-Scott adjusted chi-squares were conducted using Taylor Series Linearization found in STATA13 software (StataCorp, 2013). The percentages reported are based on the weighted sample sizes and are considered representative for the population surveyed. The data were entered in a series of blocks to examine the effect of TBI before and after controlling for other variables. Four logistic regression models were conducted to determine the adjusted odds ratio of problem gambling within the past 12 months associated with TBI, while controlling for sociodemographic variables (sex, age, education), hazardous drinking (AUDIT 8+), and psychological distress (Kessler 6 8+). Model 1 only included the sociodemographic variables, model 2 added TBI, model 3 removed TBI and added hazardous drinking and psychological distress, and model 4 included all the variables. For the

regression analysis, missing data (i.e., "don't know" responses and refusals) were excluded from the analysis, and all results were estimated with a nested sample size of 3,809.

3. Results

Table 1 presents the characteristics of the sample. Males and females were evenly represented. Most respondents (37.9%) were 55 or over, and only 25.7% between 18 and 35. Neither age or sex were significantly related to problem gambling. The sample was well-educated with 38.9% reporting having completed a post-secondary education, and 35.6% having some post-secondary education. Only 18.4% of moderate to severe problem gamblers reported completing a post-secondary education, compared to 39.2% of those who score 0 to 2 on the PGSI.

Insert Table 1about here

Of the sample, 60 individuals (1.6%) reported gambling problems (a score of 3 or more on the PGSI) which includes 11 individuals with a severe gambling problem (0.2%; 8 or more on the PGSI). As shown in Table 1, there were significant relationships between problem gambling and lifetime TBI, hazardous drinking and psychological distress. Hazardous drinking (scores 8 and above) was observed among 34.3% of individuals who scored 3 or more on the PGSI, but only reported by 13.5% of those who scored 0 to 2 on the PGSI. The key variable for this paper was TBI was reported by 36.2% of those who scored 3 or more on the PGSI, but only reported by 14.3% those who scored 0 to 2 on the PGSI. Similarly a moderate to severe level of psychological distress as measured with the Kessler 6 (8+) was reported by 29.7% of those who scored 3 or more on the PGSI, compared to 10.9% among those who score 0 to 2 on the PGSI. Analysis of variance showed that moderate to severe problem gambling, $F(1, 3992) = 18.5$, and

TBI were both significantly related to psychological distress. $F(1, 3992) = 4.5$, $p < .05$, and there was no interaction between TBI and moderate to severe problem gambling, $F(1, 3992) < 1$, ns.

We conducted four models to determine the relationship between TBI and problem gambling, presented in Table 2. In all models, sex, age, and education were entered as control variables. Sex and age were not related to problem gambling in this sample. For education, people who completed post-secondary school had lower odds of having a moderate to severe gambling problem compared to those who completed a high school education or less. . The effect for completed post-secondary school was AOR = 0.30 (CI: 0.13 to 0.67) in model 1 indicating that individuals who completed post-secondary education were 70% less likely than those with a high school education or less to have a gambling problem. Age and sex were not significant in any model, while post-secondary education was significant in all four models.

Model 2 added TBI which was significant (AOR=3.32; CI: 1.62 to 6.83), and the overall model was highly significant, $F(6, 3920) = 3.76$, $p < .001$. Model 3 removed TBI and added psychological distress (AOR 3.14, CI 1.31 to 7.48) and hazardous drinking (AOR=2.91, CI: 1.40 to 6.05) which were both significantly associated with problem gambling.

Finally, model 4 included all the variables, and the effect of TBI was significant, but the adjusted odds ratio was a little smaller than in model 2 (AOR = 2.80, CI: 1.35 to 5.79). Similarly the effect of psychological distress (AOR 2.74, CI: 1.17 to 6.43), and hazardous drinking (AOR = 2.69: CI: 1.32 to 5.49) were also had slightly smaller adjusted odds ratios in model 4, but still significant.

Insert Table 2 about here

4. Discussion

This article found that in a population-level representative survey people with a history of traumatic brain injury were 2.8 times more likely to have a moderate to severe gambling problem. The analysis found that the effect of TBI was present both before (model 2) and after (model 4) controlling for psychological distress and hazardous drinking indicating that this link is not merely due to the comorbidity with hazardous drinking and psychological distress, but that TBI is independently related to problem gambling. Furthermore, this study demonstrates that the association between TBI and moderate to severe problem gambling is not attributable to other sociodemographic factors.

This study provides strong corroboration of the previous studies using non-probability and clinical samples (e.g., Guercio et al., 2012; Hodgins and Holub, 2015; Whiting et al., 2016). Controlling for hazardous drinking and psychological distress was important because these variables have been shown to be related to TBI in previous studies (Anstey et al., 2004; Ilie et al., 2015a; Ilie et al., 2014) and are also known to be associated with problem gambling (Grant et al., 2002; Turner et al., 2011; Turner et al., 2008).

In this study we found that only 1.6% of the general population sample reported having moderate to severe problem gambling. This rate is lower than most other studies of problem gambling, but is consistent with a general trend in prevalence studies to find that the rates of problem gambling have been falling since the early 2000s (Williams et al., 2012). In contrast to the low rate of problem gambling, 13.5% of the sample reported drinking at hazardous levels, providing confirmation of previous studies indicating that hazardous drinking is more common than problem gambling in Canada (e.g., Adlaf et al., 2005; Ialomiteanu et al., 2016; McCready et al., 2008; Williams and Volberg, 2013).

As a cross-sectional study, it is impossible to determine the cause and effect nature of the observed relationship. As noted in the introduction, previous studies have shown that both people with gambling problems (Korman et al., 2008; Loxton et al., 2008; Maccallum et al., 2007; Parke and Griffiths, 2005) and people who have experienced a TBI (Dooley et al., 2008; Ilie et al., 2015a; Ilie et al., 2017a; Ilie et al., 2017b; McAllister, 2008; Slomine et al., 2005; Williams et al., 2010) may be characterized by increased aggressiveness, risk-taking and impulsivity in comparison to the general population. Longitudinal research is needed to determine if TBI causes problem gambling, or if problem gambling and TBI are the result of a shared underlying trait of risk-taking or impulsivity.

The study results are validated by a pattern of comorbidity that is very similar to previous studies. Problem gamblers had more than triple the odds of reporting hazardous drinking compared to people who did not have a gambling problem, similar to previous research (e.g., Rennert et al., 2014; Welte et al., 2004). In addition, psychological distress was associated with problem gambling, which is consistent with previous research showing that problem gambling is associated with elevated scores on measures of depression and anxiety a (e.g. Kerber et al., 2008). Interestingly, unlike previous studies (Holdsworth et al., 2012), age and sex were not significantly related to moderate to severe problem gambling in this study. The percentages for sex were in the typical direction (e.g., male > females), but this difference was not significant. Although males often have significantly more gambling problems (Holdsworth, et al., 2012), this is not always the case. For example, Abbott et al. (2018) in a stratified random longitudinal sample of Swedish adults found no difference between genders in the first incidence of problem gambling but much higher rates of relapse among men. In addition, two recent studies by our team in Ontario with older adults (55+) using different methodologies (Turner et al., 2018; van

der Maas et al. 2018) found that sex was not significantly associated with problem gambling. These findings may reflect Volberg's (2003) prediction of the "feminization of problem gambling". She suggests that rates of problem gambling will level off between genders, partly due to gambling providers' increased focus on forms of gambling preferred by women, namely electronic gaming machines.

It is too early in this research to draw any strong policy recommendations because we do not know if there is any causal relationship between TBI and problem gambling; however, given the potential for devastating financial consequences of excessive gambling, doctors who treat patients who have suffered head injuries may wish to discuss problem gambling with their patients (along with hazardous drinking, and psychological distress) as a possible consequence of brain injury. Likewise, those seeking treatment for problem gambling should be checked for past TBI as it may contribute to the emotional vulnerability and/or impulsivity of the client which can complicate the treatment process (Blaszczynski & Nower, 2002).

4.1. Limitations

While these results are of substantial interest, they are subject to important limitations. The findings are derived from a cross-sectional survey and thus the findings are correlational in nature. Furthermore, we do not have detailed information on the part of the brain injured, the severity of the injury or the temporal sequence of the head injury and the onset of problem gambling. The relationship between TBI and gambling could perhaps be explained by impulsivity. It is possible that pre-existing impulsiveness led to both gambling and the brain injury, thereby confounding the relationship. Alternatively, perhaps the injury lead to greater impulsiveness which lead to problem gambling. Further research is needed to understand the

causal pathways involved. As well, because the data are based on self-report, they may be subject to bias resulting from these procedures as well as potentially errors in remembering details of the events. Finally, the sample only captures non-institutionalized adults which might miss some of the more severe cases of TBI.

4.2. Conclusions

Individuals who have experienced TBI in their lives are significantly more likely to experience problem gambling. Further, this study demonstrates that the association between problem gambling and TBI is independent, and not attributable to comorbidity between gambling and risky alcohol use or psychological distress. We anticipate that this finding will drive further research exploring potential causal pathways. In addition, the link can help inform policy-makers and healthcare providers as they design prevention and treatment strategies. In particular, there may be value in targeting prevention initiatives on the risk of problem gambling towards people who have experienced a TBI.

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Table 1: Socio-demographic characteristics of the sample, by problem gambling, respondents aged 18 and older, CAMH Monitor 2015-2016, Ontario, Canada.

Variables			**Problem Gambling**				
			PGSI 0-2 (*n*=3749)		**PGSI 3+** (*n*=60)		
	n	%	%	(95% CI)	%	(95% CI)	
Sex				Ns			Ns
Female	2003	52.5	52.6	(50.5-54.7)	43.4	(28.0-60.1)	
Male	1814	47.5	47.4	(45.3 -49.5)	56.6	(39.9-72.0)	
Age				Ns			Ns
18-34	981	25.7	25.6	(23.4-27.8)	34.9	(18.9-55.1)	
35-54	1391	36.4	36.5	(34.6-38.5)	30.6	(17.8-47.4)	
55+	1446	37.9	37.9	(36.1-39.8)	34.5	(22.5-48.0)	
Education				**			*
High School or less	975	25.5	25.3	(23.5-27.1)	41.3	(25.6-59.1)	
Some Postsecondary	1358	35.6	35.5	(33.5-37.5)	40.3	(24.9-57.8)	
Completed Postsecondary	1485	38.9	39.2	(37.2-41.3)	18.4	(10.1-31.2)	
Lifetime TBI				***			***
Yes	545	14.3	13.9	(12.6-15.4)	36.2	(21.7-53.8)	
No	3272	85.7	86.1	(84.6-87.4)	63.8	(46.2-78.3)	
Hazardous Drinking				**			**
AUDIT =>	516	13.5	13.2	(11.7-14.8)	34.3	(19.0-53.6)	
AUDIT < 8	3302	86.5	86.8	(85.2-88.3)	65.7	(46.4-81.0)	
Psychological distress				*			***
Kessler K6 => 8	415	10.9	10.6	(9.2-12.0)	29.7	(16.4-47.7)	
Kessler K6 < 8	3403	89.1	89.4	(88.0-90.8)	70.3	(52.3-83.6)	

Note: All percentages reported are based on the weighted sample size; * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Table 2: Logistic regression model of self-reported problem gambling by demographic characteristics, lifetime traumatic head injuries, hazardous drinking and psychological distress, CAMH Monitor 2015-2016, Ontario, Canada.

	Model 1				Model 2				Model 3				Model 4			
	AOR	95%CI			AOR	95%CI			AOR	95%CI			AOR	95%CI		
Sex																
(ref = female)	1.37	0.71	2.68		1.24	0.63	2.45		1.21	0.64	2.29		1.15	0.61	2.19	
Age (ref = 18-34)																
2. 35-54	0.72	0.28	1.84		0.68	0.26	1.78		0.89	0.34	2.33		0.85	0.32	2.21	
3. 55+	0.69	0.29	1.61		0.63	0.27	1.51		0.98	0.43	2.24		0.89	0.40	2.01	
Education (ref = High School/Less)																
Some Postsecondary	0.69	0.31	1.53		0.69	0.31	1.55		0.71	0.31	1.62		0.72	0.32	1.60	
Completed Postsecondary	0.30	0.13	0.67	**	0.32	0.14	0.71	**	0.35	0.15	0.81	*	0.37	0.16	0.83	*
Lifetime TBI (ref = No)																
Yes					3.32	1.62	6.83	**					2.80	1.35	5.79	**
Hazardous Drinking(ref < 8)																
AUDIT 8+									2.91	1.40	6.05	**	2.69	1.32	5.49	**
Psychological distress (ref<8)																
Kessler K6 8+									3.14	1.31	7.48	*	2.74	1.17	6.43	*

Note: Design-adjusted Wald statistical significance: * $p<0.05$; ** $p<0.01$; *** $p<0.001$; AOR=adjusted odds ratio (holding fixed values for age, sex, education, TBI, AUDIT, and K6); ref = reference category; 95% CI=95% confidence intervals.