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# The Prevalence of Gambling and Gambling Related Harm in Individuals with Neurodevelopmental Disorder (NDD): A Systematic Review

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**Abstract:** *Background*: Global prevalence of gambling disorder (GD) ranges from 0.12–5.8%. Neurodevelopmental disorders (NDDs) pose further vulnerabilities to gambling-related harms. Studies have described a relationship between attention deficit hyperactivity disorder (ADHD) (an NDD) and GD; however, little is known about the comorbidity of other NDDs and GD. *Method*: This systematic review included studies published between 1st January 1994 and 31st August 2023 which reported GD and NDDs as defined by DSM V criteria. Studies were excluded if not published in English. This review is compliant with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The protocol for this systematic review was registered with PROSPERO (CRD42021295190). *Results*: Of the 867 studies identified through database searches, 57 met inclusion criteria. Of these, 45 related to ADHD and GD. The remainder looked at intellectual disability, special educational needs, learning disorder and autism. GD and NDD comorbidity ranged from 2.4% to 62.55%. *Conclusion*: Features of impulsivity, emotional regulation problems, compulsivity and cognitive distortions are shared in NDDs and GD and may be an important therapeutic target in this population. Further research is required to investigate this comorbidity which has implications for: the safeguarding of vulnerable individuals; policy makers and the gambling industry; diagnosis and treatment of GD in the context of neurodiversity or NDD.

**Keywords**: Systematic Literature Review, Gambling, Harm, Neurodevelopmental Disorders, Neurodiversity.

## Introduction

Whilst several individual factors have been identified in the risk of GD such as involvement of multiple neurotransmitter systems (dopaminergic, glutamatergic, serotonergic, noradrenergic, opioidergic), genetic predisposition, mental illness, and personality disorders, little is known about how underlying neurodevelopmental disorders (NDDs) may impact the risk and course of GD. Research has shown a link between ADHD and addictions including GD (Theule et al., 2019). However, comorbidity of GD with other NDDs remains under-investigated and is likely under-reported. Given the extent of shared characteristics between GD and NDDs in terms of neurobiological, neurocognitive, social, and behavioural deficits; identification of comorbidity rates in this potentially more vulnerable subgroup is of importance.

### Gambling Disorder (GD)

DSM V defines GD as "persistent and problematic gambling behaviour leading to clinically significant impairment or distress" with symptoms present for at least 12 months such as; preoccupation, inability to control or stop gambling, irritability/restlessness, repeated engagement despite negative/harmful consequences" (APA,2013). In line with current convention, we will use the terms 'gambling disorder' (GD) or disordered gambling throughout this review, except where other terms are used in the primary studies or surveys. Many of those studies use the term 'Problem Gambling' in correspondence with the scales used which we refer to as PG.

Gambling has been a feature of most societies throughout the historical record (Binde,2001). Whilst a pleasurable activity for many, for a minority, it may lead to significant problems. Globally, prevalence of GD ranges from 0.12–5.8% (Calado & Griffiths,2016). The variance reflects differences in measurement, availability and opportunity, and a range of complex social, cultural, and economic factors which may be involved in the development of GD and gambling related harms (GRH) (Abbott et al., 2018).

In the United Kingdom (UK), according to the most recent figures for Problem Gambling Severity Index (PGSI) scores, 2.8% of adults were identified as 'at-risk' or 'problem gamblers' with the latter accounting for 0.3% of this total (NHS Digital, 2023). The World Health Organization (WHO) has suggested that at least two to three times as many people are at risk of problem gambling compared to those who meet full criteria for GD(Abbott, 2007). These figures were corroborated in a more recent systematic review which reported prevalence of moderate risk/at risk gambling to be 2.43% and problem/pathological gambling to be 1.29% in adults (Gabellini et al, 2023).

### Neurodevelopmental disorders (NDDs)

NDDs are defined as a group of disorders that affect development of the brain and/or central nervous system, usually manifesting in early

childhood with an element of chronicity, lasting into adulthood. The aetiology of NDDs is multi-faceted and results from a combination of genetic, biological, psychosocial, intrauterine, and environmental factors.

DSM V subcategorises NDDs into the following; (1) disorders of intellectual development (intellectual disability (ID)), (2) developmental speech or language disorders, (3) autism spectrum disorders (ASD), (4) developmental learning disorders, (5) developmental motor coordination disorder, (6) attention deficit hyperactivity disorder (ADHD), (7) stereotyped movement disorder, and (8) other neurodevelopmental disorders (APA,2013). According to DSM V, NDDs are characterised by developmental deficits that can lead to impaired personal, social, academic, or occupational functioning. The severity ranges from mild to severe/profound, depending on whether developmental deficits are in specific areas such as learning or executive function, or whether they involve more global impairments in intellectual ability or social skills, for example.

A recent systematic review on the global prevalence of NDDs in childhood concluded that prevalence ranges from 4.7% (in Scotland) to 88.5% (in Japan) (Frances et al.,2022). This widespread variation may be explained by several factors including disparity in assessment methodologies and diagnostic training, as well as diversity in the methods used to estimate prevalence in the scientific literature. Furthermore, prevalence in low and middle-income countries is believed to be underestimated due to under-reporting of such conditions.

Whilst there remains some debate, recent reviews have suggested that the validity of NDDs as a construct is supported by the high rates of comorbidity between various disorders within the diagnostic grouping (Morris-Rosendahl & Crocq, 2020). For example, a systematic review by Lai et al (2019) reported the pooled prevalence estimate of ADHD in people with autism was 28%. O'Nions et al (2023) found that 18.36% of people with ID had autism. Elsewhere, Gnanavel et al (2019) found comorbidity rates of ADHD with ASD was 42%, ADHD with ID was 17%, ADHD with learning disorders was 10%-92% and ADHD with Tourette's syndrome was 55%.

**Gambling and neurodevelopmental disorders**

The presence of mental disorders increases the risk of gambling problems (Hartman and Blaszczynski,2016). People with NDD or neurodiversity are also more susceptible to mental disorders compared to the neurotypical population. For example, individuals with ID are four times more at risk of other mental health disorders compared to the general population (Hughes-McCormack et al., 2017). People with ADHD are at greater risk of mood and personality disorders (Katzman et al., 2017). Therefore, the underlying vulnerabilities associated with NDD poses increased risk of GD and severity of GRH in this population.

Commonalities exist in the underlying cognitive, behavioural, biological and neurochemical pathways affected in people with NDD and GD; in particular, deficits in striatal function, dopaminergic pathways, fronto-striatal circuitry and impulsivity traits. Poole et al., (2017) also describe shared psychosocial risk factors such as increased rates of adverse childhood experiences.

Neurobiological studies have demonstrated impairments of impulse control and executive functions in pathological gamblers and people with ADHD (Grant et al,2016). Deficits in aspects of inhibition, working memory, planning, cognitive flexibility, and time management/estimation have been reported in individuals with GD as well as ASD and ADHD (Grant et al,2016). Impulsivity, compulsivity, and ritualistic behaviours such as "lucky numbers" or "lucky" accessories may feature in GD, ADHD, and ASD (Grant et al,2016). Social cognitive deficits (e.g., in emotion recognition, theory of mind) and non-social cognitive deficits (e.g., in attention, learning and memory, processing speed, reasoning and problem solving) are prominent in ASD. Although in the literature and clinical settings, there is often greater focus on social cognitive deficits. However, non-social cognitive impairments in processing speed for example, are more prevalent in people with ASD compared to those without (Velikonja et al.,2019). Such underlying non-social cognitive deficits may increase the risk of GD or GRH, which may influence the course and severity of GD.

There is an established association between ADHD and addiction (Carpentier et al.,2011; van Emmerik-van Oortmerssen et al., 2012; Vogel et al., 2016). However, the data and consensus on comorbidity rates for GD specifically from published studies is limited. Early studies suggest ADHD during childhood is a potential risk factor for the development of GD in adulthood (van Emmerik-van Oortmerssen et al., 2012; Carlton & Manowitz,1992; Carlton et al.,1987; Specker et al., 1995). A review and meta-analysis by Theule et al (2019) found a weighted mean correlation between ADHD symptomology and gambling severity of $r$ = .17, 95%, confidence interval (CI) = [0.12, 0.22], $p < .001$.

There have been few studies in relation to other NDDs and GD. This is compounded by some studies specifying presence of ID or learning disorder as part of exclusion criteria (Grall Bronnec et al., 2011; Dai et al., 2016). People with ID may have difficulties in assessing risk, potential harms, and consequences of gambling. In a series of interviews with social care stakeholders, Bramley et al (2019) heard of several examples of individuals with ID who were permitted to gamble excessively without supervision or intervention. Similarly, people with learning disorders experiencing deficits in numeracy and literacy may be at greater risk of GRH due to underlying cognitive biases or deficits in understanding mathematical probabilities and odds.

A key aim of the UK Gambling Act 2005 includes protecting the vulnerable from harm, which implies a responsibility on the regulator – The Gambling Commission. The latter notes that an impairment of decision-

making capacity may be a vulnerability factor. The way in which current gambling safety awareness messages are portrayed does not appropriately consider people with NDDs or neurodiversity as these are often in small print, with no easy read or visual alternatives. In the same year that the Gambling Act was passed, the landmark Mental Capacity Act (2005) emerged, which has clear frameworks for assessing decision-making capacity and best interests' decisions on behalf of those who lack capacity to make specific decisions. It is notable that to date, there is no data or research on gambling and mental capacity.

There are significant concerns around the potential for increased GRH in people with NDD and the adequacy of knowledge, regulation, and appropriate interventions in this area. This highlights an important gap in research and governance. We therefore aimed to review the literature on gambling and NDD to provide useful information to clinicians and regulators and inform public health policy around GD.

### Aims

Given the relationships between NDD and gambling risk, we sought to identify the prevalence of GD in individuals with NDD, and of NDD in individuals with GD. Additionally, we aimed to examine risk factors associated with NDDs for GD and to identify specific factors that may mediate or moderate the relationship between NDDs and GD.

## Methods

The protocol of this systematic review was developed in accordance with PRISMA guidelines (Moher et al., 2009) and registered on PROSPERO (International Prospective Register of Systematic Reviews) on 30th November 2021 (Reference No CRD42021295190). The search strategy and selection criteria are included in supplementary material (Appendices 1 and 2).

Two members of the study team independently screened articles by abstract and title based on the criteria specified below. Papers identified after screening were independently read by the same two reviewers and included or excluded based on agreed criteria. Disagreements regarding the inclusion of papers were resolved through discussion. The inter-rater agreement across the two reviewers after discussion was 100%.

### Inclusion criteria

Participants at the time of the study had an NDD or childhood diagnosis of NDD, as well as current or prior experience of disordered gambling or at-risk gambling. This review aimed to synthesise and analyse already published studies relating to our research questions, therefore written informed consent from participants was not obtained.

The full inclusion and exclusion criteria are listed in the supplementary material. The review included studies reporting on NDD and GD. An inclusive approach to the definition and measurement of GD and

NDD was adopted, i.e., studies utilising self-reported, clinically diagnosed, validated and non-validated diagnostic measures were included. The review included studies conducted worldwide, involving participants of all ages. Study populations included general population and clinical samples receiving treatment for gambling problems or psychiatric comorbidities.
We included experimental studies, randomised and non-randomised control trials, cohort studies and case series reports. Including a diverse range of study designs enabled us to address all outlined aims for this review, including comorbidity prevalence and risk factors.

**Data Analysis**

Data was extracted on study and population characteristics, design and aim of study, assessments of NDD and GD and summary estimates of prevalence and comorbidity. Where reported, odds ratios were included. The absence of odds ratios or sufficient data regarding comorbidity and significant heterogeneity in populations, methods and measures across the studies meant that meta-analysis was not feasible for this review.
Risk of bias was determined for each study using the Joanna Briggs Critical Appraisal Checklist (Appendix Table 3) (Moola et al,2020). As part of our risk of bias assessment, we also reviewed whether authors reported any industry funding or conflicts of interest as this is increasingly recognised as important, especially in relation to gambling (Batra,2018).

## Results

The search identified 873 studies (see Figure 1 for PRISMA flow chart). After screening of titles and abstracts, 80 potentially relevant full-text articles were identified, of which 57 met inclusion criteria.

Studies were mostly from high-income countries with significant contribution from USA (n=14), and Canada (n=11). In total, 56160 subjects were represented across the studies. Details of all 57 studies can be found in Table 1 (supplementary material).

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 1 | Abouzari et al 2016<br><br>Cohort study | 20 participants; 5 ADHD gamblers, 5 ADHD non-gamblers,<br><br>10 healthy controls<br><br>Alberta, Canada<br><br>Mean age 28.6<br><br>Gender not reported | Aimed to compare brain electrical responses in reward learning between gamblers with ADHD and gamblers without ADHD.<br><br>EEG recorded whilst engaged in a gambling task. | ADHD confirmed by the Conners' ADHD scale as well as the ASRS<br><br>self reported<br><br>50% had ADHD | 50% gamblers<br><br>DSM-IV criteria<br><br>CPGI<br><br>NODS | 25% | Very small numbers in the study<br><br>The two main groups (ADHD gamblers and ADHD non gamblers) were not significantly different in age, sex and NIDA−modified ASSIST score. There were no significant differences between the two main groups and control group with demographic data. |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
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| 2 | Aymami et al, 2015<br><br>Cohort Study | 354 participants<br><br>Barcelona, Spain<br><br>Mean age 42.2 years<br><br>89.5% male, 10.5% female | To assess prevalence of ADHD symptoms in treatment seeking gambling disordered patients and exploration of clinical and sociodemographic differences between patients who scored high and low on the ADHD measure, psychopathology, and personality traits | Short screener version of ASRS for ADHD. Self reported<br><br>23.2% of the sample had "high" ADHD score | 100% gambling for mean of 5.4 years<br><br>SOGS<br><br>Stinchfield's Diagnostic Questionnaire for Pathological Gambling according to DSM-IV criteria | 23.2% | Prevalence of ADHD symptoms in a consecutive clinical sample of treatment-seeking GD individuals was 23.2%. |
| 3 | Brandt & Fischer, 2019<br><br>Cross sectional study | 80 participants<br><br>Vienna, Austria<br><br>21-70 years<br><br>16 female | (a) To review retrospective childhood and adult ADHD symptomatology in treatment-seeking gamblers,<br><br>(b) Understand characteristics of the association between pathological gambling (PG) and ADHD, | WURS and ASRS<br><br>Self reported<br><br>42.5% screened positive for childhood ADHD, 11.3% persisted into adulthood | 100% - all study participants had to meet at least 3 of the DSM IV criteria for PG.<br><br>Most patients were classified as severe pathological gamblers (56.3% met ≥8 DSM IV criteria.)<br><br>DSM IV criteria for PG | 42.5% of the cohort screened positive for childhood ADHD, 11.3% persisted into adulthood | Childhood and adult ADHD were assessed via screening instruments. These can only serve as pointers for the presence of ADHD and do not substitute clinical diagnosis by an expert. Also, self-reporting of retrospective childhood ADHD (WURS-k) may have reduced the validity of results. Small sample size, significance thresholds not corrected for multiple comparisons<br><br>Patients with ADHD had more severe gambling problems and a higher number of psychiatric comorbidities compared to those without ADHD |

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| | | | (c) Identifying risk factors for a history of ADHD | | Attitudes and Beliefs survey | | |
| 4 | Breyer et al, 2009<br><br>Longitudinal study of ADHD beginning in 1991 | 235 participants;<br><br>142 with ADHD, 93 controls<br><br>Minnesota, USA<br><br>Average age 20.2 years. Range 18-24 years | To examine the association of gambling behaviours among young adults with their longitudinal history of ADHD | Childhood diagnosis of ADHD obtained using revised parent version of Diagnostic Interview for Children and Adolescents (DICA-R)<br><br>Interview<br><br>60.4% had ADHD | Possible problem gamblers (PPGs) = 8% (n=19),<br><br>social gamblers= 70% (n=165),<br><br>non-gamblers = 22% (n=51)<br><br>SOGS-Revised for Adolescents | 19% of those with ADHD were PPG | Over half of the sample had childhood ADHD but not as adults<br><br>19% of those with current ADHD met criteria for possible problem gambling, vs 5% of controls<br><br>79% of those with current ADHD reported gambling in the past year<br><br>80% of the control group reported gambling past year activity |

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| | | Male = 76%<br><br>Female= 24% | | | | | Individuals who report childhood ADHD symptoms which persist into young adulthood experience greater gambling problem severity than participants with no ADHD or those with non-persistent ADHD<br><br>Significant differences were found for high school graduation status- the control group had a higher percentage of high school graduates, followed by the ADHD desisters and ADHD persisters, respectively (P<05). |
| 5 | Black et al, 2013<br><br>Case control study | 119 participants<br><br>Iowa, USA<br><br>>=18 years, mean age was 45.3 years<br><br>65% of PG = female | To understand how neuropsychological performance, trait impulsivity, Cloninger's personality characteristics, and symptoms of ADHD interrelate in problem gambling | ADHD rating scale<br><br>self reported<br><br>Weschler Abbreviated Scale of Intelligence to assess overall intellectual functioning<br><br>Wide Range achievement test-3 to assess reading skills and estimate | 45% problem gamblers (n=54)<br><br>DSM IV criteria for PG<br><br>NODS<br><br>score >=5 on SOGS<br><br>GSAS | 9% | Subjects with PG were found to have higher levels of depression (BDI) (p<0.001), ADHD symptoms (p 0.001) and lower IQ compared to controls (WASI full scale IQ) (p 0.003)<br><br>PGs more likely than controls to have co-occurring lifetime psychiatric disorders |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
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| | | 35% of PG = male<br><br>58% of controls = female<br><br>42% of controls= male | | premorbid level of cognitive function<br><br>5.4% of total sample had ADHD | | | |
| 6 | Black et al, 2015<br><br>Cohort study | 255 participants<br><br>Iowa, USA<br><br>>18 years<br><br>56% female,<br><br>44% male | To review age at onset of pathological gambling and compare demographic and clinical characteristic between early vs late onset | ADHD assessed using a module from the Mini International Neuropsychiatric Interview (MINI)<br><br>interview<br><br>15% ADHD | 100% of the sample had PG<br><br>DSM IV criteria for PG<br><br>SOGS<br><br>NODS | 15% | Significant predictors of early-onset PG include age, male gender (OR=4.46, P<0.001), a lifetime substance use disorder (OR=2.58, P=0.039), and lifetime ADHD (OR=5.13, P=0.006)<br><br>Early-onset PG was also associated with greater trait impulsiveness (P=0.031); lifetime substance use disorders (P<0.001), ADHD (P<0.001), antisocial personality disorder (P=0.009), and social anxiety disorder (P=0.032 |

| | **Authors & date of publication**<br><br>**Study type** | **Sample size (n)**<br><br>**Country & Region** | **Aim of study** | **NDD Diagnosis**<br><br>**Measure used- if any**<br><br>**Self reported or interview**<br><br>**Proportion reporting NDD (%)** | **Proportion reporting gambling (%)**<br><br>**Measure of gambling** | **NDD and gambling comorbidity** | **Key findings** |
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| 7 | Black et al 2017<br><br>Prospective follow up study | 175 participants<br><br>Iowa, USA<br><br>March 2011 to Dec 2015<br><br>>18 years<br><br>43% female<br><br>57% male | To measure how problem gambling changes with age and over time, with a hypothesis that elders with PG would show greater improvement than younger PGs | ADHD assessed using a module from the MINI (mini-international neuropsychiatric interview)<br><br>interview<br><br>Not reported | 71% pathological gambling.<br><br>(n=125)<br><br>DSM IV criteria for PG<br><br>SOGS<br><br>NODS scores >=5 | Not reported | Several lifetime disorders were more common among younger than older PGs including drug use disorders (42% vs. 6%), obsessive-compulsive disorder (17% vs. 4%), and **attention deficit/hyperactivity disorder (24% vs. 8%).** |
| 8 | Canu & Schatz, 2011<br><br>Cohort study | 224 participants<br><br>North Carolina, USA | To find whether there is an association between ADHD traits and gambling | Conners Adult ADHD rating scale (CAARS), WURS for ADHD<br><br>self reported | Not reported<br><br>SOGS | Not reported | An association between impulsivity and gambling was found only in males. Hyperactivity and inattention were unrelated to gambling. |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
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| | | Average age 20.3 years, all were 18 or over<br><br>71% male, 29% female | | 18.8% had self reported ADHD traits that exceeded the accepted criteria for clinical concern (n= 42) | | | Statistically significant gender differences noted in the following variables:<br><br>CAARS Inattention (IA)- p<0.001<br><br>CAARS Hyperactivity-Impulsivity (HI) - p 0.037<br><br>CAARS Impulsivity (Imp)- p 0.046<br><br>SOGS- p 0.004 |
| 9 | Chamberlain et al, 2015<br><br>Case control study | 126 participants<br><br>Cambridge, UK<br><br>18-29 years<br><br>62.7% male, 37.3% female | To review the impact of ADHD symptoms on clinical and cognitive aspects of problem gambling | ASRS to screen for current ADHD symptoms- score of >=4 indicated “probable ADHD.”<br><br>self reported<br><br>“probable current ADHD” in 21.4%<br><br>(n=27) | 100% had problem gambling and were non-treatment seeking<br><br>Modified structural clinical interview for gambling disorder (SCI-GD)- problem gambling defined as a score of >=1 on SCI-GD | “probable current ADHD” in 21.4% | Probable current ADHD associated with earlier age at onset of gambling behaviours.<br><br>Problem gamblers with and without ADHD did not differ on demographic characteristics or the rate of other psychiatric disorders, depression scores, nicotine and alcohol consumption, and body mass index |

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| | | | | | | | |
| 10 | Clark et al , 2013<br><br>Cohort study | 6145 participants<br><br>USA<br><br>Average age 21.7 years<br><br>48.3% male<br><br>51.7% females | To find the extent to which retrospectively reported ADHD symptoms are associated with gambling behaviour in young adults | As part of the survey, participants were asked retrospective questions reflecting DSM-IV ADHD criteria, although no official clinical diagnosis identified<br><br>25.8% of the sample endorsed symptoms of ADHD | 62.9% of participants reported gambling 'at some point' in their lifetime<br><br>Participants asked 8 questions which "loosely parallel some items" from DSM-IV-TR and SOGS, but not specific DSM or SOGS questions | Not reported | Self-reported Combined type ADHD symptoms proved insignificant in predicting future gambling behaviours. However, Hyperactive-Impulsive type symptoms were statistically significant predictors of gambling behaviour, with a coefficient of 0.0169.<br><br>Individuals who identify themselves with Inattentive type ADHD symptoms were less likely than the rest of the sample to identify with gambling behaviours |

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| | | | | | | | |
| 11 | Dai et al, 2016<br><br>Case control study | 60 participants;<br><br>Canterbury<br><br>New Zealand<br><br>Age range 17.3-64.3 years<br><br>52% Female<br><br>48% Male | To investigate the relationship between impulsivity and gambling-related cognitions and behaviour in adults with and without ADHD | Conners' adult ADHD diagnostic interview for DSM IV (CAADID)<br><br>CAARS<br><br>self reported<br><br>48.3% ADHD (n=29) | 9.6% of ADHD participants probable pathological gambling in a lifetime<br><br>(n=3)<br><br>GRCS self report<br><br>SOGS | 9.6% of ADHD participants probable pathological gambling in a lifetime (i.e. SOGS>5) (n=3) | None of the controls had gambling disorder<br><br>The ADHD group was more likely to meet criteria for problem gambling and was more impulsive than controls.<br><br>35.5% of the ADHD group reported having no lifetime problems with gambling (SOGS = 0), which was significantly less than the control group (76.9%), $p<0.05$ |

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| | | | | | | | |
| 12 | Dannon et al, 2006<br><br>Cross sectional | 52 participants with pathological gambling, 93 first degree relatives of this patient group.<br>96 matched normal controls<br><br>Rehovot, Israel<br><br>21-67 years<br><br>100% male | To present comorbid psychiatric diagnoses seen in those with problem gambling and their first degree relatives | ADHD semi-structured clinical interview<br><br>5.8% had ADHD | 100% of the 52 patients were diagnosed of pathological gambling<br><br>DSM IV criteria<br><br>SOGS | 5.8% | There were significantly higher rates of comorbid mood disorders, substance abuse, obsessive compulsive spectrum disorders.<br><br>Results may be influenced by bias as patients were selected from an ambulatory psychiatric care setting with most of them initially presenting with a comorbid psychiatric condition. |

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| 13 | Davtian et al, 2012<br><br>Case control study | 95 participants;<br><br>Los Angeles, California, USA<br><br>>=18 years<br><br>73% male<br><br>27% female | To explore facets of personality in pathological gamblers (PG) with and without ADHD | ASRS for ADHD<br><br>self reported<br><br>57 % ADHD (n = 52) | 100% pathological gamblers<br><br>NODS | 57%<br><br>(n = 52) | Scores on both the ASRS and the NODS differed significantly between ADHD PGs and non-ADHD PGs. Although the effect sizes were large for symptoms of ADHD on the ASRS, differences between gambling symptoms as measured by the NODS yielded small effect sizes, suggesting the groups were comparable on their respective level of gambling severity.<br><br>Several facets reflecting Neuroticism were significantly higher among ADHD PGs, suggesting a greater tendency to experience negative emotions such as anxiety, worry, depression, sadness and loneliness compared with non-ADHD PGs. The ADHD gamblers also experienced greater levels of social discomfort, interpersonal sensitivity, feelings of inferiority and stress proneness.<br><br>The sample size failed to allow for analysis based on gender difference |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
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| 14 | Dowling et al 2015<br><br>Systematic review and metaanalysis | 36 studies; sample sizes ranged from 14-592 across the studies<br><br>Melbourne, Australia<br><br>Only adults (range= 33.2-64.9 years) (studies with adolescent samples were excluded from the review)<br><br>Proportion of males in the samples ranged from 42-100% | To systematically review and metaanalyse the prevalence of co-morbid psychiatric disorders (DSM-IV Axis I disorders) among treatment-seeking problem gamblers | ADHD measured by clinical diagnosis, ASRS, MINI<br><br>self reported and interviews | Most samples restricted to pathological gamblers only (77.8%) measured via diagnostic criteria in 69.4%.<br><br>Less commonly reported data were on problem gambling activity (47.2% mixed, 2.8% electronic gaming machines only, 50% not reported)<br><br>Variety across the studies in screening tools used including clinician administered interviews and self report questionnaires; DSM IV criteria, SOGS, NODS, PGSI, VGS, SCI-PG, DIS, DQ-PG.<br><br>Included studies which reported gambling severity as problem or pathological | 9.3% | High variability across the studies eg. type of treatment facility (outpatient vs residential treatment services), jurisdiction in which the study was conducted eg US compared to treatment services in Europe<br><br>Included risk of bias assessment<br><br>**88.9% of studies comorbidity measures were clinician administered interviews, with 11.1% of studies using self-report measures.**<br><br>compliant with PRISMA and MOOSE<br><br>Non electronic and Electronic databases searched (Jan 1990 to Aug 2011), only included peer-reviewed<br><br>published studies |

| | **Authors & date of publication**<br><br>**Study type** | **Sample size (n)**<br><br>**Country & Region** | **Aim of study** | **NDD Diagnosis**<br><br>**Measure used- if any**<br><br>**Self reported or interview**<br><br>**Proportion reporting NDD (%)** | **Proportion reporting gambling (%)**<br><br>**Measure of gambling** | **NDD and gambling comorbidity** | **Key findings** |
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| 15 | El Archi et al 2023<br><br>Cross sectional study | 65<br><br>France<br><br>Mean age 38.4<br><br>66%male | Aimed to investigate ADHD in adult outpatients seeking treatment for a behavioral addiction and to identify the specificity of psychopathological features if the behavioral addiction co-occurs with adult ADHD. | DIVA-5 for ADHD<br><br>40% significant childhood ADHD.<br>88% of those = persistence to adulthood | 4.16% of those with ADHD also had GD, (compared to 7.59% of those without ADHD)<br><br>CPGI | 4.16% | Lower rate of gambling disorder in those with ADHD than those without |

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| 16 | Faregh & Derevensky, 2011<br><br>Cross sectional study | 1130 participants,<br><br>Montreal, Canada<br><br>Age 12-19 years<br><br>50.4% female<br><br>49.6% male | To examine ADHD key symptoms, and gambling behaviours and problem severity among adolescents | Conners-Wells' Adolescent Self Report Scale for ADHD<br><br>29.4% of the sample screened positive for ADHD | 70.4% social gamblers<br><br>19.3% non-gamblers, 7.2% at risk gamblers 3% probable pathological gamblers<br><br>Gambling activities questionnaire (GAQ)<br><br>DSM-IV-MR-J adapted for adolescents from DSM IV criteria for adult pathological gambling | 17.4% | Among at risk and probable pathological gamblers (PPGs), proportion of ADHD and non-ADHD's did not differ significantly (50.9% vs 49.1%)<br><br>Among individuals with ADHD, 17.4% also had gambling problems, whereas only 7% of non-ADHDs had gambling problems |

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| 17 | Fatseas et al, 2016<br><br>Cohort study | 217 participants<br><br>Bordeaux, France<br><br>18-65 years<br><br>Mean age 37.7 years<br><br>66.4% male, 33.6% female | To examine addiction severity in patients with co-occurring addictive disorders and ADHD, controlling for the influence of any psychiatric comorbidity | ADHD: Conners Adult ADHD Diagnostic Interview for DSM IV (CAADID)<br><br>Prevalence of lifetime ADHD 23%<br><br>12% of the participants had only childhood ADHD<br><br>11.1% had ADHD which persisted into adulthood | 6.5% met criteria for current pathological gambling disorder<br><br>DSM IV pathological gambling criteria | Not reported | History of ADHD was associated with an earlier onset of addiction, poly-dependence and borderline personality disorder<br><br>Highly prevalent psychiatric comorbidity in the sample:<br>- 40.7% current mood disorder<br>- 47.2% anxiety disorder<br>- 11.1% antisocial personality disorder<br>- 18% borderline personality disorder |

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| 18 | Fatseas et al, 2016<br><br>Cohort study | 599 participants<br><br>Bordeaux, France<br><br>18-65 years<br><br>Mean age 43.4 years<br><br>66.6% male,<br><br>33.4% female | To examine whether ADHD is associated with specific severity patterns in terms of gambling behaviour, psychopathology, and personality traits | ADHD; WURS,<br><br>ASRS<br><br>self reported<br><br>20.7% of the gamblers screened positive for lifetime or current ADHD<br><br>11.5% screened for childhood ADHD only and 9.2% for both childhood and adult ADHD | 100% of the sample were gamblers, however only 59.2% met criteria for problem gambling<br><br>SOGS<br><br>Problem gamblers threshold set at >=3 DSM IV criteria for this study<br><br>GABS | 28.2% of those with problem gambling had history of ADHD | Among problem gamblers, those with ADHD were more likely to be unemployed, younger, start gambling at an earlier age, have greater gambling severity profile (higher number of DSM IV criteria, SOGS score, frequency of gambling) They also displayed a higher number of psychiatric comorbidities, especially mood and anxiety disorders and antisocial personality disorder (mood disorder $p<0.0001$; anxiety disorder $p<0.0001$; psychotic disorder p 0.0008; antisocial personality disorder p 0.001) |

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| 19 | Grall-Bronnec et al, 2011<br><br>Cross sectional study | 84 participants<br><br>Nantes, France<br><br>19-74 years<br><br>85.7% male<br>14.3% female | To examine the frequency of pathological and at-risk gamblers having a previous history of ADHD and identify risk factors for a history of ADHD | WURS-C- validated for retrospective evaluation in adults of ADHD in childhood (>46/100 used as cut off score for diagnosis)<br><br>ASRS<br><br>self reported<br><br>15.8% had ADHD characteristics only in childhood, 10.5% had ADHD characteristics “probably persisting” into adulthood | 100% of the sample was either at risk or pathological gamblers<br><br>Mini screening test based on the 10 diagnostic criteria in DSM IV<br><br>GABS- self rated questionnaire | 10.5% had ADHD characteristics “probably persisting” into adulthood | Study was not able to obtain all self questionnaires from the subjects<br><br>Factors independently associated with a history of ADHD included:<br><br>-Anxiety disorders (current or past) odds ratio 4.08 (p value 0.0294)<br><br>-Urgency: odds ratio 1.20 (p value 0.0016)<br><br>Those with ADHD had more severe gambling problems and a higher frequency of psychiatric comorbidities and an increased risk of suicide. |

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| 20 | Grant and Chamberlain, 2021<br><br>Exploratory study | 102 participants<br><br>Chicago, USA<br><br>18-29 years<br><br>59.8% male, 40.2% female | To examine the clinical characteristics and facets of cognition in young adults who gamble and have autistic traits | Brief Autism Quotient (AQ10) to screen for autistic traits<br><br>ASRS v1.1- screen for ADHD symptoms<br><br>self reported<br><br>Those with likely autistic traits (i.e. scoring >6 on AQ10) = 7.1% of the sample.<br><br>No reported figures for proportion reporting ADHD in the sample | 100% Non-treatment seeking and must have gambled at least 5 times in the last year in order to be included in the study<br><br>8.8% had gambling disorder<br><br>SCI-GD<br><br>PG-YBOCS | 7.1% with likely autistic traits | Autistic traits were correlated with disordered gambling symptoms, attention-deficit/hyperactivity disorder (ADHD) symptoms, trait impulsivity, and some types of obsessive–compulsive symptoms<br><br>the link between autistic traits and disordered gambling symptoms was robust even controlling for ADHD.<br><br>AQ10 scores correlated significantly with worse quality of life, p 0.004.<br><br>AQ10 total scores were significantly correlated with ADHD total scores, p 0.048. |

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| 21 | Gupta et al, 2013<br><br>Cohort study | 1133 participants<br><br>Montreal, Canada<br><br>13-18 years<br><br>Of the 109 gamblers, there were 78 males and 31 females | To test the applicability of the Integrated Pathways Model for gambling to adolescent problem gamblers | Conners-Wells' Adolescent Self Report Scale for ADHD<br><br>Not reported | 9.6% problem gamblers<br><br>6.9% at risk gamblers,<br><br>2.7% probable pathological gamblers<br><br>GAQ<br><br>DSM IV Multiple Response Juvenile (MR-J) | Not reported | Females were more likely to be non-gamblers, and males are more likely to be experiencing gambling-related problems. These gender differences were statistically significantly p<.001 |

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| 22 | Hardoon et al 2002<br><br>Cross sectional study | 2336 participants<br><br>Ontario, Canada<br><br>11-19 years<br><br>981 males<br><br>1326 females<br><br>Gender not reported for 29 participants | To examine the relationship between several risk and protective variables associated with adolescent gambling. | 10% reported having "learning disability or learning problem"<br><br>19% met criteria for ADHD<br><br>ADHD Index<br><br>Conners-Wells' Adolescent Self-Report Scale: Long Version (CASS:L)<br><br>Academic questions posed to participants relating to performance at school, ability to learn and whether they had a diagnosis of learning disability | 4.9% probable pathological gamblers<br><br>GAQ<br><br>DSM IV MR-J | 22.3% of probable pathological gamblers had a diagnosis of intellectual disability<br><br>49.6% of probable pathological gamblers had scores in the clinical range on the ADHD Index subscale | A significantly greater percentage of probable pathological gamblers reported having been diagnosed with a learning disability (22.3%), and classified themselves as slow learners (16.8%) compared to non-gamblers (9.4%)<br><br>Probable pathological gamblers (29.2%) reported more clinical symptoms related to hyperactivity compared to at-risk (18.8%), social (13.3%), and non-gamblers (13.3%). More probable pathological gamblers (49.6%) had scores in the clinical range on the ADHD Index subscale than at-risk (31.7%), social (18.2%) and non-gamblers (12.7%)<br><br>This study exclusively used self report data and did not obtain corroboration |

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| 23 | Hellstrom et al, 2017<br><br>Cohort study | 4440 participants<br><br>Vasteras, Sweden<br><br>15-18 years<br><br>49.2% male<br><br>50.8% female | To investigate the association between gambling frequency, ADHD symptoms and problem gambling | ASRS first 6 questions as a short screening<br><br>self reported<br><br>18.8% ADHD | 31.8% gamblers (n=1412).<br><br>Of the 31.8%, 86.5% were either no/low risk of problem gambling (PG) (n= 1222), 8.3% moderate risk of PG (n= 117), 5.2% high risk of PG (n= 73))<br><br>Gambling frequency questions included in the survey.<br><br>Participants identified as gamblers completed the PGSI | Not reported | Adolescents with ADHD symptoms may be more sensitive to gambling in terms of being susceptible to developing gambling related problems. 10% of adolescents gambled online and offline poker.<br><br>Higher prevalence of ADHD among girls in the sample; 20.8% (compared to 16.8% in boys)<br><br>Gambling under 18 years old is illegal in Sweden, therefore may explain why few adolescents in the sample reported gambling problems<br><br>Risk of information bias due to all analyses being based on self reports<br><br>A significant interaction effect was revealed between sex and gambling frequency in relation to gambling problems ($p < 0.001$) i.e. sex may be an influencing factor for gambling frequency |

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| 24 | Jacob et al, 2018<br><br>Cross sectional study | 7403 participants<br><br>Leicester, UK<br><br>>=16 years<br><br>48.6% male<br>51.4% female | To examine the association between ADHD symptoms and gambling problems and to identify any potential mediating factors of this association. | ASRS screener (i.e. 6 items of the full ASRS 18 item scale) for ADHD<br><br>self reported<br><br>ADHD sample prevalence unclear | Overall sample prevalence unclear.<br><br>Questionnaire based on the 10 DSM IV criteria for pathological gambling | Problem gambling 2.4% in those with ADHD | The prevalence of at-risk (5.3% vs. 2.4%) and problem gambling (2.4% vs. 0.6%) was higher in individuals with ADHD than in those without ADHD<br><br>ADHD symptoms were significantly associated with both at-risk (OR=2.15;95% CI=1.22–3.79) and problem gambling (OR=3.57; 95% CI=1.53–8.31) when adjusted for age, sex, and ethnicity. |

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| 25 | Jaisoorya et al, 2016<br><br>Cross sectional epidemiological survey | 4989 participants<br><br>Kerala, India<br><br>15-19 years<br><br>50.8% male, 29.2% female | To examine the point prevalence of gambling and its psychosocial correlated among high school students in Kerala, India. Participants divided into 3 groups; non-gamblers, non-problem gamblers, problem gamblers. | Barkley Adult ADHD rating scale IV (BAARS-IV) to retrospectively self report ADHD symptoms between age 5-12 years<br><br>ADHD prevalence not reported | 7.1% problem gamblers<br><br>NODS-CLip | Not reported*<br><br>* In this study, they compared ADHD total scores between the groups, as a diagnosis of ADHD could not be made due to corroborative information from other sources being unavailable | There were statistically significant differences between the 3 different groups; non gamblers; non-problem gamblers; problem gamblers in the following areas with p value <0.0001 for each of the following (where problem gamblers had greater prevalence of):<br>- Failed in a year of school<br>- Lifetime alcohol use<br>- Psychological distress score<br>- Suicidal thoughts<br>- Suicide attempt<br>- Non-contact sexual abuse<br>- Contact sexual abuse<br>- ADHD symptom score<br><br>There was a greater proportion of males in the problem gambling group compared to the non-gambling and non-problem gambling group (p <0.001) |

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| 26 | Karaca et al, 2017<br><br>Systematic review | 14 studies included, published prior to December 2015<br><br>Antalya, Turkey<br><br>Adults >=18 years in 4 of the studies, 1 study did not report age<br><br>2 studies included only males | To examine prevalence of comorbid ADHD and behavioural addictions including gambling, food/binge-eating, sex/hypersexuality.<br><br>Followed MOOSE guidelines | MINI and CIDI to assess for ADHD<br><br>5 studies reporting ADHD and gambling disorder | The studies used structured interview, DSM IV criteria, CIDI and NODS for assessing gambling disorder | The prevalence of ADHD in gambling disorder ranged from 5.8% to 20% across the 5 studies included in this systematic review | 4 of the 5 studies on ADHD and gambling used participants with pathological gambling and the remaining study included participants from a US household population. |

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| 27 | Kerber et al,<br><br>2008<br><br>Cohort study | 40 participants<br><br>Illinois,<br><br>USA<br><br>55-83 years<br><br>62.5% male, 37.5% female | To examine rates of comorbid psychiatric disorders in older adults with lifetime pathological gambling using structured assessments | MINI to assess for ADHD<br><br>7.5% had ADHD | 100%<br><br>(Participants had moderate to severe gambling disorder)<br><br>NODS<br><br>SOGS | 7.5%<br><br>(n=3) | Small number of participants who had comorbid ADHD and GD (n=3)<br><br>82.5% of the participants suffered from a mood disorder. 47.5% suffered from an anxiety disorder. 60% had a personality disorder |

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| 28 | Kessler et al, 2008<br><br>Cross sectional study | 3435 participants<br><br>Boston, USA<br><br>>= 18 years old<br><br>Gender not reported | To examine lifetime gambling symptoms and pathological gambling (PG) and other DSM-IV disorders | CIDI to look at ADHD symptoms in childhood<br><br>retrospectively self-reported<br><br>ADHD prevalence not reported | Prevalence estimate of problem gambling = 2.3%<br><br>Prevalence estimate of pathological gambling = 0.6%<br><br>CIDI | 13.4% of pathological gamblers had ADHD | A dose–response relationship exists between the number of times gambled and the probability of problem gambling.<br><br>Prevalence of ADHD in pathological gambling was 13.4% (OR 1.8, 95%CI 0.4-7.3) |
| 29 | Mak et ak,2018<br><br>Cross sectional study | 65 participants<br><br>Singapore<br><br>Mean age 36<br><br>98.5% male | The primary objective was to observe the rate of patients screening positive for ADHD. | The Adult ADHD Self-Report Scale (ASRS-v1.1)<br><br>20% “likely” ADHD<br><br>(n=13) | 100%<br><br>10-item checklist based on the 10 diagnostic criteria of the DSM-IV for pathological gambling | Patients with ‘Likely ADHD’ status had a lower mean score of Pathological Gambling criteria | Patients with the ‘Likely ADHD’ status tended to have lower levels of gambling-related cognitions, which may indicate that the gambling behaviour in patients with ADHD-Pathological Gambling comorbidity is driven by impulsivity, rather than distorted gambling-related cognitions. |

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| | | | | | | (7.1) compared to patients with the 'Not likely ADHD' status (7.3). | |
| 30 | Martins et al, 2007.<br><br>Prospective longitudinal | 232<br><br>Baltimore<br><br>USA<br><br>Mean age= 17<br><br>100% female | To explore differences in mental health and behavioral disturbances between female gamblers versus non gamblers from a community sample of female urban youth. | Previous parental rating of childhood hyperactivity<br><br>High hyperactivity 32%<br><br>(n=74)<br><br>High impulsivity<br><br>35%<br><br>(n=81) | 5.9% = past year gambling<br><br>(n=14)<br><br>SOGS RA | High hyperactivity (32%) in<br><br>Gamblers compared to non-gamblers OR 2.23 (1.03-4.82)<br><br>High impulsivity<br><br>(35%) in<br><br>Gamblers compared to non-gamblers | In urban samples of youth, females with high levels of childhood hyperactivity are more likely to gamble in adolescence |

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| | | | | | | OR1.03 (0.48-2.22) | |
| 31 | Martins et al, 2008,<br><br>Prospective, longitudinal | 452.<br><br>Baltimore, USA<br><br>All 17 years<br><br>54% male (n=244) | To explore gender differences in lifetime and recent substance use/internalizing behaviour, childhood externalizing behaviour, and gambling preferences among African American youth gamblers | Parent observation of child adaptation (POCA)<br><br>Impulsivity and Hyperactivity | Past year gambling problems among male and female gamblers was 23.2% (n=32, 20 at-riskgamblers and 12 problem gamblers) and 6.6% (n=5, 4 at-risk gamblers and 1 problem gambler), respectively.<br><br>SOGS RA | Gamblers more likely than non gamblers to have high childhood hyperactivity OR 2.67 (1.23–5.78)<br><br>and high childhood impulsivity.<br><br>OR 2.39 (1.27–4.50) | Male and female gamblers had been rated by parents as having had high levels of childhood impulsivity and hyperactivity. No formal diagnosis of ADHD given to participants |

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| 32 | Mcdonald et al 2021<br><br>Cross sectional study | 3817,Ontario, Canada<br><br>18 years +<br><br>52.5% female | To examine whether adult ADHD symptoms are associated with psychological distress, hazardous drinking, and problem gambling, after controlling for traumatic brain injury and sociodemographic characteristics. | ASRS<br><br>ADHD 6.9%<br><br>(n=263) | 1.6%<br><br>(n=61)<br><br>PGSI | ADHD and PG<br><br>OR 0.61 (0.15-2.51) | In both unadjusted and adjusted models, ADHD symptoms were not significantly related to problem gambling |
| 33 | McNamara et al, 2008<br><br>Cross sectional study | 644<br><br>Ontario,<br><br>Canada<br><br>range 13 to 18 years (Mean =15.78 years)<br><br>350 male<br><br>294 female | To compare the risk-taking behaviour of adolescents with learning disability (LD) with comorbid LD/ADHD (, and without LD or ADHD on their substance use, engagement in major and minor delinquency, acts of aggression, sexual activity, and gambling activities. | Self report diagnosis of adolescents with LD (n=230),<br><br>comorbid LD/ADHD (n=92) | GD prevalence not reported<br><br>Frequency of 8 gambling activities. | No between-group difference was found for gambling | Four important mediating psychosocial characteristics emerged—the adolescent's relationship with one's mother, the adolescent's engagement in school and extracurricular activities, the adolescent's feeling of well-being, and the adolescent's feeling of being victimized |

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| 34 | Mestre Bach et al, 2021<br><br>Cross sectional study | 98<br><br>Spain<br><br>90.8% male<br><br>Mean age- 42.7 years | To examine relationships between ADHD symptoms, emotion regulation (ER), and gambling disorder severity | ASRS-v1.1.<br><br>ADHD prevalence not reported | GD prevalence not reported<br><br>SOGS | Generally, patients in the ASRS-positive group reported higher GD severity and mean scores | Analyses indicate a direct association between ADHD symptomatology and ER and between ER and GD severity, with ER being a mediator between both disorders. However, a direct significant association between ADHD symptomatology and GD severity was not found. These results underscore the role of ER difficulties in the comorbidity between both disorders. ER deficits may therefore be a core clinical feature related to higher levels of psychopathology and impulsive behaviours |

| | **Authors & date of publication**<br><br>**Study type** | **Sample size (n)**<br><br>**Country & Region** | **Aim of study** | **NDD Diagnosis**<br><br>**Measure used- if any**<br><br>**Self reported or interview**<br><br>**Proportion reporting NDD (%)** | **Proportion reporting gambling (%)**<br><br>**Measure of gambling** | **NDD and gambling comorbidity** | **Key findings** |
|---|---|---|---|---|---|---|---|
| 35 | Moon et al 2017<br><br>Cross sectional study | 150,<br><br>Ontario,<br><br>Canada<br><br>50<br>% female | To examine whether distinct subgroups could be identified among sample of non-treatment-seeking gamblers, problem gamblers, and pathological/disordered gamblers (PG) using Blaszczynski and Nower's pathways model | Conners' Adult ADHD Rating Scale<br><br>Self report<br><br>ADHD 20.29% | 100%<br><br>NODS | ADHD 14.89,%, 18.21% and 27.58% in the three sub groups of gamblers | Anti social impulsivist gamblers (n=50) reported the highest levels of antisocial personality disorder and ADHD symptoms, as well as higher rates of impulsivity and risk-taking than other subtypes of gamblers. |
| 36 | Ostojic et al 2014<br><br>Cross sectional study | 142<br><br>Ontario<br><br>Canada<br><br>Age 14-15 years | To compare rates of early addictive behaviours in a clinic sample of youth with childhood attention-deficit/hyperactivity disorder (ADHD) with those in community populations | Kiddie-SADS-Present and Lifetime Version (Kaufman et al., 1997)<br><br>100% ADHD | 7.9% (all male) met SOGS criteria for PG<br><br>SOGS RA | There is a non-significant trend for ADHD youth to report gambling more frequently than the provincial average, 7.9% (3.3-17.9) vs. 4.3% (2.9-6.3). | The study highlights the need for a specific focus on the potential for problem gambling in youth previously diagnosed with ADHD. |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 37 | Parker et al 2013<br><br>Cross sectional study | 532<br><br>Ontario,<br><br>Canada<br><br>The Learning disorder (LD) group consisted of 189 students (124 males, 65 females)<br><br>the behavioural/mental health problems group consisted of 77 students (45 males, 32 females)<br><br>Mean age=16 in both groups | To examine the hypothesis that adolescents with learning disorders are at elevated risk for disordered gambling | Conners-Wells' Adolescent Self-Report Scale: Short Form<br><br>LD sample 189<br><br>ADHD sample 77 | 4.6% of LD group and 6.3% of ADHD group = probable pathological gamblers<br><br>DSM-IV-J and SOGS RA | Using the SOGS-RA, there were significantly more at risk adolescents in the learning disorder group compared to the control or behaviour / mental health problem groups | The pattern of results suggests that adolescents with learning disorders are in fact at greater risk than those without learning disorders of developing disordered gambling |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 38 | Peter et al 2016<br><br>Cross sectional study | 99<br><br>Southwester US | to explore differences in psychological distress and coping strategies among individuals presenting to an outpatient gambling treatment centre with and without co-occurring adult ADHD. | Brown Attention-Deficit Disorder Scales – Adult Form (BADDS; Brown, 1996)<br><br>Self report<br><br>42% ADHD | 100%<br><br>10 DSM-IV criteria for pathological gambling.<br><br>Clinician assessment. | 42% | Individuals with ADHD (n=42) experienced more severe gambling pathology and psychological distress and reported using fewer problem-focused coping strategies and more emotion-focused strategies, compared to those without ADHD |
| 39 | Piasecki et al 2019<br><br>Cross sectional study | 9129<br><br>USA<br><br>Age range 24-34 | investigated whether gambling and disordered gambling (DG) are associated with polygenic risk scores for four psychiatric conditions found to be comorbid with DG in epidemiologic surveys: | Polygenic risk score for ADHD score was calculated using statistics from a study of 20,183 cases and 35,191 controls<br><br>ADHD sample prevalence not reported | 1.3% (n=70)<br><br>A single question 'Has your gambling ever caused serious financial problems or problems in your relationships with any of your family members or friends?' | OR for ADHD and DG 1.007 [0.842, 1.361] . | Polygenic risk scores for MDD and ADHD were not related to either gambling or gambling disorder |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 40 | Pitt et al, 2021<br><br>Qualitative study | 19<br><br>Australia<br><br>52.6% Male<br><br>Age range 20-70<br><br>Mean 44 | To assess the risks and benefits of community gambling venues as recreational spaces for people with lifelong disability | Association with disability advocacy organisation was criteria for recruitment<br><br>100% Intellectual disability | GD prevalence not reported, although all participants recalled gambling<br><br>Visits to community gambling venues. Participants were asked about their definitions of gambling, awareness and understanding of gambling products, how they understood the risks and benefits of gambling, and their awareness of responsible gambling messages | Not reported | While many people with lifelong disability have positive experiences in pubs and clubs, some are vulnerable to the harms associated with risky products such as gambling within the clubs. Less than half of the participants had awareness of 'responsible gambling.'<br><br>Most participants knew what gambling related harms meant and cited main harm being losing money. They either had experienced harms themselves or knew others who had |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 41 | Preston et al, 2012<br><br>Cross sectional study | 254<br><br>Canada<br><br>100% Male<br><br>Mean age = 34.6 | To examine the relationship between problem gambling, mental health, and criminal behavior in a sample of incarcerated Canadian male federal offenders | ADHD Clinical measure based on DSM- IV criteria | 9.4% problem gamblers ( PGSI)<br><br>13% probable pathological gamblers ( SOGS)<br><br>SOGS<br><br>PGSI and<br><br>12 item harmful consequences of gambling scale | Not reported | Problem gambling was significantly correlated with impulsiveness, and current and childhood attention-deficit/hyperactivity disorder (ADHD) symptoms in this offender sample. |
| 42 | Reid et al, 2020<br><br>Cross sectional study | 126 (39 gamblers with comorbid adult ADHD and 87 without)<br><br>Florida and California,<br><br>USA<br><br>Mean age = 47.7 | To investigate characteristics of treatment seeking problem gamblers with adult ADHD (n= 39) and those without ADHD | Clinical diagnoses of DSM-5 adult ADHD were made based on semi structured interviews using Adult ADHD Clinical Diagnostic Scale (ACDS)<br><br>31% ADHD | 100%<br><br>NODS | 9.1% | Earlier age for first gambling activities, onset of gambling problems, and higher severity of gambling problems noted among gamblers with ADHD. The PG- ADHD group also showed significantly higher scores for alcohol abuse, drug abuse and impulsivity |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 43 | Retz et al 2016<br><br>Cross sectional study | 163<br><br>Saarland Germany<br><br>Mean Age = 42.2. years | To investigate the association of ADHD with gambling disorder (GD) | Standardised instrument for ADHD, based on DSM 5<br><br>Expert assessment, and self rating<br><br>28.8 % childhood symptoms of ADHD detected 25.2 % diagnostic criteria for ADHD | 100%<br><br>ICD10 criteria | 28.8 % childhood symptoms of ADHD detected 25.2 % diagnostic criteria for ADHD | The prevalence of co-morbid substance use disorders and adjustment disorders and cluster B personality disorders was higher in GD patients with current ADHD than in the group without. Also, an increased rate of suicide attempts was detected in gamblers with ADHD. In contrast with gamblers without ADHD, those with ADHD were reported to spend more time with gambling, a sedative effect of gambling and a faster development of GD |
| 44 | Rodriguez-Jimenez et al 2006<br><br>Cross sectional study | 95<br><br>Spain<br><br>100% Male<br><br>Age Range<br><br>18-45 years | To compare different impulsivity and sustained attention variables, in a group of pathological gamblers with a history of childhood ADHD (PG-ADHD; n = 16), a group of pathological gamblers without this history (PG-non-ADHD; n = 39), and a control group (n = 40) | WURS<br><br>Self report<br><br>16% ADHD | 100%<br><br>SOGS | 29% of pathological gamblers had a history of childhood ADHD | Patients in the PG-ADHD group exhibit a significantly lower capacity to delay gratification than those in the PG-non-ADHD and control groups, and less inhibitory control than patients in the PG-non-ADHD group |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 45 | Romo et al 2015<br><br>Cross sectional study | 720<br><br>Paris<br><br>France<br><br>61.9% Male<br><br>Mean age =18.95 | To evaluate the association between ADHD and gambling among young students; (2) determined which symptom among ADHD's three symptoms (attention deficit, hyperactivity, or impulsivity) had the strongest association with video game addiction and gambling | WURS and ASRS<br><br>13.33 % of the participants had symptoms of ADHD during childhood (WURS scale score) and 40.41 % of them have symptoms of ADHD in adulthood (ASRS score) | 37.5 % had 'excessive gambling addiction'<br><br>CPGI | Association between ADHD and PG OR 1.3 (1.05-1.6) | Significant associations were observed between ADHD and impulsivity, academic difficulties and gambling addiction |
| 46 | Romo et al 2016<br><br>Cross sectional study | 600<br><br>France<br><br>66.3% Male<br><br>Mean Age 43.5 | The primary outcome of the study was to assess the links between the level of cognitive distortions and the severity of gambling disorder. Also, to assess the links between patient gambling trajectories and attention deficit and hyperactivity disorder (ADHD). | WURS C<br><br>ADHD prevalence not reported | 100%<br><br>DSM- IV –TR<br><br>SOGS<br><br>GABS | Not reported | Hypothesis confirmed as ADHD gamblers scored higher on every dimension (at least p<.01 for each dimension) of the GABS as well as on the overall score.<br><br>ADHD gamblers significantly more likely than non-ADHD gamblers to have gambling related cognitions (p <.0001) |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 47 | Romo et al 2018<br><br>Cross sectional study | 1517<br><br>France<br><br>56% Female<br><br>Mean age = 20.6 | The aim of this study was to determine the possible links between attention-deficit hyperactivity disorder (ADHD)and the presence of concomitant addictions with or without substance use in a French student population. | ASRS<br><br>The prevalence of ADHD (defined as current ADHD with a history of ADHD in childhood) among the students was 5.6% (95% CI: 4.4%–6.8%) | 20% of those with ADHD showed problem gambling<br><br>(n=17)<br><br>PGSI | Problem gambling in ADHD v non ADHD sample OR 1.76 (0.94–3.31).08 | ADHD students had significantly higher scores on substance (alcohol, cannabis, and tobacco) as well as behavioral addictions (gambling, compulsive buying disorder, eating disorders, and Internet addiction) |
| 48 | Scheidemantel et al 2019<br><br>Case series | 3<br><br>USA<br><br>2 Male, 1 Female | To review cases that illustrate common challenges faced by people with Intellectual and Developmental Disabilities (IDD) and Problem Gambling. | Case descriptions<br><br>100% (n=3) IDD | 100%<br><br>(n=3) | 100% (n=3) | Most of these individuals live within tight budgets, with little personal means. They may lack capacity to understand or appreciate the risks and consequences associated with this behaviour. |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 49 | Shoham et al 2021<br><br>Cross sectional | 200<br><br>Israel<br><br>54% Female<br><br>(n=108) | This study tests whether ADHD is associated with a pervasive tendency to engage in risky behaviour across a spectrum of activities and domains, and whether this tendency is driven by comorbid disorders. | ASRS, DIVA 2.0<br><br>Self report<br><br>ID=52% (n=50)<br><br>ADHD 48.5% (n=97) | Gambling = 2 items on Adult Risk Taking Inventory | Those with ADHD significantly more likely to engage in all risky behaviours than controls<br><br>Effect size 0.69 ( p= <0.001) | Participants with ADHD reported a pervasive tendency to engage in risky behaviours across multiple activities. This tendency was associated with ADHD over and above the contribution of comorbid psychiatric disorders. |
| 50 | Silbernagl et al 2019<br><br>Cross sectional study | 275 (80 with PG, 142 in Opioid Maintenance Treatment ( OMT) in community, and 133 in OMT in Prison)<br><br>Austria<br><br>PG Sample | To identify patterns of psychiatric comorbidity and to examine associations between patient group and ADHD status with class membership. | ASRS<br><br>Self report<br><br>12.5% of PG patients, showed symptoms indicative of ADHD persistent in adulthood. | All 80 in PG sample<br><br>DSM-IV. | 12.5% | PG patients seem to be at an even higher risk for psychiatric comorbidities compared to Opiate Maintenance Treatment patients. |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| | | Mean Age = 43.1<br><br>20% Female | | | | | |
| 51 | Szerman et al,<br>2022<br><br>Cross sectional and Observational study | 116<br><br>Madrid, Spain<br><br>89.7% Male<br>Mean age = 39.2 years | To provide evidence of co-occurrence of GD and other mental disorders | ADHD diagnosed by ASRS and Conners' Adult ADHD Rating Scale (CAARS).<br>50% ADHD<br><br>(Having an intellectual disability was part of the exclusion criteria for the study.) | 100%<br>Gambling disorder diagnosis according to ICD11<br><br>SOGS<br><br>MULTICAGE-CAD 4 | 50% | Data collected without considering the treatment status of the patients. All patients were from specific GD treating centers.<br><br>Mean SOGS score 11.7.<br>30.2% had moderate or severe depression<br>According to BIS scale, 76.7% had an impulsivity personality trait<br><br>Mean ASRS score 25.6<br><br>Most GD patients also had an impulsivity problem independent of ADHD diagnosis |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 52 | Tanaka et al, 2023<br><br>Cohort study | 40<br><br>Yamaguchi, Japan<br><br>Median age in group with ADHD 36 years and 35 years in those without ADHD<br><br>95% male | To investigate the social background, clinical characteristics, and clinical course of initial-visit GD patients with and without ADHD in a Japanese psychiatric hospital | ADHD screened using ASRS-v1.1 and diagnosed using DSM 5 criteria by a trained psychiatrist<br><br>27.5% ADHD | 100%<br><br>DSM 5 criteria for GD | 27.5% | GD patients with ADHD had higher rates of psychiatric comorbidities and higher treatment retention rates compared to those without ADHD |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 53 | Taylor et al 2015<br><br>Cross sectional study | 2004<br><br>Canada<br><br>57% female<br><br>14-18 Years<br><br>(mean =16) | To examine the link between problematic gambling and gambling related cognitions (GRCs) in a large sample of adolescents with (N=266) and without (N=1,738) special education needs (SEN) | Proxy of Individual learning plan In place for LD or behavioural problem<br><br>Sample of 266 with 'special needs' | Prevalence not reported<br><br>DSM-IV-J | 0.74% (n=2) | Among the typically developing (TD) adolescents, age, gender, ADHD symptomatology, and negative affect were found to account for only 5 % of the variance in problem gambling scores. Among adolescents with SEN, however, these same variables accounted for 18 % of the variance in problem gambling scores, with negative affect emerging as the strongest predictor |
| 54 | Theule et al 2019<br><br>Meta analysis | Meta analysis of 24 studies, total sample size not reported<br><br>Mean age between 17 and 47<br><br>% female between 0 and 62 | This study utilized meta-analytic techniques to clarify the association between symptoms of problem gambling and symptoms of ADHD. | Various measures used to determine diagnosis of ADHD<br><br>Prevalence reported between 7-50% | Various | The correlation between symptoms of ADHD and gambling severity was statistically significant. The weighted mean effect, based on nine | Overall, there was a significant correlation between symptoms of ADHD and problem gambling. The weighted mean prevalence of ADHD in individuals with problem gambling was 18.46%, and the weighted mean prevalence of problem gambling in individuals with ADHD was 11.75%. |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| | | | | | | studies, was r = .17, 95% confidence interval (CI) = [0.12, 0.22], p < .001. | |
| 55 | Vintro Alcaraz et al 2021<br><br>Cross sectional study | 204<br><br>Spain<br><br>Mean Age =41.5<br><br>90% Male | To examine the association between ADHD symptomatology, personality traits and impulsivity in a sample of treatment-seeking patients with GD (n=204) with and without a criminal report. | ASRS<br><br>24% of gamblers with criminal report had ADHD compared to 13.9% of gamblers without criminal report | 100% treatment seeking GD<br><br>DSM-IV- TR | 24% of gamblers with criminal report had ADHD compared to 13.9% of gamblers without criminal report | These results showed that criminal behavior was related to younger age, earlier onset of GD, higher severity of the GD (according to the number of DSM-5 criteria and the bets per gambling episode), higher levels in novelty seeking, lower levels in reward dependence and self-directedness, and higher impulsivity levels (concretely in the domains of sensation seeking, positive and negative urgency, and global). The patients who reported illegal behaviour also achieved higher ADHD severity (ASRS total score), and higher likelihood for ADHD positive screening |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| 56 | Walther et al 2012<br><br>Cross sectional study | 2553<br><br>Germany<br><br>52.7% Male<br><br>Mean Age = 16.7. | To investigate co-occurrence and shared personality characteristics of problematic computer gaming, problematic gambling and substance use. | SBB-HKS (German ADHD rating scale) | Problematic gambling 4.8% (n=123)<br><br>SOGS | 6.4% v 3.8% gamblers for those with high v low ADHD ( p =0.003) | All current substance users, problematic gamblers and problematic gamers had higher values on ADHD and impulsivity.<br><br>Problematic gamblers seem to be more like substance users than problematic computer gamers. |
| 57 | Waluk et al 2016<br><br>Cross sectional study | 214<br><br>Australia<br><br>Mean Age =40.3<br><br>27% Female | This study aimed to (a) compare the prevalence of ADHD in treatment-seeking problem gamblers to the general population; (b) investigate the relationships between ADHD and problem gambling severity, cluster B personality disorders, motor impulsivity, alcohol use, substance use, gender, and age; and (c) investigate the degree to which these factors moderate the | ASRS<br><br>self report<br><br>24.9% ADHD (n=47/189) | 92.%<br><br>(n=197) met criteria for PG<br><br>PGSI | 24.9% (n=47/189) | A one-sample z-test revealed that a significantly higher proportion of the sample of treatment-seeking problem gamblers received a positive endorsement for probable ADHD (24.9 %, n=47/189 participants with no missing ASRS item responses pre-imputation,95 % CI 19.3–31.3) than the general US community (14.0 %, Kessler et al.2007,z=4.60,p\.0001). |

| | Authors & date of publication<br><br>Study type | Sample size (n)<br><br>Country & Region | Aim of study | NDD Diagnosis<br><br>Measure used- if any<br><br>Self reported or interview<br><br>Proportion reporting NDD (%) | Proportion reporting gambling (%)<br><br>Measure of gambling | NDD and gambling comorbidity | Key findings |
|---|---|---|---|---|---|---|---|
| | | | relationship between ADHD and problem gambling severity | | | | |

Most studies had clear objectives, provided description of study populations and used validated measures for NDD and GD. Three of the studies were rated as low quality (high risk of bias) due to a lack of validated measures for exposures and/or outcomes, or a lack of appropriate statistical analysis. (See Appendix Table 3). None of these were included in the subset of studies which were included in the assessment of comorbidity.

Of the 57 studies, 5 reported industry funding and 10 did not report whether they received industry funding or not. Those that did report industry funding all reported scientific independence over design, analysis, and publication of results and all those studies were deemed low risk of bias on our checklist.

All studies were included in the narrative synthesis. Of the 57 studies, only 36 specifically reported comorbidity data on NDD and GD (see Tables 2 and 3). Of the remaining 21, there were 2 systematic reviews and 1 meta-analysis. Although the remaining 18 studies did not report comorbidity data, they provided useful qualitative data and highlighted the scope of the problem of comorbidity. (See Tables 2 and 3).

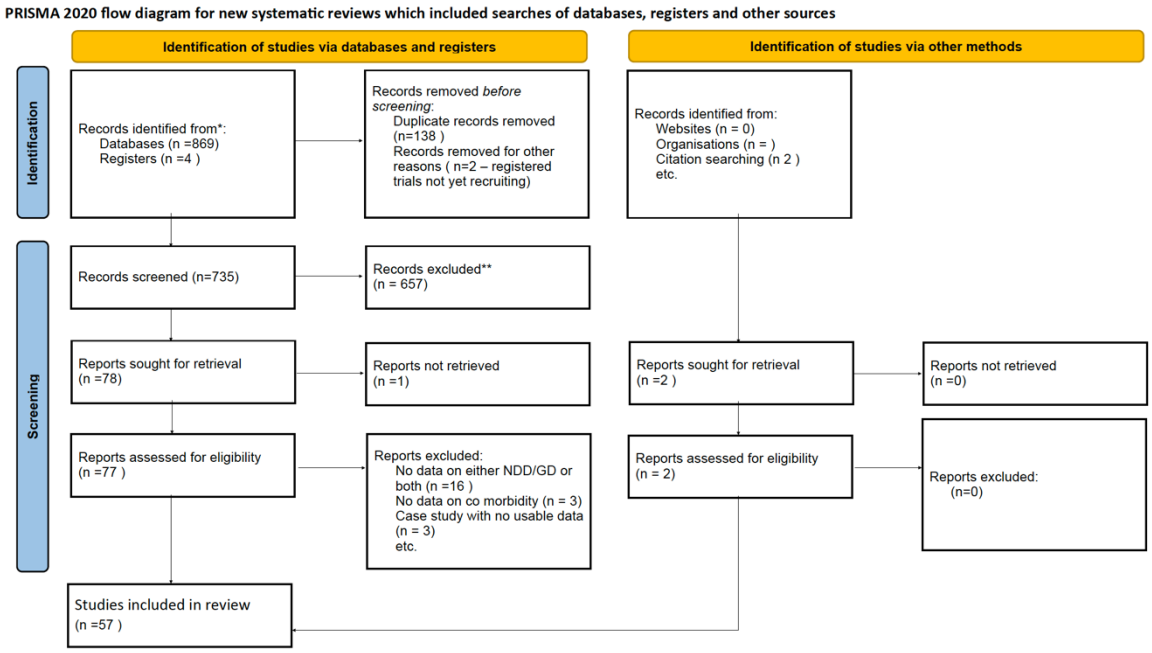


Figure 1. Flowchart of included studies

Table 2: Number of studies that reported comorbidity data on NDD and GD

| **NEURODEVELOPMENTAL DISORDER (NDD)** | **Number of studies reporting comorbidity figures** | **Number of studies without comorbidity figures** |
|---|---|---|
| ID* and ADHD** | 1 | 1 |
| ID | | 3 |
| ASD***/autistic traits | 1 | |
| ADHD | 32 | 12 (+2 studies looking at hyperactivity/impulsivity symptoms but no official diagnosis of ADHD) |
| Learning disorders | 1 | |
| Special Educational Needs | 1 | |

*Intellectual disability
**Attention deficit hyperactivity disorder
***Autism spectrum disorder

Studies varied in terms of population studied, which led to significant variations in comorbidity figures. Some studies included GD treatment-seeking participants, others specified non-treatment seeking, and conversely there were some that sought to estimate GD prevalence in people with established NDD. As shown in Table 3, the range of GD and NDD comorbidity reported is correspondingly wide, from 2.4% to 62.5%.

| Table 3: Summary of studies reporting comorbidity rates of gambling disorder and neurodevelopmental disorders | | | | | | |
|---|---|---|---|---|---|---|
| | **Authors & date of publication**<br><br>**Study type** | **Aim of study** | **Participants** | **Study Population** | **Neurodevelopmental disorder (NDD)** | **NDD and gambling comorbidity** |
| 1 | Aymami et al, 2015<br><br>Cohort Study | To assess prevalence of ADHD symptoms in treatment seeking gambling disordered patients and exploration of clinical and sociodemographic differences between patients who scored high and low on the ADHD measure, psychopathology and personality traits | 354 | Treatment seeking gamblers,<br><br>Spain | ADHD | 23.2% |
| 2 | Brandt & Fischer, 2019<br><br>Cross sectional study | (a) To review retrospective childhood and adult ADHD symptomatology in treatment-seeking gamblers,<br>(b) Understand characteristics of the association between pathological gambling (PG) and ADHD,<br>(c) Identifying risk factors for a history of ADHD | 80 | Treatment seeking gamblers,<br><br>Austria | ADHD | 42.5% of the cohort screened positive for childhood ADHD, 11.3% persisted into adulthood |
| 3 | Breyer et al, 2009<br><br>Longitudinal study of ADHD beginning in 1991 | To examine the association of gambling behaviours among young adults with their longitudinal history of ADHD | 235 | Young adults with ADHD,<br><br>USA | ADHD | 19% |
| 4 | Black et al, 2013<br><br>Case control study | To understand how neuropsychological performance, trait impulsivity, Cloninger's personality characteristics and symptoms of ADHD interrelate in problem gambling | 119 | Community sample Individuals with diagnosed PG and controls. | ADHD | 9% |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | USA | | |
| 5 | Black et al, 2015<br><br>Cohort study | To review age at onset of pathological gambling and compare demographic and clinical characteristic between early vs late onset | 255 | Individuals with pathological gambling<br><br>USA | ADHD | 15% |
| 6 | Chamberlain et al, 2015<br><br>Case control study | To review the impact of ADHD symptoms on clinical and cognitive aspects of problem gambling | 126 | Individuals with PG, community settings<br><br>UK | ADHD | 21.4% |
| 7 | Dai et al, 2016<br><br>Case control study | To investigate the relationship between impulsivity and gambling-related cognitions and behaviour in adults with and without ADHD | 60 | Adults with ADHD (and controls without ADHD) community settings,<br><br>New Zealand | ADHD | 9.6% |
| 8 | Dannon et al, 2006<br><br>Cross sectional | To present comorbid psychiatric diagnoses seen in those with problem gambling and their first-degree relatives | 241 | Gamblers and their first-degree relatives.<br><br>Israel | ADHD | 5.8% |
| 9 | El Archi et al 2023 | To investigate ADHD in adult outpatients seeking treatment for a behavioral addiction and to identify the | 65 | Outpatients seeking | ADHD | 4.16% |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Cross sectional study | specificity of psychopathological features if the behavioral addiction co-occurs with adult ADHD. | | addiction treatment, France | | |
| 10 | Faregh & Derevensky 2011 Cross sectional study | To examine ADHD key symptoms, and gambling behaviours and problem severity among adolescents | 1130 | Adolescents from schools Canada | ADHD | 17.4% |
| 11 | Fatseas et al, 2016 Cohort study | To examine whether ADHD is associated with specific severity patterns in terms of gambling behaviour, psychopathology, and personality traits | 599 | Gamblers from addiction clinics and gambling spaces France | ADHD | 28.2% |
| 12 | Grall-Bronnec et al, 2011 Cross sectional study | To examine the frequency of pathological and at-risk gamblers having a previous history of ADHD and identify risk factors for a history of ADHD | 84 | Gamblers with, or at risk of PG, France | ADHD | 15.8% had ADHD characteristics only in childhood, 10.5% had ADHD characteristics "probably persisting into adulthood" |
| 13 | Grant and Chamberlain, 2021 Exploratory study | To examine the clinical characteristics and facets of cognition in young adults who gamble and have autistic traits | 102 | Community sample of young adults USA | Autistic traits | 7.1% |
| 14 | Hardoon et al 2002 | To examine the relationship between several risk and protective variables associated with adolescent gambling. | 2336 | Students aged 11-19 | Intellectual disability | 22.3% of probable pathological gamblers had a |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Cross sectional study | | | Canada | ADHD | diagnosis of intellectual disability<br><br>49.6% of probable pathological gamblers had scores in the clinical range on the ADHD Index subscale |
| 15 | Jacob et al, 2018<br><br>Cross sectional study | To examine the association between ADHD symptoms and gambling problems and to identify any potential mediating factors of this association. | 7403 | Community sample. Adults (>16 years) living in private households,<br><br>UK | ADHD | 2.4% |
| 16 | Kerber et al, 2008<br><br>Cohort study | To examine rates of comorbid psychiatric disorders in older adults with lifetime pathological gambling using structured assessments | 40 | Gamblers-Older adults (aged 55-83 years) with lifetime 'pathological' gambling,<br><br>USA | ADHD | 7.5% |
| 17 | Kessler et al, 2008<br><br>Cross sectional study | To examine lifetime gambling symptoms and pathological gambling (PG) and other DSM-IV disorders | 3435 | Community sample<br><br>USA | ADHD | 13.4% |

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| 18 | Mak et al, 2018<br><br>Cross sectional study | The primary objective was to observe the rate of patients screening positive for ADHD. | 65 | Gamblers Treatment seeking adults with diagnosis of problem gambling or pathological gambling<br><br>Singapore | ADHD | 20% |
| 19 | Mcdonald et al 2021<br><br>Cross sectional study | To examine whether adult ADHD symptoms are associated with psychological distress, hazardous drinking, and problem gambling, after controlling for traumatic brain injury and sociodemographic characteristics. | 3817 | Adult community sample<br><br>Canada | ADHD | 2.3% |
| 20 | Mestre Bach et al 2021<br><br>Cross sectional study | To examine relationships between ADHD symptoms, emotion regulation, and gambling disorder severity | 98 | Treatment seeking gamblers<br><br>Spain | ADHD | 24% |
| 21 | Moon et al 2017<br><br>Cross sectional study | To examine whether distinct subgroups could be identified among sample of non-treatment-seeking, problem and pathological/disordered gamblers (PG) using Blaszczynski and Nower's pathways model | 150 | Community and university samples meeting criteria for PG<br><br>Canada | ADHD | 14.89%,18.21% and 27.58% in three sub-groups of gamblers |

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| 22 | Ostojic et al 2014<br><br>Cross sectional study | To compare rates of early addictive behaviours in a clinic sample of youth with childhood attention-deficit/hyperactivity disorder (ADHD) with those in community populations | 142 | 12-16 year olds diagnosed with ADHD<br><br>Canada | ADHD | 7.9% |
| 23 | Parker et al 2013<br><br>Cross sectional study | To examine the hypothesis that adolescents with learning disorders are at elevated risk for disordered gambling | 532 | Adolescents with learning disorders or behavioural /mental health problems<br><br>Canada | Learning disorders | 20% |
| 24 | Peter et al 2016<br><br>Cross sectional study | To explore differences in psychological distress and coping strategies among individuals presenting to an outpatient gambling treatment centre with and without co-occurring adult ADHD. | 99 | Treatment-seeking gamblers presenting to outpatient gambling treatment centre<br><br>USA | ADHD | 42% |
| 25 | Reid et al, 2020<br><br>Cross sectional study | To investigate characteristics of treatment seeking problem gamblers (PG) with adult ADHD (n= 39) and those without ADHD | 126 | Treatment seeking gamblers<br><br>USA | ADHD | 31% |

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| 26 | Retz et al 2016<br><br>Cross sectional study | To investigate the association of ADHD with gambling disorder (GD) | 163 | Inpatients with GD,<br><br>Germany | ADHD | 25.2 % |
| 27 | Rodriguez-Jimenez et al, 2006<br><br>Cross sectional study | To compare different impulsivity and sustained attention variables, in a group of pathological gamblers with a history of childhood ADHD (PG-ADHD; n = 16), a group of pathological gamblers without this history (PG-non-ADHD; n = 39), and a control group (n = 40) | 95 | Gamblers with diagnosed PG and childhood ADHD<br><br>Spain | ADHD | 29.1% |
| 28 | Romo et al 2015<br><br>Cross sectional study | evaluated the association between ADHD and gambling among young students; (2) determined which symptom among ADHD's three symptoms (attention deficit, hyperactivity, or impulsivity) had the strongest association with video game addiction and gambling | 720 | Students (Age 17-27) in higher education<br><br>France | ADHD | 62.5% Adult ADHD (n= 5 of 8 'excessive gamblers'))<br>50% childhood ADHD<br>(n=4 of 8 'excessive gamblers') |
| 29 | Romo et al 2018<br><br>Cross sectional study | The aim of this study is to determine the possible links between attention-deficit hyperactivity disorder (ADHD)and the presence of concomitant addictions with or without substance use in a French student population. | 1517 | University Students (mean age 20.6 years)<br><br>France | ADHD | 20% |
| 30 | Silbernagl et al 2019<br><br>Cross sectional study | To identify patterns of psychiatric comorbidity and to examine associations between patient group and ADHD status with class membership. | 80 | Problem gamblers in treatment, recruited from either community or prison | ADHD | 12.5% |

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| | | | | Austria | | |
| 31 | Szerman et al, 2022<br><br>Cross sectional and Observational study | To provide evidence of co-occurrence of GD and other mental disorders | 116 | Adults with GD<br><br>Spain | ADHD | 50% |
| 32 | Tanaka et al 2023<br><br>Cohort study | To investigate the social background, clinical characteristics, and clinical course of initial-visit GD patients with and without ADHD in a Japanese psychiatric hospital | 40 | Treatment-seeking GD outpatients<br><br>Japan | ADHD | 27.5% |
| 33 | Taylor et al 2015<br><br>Cross sectional study | To examine the link between problematic gambling and gambling related cognitions (GRCs) in a large sample of adolescents with (N=266) and without (N=1,738) special education needs (SEN) | 2004 | Adolescents with and without special educational needs (SEN)<br><br>Canada | Special educational needs | 0.74% (n=2) |
| 34 | Vintro Alcaraz et al 2021<br><br>Cross sectional study | To examine the association between ADHD symptomatology, personality traits and impulsivity in a sample of treatment-seeking patients with GD (n=204) with and without a criminal report. | 204 | Treatment seeking gamblers with and without criminal report<br><br>Spain | ADHD | 24% of gamblers with criminal report had ADHD compared to 13.9% of gamblers without criminal report |

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| 35 | Walther et al 2012<br><br>Cross sectional study | To investigate co-occurrence and shared personality characteristics of problematic computer gaming, problem gambling and substance use. | 2553 | Students (12-25 years)<br><br>Germany | ADHD | 6.4% v 3.8% gamblers for those with high v low ADHD (p =0.003) |
| 36 | Waluk et al 2016<br><br>Cross sectional study | This study aimed to (a) compare the prevalence of ADHD in treatment-seeking problem gamblers to the general population; (b) investigate the relationships between ADHD and problem gambling severity, cluster B personality disorders, motor impulsivity, alcohol use, substance use, gender, and age; and (c) investigate the degree to which these factors moderate the relationship between ADHD and problem gambling severity | 214 | Treatment seeking gamblers<br><br>Australia | ADHD | 24.9% |

**ADHD**

Most studies related to ADHD, with varying rates of comorbidity reported. Whilst some studies looked at ADHD and other comorbid NDDs, only three studies did not feature ADHD. In populations with ADHD, rates of GD varied from 7.9% in12–16-year-olds in Canada, to 19.0% in young adults in the USA (Breyer et al., 2009). In populations with GD, rates of ADHD varied from 4.16% in France (El Archi et al., 2023) to 27.5% in treatment-seeking gamblers in Japan (Tanaka et al.,2023) and 42.5% in Austrian treatment-seeking gamblers (Brandt &Fischer, 2019) and 50% in a Spanish sample of adults with GD (Szerman et al.,2023). Some studies assessed the presence of core features of ADHD such as hyperactivity and impulsivity, although in this instance, participants did not formally have a diagnosis of ADHD. For example, Martins et al., (2008) found that male and female gamblers were rated by their parents as having high childhood impulsivity and hyperactivity. Many studies emphasised the correlation of impulsivity with GD, which is discussed further below.

Several studies assessed larger community samples, with some reporting high comorbidity rates, however numbers of such individuals within these community samples were small. For example, a study of 720 students in higher education in France (Romo et al., 2018) reported GD and ADHD comorbidity of 62.5%. However, this comorbidity relates to a total of 8 participants termed “excessive gamblers” of which only five met the criteria for ADHD.

**Autism**

In the only study featuring autism, Grant and Chamberlain (2020) concluded that the relationship between autistic traits and disordered gambling symptoms remained statistically significant even after controlling for ADHD. The study included participants from 2 mid-western communities in the USA, aged18-29 years, who were not receiving treatment for gambling disorder but had gambled at least 5 times in the last year. The study also found that autistic traits significantly correlated with impulsiveness, particularly attentional impulsivity, suggesting a potential mediator for the association between autism and GD.

**Intellectual disability (ID)**

Hardoon and Derevensky (2002) found that 22.3% of probable pathological gamblers had a diagnosis of ID which was significantly greater than non-gamblers and social gamblers ($p<0.001$). They also found that the prevalence of cognitive problems in probable pathological gamblers was 42.5% and 27.4% in at-risk gamblers (27.4%) compared to 16.9% and 13.6% in social gamblers and non-gamblers, respectively.

Although not part of the abridged sample of 36 studies due to either sample selection bias or lack of comorbidity data, we identified three further studies involving individuals with ID and GD (McNamara et al.,2008; Pitt et al., 2021; Scheidemantel et al.,2019). (see Table 1). These studies

highlighted concerns around mental capacity to understand gambling-related risks and harms, as well as the challenges faced by this sub-group.

**Learning disorders and special educational needs (SEN)**

A study of 532 participants (Parker et al.,2013) reported that the rates of disordered gambling in male adolescents with learning disorders were significantly higher (27.4%) than in those without learning disorders (control group, 8.9%), even after controlling for negative affectivity and ADHD. The study noted that there were more social gamblers in the female group compared to males, however rates for at-risk and probable pathological gambling problems were higher for males compared to females. Overall comorbidity of learning disorder and GD was reported at 20%.

In addition, Taylor et al (2015) reported on adolescents with SEN (which included those with learning disorders and/or behavioural/mental health problems) and GD. They found that adolescents with SEN had more "erroneous beliefs" around gambling and were more likely to develop gambling related problems compared to adolescents without SEN.

**Risk factors**

A secondary aim of the study was to identify risk factors for GD in those with NDDs. Several studies identified various factors which may moderate the relationship between NDDs and GD including; deficits in executive functioning (e.g. planning, working memory) and behavioural inhibition (e.g. ability to delay responses) (Taylor et al., 2015)**;** substance use (Jacob et al.,2018; Retz et al.,2016); higher severity of gambling (Fatseas et al.,2016; Peter et al.,2016)**;** earlier onset of gambling (Fatseas et al.,2016; Peter et al.,2016; Black et al., 2015); poorer educational attainment (Grant &Chamberlain 2016; Hardoon, & Derevensky, 2002; Peter et al.,2016); cognitive and emotional problems, poor familial and social support, higher rates of socioeconomic deprivation (Hardoon, & Derevensky, 2002)**;** comorbid mental disorders including borderline personality disorder (Fatseas et al.,2016 ; Waluk et al.,2016)**;** major depression (Fatseas et al.,2016; Grall Bronnec et al., 2011**;** Silbernagl et al.,2019**)** and suicidality (Retz et al.,2016; Grall Bronnec et al., 2011).

## Discussion

A 2019 meta-analysis by Theule et al (2019) included studies on ADHD and GD published up to 2014. The present review provides an update to this data by including almost a decade's worth of additional studies. 38 of the 57 included studies in this review were published between 2014-2023 and confirm a clear convergence between ADHD and GD.

In addition, this review highlights the lack of data relating to comorbidity of other NDDs (other than ADHD) and GD, with only four studies reporting on autistic traits, learning disorders, special educational needs, and intellectual disability. There were 21 studies which met the initial

inclusion criteria but did not report comorbidity data. Some of these studies highlighted critical issues in safeguarding and protecting vulnerable individuals with ID and learning disorders (McNamara et al.,2008; Pitt et al.,2021; Scheidemantel et al.,2013; Parker et al.,2019). Pitt et al (2020) raised issues around accessibility and inadvertent encouragement to engage in gambling. They referred to Australian 'clubs' attended by people with ID for non-gambling recreational activities, socialising and affordable meals. However, these venues also house gambling products, providing them with exposure and opportunity to engage in gambling. Often the products available in these venues include scratch cards or electronic gaming machines which may be more accessible forms of gambling to people with an ID, considering their cognitive abilities.

There was significant variation across the studies in methods, population demographics, psychiatric comorbidities, and GD treatment-seeking status. Many studies utilised multiple rating scales, screening tools and diagnostic criteria for diagnosis of the same condition, whilst some used 'versions' of recognised scales or adapted the criteria (See Appendix 3).

**Neurobiological and clinical correlates**

The neurobiological and clinical pathways involved in the development, course and maintenance of GD may be impacted differently according to the type of NDD. For example, novelty-seeking traits are common to both GD and ADHD and play a role in exacerbating the severity of GD (Tanaka et al.,2023). Eme (2017) reports on common deficiencies in ADHD and addictions in the mesolimbic and mesocortical dopaminergic systems, which produce a blunted response to typical rewards, thereby providing motivation to engage in impulsive, reward-seeking and novelty-seeking behaviour. Whilst in addiction these deficits are acquired, in people with ADHD these deficits are neurodevelopmental in origin and therefore ADHD itself poses a risk factor for development of addiction. Conversely, in the case of individuals with ID, depending on the severity of the disability, exploratory and novelty-seeking behaviours may be less prominent. Similarly, novelty-seeking and exploratory traits are less common to people with ASD, with restricted and repetitive behaviours being a core feature of the diagnosis (Pierce & Courchesne 2001). On the other hand, individuals with GD often display marked compulsivity, response perseveration and cognitive inflexibility; traits which are also found in individuals with ASD (Grant et al.,2016). The existing complexities in the aetiology and course of GD are further complicated by the presence of an NDD. Both GD and NDDs share the problem of being multifaceted in aetiology, course, and manifestation, and are influenced by the interaction of various biopsychosocial variables.

Existing literature supports a pathways model of gambling disorder as having good validity (Black et al.,2015).This theoretical model integrates the complex biopsychosocial and ecological factors involved in the aetiology of gambling disorder (Blaszczynski, & Nower,2002).Taking these

variables into account, the pathways model suggests there are distinct subtypes of gamblers influenced by different underlying issues and triggers for gambling which may affect their clinical course, interventions and management. They may be sub-categorised into three discrete pathways to the development of a gambling disorder; impulsivity, behavioural conditioning, and issues with emotional regulation.

More broadly, through this review, we identified key cognitive factors that may mediate and/or moderate the relationship between NDDs and GD. These include cognitive distortions, impulsivity, compulsivity, and deficits in emotional regulation. The next section considers the findings and implications of the studies included within this review in terms of these risk factors.

**Cognitive Distortions**

Cognitive distortions are biases or irrational thoughts that may influence emotions. Deficits in decision making and cognitive distortions such as illusions of control, magical thinking and the gamblers fallacy play a significant role in the development and perpetuation of GD (Labrador et al,2020). Other distorted cognitive schema in relation to gambling include those around personal skill, failure attribution, control over outcome, biased evaluations, erroneous perceptions, superstitious thinking, and probability theory (Blaszczynski & Nower,2002). Taylor et al (2015) utilised the Gambling Related Cognitions Scale (GRCS), a 23-item self-report scale to assess a range of gambling-related cognitive biases and errors. They reported that adolescents with SEN demonstrated more erroneous beliefs than those without SEN. The study also found that adolescent boys with SEN scored higher than typically developing peers on problem gambling measures, GRCS subscales and total scores. Parker et al (2013) and Taylor et al (2015) reported that the presence of literacy and numeracy deficits influences cognitive biases around mathematical odds and probabilities, thereby increasing vulnerability to GRH.

On the other hand, Mak et al (2018) found that gambling related cognitions were lower in those with GD and ADHD, suggesting that impulsivity rather than gambling related cognitions drives gambling behaviour. This suggests that the severity and extent of gambling related cognitions may differ according to different underlying NDDs.

**Impulsivity**

Impulsivity refers to behaviours or acts committed with haste, often inappropriate and dangerous with negative consequences (Ioannidis et al, 2019). The Barratt Impulsiveness Scale (BIS) used in some of the included studies, measures three major components of impulsivity; cognitive impulsiveness (making quick decisions), motor impulsiveness (acting without thinking), and non-planning impulsiveness (lacking forethought). Whilst impulsivity alone may have negative outcomes, it may additionally render an individual more likely to accept cognitive distortions thus

increasing the risk of GRH.

Impulsivity is a core feature of ADHD. Existing literature has suggested that ADHD and problem gambling share the same form of impulsivity, in the form of poor decision making (Brandt & Fischer,2019). Given that most of the included studies focused on ADHD, it is unsurprising that impulsivity has been cited across multiple studies as a significant mediator or moderator of GD. However, impulsivity is also a feature of other NDDs such as autism and ID. People with ID display greater levels of impulsivity compared to those without ID due to cognitive development being associated with behavioural inhibition (Farrokhian et al.,2020). Another study showed that 1 in 2 adolescents with ID and autism exhibited impulsive behaviours (Bradley & Isaacs ,2006). Similarly, Grant et al (2020) found that autistic traits were correlated more specifically with attentional impulsivity.

This review found several studies corroborating the association between impulsivity, ADHD and GD (Martins et al.,2008; Jacob et al.,208; Fatseas et al.,206; Grall Bronnec et al.; 2011; Mak et al.; 2018; Reid et al.,2020; Rodriguez-Jimenez et al.,2006; Walthere et al.,2012; Faregh & Derevensky, 2011). Although some did not confirm this association (Faregh & Derevensky, 2011) the strength of those conclusions is weakened by sample sizes in comparator groups being underpowered to detect significant differences.

El Archi et al (2023) report that co-occurring ADHD and GD are independently correlated with impulsivity, especially in aspects of 'sensation seeking' and 'positive urgency'. Black et al (2015) found that trait impulsivity and ADHD were associated with early onset of GD ($p<0.001$), whilst Canu & Schatz (2011) found an association between impulsivity and gambling only in males with ADHD. Clark et al (2013) noted that whilst ADHD per se was not associated with GD, a subset of those with ADHD who reported hyperactive- impulsive type symptoms, were significantly more likely to have GD. This was confirmed in linear probability and logistic regression models. Chamberlain et al (2015) also report that gamblers with ADHD scored more highly than those without on all three subscales of impulsivity on the (BIS-11).

Dai et al (2006) investigated the relationship between impulsivity (measured by delay and probability discounting), gambling related cognitions and behaviour. Low probability discounting (rather than delay discounting) was found to explain the significant variance in gambling after controlling for ADHD symptoms. The authors concluded that facets of impulsivity relating to risk proneness may be an independent risk factor for problem gambling in people with ADHD. Further research is required to ascertain if this relationship extends to other NDDs and GD.

**Emotional Regulation**

Emotional regulation refers to "conscious or unconscious processes of monitoring, evaluating, modulating, and managing emotional

experiences and expression of emotion in terms of intensity, form and duration of feelings, emotion-related physiological states and behaviours" (Kok, 2020, 471). People with NDDs often experience difficulties in emotional regulation. El Archi et al (2023) found that difficulties in emotional regulation were highly linked to aspects of impulsivity, such as 'impulse control' and 'goal directed behaviour' in participants with comorbid ADHD and GD.

Davtian et al. (2012) found that gamblers with ADHD had more emotional instability, interpersonal sensitivity and stress proneness, lower self-esteem, greater difficulty in being assertive and lower levels of self-discipline compared to gamblers without ADHD. Peter et al. (2016) found that disordered gamblers with ADHD displayed more severe GD and psychological distress along with maladaptive coping strategies in response to stress, compared to those without ADHD.

Interestingly, Mestre Bach et al (2021) found that the association between GD and ADHD was strongly mediated by emotional regulation (correlation = 0.27) and that there was no significant relationship between ADHD and GD severity without this mediating factor.

**Compulsivity**

Compulsivity is a core feature of addiction disorders, characterized by maladaptive repetitive behaviours that an individual feels forced to carry out and are not in line with their overall goal. In a 2018 systematic review, van Timmerman et al. reported that impairments in general compulsivity-related executive functions, such as perseverative behaviours or cognitive inflexibility, may be related to addiction. Grant and Chamberlain (2020) found that whilst a link between compulsivity and autistic traits exists, it was only found specifically for checking compulsions and thoughts of harm to self/others, rather than for all types of compulsivity Whilst the research and discussion around compulsivity as a feature in comorbid NDDs and GD is limited, we regard this factor as a potentially important area which warrants further research, given its centrality to addiction disorders as well as prevalence within some NDDs, particularly autism.

**The Pathways Model**

The pathways model of problem and pathological gambling proposes three distinct types of gamblers with different pathways into gambling; 'behaviourally conditioned,' 'emotionally vulnerable' and 'antisocial impulsivist' (Blaszczynski & Nower,2002). This model may be a useful starting point to conceptualise how and where certain NDDs may influence specific subgroups of gamblers. For example, people with ID or ASD who gamble may be more susceptible to cognitive distortions around probabilities and poor decision-making, thereby increasing their risk of becoming 'behaviourally conditioned' gamblers. El Archi et al. (2023) also refer to this well-known model, citing that the 'antisocial impulsivist' gamblers show higher scores on measures of impulsivity. This group

exhibits greater severity of gambling, earlier onset, and affective instability (Blaszczynski & Nower,2002). Moon et al. (2017) note significantly higher levels of ADHD and antisocial personality disorder in gamblers classed as 'antisocial impulsivist'. Similarly, Peter et al (2016) report that individuals (such as those with ADHD) who fall into both the 'emotionally vulnerable' and 'antisocial impulsivist' pathways are prone to psychosocial vulnerabilities, maladaptive coping strategies and problem-solving abilities, with trait impulsivity preceding the onset of gambling.

This conceptualisation may be useful in terms of risk profiling and understanding perpetuating factors for people with different NDDs who are likely to fall into specific gambler sub-groups. For example, those that become 'behaviourally conditioned' gamblers are often those who have exposure to gambling by chance or through family/peer groups and gamble for entertainment or socialisation. This group displays the least severe form of GD, and they benefit from counselling/minimal intervention programmes (Blaszczynski & Nower,2002). Pitt et al (2020) refer to this accessibility and exposure being of particular concern for individuals with ID who attend 'clubs' in Australia as part of supported recreational activities. In contrast, the 'emotionally vulnerable' group (which can include those with ADHD) has underlying biopsychosocial characteristics that may contribute to increased risk and severity of GD, perpetuated through negative reinforcement of reducing anxiety or depressive symptoms by gambling. In this case, it would be prudent to treat the underlying vulnerabilities as well as the GD which may require a cognitive behavioural therapy approach.

**Implications**

The findings of this review have implications for practice and research. This review confirms that the literature on GD and NDDs beyond ADHD remains limited and further research is required in this area.

There are shared biopsychosocial risk factors for NDD and GD, which increases the risk of this comorbidity. Both have roots in neural development and cognitive changes, with high rates of psychiatric comorbidity and increased risk of economic, cultural, and social deprivation. It is prudent to understand this temporal sequencing better. We know that NDDs predispose to increased risk of mental health problems and that mental health problems can increase the risk of GD. People with NDDs may be more vulnerable to GRH due to cognitive deficits, concerns around informed decision-making and mental capacity, ability to understand gambling safety information, increased impulsivity, poorer emotional regulation, risks of exploitation through online gambling and limitations in social awareness. Senior clinicians and researchers in the UK have recently highlighted priorities for gambling research and note the need to better understand the neurobiological basis of gambling, including impulsivity (Bowden Jones et al.,2022).

Szerman et al (2022) propose that a 'gambling dual disorder,' is warranted, given its significant comorbidity with other disorders. Similarly,

we support the need to consider a dual diagnosis of GD and NDDs which has implications for clinical practice. With the rapid roll out of new NHS clinics for treatment of GD (NHS England, 2023), the need to plan and offer the most effective and appropriate services for those with GD and NDDs is particularly acute.

Evidence from this review highlights impulsivity as a significant underlying factor in the GD/NDD relationship, with a smaller number of studies also citing emotional regulation and cognitive distortions as key. Certain NDDs are more likely to be associated with these factors and therefore understanding these behaviours and cognitions in the context of NDD may help in developing appropriately tailored interventions. For each of these three issues, specific CBT and Mindfulness interventions have evidence of efficacy e.g. impulse control training for impulsivity (Smith et al, 2019); ACT and DBT for emotional regulation (Moore et al, 2022); and cognitive therapies for reducing cognitive distortions (Goodie et al, 2019). Whilst standard CBT is currently a mainstay of gambling treatment, these interventions may need to be modified for those with comorbid NDD.

Black et al (2013) noted that in GD treatment, ADHD symptoms reduce/improve in parallel with reductions in GD scores, suggesting that appropriate treatment helps those with GD to improve their planning and attention skills thereby reducing gambling and other impulsive behaviours. For people with mild to moderate ID, CBT based interventions can be effective (Unwin et al., 2016) given appropriate support and preparation such as 'cognitive mediation' (Stott et al, 2017). For those with more severe cognitive impairments and GD, issues of mental capacity, best interests and appropriate safeguarding procedures may be important to consider.

In the UK, only those over the age of 18 years are permitted to enter licenced gambling premises or purchase National Lottery products, including draw-based games, scratch cards and online instant-win games. This age restriction poses potential problems when considering people with ID given that their developmental and chronological ages are not aligned. People with ID have a developmental age of 11 years old or less, depending on the severity of the intellectual disability (Patel et al.,2020). Therefore, issues around mental capacity to understand the risks and consequences of gambling and the way in which information around gambling harms is conveyed, needs to be carefully considered in the context of neurodiversity.

## Limitations

The present study has several limitations. There were few studies on NDDs other than ADHD. The lack of studies on intellectual disability, learning disorders, autism and other NDDs meant that we were unable to obtain sufficient quantitative data to perform analyses or come to clear conclusions about any associations between these issues and GD. However, several studies discussed the significant morbidity and risk amongst this population, providing valuable qualitative evidence as to the associations between other NDDs and GD which we have included in our discussion.

Many of the studies used self-report scales for the phenomenon of interest and in some cases asked participants to retrospectively report on presence of symptoms in childhood, leading to risk of participant and recall bias. In some cases, the diagnosis of ADHD was not certain, with authors reporting on "probable current ADHD.' The breadth of assessment tools used in studies (some validated and some not) causes difficulty in determining consistency between study findings. An overview of measurement issues across the studies has been included in Appendix 3. Study population sizes also varied widely, giving rise to wide ranging comorbidity figures which causes issues with accurately determining comorbidity prevalence. Other confounding factors included participant GD treatment-seeking/non-treatment-seeking status, and multiple psychiatric and NDD comorbidities, leading to challenges in determining the relationship between a specific NDD and GD.

## Conclusions

Despite the limitations noted above, this study is to our knowledge, the first international review of the prevalence of GD and comorbid NDDs as per DSM V NDD sub-categorisation. It has highlighted a need for further research into other NDDs besides ADHD, given the biopsychosocial vulnerabilities that present with other NDDs and neurodiversity. Further, we have shown that impulsivity, emotional regulation, and cognitive distortions may be key factors which relate to both GD and NDD, representing potential assessment and treatment targets. Our review provides findings which may be helpful for architects of assessment and treatment guidance, such as NICE guidelines, and points the way to future studies to be aligned towards filling in the gaps in existing evidence.

Future research needs to use gold standard measures for assessing both GD and NDDs; and to explore the relationship between different NDDs and GD as a central aim, rather than this analysis being an afterthought in studies exploring other issues. Studies also need to go beyond quantifying prevalence or establishing association, to translating this research to target prevention and providing appropriately tailored clinical practice. More longitudinal studies are required to understand the risks, onset, course, severity, abstinence, and treatment adherence of GD in people with NDDs.

The following recommendations are proposed; 1) GD treatment clinics should routinely screen for ADHD and ASD; 2) Gambling treatment services should consider developing treatment strategies tailored to those with neurodiversity or NDD; 3) Gambling regulators should consider implementing neurodiverse-friendly gambling safety messages and easy read materials; 4) Future research should include all NDDs and consider functional MRIs in people with NDD and GD to understand the neurobiological basis of this comorbidity.

**Statement of Competing Interests**

NB: none declared. JR has received funding for gambling research from regulatory settlement money paid to the UK gambling commission by gambling operators and administered via GREO. AR has received funding for gambling research from regulatory settlement money paid to the UK gambling commission by gambling operators and administered via GREO.

**Relative Contribution**

JR and NB conceived the study and wrote the first draft of the paper. All authors contributed to the review process and wrote the final version of the paper.

**Ethics Approval**

N/A.

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None.

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## Appendix 1

Search Strategy and Selection Criteria

Electronic searches of relevant databases were conducted using a combination of keywords and wildcards relating to gambling and NDD. The following were included:

MEDLINE, Embase, PsycINFO, CINAHL, Cochrane Library, PubMed, SCOPUS and Web of Science. Additionally, the following websites were searched; British Psychological Society, DH, DHSPSS-NI, MFH, NHS, NHS Scotland, Royal College of Psychiatrists, Welsh Government. The reference lists of included studies were also searched manually.

Best practice involves searching for unpublished studies to synthesize the totality of available evidence and reduce bias (Hunter et al, 2022). Therefore, the most common trial registers; clinical trials.gov and WHO ICTRP were searched.

The following search strings were used; (Gambling/ OR (problem* or patho* or harm ADJ2 gambl*).ab, ti. OR (addict* ADJ2 gambl*).ab, ti. OR (disorder* ADJ2 gambl*).ab, ti. ) AND (neurodevelopmental disorders OR calulia* OR praxia* OR mental retardation OR developmental learning disorders OR dyspraxia OR dyslexia OR Downs OR Fragile X OR Foetal alcohol OR fetal alcohol OR pervasive developmental disorder OR asperger OR disorders of intellectual development OR learning disability OR intellectual disability OR adhd or attention deficit hyperactivity OR adhd OR attention deficit-hyperactivity disorder OR autism OR speech and language OR tic OR tourette).

## Appendix 2:

Inclusion/exclusion criteria

Inclusion criteria: Qualitative or quantitative studies which include reports of an NDD and gambling disorder or gambling related harm. The review will include experimental studies, randomised and non-randomised control trials, cohort studies, case series reports and single case studies. The review will adopt an inclusive approach to the definition and measurement of gambling related harm, including studies of patients reporting data on brief screens for disordered gambling, as well as studies of problem or pathological gambling identified using other assessment tools. As there is no gold standard for measuring gambling problems in the general population, we will also consider a range of scales and other measures of gambling related harm. Relating to NDD, all conditions under this category as defined by DSM V will be included. This will include studies which report diagnosed or probable NDD using brief screening tools or comprehensive clinical interviews, retrospective diagnoses, or core features of diagnoses in the case of ADHD (i.e., hyperactivity, impulsivity, inattention) as well as special educational needs.

Exclusion criteria: Studies will be excluded if they fail to report findings relating to gambling and/ or gambling related harm and NDD, and if they are not published in English.

## Appendix 3:

Q1 Were the criteria for inclusion in the sample clearly defined?
Q2. Were the study subjects and the setting described in detail?
Q3. Was the exposure measured in a valid and reliable way?
Q4. Were objective standard criteria used for measurement of the condition?
Q5. Were confounding factors identified?
Q6. Were strategies to deal with confounding factors stated?
Q7. Were the outcomes measured in a valid and reliable way?
Q8. Was appropriate statistical analysis used?

N/A = Not applicable
NR = Not
reported

Risk of Bias Table

| Authors | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Do authors report on industry funding or conflicts of interest? | Risk Of Bias rating: low/moderate/high |
|---|---|---|---|---|---|---|---|---|---|---|
| Abouzari et al , 2016 | no | yes | yes | yes | no | no | yes | yes | Not reported | Moderate |
| Aymami et al, 2015 | no | yes | no | yes | yes | yes | yes | yes | Several sources of funding reported, no industry funding. No conflicts of interest declared | Moderate |
| Brandt & Fischer, 2019 | yes | yes | yes | yes | yes | yes | yes | yes | No conflicts of interests declared. Funding from Jubilee Fund of the Austrian National Bank | Low |
| Breyer et al, 2009 | no | yes | yes | yes | yes | yes | yes | yes | Funded by National Institute on Drug Abuse grants | Low |
| Black et al, 2013 | yes | yes | yes | yes | yes | no | no | yes | Funded in part through grants from the National Center for Responsible Gaming (Washington, DC) and the | Moderate |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | National Institute on Drug Abuse. Also Dr Black receives research support from AstraZeneca | |
| Black et al, 2015 | yes | yes | yes | yes | yes | no | yes | yes | National Institute on Drug Abuse and the National Institute on Aging. Dr. Black also receives research support from AstraZeneca | Low |
| Black et al, 2017 | yes | yes | yes | yes | yes | no | no | no | Funding from National Institute on Aging. Dr. Black also receives research support from AstraZeneca | Moderate |
| Canu, 2011 | no | no | yes | yes | no | no | yes | yes | Not reported | Moderate |
| Chamberlain et al, 2015 | yes | yes | yes | yes | yes | no | yes | yes | Several sources of funding, no industry funding. Conflict of interests declared; research grants from NIMH, National Center for Responsible Gaming, and Forest and Roche Pharmaceuticals. Author receives yearly compensation from Springer Publishing for acting as Editor-in-Chief of the Journal of Gambling Studies | Low |
| Clark et al, 2013 | no | no | no | no | yes | no | no | yes | Funded by a grant from US National Institute of Child Health and Human Development, | High |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | with cooperative funding from 17 other agencies. No reports on conflict of interest | |
| Dai et al, 2016 | yes | yes | yes | yes | yes | yes | yes | yes | No funding and no conflicts of interest | low |
| Dannon et al, 2006 | no | yes | yes | yes | yes | yes | yes | yes | Not reported | Low |
| Davtian et al, 2012 | yes | yes | yes | yes | yes | yes | yes | yes | Not reported | Low |
| Dowling et al, 2015 | yes | yes | yes | yes | yes | NR | yes | yes | No specific grant from any funding agency in the public, commercial, or not-for-profit sectors. No conflicts of interest | Low |
| El Archi et al, 2023 | yes | yes | yes | yes | yes | yes | yes | yes | Authors report funding from pharmaceutical companies | low |
| Faregh and Derevensky 2011 | no | no | no | yes | yes | no | yes | yes | Not reported | Moderate |
| Fatseas et al, 2016 | yes | yes | yes | yes | yes | yes | yes | yes | The funding sponsors had no role in the design and conduct of the study, in the collection, analysis, and interpretation of the data, or in the preparation, review, or approval of the manuscript. The researchers confirm their independence from funders and sponsors. All authors report no conflict of interests. | Low |

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| Fatseas et al, 2016 | yes | yes | yes | yes | yes | yes | yes | yes | The funding sponsors had no role in the design and conduct of the study, in the collection, analysis, and interpretation of the data, or in the preparation, review, or approval of the manuscript.The researchers confirm their independence from funders and sponsors. All authors report no conflict of interests. | Low |
| Grall-Bronnec et al, 2011 | yes | yes | yes | yes | yes | yes | yes | yes | Funding from the University Hospital of Nantes and gambling industry operators (FDJ and PMU) | Low |
| Grant and Chamberlain 2021 | yes | yes | yes | yes | yes | yes | yes | no | Funded by a Center of Excellence grant from The National Center for Responsible Gaming (NCRG). Jon Grant has received research grants from the TLC Foundation for Body Focused Repetitive Behaviors, Otsuka and Promentis Pharmaceuticals. Dr. Grant receives yearly compensation from Springer Publishing for acting as Editor-in-Chief of the Journal of Gambling Studies | Moderate |

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| Gupta et al, 2013 | no | no | yes | yes | yes | no | yes | yes | Not reported | Moderate |
| Hardoon et al, 2002 | yes | yes | yes | yes | yes | yes | no | yes | Authors reported receiving funding from Ontario Problem Gambling Research Centre, but no industry funding reported. Authors did not report any conflict of interest | Low |
| Hellstrom et al, 2017 | no | yes | yes | yes | yes | no | yes | yes | No conflicts of interests. Study had funding from various organisations but study sponsors had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. | Low |
| Jacob et al, 2018 | no | no | yes | yes | yes | no | yes | yes | Funded by ISCIII and European Regional Development Fund (ERDF-FEDER). These funders had no role in the study design, collection, analysis and interpretation of the data; writing of the report; and the decision to submit the article for publication. Authors had no conflicts of interest | Moderate |
| Jaisoorya et al, 2016 | no | yes | yes | yes | yes | no | yes | yes | Funded by National Rural Health Mission, no conflicts of interest | Low |

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| Karaca et al, 2017 | yes | N/A | yes | yes | yes | yes | yes | yes | Industry and pharmacetuical funding. Several competing interests declared by authors | Low |
| Kerber et al, 2008 | no | no | yes | yes | yes | no | yes | yes | Not reported | Moderate |
| Kessler et al, 2008 | no | no | yes | yes | yes | no | yes | yes | Funding from several sources including industry funding. Authors declare competing interests involving alliance with pharmaceutical companies | Moderate |
| Mak et al 2018 | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Authors report Centre Grant Research Seed Funding (Pilot Study) at the Institute of Mental Health, Singapore CRC | Low |
| Martins et al 2007 | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | The study was supported by a Young Investigator Incentive Grant from the Institute for Research on Pathological Gambling and Related Disorders, Division on Addictions, Harvard Medical School, Cambridge Health Alliance. Author competing interests declared | Low |

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| Martins et al 2008 | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | The study was supported by a Young Investigator Incentive Grant from the Institute for Research on Pathological Gambling and Related Disorders, Division on Addictions, Harvard Medical School, Cambridge Health Alliance. Author competing interests declared | Low |
| McDonald et al 2021 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Several sources of funding, but no industry funding. | Low |
| McNamara et al 2008 | Yes | Yes | No | No | Yes | Yes | No | Yes | Not reported | Moderate |
| Mestre Bach et al 2021 | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Several sources of funding, but no industry funding. | Low |
| Moon et al 2014 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | The research was supported by the Ontario Problem Gambling Research Centre, the Joe Young Sr–Helene Lycaki Funds from the State of Michigan, and the Detroit Wayne Mental Health Authority. Authors report no conflicts of interest | Low |
| Ostojic et al 2014 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | The authors declare that they have no financial relationships to report. | Low |

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| Parker et al 2013 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Several sources of funding but no industry funding reported | Low |
| Peter et al 2016 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | The authors report no funding source and no conflict of interest | Low |
| Piasecki et al 2019 | yes | yes | Yes | Unclear | Unclear | Unclear | no | yes | Several sources of funding but no industry funding reported | High |
| Pitt et al 2020 | yes | yes | n/a | n/a | n/a | n/a | n/a | n/a | Several sources of funding but no industry funding reported | Moderate |
| Preston et al 2012 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Several sources of funding but no industry funding reported | Low |
| Reid et al 2020 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Financial support for this study was provided in part from the Florida Council on Compulsive Gambling, the Seminole Tribe of Florida, and the Office of Problem Gambling, California Department of Public Health. | Low |
| Retz et al 2016 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Not reported | Low |
| Rodriguez-Jimenez et al 2006 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Not reported | Low |
| Romo et al 2015 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Received funding directly from the gambling industry operators (FDJ and PMU). Scientific independence towards gambling | Low |

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| | | | | | | | | | industry operators is warranted. There were no constraints on publishing | |
| Romo et al 2016 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Funding directly from the gambling industry, although authors report this funding had no influence on this work. Scientific independence toward the gambling industry is assured. Authors declare that they have no conflict of interest. | Low |
| Romo et al 2018 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | The authors report that the study was self funded and declare no conflict of interest | Low |
| Scheidemantel et al 2019 | No | Yes | Yes | Yes | No | No | No | N/A | Several sources of funding but no industry funding reported. No conflicts of interest | High |
| Shoham et al 2021 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | The study was conducted with the financial support of an internal grant of the authority for research and development, Hebrew University of Jerusalem | Low |
| Silbernagel et al 2019 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Several sources of funding but no industry funding reported. No | Low |

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| Szerman et al 2022 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Several sources of funding but no industry funding reported | Low |
| Tanaka et al 2023 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No funding received for the study | Low |
| Taylor et al 2015 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Several sources of funding but no industry funding reported | Low |
| Theule et al 2019 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | This research was funded by the Manitoba Gambling Research Program of Manitoba Liquor & Lotteries; however, the findings and con-clusions of this paper are those solely of the author(s) and do not necessarily represent the views of Manitoba Liquor & Lotteries. | Low |
| Vintro Alcatraz et al 2021 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | FFA received consultancy honoraria from Novo Nordisk and editorial honoraria as EIC from Wiley. The rest of the authors declare no confict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in | Low |

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| | | | | | | | | | the decision to publish the results. | |
| Walther et al 2012 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | This study was financed by the Ministry of Employment, Social Affairs and Health of the German federal state of Schleswig-Holstein, which did not participate in the study design, collection and analysis of data or in the writing and submission of the manuscript. | Low |
| Waluk et al 2016 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | The authors declare that they have no conflict of interest. | Low |