Clinical Psychology Review 74 (2019) 101784

Contents lists available at ScienceDirect

Clinical Psychology Review

journal homepage: www.elsevier.com/locate/clinpsychrev

Review

The diagnostic accuracy of brief screening instruments for problem gambling: A systematic review and meta-analysis

N.A. Dowling[a,b,*,1], S.S. Merkouris[a,1], S. Dias[a], S.N. Rodda[c], V. Manning[d,e], G.J. Youssef[a,f], D.I. Lubman[d,e], R.A. Volberg[g]

[a] School of Psychology, Deakin University, 1 Gheringhap St, Geelong, VIC 3220, Australia
[b] Melbourne Graduate School of Education, University of Melbourne, Kwong Lee Dow Building, 234 Queensberry Street, Parkville, VIC 3053, Australia
[c] School of Population Health, Faculty of Medical and Health Sciences, 216 Morrin Road, Auckland 1142, New Zealand
[d] Eastern Health Clinical School, Faculty of Medicine, Nursing & Health Sciences, Monash University, Level 2, 5 Arnold Street, Box Hil, 3128 Melbourne, Victoria, Australia
[e] Turning Point, Eastern Health, 110 Church Street, Richmond 3121, VIC, Australia
[f] Centre for Adolescent Health, Murdoch Children's Research Institute, Royal Children's Hospital, Flemington Road, Parkville 3052, Victoria, Australia
[g] School of Public Health and Health Sciences, University of Massachusetts, 715 N. Pleasant Street, Amherst, MA 01003, USA

HIGHLIGHTS

- Review is a valuable resource for health service providers and researchers.
- Identification of most accurate (1–5 item) problem gambling screening instruments.
- Diagnostic accuracy across settings, age groups, and instrument timeframes explored.
- Five instruments satisfactorily detected both problem and at-risk gambling.
- These are BPGS (2-item), NODS-CLiP, PGSI-Short Form, NODS-PERC, and NODS-CLiP2.

ARTICLE INFO

Keywords:
Gambling
Screening
Sensitivity
Specificity
Classification accuracy
Diagnostic accuracy
Systematic review

ABSTRACT

Non-gambling specialist services, such as primary care, alcohol and other drug use, and mental health services, are well placed to enhance the identification of people with gambling problems and offer appropriate generalist first level interventions or referral. Given time and resource demands, many of these clinical services may only have the capacity to administer very short screening instruments. This systematic review was conducted to provide a resource for health service providers and researchers in identifying the most accurate brief (1–5 item) screening instruments to identify problem and at-risk gambling for their specific purposes and populations. A systematic search of peer-reviewed and grey literature from 1990 to 2019 identified 25 articles for inclusion. Meta-analysis revealed five of the 20 available instruments met criteria for satisfactory diagnostic accuracy in detecting both problem and at-risk gambling: Brief Problem Gambling Screen (BPGS-2), NODS-CLiP, Problem Gambling Severity Index-Short Form (PGSI-SF), NODS-PERC, and NODS-CLiP2. Of these, the NODS-CLiP and NODS-PERC have the largest volume of diagnostic data. The Lie/Bet Questionnaire and One-Item Screen are also promising shorter options. Because these conclusions are drawn from a relatively limited evidence base, future studies evaluating the diagnostic accuracy of existing brief instruments across settings, age groups, and time-frames are needed.

1. Background

The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) has classified gambling disorder as an addiction and related disorder, along with substance use disorders (American Psychiatric Association, 2013). In contrast, consistent with public health frameworks that conceptualise gambling problems across a continuum of risk (Shaffer & Korn, 2002), the term problem gambling is employed in many jurisdictions to refer to all forms of gambling that lead to adverse consequences for the gambler, others, or the community

* Corresponding author at: School of Psychology, Melbourne Burwood Campus, 221 Burwood Highway, , Burwood, VIC 3125, Australia.
E-mail addresses: nicki.dowling@deakin.edu.au (N.A. Dowling), s.rodda@auckland.ac.nz (S.N. Rodda), rvolberg@umass.edu (R.A. Volberg).
[1] Shared first authorship.

https://doi.org/10.1016/j.cpr.2019.101784
Received 21 January 2019; Received in revised form 22 October 2019; Accepted 26 October 2019
Available online 13 November 2019

(Neal, Delfabbro, & O'Neil, 2005). The average standardised past-year prevalence rate in adults approximates 2.3% across countries (Williams, Volberg, & Stevens, 2012). Despite ostensibly being an activity that is legally restricted to adults (typically aged 18 years or older) in many jurisdictions, gambling is also a relatively popular activity among adolescents. Although multiple situational and measurement issues may have inflated rates of problem gambling in young people (see Derevensky, Gupta, & Winters, 2003; Shaffer & Korn, 2002), estimates of past year gambling problems in young people internationally range from 0.2% to 12.3% (Calado, Alexandre, & Griffiths, 2017). Despite problem gambling being a relatively low base-rate phenomenon, the burden of harm resulting from gambling-related problems is of a level approximately two-thirds that of alcohol abuse/dependence and major depressive disorder (Browne, Greer, Rawat, & Rockloff, 2017). The negative sequelae of gambling problems can include financial harm, relationship dysfunction and conflict, emotional distress, health decrements, cultural harm, reduced work or study performance, and criminal activity (Langham et al., 2016).

1.1. Screening for problem gambling in clinical settings

Despite the considerable harms that can result from gambling problems, relatively few people with gambling problems seek professional help from specialist gambling services (Séguin et al., 2013; Suurvali, Hodgins, Toneatto, & Cunningham, 2008). There is, however, growing evidence to suggest that people with gambling problems are over-represented in primary care (Goodyear-Smith et al., 2006; Levens, Dyer, Zubritsky, Knott, & Oslin, 2005; Morasco, Vom Eigen, & Petry, 2006; Pasternak & Fleming, 1999) alcohol and other drug use (AOD) services (Cowlishaw, Merkouris, Chapman, & Radermacher, 2014), psychiatric inpatient services (Aragay et al., 2012), psychiatric outpatient services (Dowling et al., 2014; Henderson, 2004; Manning et al., 2017; Nehlin, Gronbladh, Fredriksson, & Jansson, 2013), and specific mental health populations, such as those with mood disorders, anxiety disorders, and psychotic disorders (Aragay et al., 2012; Cowlishaw, Hakes, & Dowling, 2016; Dowling et al., 2014; Haydock, Cowlishaw, Harvey, & Castle, 2015; Henderson, 2004; Jones et al., 2015; Kennedy et al., 2010; Manning et al., 2017; McIntyre et al., 2007; Nehlin et al., 2013; Quilty, Watson, Robinson, Toneatto, & Bagby, 2011). Individuals with problem gambling also present to other services, such as family violence (2.2%) and financial counselling services (10.6%; Dowling et al., 2014).

The presence of problem gambling complicates the clinical profile of patients with mental health disorders as it is associated with more severe psychiatric symptoms, alcohol and drug use problems, interpersonal and financial problems, poorer physical health and social functioning, cognitive impairment, impulsivity, suicidality, and personality disorder pathology (Biddle, Hawthorne, Forbes, & Coman, 2005; Cowlishaw et al., 2016; Di Nicola et al., 2010; Haydock et al., 2015; Henderson, 2004; Jones et al., 2015; Kennedy et al., 2010; Manning et al., 2017; McIntyre et al., 2007; Zimmerman, Chelminski, & Young, 2006). Moreover, the findings of age of onset studies using retrospective methodologies suggest that at least one other psychiatric disorder typically occurs after the development of problem gambling in approximately one-quarter of cases (Hodgins, Peden, & Cassidy, 2005; Kessler et al., 2008). There is also evidence from longitudinal studies that problem gambling predicts the subsequent development of a range of disorders, including AOD, mood, and anxiety disorders (Chou & Afifi, 2011; Dussault, Brendgen, Vitaro, Wanner, & Tremblay, 2011; Parhami, Mojtabai, Rosenthal, Afifi, & Fong, 2014; Pilver, Libby, Hoff, & Potenza, 2013). Taken together, these findings suggest that problem gambling has the potential to compromise engagement, management plans and mental health outcomes, particularly if it goes undetected and untreated (Brett et al., 2014; Chou & Afifi, 2011; Himelhoch et al., 2015).

These findings highlight the importance for services located in local communities, such as primary care, AOD, and mental health services, to accurately screen for problem gambling. These highly accessible services are logistically well placed to enhance the identification of people with gambling problems and offer appropriate generalist first level interventions or referral (Brett et al., 2014; Dowling et al., 2018; Goodyear-Smith, Arroll, & Coupe, 2009; Manning et al., 2017; Rockloff, Ehrich, Themessl-Huber, & Evans, 2011; Rodda, Manning, Dowling, Lee, & Lubman, 2018; Sullivan, McCormick, Lamont, & Penfold, 2007). Although health providers in these services acknowledge that they have a role in helping clients with gambling problems (Corney, 2011; Rodda et al., 2018; Sanju & Gerada, 2011; Sullivan et al., 2007; Sullivan, Arroll, Coster, Abbott, & Adams, 2000; Temcheff, Derevensky, St-Pierre, Gupta, & Martin, 2014), they hold generally negative attitudes towards screening (Sullivan et al., 2000) and report low rates of screening behaviour (Achab et al., 2014; Manning et al., 2017). Perceived barriers to such screening include lack of time, an absence of information about the effectiveness of screening, a lack of knowledge and skills, the presence of gambling-related stigma, a perception that problem gambling has a low burden of disease, an absence of effective interventions, and limited access to specialist referral services (McCambridge & Cunningham, 2007; Rodda et al., 2018; Rowan & Galasso, 2000; Sullivan, 2011; Sullivan et al., 2000; Sullivan et al., 2007). The low rate of screening may also be, in part, due to the relatively slow development of brief screening instruments and a lack of easily accessible information on their diagnostic accuracy. In the previous decade, however, there has been a rapid growth in the development of brief screening instruments to detect gambling problems.

1.2. Screening for problem gambling in research

In addition to screening for problem gambling in clinical settings, brief screening instruments are increasingly employed in problem gambling research, including population-level epidemiological studies (e.g., Gebauer, LaBrie, & Shaffer, 2010; Scholes-Balog, Hemphill, Dowling, & Toumbourou, 2014; Scholes-Balog, Hemphill, Toumbourou, & Dowling, 2015, 2016; Toce-Gerstein, Gerstein, & Volberg, 2009) or school-based research (Lepper & Haden, 2013; Rossow & Molde, 2006). Extended self-report instruments or the inclusion of full diagnostic instruments is often not practical or affordable (Gebauer et al., 2010; Lepper & Haden, 2013; Rossow & Molde, 2006; Toce-Gerstein et al., 2009). In particular, brief instruments can be incorporated into population surveys to provide more cost-effective data collection compared to conducting gambling-specific studies (Rossow & Molde, 2006).

1.3. Brief screening instruments for problem gambling

Accurate screening instruments have the potential to improve care and reduce healthcare costs (Tiet, Finney, & Moos, 2008). There is, however, currently limited systematic evidence to guide clinicians and researchers in their selection of a psychometrically sound instrument to screen for problem gambling for their purpose, population, or setting of interest. Although several reviews exploring the psychometric properties of problem gambling assessment instruments are available (Edgren et al., 2016; Stinchfield, 2010, 2014; Stinchfield, Govoni, & Frisch, 2007), these are mostly narrative in nature. To date, only one systematic review is available, which explores the diagnostic accuracy and psychometric properties of instruments measuring at-risk and problem gambling among young individuals (Edgren et al., 2016).

The available reviews have generally failed to provide an up-to-date catalogue of brief screening instruments for problem gambling due to their rapid growth in development over recent years. Given time and resource demands, many clinical services or research protocols may only have the capacity to administer very short screening instruments that require little time to administer (Himelhoch et al., 2015). It is therefore essential that screening instruments employed in these clinical settings are brief, easy to use, easily scored, and require minimal training (Brett et al., 2014; Goodyear-Smith et al., 2008; Rockloff et al., 2011; Stinchfield & McCready, 2014; Toce-Gerstein et al., 2009;

Volberg, Munck, & Petry, 2011). Consistent with other areas of addiction, one- to five-item instruments developed to screen for problem gambling are considered brief because they can be administered in a short period of time (typically one to two minutes; Stinchfield, 2014).

The available reviews have also generally focussed on the identification of gambling problems at the more severe end of the risk continuum (i.e., problem gambling and gambling disorder/pathological gambling). Recent research, however, suggests that at-risk gamblers contribute to the majority of the total gambling-related burden of harm due to their higher prevalence in the population (Browne et al., 2017), highlighting the need for accurate screening and appropriate early intervention for this group.

The selection of a screening instrument may also be determined by other clinical service or research needs, such as the setting in which the screening is conducted, the age of the population, and the timeframe of the instrument (Himelhoch et al., 2015). First, because some indices of diagnostic accuracy are a function of the base prevalence rate of the disorder within the population in which it is used (Eusebi, 2013; Šimundić, 2009), different instruments may be selected within general population settings and clinical settings. Second, the use of brief screening instruments developed for use in adult samples may not be appropriate for screening in adolescent populations, given that their gambling behaviour or harms may be qualitatively different to those of adults (Derevensky et al., 2003; Stinchfield, 2010; Stinchfield et al., 2007; Stinchfield & McCready, 2014) and their responses may be influenced by the wording of questions (Lepper & Haden, 2013). Finally, the timeframe used by the instrument should be determined by the purpose of the screening; for example, instruments measuring lifetime problem gambling do not adequately discriminate between individuals experiencing current problem gambling and those in remission or recovery (Stinchfield et al., 2007; Stinchfield & McCready, 2014).

1.4. Review aims

The primary aim of this systematic review and meta-analysis is therefore to serve as a resource for various health, social, and welfare service providers, as well as researchers, in the identification of the most accurate brief screening instruments for both problem and at-risk gambling for their specific purposes and populations. Secondary aims are to compare the diagnostic accuracy of brief screening instruments according to setting (general population settings, non-gambling clinical settings), age group (adults, adolescents), and instrument timeframe (current, lifetime) using subgroup analyses; and to explore whether the findings were robust to the quality of methodology utilised in the included studies using sensitivity analyses.

2. Method

The reporting of this systematic review is compliant with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA; Moher, Liberati, Tetzlaff, & Altman, 2009).

2.1. Protocol registration

The protocol for this systematic review was registered with PROSPERO (ID: CRD42018091863). Differences between the PROSPERO protocol and the published review include: (1) the search was updated to include articles published to February 2019 instead of January 2018; (2) given the density of the manuscript, data relating to two additional QUADAS risk of bias items (whether all participants were administered both the screening measure and the reference standard; and whether the reference standard was independent of the screening measure) were not reported and the associated sensitivity analyses were not conducted; and (3) given the small number of included articles conducted in non-gambling clinical settings, the proposed setting subgroup analysis was restricted to any non-gambling clinical setting instead of primary care vs AOD services vs mental health services.

2.2. Search strategy

A detailed description of the search strategy is provided in Appendix A. The systematic search procedure included an electronic and grey literature search to identify studies that provided estimates of diagnostic accuracy of brief problem gambling screening instruments. Electronic databases, including Medline and PsycINFO were searched for peer-reviewed articles. The search terms used incorporated a combination of keywords and wildcards relating to gambling (e.g., gambl* or wager*), specific screening instruments (e.g., screen* or lie-bet), and diagnostic accuracy (e.g., sensitivity or specificity). The search was limited to articles and reports published in English from January 1990 to February 2019, consistent with the development of the first studied and validated measure of problem gambling (Lesieur & Blume, 1987). The search was limited to English language and the gambling search terms were limited to title, abstract, and keywords. The *Journal of Gambling Issues* (2000 – 2003) was manually searched as it is not indexed in the aforementioned electronic databases. The grey literature search was conducted using Google, whereby the first 100 citations (10 pages) were examined. The search terms for this search were (gambling or gamble or gamblers) and (screening or assessment or screen or assess or short or brief). Finally, the reference lists of all included studies and several narrative (Stinchfield, 2010, 2014; Stinchfield et al., 2007) and systematic (Edgren et al., 2016) reviews were searched manually.

2.3. Eligibility criteria

Studies were included in the review if they: (1) examined the diagnostic accuracy of a brief (1–5 item) screening instrument designed to identify problem gambling, pathological gambling, or gambling disorder (index test); (2) employed a study design that compared the diagnostic accuracy of a brief screening instrument to an appropriate reference standard (such as a self-report assessment instrument with more than five items or a structured/semi-structured clinical interview designed to identify problem gambling, pathological gambling, or gambling disorder) or a case-control design (in which one group known to have the disorder, such as treatment-seeking gamblers, is compared to a second group without the disorder, such as the general population); (3) provided estimates (true positives, true negatives, false positives, false negatives) that enable the calculation of diagnostic accuracy coefficients for inclusion in the synthesis of findings (sensitivity and specificity); or enough information to allow for the calculation of these estimates; (4) were published in English; and (5) were reported in a complete manuscript outlining original work published from 1990 onwards. Studies were excluded from the review if they: (1) were a qualitative report, a review, a case report, a letter, a thesis, or conference presentation slides; (2) evaluated an instrument designed to evaluate gambling behaviour only; (3) evaluated an instrument that consisted of more than five items; (4) compared the diagnostic accuracy of two brief (1–5 item) screening instruments; (5) failed to provide sufficient methodological or statistical information to enable inclusion in the synthesis of findings; or (6) were published in a language other than English.

2.4. Data extraction

The title and abstracts of the search records were independently reviewed for inclusion by two separate investigators. Full-text articles that were deemed potentially eligible were also independently reviewed for inclusion by two separate investigators. Data were extracted and collated from the included studies using a standardised, pilot-tested extraction sheet. Data extracted included basic descriptive study information (e.g., year of publication, study jurisdiction, sample size, sample type/setting, sample age, sample gender, study design), the

brief screening instrument examined (e.g., number of items, timeframe, response options, cut-offs), the reference standard employed (e.g., timeframe, cut-offs), and statistical and methodological considerations, including all data relating to indices of diagnostic accuracy (e.g., true positives, true negatives, false positives, false negatives, sensitivity, specificity, false positive rate, false negative rate, positive predictive value, negative predictive value and overall diagnostic accuracy [effectiveness]). Three investigators were involved in this data extraction; with double data extraction conducted for all of the included studies. Discrepancies were resolved though group discussions with a separate investigator as arbiter.

2.5. Risk of bias assessment

The methodological quality of all included studies was assessed across the four domains of the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2; Whiting et al., 2011): the patient selection domain (assesses whether the selection of patients could have introduced bias), the index test domain (assesses whether the conduct or interpretation of the index test [i.e., brief screening instrument] could have introduced bias), the reference standard domain (assesses whether the reference standard, its conduct, or its interpretation could have introduced bias), and the flow and timing domain (assesses whether the patient flow [i.e., all patients were treated in the same manner] could have introduced bias). Each included study sample was rated as having a low, high or unclear risk of bias for each of the 2 to 4 signalling items within each domain. For a study sample to be classified as having a low risk of bias in relation to a domain, consistent affirmative responses across all signalling items within that domain were required. Studies were classified as having a high risk of bias in relation to a domain if a negative response to any signalling question within that domain was identified (Whiting et al., 2011). For a study to be classified as having an unclear risk of bias in relation to a domain, consistent unclear responses across all signalling items, or differing responses to signalling questions (i.e., an affirmative and unclear response given to signalling questions within the same domain) within that domain were required. Three investigators were involved in the risk of bias data extraction; with double data extraction conducted for one-third of the included studies. Discrepancies were resolved though group discussions with two other investigators as arbiter. These risk of bias assessments were recorded during the data extraction process and served as the basis for the meta-analytic sensitivity analyses.

2.6. Data analysis

2.6.1. Diagnostic accuracy coefficients

Diagnostic accuracy coefficients for each brief screening instrument were computed. These included sensitivity (the true positive rate, i.e., the proportion of positive test results among those with gambling problems), specificity (the true negative rate, i.e., the proportion of negative test results among those without gambling problems), false positive rate (the proportion of positive test results among those without gambling problems), and false negative rate (the proportion of negative test results among those with gambling problems; Eusebi, 2013; Šimundić, 2009). Coefficients influenced by the base rate of problem gambling in the population being tested included overall diagnostic accuracy (effectiveness; hit rate overall proportion of correct test results calculated by the total number of true positives and true negatives divided by total sample size), positive predictive values (percentage of those with a positive test who actually have a gambling problem), and negative predictive values (percentage of those with a negative test who do not have a gambling problem; Eusebi, 2013; Šimundić, 2009).

In this review, a 2 × 2 contingency table was constructed for each brief screening instrument examined. This contingency table compares the results of the index test (brief screening instrument) with the reference measure and provides the true positive, false positive, false negative and true negative estimates of the brief screening instrument. For descriptive purposes, the 2 × 2 contingency tables and diagnostic accuracy estimates for each study are presented in Appendix B. These estimates were used to calculate all other indices of diagnostic accuracy.

2.6.2. Meta-analysis

Sensitivity and specificity data was meta-analysed using the Meta-Analysis of Diagnostic Accuracy (MADA) package (Doebler, 2017) in R software (R Core Team, 2013). A meta-analysis was conducted when data from two independent 2 × 2 contingency tables were available. A bivariate model for diagnostic meta-analysis was utilised to obtain a pooled sensitivity and pooled specificity (1 - false positive rate; Reitsma et al., 2005). The bivariate model is advantageous as it uses a random effects approach to jointly analyse pairs of sensitivity and specificity estimates and takes into consideration any correlation between these two estimates (Reitsma et al., 2005). The criterion for the selection of an appropriate brief screening instrument in this review was satisfactory diagnostic accuracy, as identified by sensitivity, specificity, and overall diagnostic accuracy equal to or greater than 0.80 (DiStefano & Morgan, 2011; Glascoe, 2005). In addition, 95% confidence intervals (CIs) were included for the pooled sensitivity and specificity estimates. Heterogeneity was explored by visual examination of forest plots, and through the conduct of chi-square tests for equality of sensitivities and also for specificities (performed univariately, see Doebler, 2017), whereby *p*-values less than 0.05 are indicative of heterogeneity.

Because clinicians and researchers may have different needs in relation to the severity of gambling problem they wish to identify, two sets of meta-analyses were conducted in the current review. The first set of analyses examined the diagnostic accuracy of brief screening instruments in identifying cases of problem gambling (including gambling disorder/pathological gambling). The second set examined the diagnostic accuracy of brief screening instruments in identifying cases of both problem gambling (including gambling disorder/pathological gambling) and at-risk gambling (i.e., sub-clinical or sub-threshold cases in which individuals exhibit some symptoms of problem gambling but not enough to be classified in the problem or gambling disorder/pathological gambling categories). Several of the included studies explored the diagnostic accuracy of numerous brief screening instruments across multiple cut-offs, and numerous reference standards across multiple cut-offs, within the same study sample. In these instances, decision rules relating to the inclusion of data within each meta-analysis were followed. These decision rules are provided in Appendix C.

2.6.3. Subgroup analyses

The observation of heterogeneity across studies precipitated consideration of factors that could explain these between-study differences. Subgroup analyses were conducted to examine potential sources of heterogeneity for diagnostic accuracy that had a sufficient number of independent estimates available (2 in each subgroup). This involved the: (1) conduct of meta-regressions, in which variables are added as covariates to the bivariate model; and (2) production of separate estimates of pooled sensitivity and specificity (with 95% CIs) for subgroups of studies, as well as *p*-values comparing the sensitivity and specificity of each screening instrument for these subgroups of studies. Based on previous literature, several study characteristics potentially explaining the observed variance were identified prior to the commencement of analysis. These were: setting (general population settings, non-gambling clinical settings [such as primary care, AOD, and mental health services]), age group (adults, adolescents), and instrument timeframe (current, lifetime).

2.6.4. Sensitivity analyses

Sensitivity analyses were conducted to explore whether the findings were robust to the quality of methodological approaches of the included

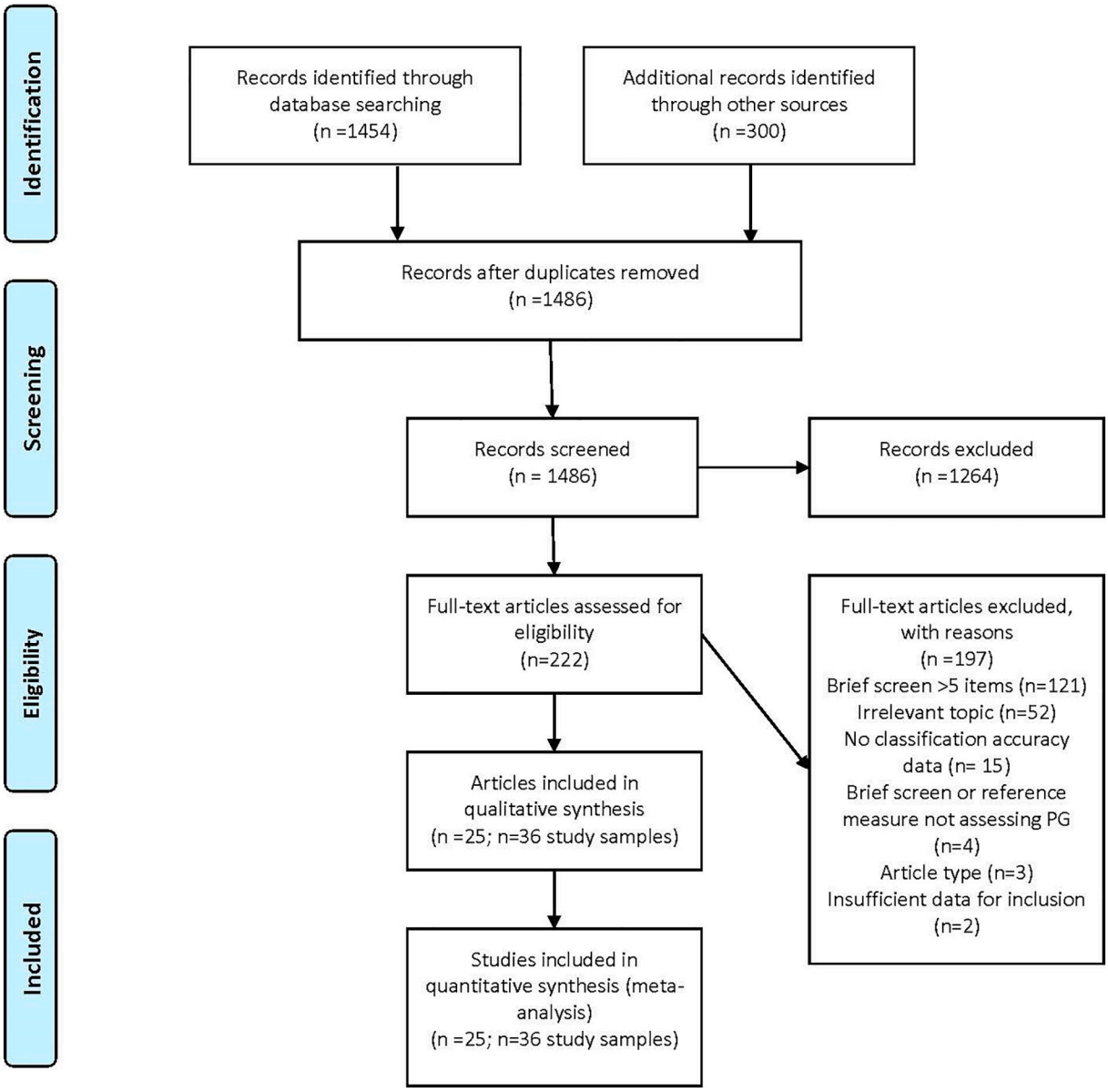

Fig. 1. PRISMA flow diagram.

studies. Sensitivity analyses involve undertaking the meta-analysis twice: first, including all included studies and second, only including those that are definitely known to be eligible based on pre-determined methodological criteria (Macaskill, Gatsonis, Deeks, Harbord, & Takwoingi, 2010). For the purpose of this review, the sensitivity analyses were sequentially limited to studies that had been categorised as having a low risk of bias on the QUADAS-2 methodological criteria of patient selection, index test, reference test, and flow and timing domains. In this review, a sensitivity analysis for each brief screening instrument was conducted when there were two or more eligible independent estimates.

3. Results

3.1. Search results

A PRISMA flow diagram of the literature search results is displayed in Fig. 1. The search identified 1486 studies after duplicate records were removed. The full-texts of the 222 articles that were deemed potentially eligible were retrieved. Overall, 36 study samples published in 25 articles met the inclusion criteria and were included in the meta-analysis. There was some overlap in the study samples published across two articles (Volberg & Williams, 2011, 2012), however, these samples were treated separately as the methodologies, sample size, and brief screening instruments assessed differed across the articles.

3.2. Identification of brief screening instruments

The included studies provided data to enable the calculation of diagnostic accuracy coefficients for 20 brief screening instruments: the One-Item Screen (Thomas, Jackson, Browning, & Piterman, 2010), the Lie/Bet Questionnaire (Johnson, Hamer, & Nora, 1997), the Case Finding and Help Assessment Tool (CHAT; Goodyear-Smith et al., 2008), the National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation (NODS-CLiP; Toce-Gerstein et al., 2009), the Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease and its short form (QUIP and QUIP-S; Weintraub et al., 2009), the Brief Biosocial Gambling Screen (BBGS; Gebauer et al., 2010), the Brief Problem Gambling Screen (BPGS; 2–5 item versions; Volberg & Williams, 2011), the

National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships (NODS-PERC; Volberg et al., 2011), the National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation 2 (NODS-CLiP2; Volberg et al., 2011), the Problem Gambling Severity Index (PGSI) Short Form (Volberg & Williams, 2012), the Consumption Screen for Problem Gambling (CSPG; Rockloff, 2012), the National Lottery screen – Loss of Control, Lying and Preoccupation (NLCLiP; Lepper & Haden, 2013), the Rapid Screener for Problem Gambling (RSPG; self-assessment and interview versions; Challet-Bouju et al., 2016), the Brief Adolescent Gambling Screen (BAGS; Stinchfield, Wynne, Wiebe, & Tremblay, 2017), and the Short South Oaks Gambling Screen (SOGS; Room, Turner, & Ialomiteanu, 1999).

A summary description of each of these brief screening instruments is provided in Appendix D. Of the 20 brief screening instruments described in this table, all but five (2–3 item versions of the CHAT, the One-Item Screen, the CSPG, and the BAGS) were derived from DSM-IV criteria or from existing assessment instruments based on DSM-IV diagnostic criteria. Not all have explicitly reported the intended setting for use; although there are instruments designed for use in population research and clinical settings, such as primary care and AOD treatment services. There is only one 1-item screening instrument, but four 2-item, nine 3-item, three 4-item, and four 5-item screening instruments. Almost all were developed for adult samples, with only the NLCLiP and the BAGS developed specifically for use in screening for gambling problems in children and adolescents. Finally, nine are designed to screen for gambling problems in the previous 12 months, five are designed to screen for lifetime gambling problems, four are designed to screen for current gambling problems, two are designed to screen for gambling problems from the time of a Parkinson's disease diagnosis, and one is designed to screen for gambling problems in the previous three months. All have binary response options (yes/no), with the exception of five instruments (PGSI Short Form, CSPG, NLCLiP, RSPG [self-assessment version], and BAGS). All of the available brief screening instruments have cut-off scores that screen for problem gambling, with only the PGSI Short Form also attempting to screen for at-risk gambling.

3.3. Characteristics of included studies

The characteristics of included study samples are presented in Appendix E. The majority of study samples were published in articles/reports from 2010 onwards (k = 28, 82.4%), with most study samples recruited from the USA (k = 16, 44.4%), followed by Canada (k = 7, 19.4%), the UK (k = 5, 13.9%) and Australia (k = 4, 11.1%). The majority of study samples consisted of adult samples (k = 32, 88.9%), with only four studies recruiting adolescent samples (11.1%). The most commonly employed setting was the general population (k = 14, 38.9%). Several studies also employed case-control designs (k = 10, 27.8%), whereby participants were recruited from general population and clinical gambling services. In these designs, participants recruited from clinical gambling services are assumed to meet criteria for problem gambling and participants from the general population are assumed to not meet criteria for problem gambling. In the remaining study samples, the most commonly employed reference measures were the PGSI (k = 8, 22.2%), self-reported DSM-IV or DSM-5 criteria (k = 8, 22.2%), and diagnostic clinical interview (k = 7, 19.4%). The size of the included samples ranged from 93 to 14,439 (M = 2945, SD = 4066, median = 866).

3.4. Risk of bias assessment

A summary of the number of included study samples that had a low, high, or unclear risk of bias for each domain in the QUADAS-2 assessment is displayed in Fig. 2. The risk of bias assessment for each of the signalling items is displayed in Appendix F. The risk of bias assessment revealed that for the patient selection domain, just over half of the study samples (52.8%) were classified as having a high risk of bias, with the remaining study samples (47.2%) classified as having a low risk of bias. Within this domain, study samples were classified as having a high risk of bias if they did not avoid a case-control design (27.8%), did not enrol a consecutive or random sample (22.2%), or employed inappropriate exclusion criteria (16.7%).

In relation to the index test domain, the majority of study samples were classified as having a high risk of bias (63.9%), with fewer study samples classified as having a low risk (33.3%) or unclear risk of bias

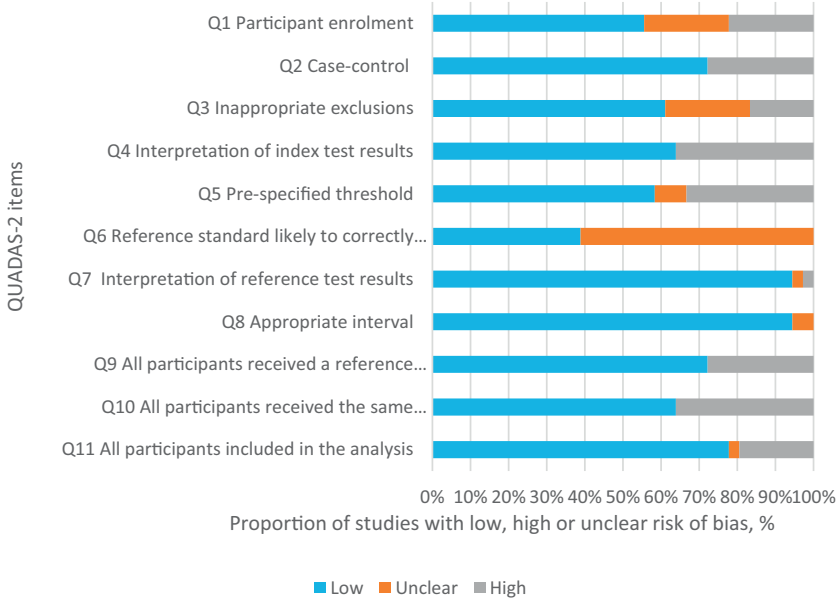

Fig. 2. QUADAS-2 risk of bias assessment results.

(2.8%). Within this domain, study samples were classified as having a high risk of bias if they interpreted the index test results with knowledge of the results of the reference standard (36.1%) or did not pre-specify a threshold for the index test (33.3%).

For the reference standard domain, the majority of the study samples (58.3%) were classified as having an unclear risk of bias, with fewer study samples classified as having a low risk of bias (38.9%) and high risk of bias (2.8%). Within this domain, only 2.8% of study samples indicated that the reference standard results were interpreted with knowledge of the results of the index test, with no studies employing a reference standard that was unlikely to correctly classify the target condition. The majority of studies (61.1%), however, were classified as having an unclear risk of bias for this item as insufficient detail on the reference standard was provided or a case-control design was employed.

In relation to the flow and timing domain, just over half of the study samples (55.6%) were classified as having a high risk of bias, with fewer study samples classified as having a low risk of bias (41.7%) and unclear risk of bias (2.8%). Within this domain, study samples were classified as having a high risk of bias if they did not employ the same reference standard for all participants (36.1%), did not administer a reference standard to all participants (27.8%), or did not include all of the participants in the analysis (19.4%). In contrast, no studies used an inappropriate time interval between the index test and reference standard.

3.5. Problem gambling diagnostic accuracy

The 2 × 2 contingency tables, including the diagnostic accuracy coefficients of the brief screening instruments using a problem gambling cut-off on the associated reference standard, for each study sample, is displayed in Table B.1 (in appendices).

3.5.1. Meta-analysis

Table 1 displays a summary of meta-analyses conducted to explore the problem gambling diagnostic accuracy (pooled sensitivity, specificity and area under the curve [AUC]) for each of the available brief screening instruments. All of the available brief screening instruments displayed satisfactory pooled sensitivity across study samples. Several instruments, however, failed to display satisfactory pooled specificity across studies, including the BPGS-3 (3 items), the BPGS-4 (4 items), and the BPGS-5 (5 items). Taken together, these findings suggest that several brief screening instruments display satisfactory diagnostic accuracy (i.e., sensitivity, specificity and overall diagnostic accuracy ≥0.80) across studies, including: one-item (One-Item Screen), two-item (BPGS-2, Lie/Bet, QUIP-S), three-item (BBGS, NODS-CLiP, PGSI-Short Form), four-item (NODS-PERC), and five-item (NODS-CLiP2, Short SOGS) instruments. Several additional instruments that were not subjected to a meta-analysis because they involved only one study also displayed satisfactory diagnostic accuracy: BAGS (3-items), CSPG (3-items), QUIP (5-items). There was evidence of heterogeneity in both

Table 1
Meta analytic estimates of problem gambling diagnostic accuracy.

Brief screening instrument [a,b]	Number of studies	Combined Sample size	Pooled sensitivity (95% CI)	Heterogeneity (χ^2) [c]	Pooled specificity (95% CI)	Heterogeneity (χ^2) [c]	AUC
1-item screening instruments							
One-Item Screen (1+)	10	4964	0.922 (0.806–0.971)	298.73**	0.957 (0.919–0.978)	164.71**	0.979
2-item screening instruments							
BPGS-2 (1+)	2	7360	0.933 (0.750–0.985)	8.69**	0.870 (0.583–0.970)	135.44***	0.958
Lie/Bet (1+)	18	42,725	0.946 (0.914–0.966)	63.21***	0.907 (0.862–0.938)	1315.94***	0.971
QUIP-S (1+)	2	250	0.877 (0.600–0.971)	0	0.933 (0.873–0.966)	1.10	0.959
3-item screening instruments							
BAGS (4+) [d]	1	105	0.875 (0.690–0.957)	NA	0.975 (0.914–0.993)	NA	
BBGS (1+)	16	25,249	0.965 (0.934–0.981)	295.03***	0.910 (0.829–0.954)	6194.72***	0.977
BPGS-3 (1+)	2	7360	0.990 (0.975–0.996)	0	0.799 (0.589–0.917)	95.90***	0.982
CSPG (4+) [d]	1	1396	0.967 (0.747–0.997)	NA	0.930 (0.915–0.942)	NA	
NODS-CLiP (1+)	15	20,535	0.987 (0.977–0.992)	41.80***	0.826 (0.698–0.906)	1445.24***	0.981
PGSI-Short Form (3+)	4	29,509	0.928 (0.898–0.950)	2.90	0.986 (0.958–0.995)	774.66***	0.950
RSPG-I (1+) [d]	1	425	0.952 (0.898–0.978)	NA	0.781 (0.731–0.824)	NA	
4-item screening instruments							
BPGS-4 (1+)	2	7360	0.992 (0.975–0.998)	0	0.787 (0.555–0.916)	112.86***	0.984
NODS-PERC (1+)	13	11,243	0.983 (0.972–0.989)	24.99*	0.814 (0.655–0.910)	1444.70***	0.978
RSPG-SA (1+) [d]	1	416	0.950 (0.896–0.977)	NA	0.637 (0.581–0.690)	NA	
5-item screening instruments							
BPGS-5 (1+)	10	10,607	0.991 (0.984–0.994)	8.48	0.698 (0.535–0.823)	521.16***	0.982
NODS-CLiP2 (1+)	3	7322	0.973 (0.953–0.984)	0.001	0.801 (0.580–0.922)	743.99**	0.963
QUIP (2+) [d]	1	157	0.909 (0.623–0.984)	NA	0.973 (0.932–0.989)	NA	
Short SOGS (2+)	8	3247	0.974 (0.957–0.985)	18.61*	0.889 (0.783–0.947)	167.75***	0.978

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

[a] BPGS = Brief Problem Gambling Screen (2–5 item versions); QUIP/QUIP-S = Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease (and Short Form); BAGS = Brief Adolescent Gambling Screen; BBGS = Brief Biosocial Gambling Screen; CSPG = Consumption Screen for Problem Gambling; NODS-CLiP/NODS-CLiP2 = National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation; PGSI-Short Form = Problem Gambling Severity Index Short Form; RSPG = Rapid Screener for Problem Gambling (self-assessment & interview versions); NODS-PERC = National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships; Short SOGS = Short South Oaks Gambling Screen.

[b] Numbers in parentheses represent the cut-off scores for each brief screening instrument recommended by the developers.

[c] Based on univariate analysis.

[d] No meta-analysis as only one available study.

Table 2
Problem gambling diagnostic accuracy subgroup analyses.

Brief screening instrument [a,b]	Number of studies	Pooled sensitivity (95% CI)	Pooled specificity (95% CI)	Number of studies	Pooled sensitivity (95% CI)	Pooled specificity (95% CI)	Sensitivity p-value	Specificity p-value
	Setting							
	General population settings			Non-gambling clinical settings				
Lie/Bet (1 +)	6	0.899 (0.839–0.938)	0.910 (0.834–0.953)	2	0.893 (0.674–0.971)	0.849 (0.406–0.979)	0.954	0.480
BBGS (1 +)	4	0.917 (0.853–0.954)	0.945 (0.818–0.985)	3	0.934 (0.870–0.968)	0.906 (0.851–0.943)	0.612	0.489
NODS-CLiP (1 +)	4	0.976 (0.937–0.991)	0.840 (0.701–0.921)	2	0.989 (0.897–0.999)	0.743 (0.330–0.945)	0.550	0.478
NODS-PERC (1 +)	2	0.965 (0.930–0.983)	0.814 (0.417–0.964)	2	0.989 (0.897–0.999)	0.767 (0.362–0.950)	0.102	0.828
Age group								
NA[c]								
	Instrument timeframe							
	Current timeframe			Lifetime timeframe				
Lie/Bet (1 +)	13	0.941 (0.902–0.965)	0.924 (0.874–0.954)	5	0.962 (0.876–0.989)	0.857 (0.768–0.915)	0.596	0.282
NODS-CLiP (1 +)	12	0.984 (0.972–0.990)	0.870 (0.776–0.928)	3	0.995 (0.980–0.999)	0.553 (0.184–0.905)	0.190	0.039
NODS-PERC (1 +)	11	0.975 (0.964–0.982)	0.864 (0.750–0.931)	2	0.997 (0.977–1.000)	0.357 (0.089–0.759)	0.037	0.011

[a] BBGS = Brief Biosocial Gambling Screen; NODS-CLiP = National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation; NODS-PERC = National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships.
[b] Numbers in parentheses represent the cut-off scores for each brief screening instrument recommended by the developers.
[c] Insufficient number of studies to conduct subgroup analyses.

sensitivity and specificity, or specificity only, across studies for many of the brief screening instruments examined (i.e., One-Item Screen, BPGS-2, Lie/Bet, BBGS, BPGS-3, NODS-CLiP, PGSI-Short Form, BPGS-4, NODS-PERC, BPGS-5, NODS-CLiP2, and Short SOGS).

3.5.2. Subgroup analyses

Subgroup analyses were conducted to explore the influence of setting (general population settings, non-gambling clinical settings), age group (adults, adolescents), and instrument timeframe (current, lifetime) on problem gambling diagnostic accuracy (pooled sensitivity and specificity) (Table 2).

3.5.2.1. Setting. Four brief screening instruments (Lie/Bet, BBGS, NODS-CLiP, NODS-PERC) had a sufficient number of independent estimates to compare their problem gambling diagnostic accuracy in general population settings and non-gambling clinical settings (primary care, AOD or mental health). There was little evidence for a difference in sensitivity or specificity for any instrument according to setting. Despite these findings, while all of these four brief screening instruments displayed satisfactory diagnostic accuracy in general population settings, only the Lie/Bet and BBGS displayed satisfactory diagnostic accuracy when used in non-gambling clinical settings; both the NODS-CLiP and NODS-PERC displayed adequate sensitivity, but not specificity, when they were administered in non-gambling clinical settings.

3.5.2.2. Age group. None of the brief screening instruments had a sufficient number of independent estimates to compare their problem gambling diagnostic accuracy in adults and adolescents.

3.5.2.3. Instrument timeframe. Three brief screening instruments (Lie/Bet, NODS-CLiP, and NODS-PERC) had a sufficient number of independent estimates to compare their problem gambling diagnostic accuracy when they employed a current or lifetime timeframe. There was little difference for the Lie/Bet in terms of sensitivity or specificity according to timeframe. Although the NODS-CLiP displayed better specificity when it was used with a current timeframe than when it was used with a lifetime timeframe, there was no difference in sensitivity according to timeframe. Finally, the NODS-PERC displayed better sensitivity when it was used with a lifetime timeframe than when it was used with a current timeframe. In contrast, the NODS-PERC displayed better specificity when it was used with a current timeframe than when it was used with a lifetime timeframe. Despite these findings, while all of these three brief screening instruments displayed satisfactory diagnostic accuracy when used with current timeframes, only the Lie/Bet displayed satisfactory diagnostic accuracy when used with a lifetime timeframe; both the NODS-CLiP and NODS-PERC displayed adequate sensitivity, but not specificity, when they were administered with lifetime timeframes.

3.5.3. Sensitivity analyses

Several brief screening instruments (Lie/Bet, BBGS, NODS-CLiP, PGSI-Short Form, NODS-PERC, NODS-CLiP2, and BPGS-5) had a sufficient number of independent estimates to conduct at least some of the sensitivity analyses, which restricted the meta-analyses to studies that displayed a low risk of bias across the four domains of the QUADAS-2 (Table 3). All of these brief screening instruments met the criteria for satisfactory diagnostic accuracy in the meta-analyses including all available studies, with the exception of the BPGS-5, which failed to

Table 3
Problem gambling diagnostic accuracy sensitivity analyses.

Brief screening instrument [a,b]	Number of studies	Combined Sample size	Pooled sensitivity (95% CI)	Heterogeneity (χ^2) [c]	Pooled specificity (95% CI)	Hetero geneity (χ^2) [c]	AUC
QUADAS-2 patient selection domain							
Lie/Bet (1+)	5	22,870	0.857 (0.765–0.917)	15.94**	0.903 (0.793–0.957)	254.75***	0.931
BBGS (1+)	5	6179	0.963 (0.805–0.994)	176.65***	0.845 (0.472–0.971)	2223.06***	0.967
NODS-CLiP (1+)	3	3329	0.984 (0.910–0.997)	1.96	0.829 (0.536–0.953)	273.83***	0.979
PGSI-Short Form (3+)	3	23,180	0.919 (0.864–0.953)	1.80	0.992 (0.982–0.996)	22.76***	0.956
NODS-PERC (1+)	3	3329	0.984 (0.914–0.997)	1.96	0.832 (0.578–0.947)	200.34***	0.979
NODS-CLiP2 (1+)	2	3030	0.973 (0.898–0.993)	0.00	0.875 (0.837–0.905)	6.22*	0.970
QUADAS-2 index test domain							
Lie/Bet (1+)	6	27,162	0.856 (0.795–0.900)	16.79**	0.891 (0.792–0.946)	500.30***	0.919
BBGS (1+)	5	7721	0.894 (0.848–0.928)	5.76	0.922 (0.866–0.956)	154.15***	0.940
NODS-CLiP (1+)	4	7621	0.966 (0.909–0.988)	5.86	0.817 (0.616–0.926)	348.95***	0.968
NODS-PERC (1+)	4	7621	0.964 (0.924–0.978)	4.98	0.792 (0.573–0.915)	709.16***	0.962
BPGS-5 (1+)	2	7360	0.992 (0.975–0.998)	0.00	0.783 (0.546–0.916)	117.88***	0.984
QUADAS-2 reference test domain							
Lie/Bet (1+)	5	21,163	0.955 (0.819–0.990)	60.31***	0.897 (0.862–0.924)	33.87***	0.939
BBGS (1+)	2	937	0.956 (0.872–0.986)	0.00	0.929 (0.904–0.948)	0.75	0.975
NODS-CLiP (1+)	3	10,079	0.991 (0.956–0.998)	3.68	0.694 (0.181–0.959)	660.76***	0.982
NODS-PERC (1+)	2	1212	0.992 (0.876–1.000)	1.25	0.577 (0.040–0.978)	353.41***	0.978
QUADAS-2 flow and timing domain							
Lie/Bet (1+)	5	24,709	0.911 (0.833–0.954)	21.77***	0.903 (0.794–0.957)	618.41***	0.977
BBGS (1+)	5	15,092	0.975 (0.879–0.995)	149.02***	0.867 (0.468–0.980)	7074.97***	0.979
NODS-CLiP (1+)	3	1511	0.993 (0.953–0.999)	4.79	0.548 (0.141–0.899)	351.85***	0.978
NODS-PERC (1+)	3	1511	0.993 (0.953–0.999)	4.79	0.576 (0.153–0.911)	358.30***	0.979

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$
[a] BBGS = Brief Biosocial Gambling Screen; NODS-CLiP/NODS-CLiP2 = National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation; PGSI-Short Form = Problem Gambling Severity Index Short Form; NODS-PERC = National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships; BPGS-5 = Brief Problem Gambling Screen (5 item version).
[b] Numbers in parentheses represent the cut-off scores for each brief screening instrument recommended by the developers.
[c] Based on univariate analysis.

display adequate specificity. When limiting the meta-analyses to study samples with a low risk of bias with regard to patient selection, all of the brief screening instruments for which there were a sufficient number of studies (Lie/Bet, BBGS, NODS-CLiP, PGSI-Short Form, NODS-PERC, NODS-CLiP2) met the criteria for satisfactory diagnostic accuracy. When limiting the meta-analyses to study samples with a low risk of bias in relation to the index test, only the Lie/Bet, BBGS, and NODS-CLiP met the criteria for satisfactory diagnostic accuracy. When limiting the meta-analyses to study samples with a low risk of bias in relation to the reference test, the Lie/Bet and the BBGS met the criteria for satisfactory diagnostic accuracy. Finally, when limiting the meta-analyses to study samples with a low risk of bias with regard to patient flow and timing, only the Lie/Bet and the BBGS met the criteria for satisfactory diagnostic accuracy.

3.6. At-risk gambling diagnostic accuracy

The 2 × 2 contingency tables, including the diagnostic accuracy coefficients (sensitivity, specificity, overall diagnostic accuracy, positive predictive value, negative predictive value, false positive rate, false negative rate) of the brief screening instruments using an at-risk gambling cut-off on the associated reference standard, for each study sample, is displayed in Table B.2 (in appendices).

3.6.1. Meta-analysis

Table 4 displays a summary of meta-analyses conducted to explore the at-risk gambling diagnostic accuracy (pooled sensitivity and specificity) for each of the available brief screening instruments. Several brief screening instruments failed to display satisfactory pooled sensitivity across studies: Lie/Bet (2 items), and BBGS (3 items). In contrast, all instruments displayed satisfactory pooled specificity across studies. Taken together, these findings suggest that several two-item (BPGS-2), three-item (BPGS-3, NODS-CLiP, PGSI-Short Form), four-item (BPGS-4, NODS-PERC), and five-item (BPGS-5, NODS-CLiP2) brief screening instruments display satisfactory diagnostic accuracy (i.e., sensitivity, specificity and overall diagnostic accuracy ≥0.80) across studies. The 2-item CHAT, which was not subjected to a meta-analysis because it was only investigated in one study, also displayed satisfactory diagnostic accuracy in that study. Many of the brief screening instruments examined in this meta-analysis displayed heterogeneity in both sensitivity and specificity, or specificity only, across studies: BPGS-2, Lie/Bet, BBGS, BPGS-3, NODS-CLiP, PGSI-Short Form, BPGS-4, NODS-PERC, BPGS-5, and NODS-CLiP2.

3.6.2. Subgroup analyses

Subgroup analyses were conducted to explore the influence of setting (general population settings, non-gambling clinical settings), age group (adults, adolescents), and instrument timeframe (current, lifetime) on at-risk gambling diagnostic accuracy (pooled sensitivity and specificity) (Table 5).

3.6.2.1. Setting. Only the NODS-CLiP had a sufficient number of independent estimates to compare its at-risk gambling diagnostic accuracy in general population and non-gambling clinical settings (primary care, AOD or mental health). Although the NODS-CLiP displayed better specificity when employed in non-gambling clinical settings than general population settings, there was little evidence for difference in terms of sensitivity. Moreover, while this instrument met the criteria for satisfactory diagnostic accuracy in general population settings, it failed to display satisfactory sensitivity when administered in non-gambling clinical settings.

3.6.2.2. Age group. Only the Lie/Bet had a sufficient number of independent estimates to compare its at-risk gambling diagnostic accuracy in adults and adolescents. There was little evidence of a difference for this brief screening instrument when employed with adults and adolescents in terms of sensitivity or specificity. However, while this instrument met the criteria for satisfactory diagnostic accuracy in adolescents, it failed to display satisfactory sensitivity when administered to adults.

Table 4
Meta analytic estimates of At-Risk gambling diagnostic accuracy.

Brief screening instrument [a,b]	Number of studies	Combined Sample size	Pooled sensitivity (95% CI)	Heterogeneity (χ^2) [c]	Pooled specificity (95% CI)	Heterogeneity (χ^2) [c]	AUC
2-item screening instruments							
BPGS-2 (1+)	2	7360	0.814 (0.502–0.050)	47.03***	0.937 (0.505–0.995)	150.89***	0.922
CHAT (1+) [d]	1	688	0.800 (0.376–0.964)	NA	0.981 (0.968–0.989)	NA	
Lie/Bet (1+)	7	29,139	0.728 (0.601–0.826)	82.01***	0.943 (0.894–0.970)	613.81***	0.920
3-item screening instruments							
BBGS (1+)	3	7322	0.705 (0.674–0.735)	1.54	0.963 (0.921–0.984)	90.69***	0.723
BPGS-3 (1+)	2	7360	0.960 (0.866–0.989)	8.58**	0.876 (0.566–0.975)	134.05***	0.971
NLCLiP (3+) [d]	1	8958	0.551 (0.502–0.599)	NA	0.983 (0.980–0.985)	NA	
NODS-CLiP (1+)	6	17,622	0.883 (0.667–0.966)	217.66***	0.894 (0.690–0.970)	606.71***	0.946
PGSI-SF (1+)	3	28,672	0.954 (0.899–0.980)	28.81***	0.938 (0.781–0.985)	2313.35***	0.974
4-item screening instruments							
BPGS-4 (1+)	2	7360	0.977 (0.824–0.998)	19.77**	0.865 (0.531–0.973)	152.26***	0.976
NODS-PERC (1+)	4	7697	0.840 (0.813–0.864)	54.91***	0.812 (0.473–0.954)	714.66***	0.840
5-item screening instruments							
BPGS-5 (1+)	2	7360	0.977 (0.861–0.997)	13.37***	0.863 (0.518–0.974)	160.03***	0.977
NODS-CLiP2 (1+)	3	7322	0.915 (0.893–0.933)	0.46	0.852 (0.623–0.953)	700.15***	0.918

** $P < 0.01$.
*** $P < 0.001$.
[a] BPGS = Brief Problem Gambling Screen (2–5 item versions); CHAT = Case Finding and Help Assessment Tool; BBGS = Brief Biosocial Gambling Screen; NLCLiP = National Lottery screen – Loss of Control, Lying and Preoccupation; NODS-CLiP/NODS-CLiP2 = National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation; PGSI-Short Form = Problem Gambling Severity Index Short Form; NODS-PERC = National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships.
[b] Numbers in parentheses represent the cut-off scores for each brief screening instrument recommended by the developers.
[c] Based on univariate analysis.
[d] No meta-analysis as only one available study.

Table 5
At-Risk gambling diagnostic accuracy subgroup analyses.

Brief screening instrument [a,b]	Number of studies	Pooled sensitivity (95% CI)	Pooled specificity (95% CI)	Number of studies	Pooled sensitivity (95% CI)	Pooled specificity (95% CI)	Sensitivity p-value	Specificity p-value
	Setting							
	General population settings			Non-gambling clinical settings				
NODS-CLiP (1 +)	3	0.899 (0.752–0.963)	0.899 (0.812–0.948)	2	0.688 (0.117–0.974)	0.971 (0.909–0.991)	0.289	0.049
	Age group							
	Adults			*Adolescents*				
Lie/Bet (1 +)	5	0.674 (0.597–0.744)	0.954 (0.899–0.979)	2	0.828 (0.415–0.970)	0.909 (0.772–0.967)	0.240	0.343
	Instrument timeframe							
	Current timeframe			Lifetime timeframe				
Lie/Bet (1 +)	3	0.634 (0.572–0.692)	0.957 (0.846–0.989)	4	0.735 (0.492–0.888)	0.071 (0.037–0.131)	0.330	0.508
NODS-CLiP (1 +)	4	0.767 (0.486–0.920)	0.944 (0.856–0.980)	3	0.975 (0.936–0.990)	0.669 (0.092–0.976)	0.014	0.085

[a] NODS-CLiP = National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation.
[b] Numbers in parentheses represent the cut-off scores for each brief screening instrument recommended by the developers.

Table 6
At-Risk gambling diagnostic accuracy sensitivity analyses.

Brief screening instrument [a,b]	Number of studies	Combined sample size	Pooled sensitivity (95% CI)	Heterogeneity (χ^2) [c]	Pooled specificity (95% CI)	Heterogeneity (χ^2) [c]	AUC
QUADAS-2 patient selection domain							
Lie/Bet (1 +)	6	34,847	0.726 (0.577–0.837)	82.01***	0.952 (0.910–0.974)	42.54***	0.936
BBGS (1 +)	2	3030	0.700 (0.586–0.793)	1.12	0.976 (0.963–0.984)	2.12	0.959
NODS-CLiP (1 +)	3	4088	0.766 (0.348–0.953)	69.68***	0.963 (0.918–0.984)	27.05***	0.969
PGSI-Short Form (1 +)	2	22,343	0.938 (0.892–0.965)	1.18	0.969 (0.956–0.978)	21.57***	0.984
NODS-PERC (1 +)	2	3030	0.836 (0.760–0.892)	0.18	0.941 (0.909–0.962)	5.57*	0.936
NODS-CLiP2 (1 +)	2	3030	0.922 (0.872–0.954)	0.00	0.914 (0.887–0.935)	3.43	0.948
QUADAS-2 index test domain							
Lie/Bet (1 +)	5	26,863	0.663 (0.598–0.723)	20.91***	0.948 (0.891–0.976)	516.07***	0.811
NODS-CLiP (1 +)	4	8380	0.767 (0.486–0.920)	78.69***	0.944 (0.856–0.980)	346.78***	0.946
NODS-PERC (1 +)	3	7322	0.841 (0.815–0.863)	0.44	0.890 (0.668–0.970)	664.06***	0.838
QUADAS-2 reference test domain							
Lie/Bet (1 +)	3	20,378	0.673 (0.562–0.766)	18.26***	0.954 (0.897–0.980)	72.16***	0.876
NODS-CLiP (1 +)	4	11,137	0.904 (0.547–0.987)	272.95***	0.893 (0.517–0.985)	380.80***	0.953
NODS-PERC (1 +)	2	1212	0.977 (0.455–1.000)	39.51***	0.786 (0.110–0.991)	216.67***	0.966
QUADAS-2 flow and timing domain							
Lie/Bet (1 +)	3	20,378	0.673 (0.562–0.766)	18.26***	0.954 (0.897–0.980)	72.16***	0.876
NODS-CLiP (1 +)	3	2270	0.870 (0.302–0.990)	196.39***	0.889 (0.301–0.993)	547.97***	0.938
NODS-PERC (1 +)	2	1212	0.977 (0.455–1.000)	39.51***	0.786 (0.110–0.991)	216.67***	0.966

* $P < .05$.
*** $P < 0.001$.
[a] BBGS = Brief Biosocial Gambling Screen; NODS-CLiP/NODS-CLiP2 = National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation; PGSI-Short Form = Problem Gambling Severity Index Short Form; NODS-PERC = National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships.
[b] Numbers in parentheses represent the cut-off scores for each brief screening instrument recommended by the developers.
[c] Based on univariate analysis.

3.6.2.3. Instrument timeframe. Two brief screening instruments (Lie/Bet and NODS-CLiP) had a sufficient number of independent estimates to compare their at-risk gambling diagnostic accuracy when they employed a current or lifetime timeframe. Although there was no difference for the Lie/Bet in terms of sensitivity or specificity according to timeframe, this instrument failed to meet the criteria for satisfactory diagnostic accuracy when it was employed with a lifetime timeframe and to display satisfactory sensitivity when it was employed with a current timeframe. Although the NODS-CLiP displayed better sensitivity when it was used with a lifetime timeframe than when it was used with a current timeframe, there was little evidence of a difference in specificity according to timeframe. However, the NODS-CLiP failed to display satisfactory sensitivity when it was used with a current timeframe and specificity when it was used with a lifetime timeframe.

3.6.3. Sensitivity analyses

Several brief screening instruments (Lie/Bet, BBGS, NODS-CLiP, PGSI-Short Form, NODS-PERC, and NODS-CLiP2) had a sufficient number of independent estimates to conduct at least some of the sensitivity analyses, which restricted the meta-analyses to studies that displayed a low risk of bias across the four domains of the QUADAS-2

(Table 6). All of these brief screening instruments met the criteria for satisfactory diagnostic accuracy in the meta-analyses including all available studies, with the exception of the Lie/Bet and BBGS, which failed to display adequate sensitivity. When limiting the meta-analyses to study samples with a low risk of bias in relation to patient selection, several of the brief screening instruments for which there was a sufficient number of independent estimates (PGSI-Short Form, NODS-PERC, and NODS-CLiP2) met the criteria for satisfactory diagnostic accuracy. When limiting the meta-analyses to study samples with a low risk of bias in relation to the index test, only the NODS-PERC met the criteria for satisfactory diagnostic accuracy. When limiting the meta-analyses to study samples with a low risk of bias in relation to the reference test, only the NODS-CLiP met the criteria for satisfactory diagnostic accuracy. Finally, when limiting the meta-analyses to study samples with a low risk of bias in relation to patient flow and timing, only the NODS-CLiP met the criteria for satisfactory diagnostic accuracy.

3.7. Summary of key findings

A summary of the brief screening instruments meeting the criteria for satisfactory diagnostic accuracy is provided in Table 7. Ten brief screening instruments met the criteria for satisfactory diagnostic accuracy for problem gambling (One-Item Screen, BPGS-2, Lie/Bet, QUIP-S, BBGS, NODS-CLiP, PGSI-Short Form, NODS-PERC, NODS-CLiP2, Short SOGS), five of which can also satisfactorily detect at-risk gambling (BPGS-2, NODS-CLiP, PGSI-Short Form, NODS-PERC, and NODS-CLiP2). Table 7 also summarises the brief screening instruments that meet the criteria for satisfactory diagnostic accuracy to detect: problem gambling (Lie/Bet, BBGS, NODS-CLiP, NODS-PERC) and at-risk gambling (NODS-CLiP) in general population settings; problem gambling (Lie/Bet, BBGS) in non-gambling clinical settings; at-risk gambling (Lie/Bet) in adolescents; problem gambling (Lie/Bet, NODS-CLiP, NODS-PERC) using a current timeframe; and problem gambling (Lie/Bet) using a lifetime timeframe.

4. Discussion

This is the first systematic review to explore the diagnostic accuracy of brief screening instruments to identify how well each instrument identified people with and without problem gambling and at-risk gambling. This review used robust, replicable, and reliable procedures to add new evidence that there are brief screening instruments that

Table 7
Summary of diagnostic classification accuracy for all brief screening instruments [a,b].

Brief screening instrument[c,d]	Overall		Setting				Age group				Instrument timeframe			
			General population		Non-gambling clinical		Adults		Adolescents		Current		Lifetime	
	PG	AR	PG	AR	PG	AR	PG	AR	PG	AR	PG	AR	PG	AR
1-item screening instruments														
One-Item Screen (1+)	✓													
2-item screening instruments														
BPGS-2 (1+)	✓	✓												
CHAT (1+) [e]		✓												
Lie/Bet (1+)	✓	✗	✓		✓			✗		✓	✓	✗	✓	✗
QUIP-S (1+)	✓													
3-item screening instruments														
BAGS (4+) [e]	✓													
BBGS (1+)	✓	✗	✓		✓									
BPGS-3 (1+)	✗	✓												
CSPG (4+) [e]	✓													
NL-CLiP (3+) [e]		✗												
NODS-CLiP (1+)	✓	✓	✓	✓	✗	✗					✓	✗	✗	✗
PGSI-Short Form (3+)	✓	✓												
RSPG-I (1+) [e]	✗													
4-item screening instruments														
BPGS-4 (1+)	✗	✓												
NODS-PERC (1+)	✓	✓	✓		✗						✓		✗	
RSPG-SA (1+) [e]	✗													
5-item screening instruments														
BPGS-5 (1+)	✗	✓												
NODS-CLiP2 (1+)	✓	✓												
QUIP (2+) [e]	✓													
Short SOGS (2+)	✓													

[a] PG = problem gambling; AR = at-risk gambling.
[b] Satisfactory diagnostic accuracy identified by sensitivity, specificity, and overall diagnostic accuracy equal to or > 0.80; ✓ Satisfactory diagnostic accuracy; ✗ Less than satisfactory diagnostic accuracy.
[c] BPGS = Brief Problem Gambling Screen (2–5 item versions); CHAT = Case Finding and Help Assessment Tool; QUIP/QUIP-S = Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease (and Short Form); BAGS = Brief Adolescent Gambling Screen; BBGS = Brief Biosocial Gambling Screen; CSPG = Consumption Screen for Problem Gambling; NLCLiP = National Lottery screen – Loss of Control, Lying and Preoccupation; NODS-CLiP/NODS-CLiP2 = National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation; PGSI-Short Form = Problem Gambling Severity Index Short Form; RSPG = Rapid Screener for Problem Gambling (self-assessment & interview versions); NODS-PERC = National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships; Short SOGS = Short South Oaks Gambling Screen.
[d] Numbers in parentheses represent the cut-off scores for each brief screening instrument recommended by the developers.
[e] Only one available study.

satisfactorily detect gambling problems across a range of settings. The findings from 36 study samples published in 25 articles identified ten brief screening instruments for which there is a sufficient evidence base to detect problem gambling. Moreover, although the PGSI-Short Form is the only measure designed to identify sub-clinical or sub-threshold cases (i.e., at-risk gambling), the findings of this review suggest that eight instruments have satisfactory diagnostic accuracy in detecting at-risk gambling across multiple samples. This systematic review and meta-analysis will serve as a resource for health service providers and researchers in the identification of the most accurate brief screening tools for problem and at-risk gambling for their specific purposes and populations.

4.1. Problem and at-risk gambling diagnostic accuracy

Of the 20 brief screening instruments available, ten displayed satisfactory diagnostic accuracy in detecting problem gambling across multiple samples: one-item (One-Item Screen), two-item (BPGS-2, Lie/Bet, QUIP-S), three-item (BBGS, NODS-CLiP, PGSI-Short Form), four-item (NODS-PERC), and five-item (NODS-CLiP2, Short SOGS). Five of these brief screening instruments (BPGS-2, NODS-CLiP, PGSI-Short Form, NODS-PERC, and NODS-CLiP2) also displayed satisfactory diagnostic accuracy in detecting at-risk gambling (including problem gambling) across at least two samples. Strangely, an additional three instruments (BPGS-3, BPGS-4, BPGS-5) displayed satisfactory diagnostic accuracy in the meta-analysis for detecting at-risk gambling, but not in those for detecting problem gambling. The at-risk gambling diagnostic accuracy meta-analyses for these three instruments, however, are based on only two studies, indicating the need for further research on their diagnostic accuracy. Taken together, these findings suggest that there are several brief screening instruments of various item lengths that may be used to adequately screen for problem and at-risk gambling. Several instruments also displayed satisfactory results in detecting problem gambling (BAGS, CSPG, and QUIP) and at-risk gambling (CHAT) but in only one study, suggesting that these are promising brief screening instruments that are worthy of further study.

Despite these findings, few of the brief screening instruments met the criteria for satisfactory diagnostic accuracy when limiting the analyses to studies classified as having a low risk of bias. Only two of the ten brief screening instruments (2-item Lie/Bet and 3-item BBGS) that satisfactorily detected problem gambling still met the criteria for satisfactory diagnostic accuracy when the analyses were limited to study samples classified as having a low risk of bias across all risk of bias assessments (patient selection, index test, reference test, and patient flow and timing). The 3-item NODS-CliP displayed adequate diagnostic accuracy when limiting studies with low risk of bias across two of the four domains (patient selection and the index test). Similarly, none of the eight brief screening instruments that satisfactorily detected at-risk gambling still met the criteria when the analyses were limited to studies classified as having a low risk of bias across all risk of bias assessments. Of the brief screening instruments that displayed adequate diagnostic accuracy to detect at-risk gambling, the NODS-CLiP and NODS-PERC performed the best when the analyses were limited to studies classified as having a low risk of bias. The NODS-CLiP displayed adequate diagnostic accuracy when limiting studies with low risk of bias relating to the reference test and patient flow and timing. In contrast, the NODS-PERC displayed adequate diagnostic accuracy when the analyses were limited to studies classified as having a low risk of bias in relation to patient selection and the index test. Taken together, these findings suggest that the problem gambling classification accuracies for the Lie/Bet and BBGS, and to a lesser extent, the NODS-CLiP, are robust to the inclusion of studies that may introduce a risk of bias; but that the at-risk diagnostic accuracies for the NODS-CLiP and NODS-PERC are the most robust to the inclusion of these studies.

Few brief screening instruments had a sufficient number of independent estimates to conduct subgroup analyses to explore the influence of setting on their diagnostic accuracy. Problem gambling diagnostic accuracy did not differ between general population and non-gambling clinical settings (such as primary care, AOD and mental health settings) for the four brief screening instruments for which subgroup analyses were possible (Lie/Bet, BBGS, NODS-CLiP, NODS-PERC). However, only the Lie/Bet and the BBGS displayed satisfactory diagnostic accuracy to detect problem gambling in both settings. In contrast, the NODS-CLiP and NODS-PERC only displayed satisfactory diagnostic accuracy to detect problem gambling in general population settings. Only the NODS-CLiP had a sufficient number of independent estimates to compare the at-risk gambling diagnostic accuracy in these settings. Although this instrument displayed better specificity when it was employed in non-gambling clinical settings, it failed to display satisfactory sensitivity when administered in non-gambling clinical settings. Taken together, the findings of this review appear to support the continued use of the Lie/Bet and the BBGS in detecting problem gambling in both general population and non-gambling clinical contexts; but the use of caution in employing the NODS-CLiP and NODS-PERC in non-gambling clinical services. Although the setting subgroup analyses must be interpreted with caution due to the small number of available studies, their findings also suggest that all four instruments (Lie/Bet, BBGS, NODS-CLiP and NODS-PERC) could potentially be used as measures of prevalence in general population surveys to detect problem gambling, but only the NODS-CLiP has the potential to satisfactorily detect at-risk gambling in these surveys.

Of all the available brief screening instruments, only the Lie/Bet had a sufficient number of available studies to conduct subgroup analyses to explore the influence of age group on diagnostic accuracy. While none of the brief screening instruments had a sufficient number of available studies to compare their problem gambling diagnostic accuracy in adults and adolescents, at-risk gambling diagnostic accuracy was not found to differ between adults and adolescents for the Lie/Bet. While this instrument met the criteria for satisfactory diagnostic accuracy in adolescents, it failed to display satisfactory sensitivity when administered to adults. These findings provide a preliminary indication that the Lie/Bet should be selected cautiously if the purpose is to screen for at-risk gambling in adult populations.

Finally, only three brief screening instruments had a sufficient number of available studies to conduct subgroup analyses to explore the influence of timeframe on their diagnostic accuracy (Lie/Bet, NODS-CLiP, and NODS-PERC). There was little evidence for differences in diagnostic accuracy for the Lie/Bet in detecting either problem or at-risk gambling when it was used with a current and lifetime timeframe. However, although this instrument displayed satisfactory diagnostic accuracy in detecting problem gambling when used with either timeframe, it failed to meet the criteria for satisfactory diagnostic accuracy in detecting at-risk gambling when employed with either timeframe. Taken together, these findings provide preliminary support that the Lie/Bet can be used to screen for problem gambling with either timeframe but should not be selected if the purpose is to screen for current or lifetime at-risk gambling. Interestingly, the NODS-CLiP displayed better specificity in detecting problem gambling when it was used with a current timeframe, but better sensitivity in detecting at-risk gambling when it was used with a lifetime timeframe. Despite these findings, the

NODS-CLiP only displayed satisfactory diagnostic accuracy for detecting problem gambling using a current timeframe, suggesting that it is only suitable for this use. Finally, the NODS-PERC displayed better sensitivity in detecting problem gambling when it was used with a lifetime timeframe, and better specificity in detecting problem gambling when it was used with a current timeframe. Despite these mixed findings, the NODS-PERC only displayed satisfactory classification when used with a current timeframe, suggesting that, like the NODS-CLiP, it is only suitable for use in detecting current problem gambling.

4.2. Strengths and limitations of the existing evidence base

This systematic review and meta-analysis provides information to assist clinicians and researchers in the selection of an appropriate instrument to screen for problem and at-risk gambling. The findings suggest that there is now an abundance of brief problem gambling screening instruments and that several brief screening instruments of various item lengths show promise in the screening of problem and at-risk gambling. The risk of bias assessment revealed several strengths of the available evidence base. Only approximately one-quarter of the available studies employed a case-control design, which is susceptible to selection bias towards overestimates of diagnostic accuracy if the cases are not representative of all cases within the population or if controls are not representative of the population that produced the cases (Bailey, Vardulaki, Langham, & Chandramohan, 2006). For example, treatment-seeking gamblers in these case-control design studies are likely to display more severe gambling problems and a greater variety and intensity of comorbid psychiatric disorders compared with their non-treatment seeking counterparts in studies employing alternative designs (Crockford & el-Guebaly, 1998; Slutske et al., 2001; Specker, Carlson, Edmonson, Johnson, & Marcotte, 1996). Most studies indicated that the reference standard was not interpreted with knowledge of the results of the index test, used an appropriate time interval between the index test and the reference standard, included all of the participants in the study, and administered a reference standard to all participants. Moreover, approximately two-thirds of studies interpreted the index test results without knowledge of the reference standard, and employed the same reference standard for all participants. Over one-half of the studies employed appropriate exclusion criteria, pre-specified a threshold for the index test, and employed consecutive or random samples. Moreover, the sensitivity analyses revealed that the results of the review were generally robust to the inclusion of articles with a high risk of bias.

Despite these strengths, fewer than half of the available studies were classified as having a low risk of bias for each of the QUADAS-2 domains, suggesting that the selection of patients, the conduct or interpretation of the index test or the reference standard, and patient flow could have introduced bias. Moreover, there were considerable reporting deficits in relation to several of the QUADAS-2 signalling items, such as the diagnostic accuracy of the reference standard, participant enrolment, and participant exclusions. Taken together, these findings suggest that future diagnostic accuracy studies should adopt methodologies that conform to the standards outlined in the QUADAS-2 and report their methodological quality according to these standards (Whiting et al., 2011). There are several other methodological limitations that may be important to consider when designing future research. Many of the brief screening instruments have been developed and validated using secondary data analyses of survey data collected in North America so their diagnostic accuracy data may not be generalizable to other jurisdictions or cultures. They also have good face validity with transparent items, which may contribute to a social desirability bias (Brett et al., 2014). Finally, there is a lack of independence between the brief screening instruments and the reference measure as many of the screening instruments have been developed from the problem gambling reference measures. There is some evidence that the removal of overlapping items between brief screening instruments and reference standards has an inconsistent effect on diagnostic accuracy, whereby the performance of some brief screening instruments is enhanced and the performance of other instruments is deflated (Dowling et al., 2018). This limitation, however, cannot be eliminated completely, as almost all screening and assessment instruments have been derived from DSM-IV diagnostic criteria (Stinchfield & McCready, 2014).

Finally, the review identified a relatively limited evidence base from which to draw conclusions about the diagnostic accuracy of brief screening instruments for gambling problems. Although several studies did employ multiple samples to evaluate the diagnostic accuracy of multiple screening instruments against multiple cut-offs on the reference standard, there was a limited number of articles eligible for inclusion of the review. Many of the available screening instruments have not yet undergone rigorous diagnostic accuracy evaluation and some (BAGS, CSPG, QUIP, CHAT, NLCLiP, RSPG-I, and RSPG-SA) have not yet been evaluated beyond that reported for the development of the instrument itself. In particular, the meta-analytic and sensitivity analytic results relating to the diagnostic accuracy of at-risk gambling should be interpreted with caution, given their generally lower number of included study samples. There is a clear need for future research to explore the diagnostic accuracy of the available brief screening instruments in detecting both problem and at-risk gambling.

Relatedly, there is currently limited information available to guide the selection of a brief screening instrument for problem gambling in non-gambling clinical services, such as primary care, AOD, or mental health settings. Few brief screening instruments have been developed for use in these specific clinical populations, with the exception of the One-Item Screen, the CHAT and the CSPG, which were developed for use primarily in primary care settings, and the NODS-PERC, which was developed for use in AOD treatment and other clinical settings. Moreover, because few studies have evaluated the diagnostic accuracy of brief screening instruments in these settings (Dowling et al., 2018; Goodyear-Smith et al., 2009; Stinchfield et al., 2017; Volberg et al., 2011), there was an insufficient number of study samples to differentiate diagnostic accuracy estimates in each of these specific settings. Given this limited literature, it is important that future research validate brief screening instruments for use within primary care, AOD or mental health services.

The findings of this review also suggest that there is limited research exploring the diagnostic accuracy of brief screening instruments for adolescents. Most of the available brief screening instruments have been adapted from problem gambling assessment instruments developed for use with adults. The exceptions are the NLCLiP (Lepper & Haden, 2013) and the BAGS (Stinchfield et al., 2017). These instruments have not yet been evaluated beyond that reported for the development of the instrument itself. Moreover, of all the brief screening instruments developed for adults, only the Lie/Bet has been applied to adolescent samples in a limited literature (Gotestam, Johansson, Wenzel, & Simonsem, 2004; Rossow & Molde, 2006). There is therefore a need to develop brief screening instruments that take the developmental issues of adolescents into consideration (Stinchfield, 2010) or to develop norms for existing instruments when used in adolescent samples (Stinchfield et al., 2007).

Finally, one-quarter of the brief screening instruments were developed with a lifetime timeframe. Screening instruments with lifetime timeframes are inappropriate for measuring the prevalence of problem gambling; they will likely result in an inflated false positive rate because they include respondents who are classified in the problem gambling category in the past, as well as the present (Stinchfield, 2014; Stinchfield et al., 2007). For this reason, the timeframe of all of the instruments designed to be lifetime measures (Lie/Bet, One-Item Screen, NODS-CLiP, NODS-PERC, and NODS-CLiP2) have been modified in research to screen for current problem gambling. The timeframe of the instrument should therefore be selected according to the purpose of the screening (Stinchfield et al., 2007).

4.3. Implications for research translation

These limitations notwithstanding, the findings of the current systematic review provide important new insights into the diagnostic accuracy of brief screening instruments for problem and at-risk gambling. The findings of this review revealed a number of brief screening instruments that could be readily adopted within clinical and research settings to improve early identification of gambling-related problems across the continuum of severity. The identification of at-risk gamblers is particularly important, given recent findings that the majority of total burden of harm can be attributed to this lower risk category due to their larger prevalence in the population (Browne et al., 2017). The findings suggest that five brief screening instruments seem to be suitable for clinicians or researchers wanting to screen for both at-risk and problem gambling (BPGS-2, NODS-CLiP, PGSI-Short Form, NODS-PERC, and NODS-CLiP2). These instruments can be administered in a very short period of time, use direct questions, employ simple (often dichotomous) response options, and have simple scoring algorithms and interpretations.

Of these five instruments, there were generally insufficient studies examining the classification accuracy of the BPGS-2, PGSI-Short Form, and NODS-CLiP2 to determine whether they were robust to the quality of methodological approaches and to determine their classification accuracy across settings, age groups and instrument timeframes. In contrast, the NODS-CLiP and NODS-PERC have a more extensive literature investigating their classification accuracy. These two instruments displayed the highest pooled sensitivities in the detection of problem gambling, whereby between 98 to 99% of problem gamblers were correctly identified. Pooled sensitivities in the detection of at-risk gambling were somewhat lower, but still satisfactory, with 84 to 88% of at-risk/problem gamblers being correctly identified. In detecting both problem and at-risk gambling, these instruments were robust to the inclusion of high risk of bias studies across some, but not all, QUADAS2 domains. Both instruments displayed satisfactory diagnostic accuracy in detecting problem gambling in general population settings and when administered with a current timeframe. The NODS-CLiP also displayed satisfactory diagnostic accuracy in detecting at-risk gambling in general population settings. However, neither instrument displayed satisfactory diagnostic accuracy in detecting problem gambling in non-gambling clinical contexts or when administered with a lifetime timeframe. The NODS-CLiP also failed to display satisfactory diagnostic accuracy in detecting at-risk gambling in non-gambling clinical settings or when used with either a current or lifetime timeframe. Due to an insufficient number of available studies, the diagnostic accuracy of the NODS-PERC in detecting at-risk gambling across settings and timeframes remains unclear. Similarly, there were an insufficient number of estimates to identify the diagnostic accuracy of either of these instruments in adolescents.

Clinicians and researchers who wish to screen for gambling problems in adolescents have limited options, with only the BAGS and the Lie/Bet displaying satisfactory diagnostic accuracy in this review. The 3-item BAGS is the only brief screening instrument that has been specifically developed for use in adolescent samples that displayed satisfactory classification in detecting problem gambling, albeit only in the study reporting the development of the instrument itself (Stinchfield et al., 2017). In this study, 88% of problem gamblers were accurately identified by the BAGS. The degree to which these findings are robust to the quality of study methodology and the ability of this instrument to detect at-risk gambling therefore remains unclear. Despite being developed for use with adults, the Lie/Bet displayed satisfactory diagnostic accuracy for detecting at-risk/problem gambling in adolescents, with 83% of at-risk/problem gamblers accurately identified by the Lie/Bet across two studies.

Some clinical services or research projects may only be able to accommodate a very brief (1–2 item) screening instrument. The BPGS-2 is the only shorter instrument that can satisfactorily detect both problem and at-risk gambling. Although it displayed significant heterogeneity in sensitivity estimates across studies, this instrument accurately detected an average of 81% of problem/at-risk gamblers and an average of 93% of problem gamblers. The results relating to this instrument must be interpreted with caution, however, due to the limited available literature exploring its diagnostic accuracy. Moreover, the degree to which these findings are robust to the quality of study methodology and the diagnostic accuracy across setting, age group, or instrument timeframe remains unclear.

In contrast, the 2-item Lie/Bet has accumulated the largest volume of diagnostic accuracy data to date. This instrument, however, was only able to adequately detect problem gambling. Although it displayed significant heterogeneity in sensitivity estimates across studies, 95% of problem gamblers were accurately identified by this instrument and its problem gambling diagnostic accuracy was the most robust to the inclusion of studies classified with a high risk of bias. It also displayed satisfactory diagnostic accuracy in detecting problem gambling in both general population and non-gambling clinical contexts, as well as with current and lifetime timeframes.

Finally, for services that can only accommodate a one-item instrument, the One-Item Screen displayed satisfactory detection of problem gambling. Although it displayed significant heterogeneity in sensitivity estimates across studies, 92% of problem gamblers were accurately identified by this instrument. These findings should be interpreted with caution, however, because, with the exception of one study sample, the studies exploring the diagnostic accuracy of the One-Item Screen were characterised by either a high or unclear risk of bias. There were also an insufficient number of study samples investigating this instrument to determine its performance across settings, age groups, or instrument timeframes.

A positive screen on any brief screening instrument should trigger a more comprehensive clinical assessment using self-report measures, such as the PGSI, or clinical interviews to determine problem severity or diagnostic status and provide information that can assist in treatment planning and/or referral decisions (Stinchfield et al., 2007; Volberg et al., 2011). Although the evidence base is limited and is confounded by generally low quality standards, interventions with the strongest evidence base for the treatment of problem gambling include cognitive behavioural and motivational interviewing therapies (Cowlishaw et al., 2012; Gooding & Tarrier, 2009; Yakovenko, Quigley, Hemmelgarn, Hodgins, & Ronksley, 2015). Brief interventions and online self-directed programs based on these interventions may be useful resources for organisations that intend to screen for gambling problems.

5. Conclusions

This systematic review is the first to explore the diagnostic accuracy of brief screening instruments to screen for gambling problems, with a view to providing a resource for health service providers and researchers. The findings of this review revealed a number of brief screening instruments that could be readily adopted in clinical and research settings to improve early identification of gambling-related problems across the continuum of severity. The findings from 36 study samples published in 25 articles identified ten brief screening instruments for which there is a sufficient evidence base to detect problem gambling and eight instruments for which there is a sufficient evidence base to detect at-risk gambling. Only five of the available 20 brief screening instruments met the criteria for satisfactory diagnostic accuracy in detecting both problem and at-risk gambling: BPGS-2, NODS-CLiP, PGSI-Short Form, NODS-PERC, and NODS-CLiP2. Of these five instruments, the three-item NODS-CLiP or the four-item NODS-PERC have the highest volume of diagnostic accuracy data. These instruments both display high sensitivities and some degree of robustness to study methodologies. They both displayed satisfactory diagnostic accuracy in detecting problem gambling in general population settings and when administered with a current timeframe. The NODS-CLIP may have some advantages over the NODS-PERC due to its fewer number of items and its satisfactory diagnostic accuracy in detecting at-risk gambling in general population settings. Although they have a more limited evidence base or lower diagnostic accuracy, the 2-item BPGS-2 (for screening at-risk and problem gambling), the 2-item Lie/Bet (for screening for problem gambling only), or the One-Item Screen (for screening for problem gambling only) may be options for health services and research projects that can only accommodate a shorter instrument. There is also a very limited evidence base to inform screening for gambling problems in adolescents, with only the 3-item BAGS and the 2-item Lie/Bet displaying any degree of satisfactory diagnostic accuracy in this review. These conclusions, however, are drawn from a relatively limited evidence base. Importantly, the findings of this review highlight the need for future studies to evaluate the diagnostic accuracy of the existing brief instruments for problem gambling across settings, age groups, and timeframes.

Role of funding source

This review received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Role of contributions

ND devised the review. ND and SM developed the review protocol. SM conducted the systematic search. SM, SD, and DL (see acknowledgements) conducted the data extraction, with ND as arbiter. SD, VM, and SR conducted the risk of bias information, with ND and SM as arbiters. SM conducted the data analyses, under the guidance of GY. ND and SM wrote the first draft of the manuscript. All authors contributed to and approved the final manuscript.

Declaration of Competing Interest

The authors have no competing interests to declare in relation to this article. Over the past 3 years, ND, SM, SR, VM, GY and DL have received funding from multiple sources, including government departments and the Victorian Responsible Gambling Foundation. ND, SM, SR, and GY have also received funding from the National Association for Gambling Studies (NAGS); a not-for-profit organization with individual members across all stakeholder groups, which derives its funding from member fees and conference proceeds. SM has formerly been the Victorian state representative (unpaid) on the NAGS Executive Committee (which includes representatives from all stakeholder groups). Over the past 3 years, DL has provided consultancy advice to Lundbeck and Indivior; and has received travel support and speaker honoraria from Astra Zeneca, Bristol Myers Squibb, Indivior, Janssen, Lundbeck, Shire and Servier. Over the past 3 years, RV has received funding from multiple sources, including the Massachusetts Gaming Commission, the Swedish Research Council for Health, Working Life and Welfare, the Public Health Agency of Sweden, the Canadian Consortium for Gambling Research, the Ontario Problem Gambling Research Centre, the Rutgers University Center for Gambling Studies, and the Oregon Council on Problem Gambling. None of the authors have knowingly received research funding from the gambling industry or any industry-sponsored organization. Several of the studies included in this systematic review have been co-authored by members of the author team.

Acknowledgements

The authors would like to thank Daniel Leung for assisting in the scanning of the titles and abstracts of the retrieved articles for inclusion.

Appendix A. Search strategy

A.1. Medline and PsycInfo

#1 (gambl* NOT task) OR betting OR wager*.ab,ti.

#2 screen* OR assess* OR detect* OR questionnaire OR “Problem Gambling Severity Index” OR PGSI OR NODS OR “NORC Diagnostic Screen” OR Lie-Bet OR “Brief Biosocial Gambling Screen” OR “Consumption Screen for Problem Gambling” OR “AGRI short screen” OR short OR brief OR “CHAT screen” OR “Case finding and Help Assessment Tool”.

#3 sensitivity OR specificity OR ROC OR “false positive” OR “false negative” OR classification OR reliability OR “internal consistency” OR validity OR “test-retest” OR construct OR discriminant OR convergent OR concurrent OR predictive OR psychometric OR performance.

#4 #1 AND #2 AND #3.

A.2. Google

(gambling or gamble or gamblers) and (screening or assessment or screen or assess or short or brief)

Appendix B. Raw data tables

Table B.1
Raw data for problem gambling diagnostic accuracy meta-analysis [a].

Brief screening instrument and cut-off [b,c]	Study ID	Setting	Sample type	Sample size	Time-frame	Reference measure and cut-off	TP	FN	FP	TN	Sens	Spec	PPV	NPV	FPR	FNR	Overall DA
1-item screening instruments																	
One-Item Screen (1+)	Challet-Bouji et al. 2016[d]	General population	Adult	425	Past year	Interview based on the DSM-5; 4+	93	31	45	256	0.752	0.851	0.675	0.893	0.149	0.248	0.822
	Rockloff et al., 2011	General population	Adult	1292	Past year	PGSI; 8+	5	19	30	1238	0.208	0.976	0.141	0.985	0.024	0.792	0.962
	Stinchfield & Mccready, 2014	Case-control [e]	Adult	282	Past year	Case-control [e]	223	9	0	50	0.960	1.000	1.000	0.830	0.000	0.040	0.960
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	569	Past year	Case-control [e]	280	6	6	277	0.980	0.980	0.980	0.980	0.020	0.020	0.980
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	1062	Past year	Case-control [e]	246	13	8	795	0.950	0.990	0.970	0.980	0.010	0.050	0.980
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	390	Past year	Case-control [e]	91	30	8	261	0.750	0.970	0.930	0.880	0.030	0.250	0.900
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	175	Past year	Case-control [e]	149	2	0	25	0.990	1.000	1.000	0.930	0.000	0.010	0.990
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	135	Past year	Case-control [e]	88	3	2	42	0.970	0.950	0.980	0.950	0.050	0.030	0.960
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	212	Past year	Case-control [e]	91	1	16	104	0.990	0.870	0.850	0.990	0.130	0.010	0.920
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	422	Past year	Case-control [e]	190	10	18	204	0.950	0.920	0.920	0.950	0.080	0.050	0.940
2-item screening instruments																	
BPGS-2 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	46	7	49	735	0.868	0.938	0.484	0.991	0.063	0.132	0.933
	Volberg & Williams, 2011	General population	Adult	6523	Past year	Clinical assessment (pathological)	385	13	1520	4605	0.967	0.752	0.202	0.997	0.248	0.033	0.765
Lie/Bet (1+)	Challet-Bouji et al. 2016[d]	General population	Adult	425	Past year	Interview based on the DSM-5; 4+	115	9	63	238	0.927	0.791	0.646	0.964	0.209	0.073	0.831
	Colasante et al., 2013	General population	Adult	5102	Lifetime	PGSI; 8+	67	3	559	4473	0.957	0.889	0.107	0.999	0.111	0.043	0.890
	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	43	10	45	739	0.881	0.943	0.489	0.987	0.057	0.189	0.934
	Gebaueur et al. 2010[d]	General population	Adult	11,106	Past year	DSM-IV-TR; 5+	76	3	377	10,650	0.960	0.966	0.170	1.000	0.034	0.038	0.966
	Himelhoch et al., 2015	Alcohol or other drug use service	Adult	299	Lifetime	DSM-5; 4+	114	7	61	117	0.942	0.657	0.651	0.944	0.343	0.058	0.773
	Johnson et al., 1997	Case-control [e]	Adult	362	Lifetime	Case-control [e]	190	1	16	155	0.990	0.910	0.920	0.990	0.094	0.005	0.953
	Johnson, Hamer, & Nora, 1998	Case-control [e]	Adult	423	Lifetime	Case-control [e]	146	0	42	235	1.000	0.850	0.780	1.000	0.152	0.000	0.901
	Rossow et al. 2006	General population (school)	Adolescent	14,439	Lifetime	SOGS-RA; 4+	411	77	1336	12,615	0.842	0.904	0.235	0.994	0.096	0.158	0.902
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	282	Past year	Case-control [e]	218	14	0	50	0.940	1.000	1.000	0.770	0.000	0.060	0.950
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	569	Past year	Case-control [e]	283	3	6	277	0.990	0.980	0.980	0.990	0.020	0.010	0.980
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	1062	Past year	Case-control [e]	249	10	16	787	0.960	0.980	0.940	0.990	0.020	0.040	0.970
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	390	Past year	Case-control [e]	104	17	27	242	0.860	0.900	0.860	0.900	0.100	0.140	0.890
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	175	Past year	Case-control [e]	146	5	2	23	0.970	0.920	0.990	0.820	0.080	0.030	0.960
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	135	Past year	Case-control [e]	89	2	5	39	0.980	0.880	0.940	0.950	0.120	0.020	0.950

(continued on next page)

Table B.1 (*continued*)

Brief screening instrument and cut-off [b,c]	Study ID	Setting	Sample type	Sample size	Time-frame	Reference measure and cut-off	TP	FN	FP	TN	Sens	Spec	PPV	NPV	FPR	FNR	Overall DA
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	212	Past year	Case-control [e]	92	0	26	94	1.000	0.780	0.780	1.000	0.220	0.000	0.880
	Stinchfield and Mccready, 2014	Case-control [e]	Adult	422	Past year	Case-control [e]	196	4	36	186	0.980	0.840	0.840	0.980	0.160	0.020	0.910
	Volberg & Williams, 2011[d]	General population	Adult	4292	Past year	Clinical assessment (pathological)	333	46	714	3199	0.879	0.818	0.318	0.986	0.182	0.121	0.823
	Volberg & Williams, 2011[d]	General population	Adult	2193	Past year	Clinical assessment (pathological)	14	4	72	2103	0.778	0.967	0.163	0.998	0.033	0.222	0.965
QUIP-S (1+)	Weintraub et al., 2009	Clinical (Parkinson's disease)	Adult	157	Anytime during Parkinson's disease	Semi-structured interview for compulsive gambling	10	1	7	139	0.910	0.950	0.590	0.990	0.050	0.090	0.947
	Tanaka, Wada-Isoe, Nakashita, Yamamoto, & Nakashima, 2013	Clinical (Parkinson's disease)	Adult	93	Anytime during Parkinson's disease	DSM-IV criteria; 5+	5	1	8	79	0.833	0.906	0.385	0.987	0.094	0.167	0.901
3-item screening instruments																	
BAGS (4+)	Stinchfield et al., 2017	General population (schools) and clinical (problem behaviour and substance abuse treatment services)	Adolescent	105	Past 3 months	Self-report and clinician administered DSM-5 criteria; 4+	21	3	2	79	0.880	0.980	0.913	0.963	0.020	0.120	0.950
BBGS (1+)	Brett et al., 2014	Gambling clinical	Adult	2750	Past year	Semi-structured interview based on DSM-IV; 5+	2239	2	437	72	0.999	0.141	0.834	0.973	0.859	0.001	0.840
	Challet-Bouju et al., 2016[d]	General population	Adult	425	Past year	Interview based on the DSM-5; 4+	115	9	59	242	0.927	0.804	0.661	0.964	0.196	0.073	0.840
	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	51	2	51	733	0.962	0.935	0.500	0.997	0.065	0.038	0.937
	Gebauer et al., 2010	General population	Adult	11,106	Past year	DSM-IV-TR; 5+	76	3	135	10,892	0.960	0.988	0.360	1.000	0.012	0.038	0.988
	Himelhoch et al., 2015	Alcohol or other drug use service	Adult	299	Past year	DSM-5; 4+	110	11	24	154	0.909	0.865	0.821	0.933	0.135	0.091	0.883
	Langan et al., 2019	HIV clinic	Adult	100	Past year	DSM-5; 4+	13	0	8	79	1.000	0.908	0.619	1.000	0.092	0.000	0.920
	Stinchfield, 2014 [d]	Case-control [e]	Adult	282	Past year	Case-control [e]	225	7	0	50	0.970	1.000	1.000	0.880	0.000	0.030	0.980
	Stinchfield, 2014 [d]	Case-control [e]	Adult	569	Past year	Case-control [e]	283	3	8	275	0.990	0.970	0.970	0.990	0.030	0.010	0.980
	Stinchfield, 2014 [d]	Case-control [e]	Adult	1062	Past year	Case-control [e]	251	8	16	787	0.970	0.980	0.950	0.990	0.020	0.030	0.980
	Stinchfield, 2014[d]	Case-control [e]	Adult	390	Past year	Case-control [e]	109	12	24	245	0.900	0.910	0.820	0.950	0.090	0.100	0.910
	Stinchfield, 2014 [d]	Case-control [e]	Adult	175	Past year	Case-control [e]	149	2	1	24	0.990	0.960	0.990	0.960	0.040	0.010	0.990
	Stinchfield, 2014[d]	Case-control [e]	Adult	135	Past year	Case-control [e]	90	1	5	39	0.990	0.880	0.950	0.970	0.120	0.010	0.950
	Stinchfield, 2014 [d]	Case-control [e]	Adult	212	Past year	Case-control [e]	92	0	20	100	1.000	0.830	0.820	1.000	0.170	0.000	0.910
	Stinchfield, 2014 [d]	Case-control [e]	Adult	422	Past year	Case-control [e]	195	5	33	189	0.975	0.850	0.860	0.970	0.150	0.025	0.910
	Volberg & Williams, 2011 [d]	General population	Adult	4292	Past year	Clinical assessment (pathological)	327	52	463	3450	0.863	0.882	0.414	0.985	0.118	0.137	0.880
	Volberg & Williams, 2011[d]	General population	Adult	2193	Past year	Clinical assessment (pathological)	16	2	62	2113	0.889	0.971	0.205	0.999	0.029	0.111	0.971
BPGS-3 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	53	0	101	683	1.000	0.871	0.344	1.000	0.129	0.000	0.879
	Volberg & Williams, 2011	General population	Adult	6523	Past year	Clinical assessment (pathological)	394	4	1814	4311	0.990	0.704	0.178	0.999	0.296	0.010	0.721
CSPG (4+)	Rockloff, 2012	General population	Adult	1396	Past year	PGSI; 8+	14	0	97	1285	1.000	0.930	0.126	1.000	0.070	0.000	0.931
NODS-CLiP (1+)	Challet-Bouju et al., 2016[d]	General population	Adult	425	Past year	Interview based on the DSM-5; 4+	123	1	98	203	0.992	0.674	0.557	0.995	0.326	0.008	0.767
	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	52	1	96	688	0.981	0.878	0.351	0.999	0.122	0.019	0.884

(*continued on next page*)

Table B.1 (*continued*)

Brief screening instrument and cut-off [b,c]	Study ID	Setting	Sample type	Sample size	Time-frame	Reference measure and cut-off	TP	FN	FP	TN	Sens	Spec	PPV	NPV	FPR	FNR	Overall DA
	Himelhoch et al., 2015	Alcohol or other drug use service	Adult	299	Lifetime	DSM-5; 4+	121	0	82	96	1.000	0.539	0.596	1.000	0.461	0.000	0.726
	Stinchfield et al. 2014 [d]	Case-control [e]	Adult	282	Past year	Case-control [e]	230	2	1	49	0.990	0.980	0.996	0.960	0.020	0.010	0.990
	Stinchfield, 2014[d]	Case-control [e]	Adult	569	Past year	Case-control [e]	285	1	11	272	0.997	0.960	0.970	0.996	0.040	0.003	0.980
	Stinchfield, 2014 [d]	Case-control [e]	Adult	1062	Past year	Case-control [e]	256	3	24	779	0.990	0.970	0.900	0.996	0.030	0.010	0.970
	Stinchfield, 2014 [d]	Case-control [e]	Adult	390	Past year	Case-control [e]	119	2	30	239	0.980	0.890	0.800	0.990	0.110	0.020	0.920
	Stinchfield, 2014[d]	Case-control [e]	Adult	175	Past year	Case-control [e]	150	0	2	23	1.000	0.920	0.990	1.000	0.080	0.000	0.990
	Stinchfield, 2014 [d]	Case-control [e]	Adult	135	Past year	Case-control [e]	90	1	5	39	0.990	0.880	0.950	0.970	0.120	0.010	0.950
	Stinchfield, 2014 [d]	Case-control [e]	Adult	212	Past year	Case-control [e]	92	0	62	58	1.000	0.480	0.600	1.000	0.520	0.000	0.710
	Stinchfield, 2014[d]	Case-control [e]	Adult	422	Past year	Case-control [e]	199	1	80	142	0.995	0.640	0.720	0.990	0.360	0.005	0.810
	Toce-Gerstein et al., 2009[d]	General population	Adult	8867	Lifetime	NODS; 5+	149	1	1014	7703	0.993	0.884	0.128	1.000	0.116	0.007	0.886
	Volberg & Williams, 2011[d]	General population	Adult	4292	Past year	Clinical assessment (pathological)	360	19	863	3050	0.950	0.779	0.294	0.994	0.221	0.050	0.795
	Volberg & Williams, 2011[d]	General population	Adult	2193	Past year	Clinical assessment (pathological)	18	0	150	2025	1.000	0.931	0.107	1.000	0.069	0.000	0.932
	Volberg et al., 2011	Clinical (gambling service - recruited from substance abuse and medical treatment settings)	Adult	375	Lifetime	NODS; 5+	228	0	122	25	1.000	0.170	0.651	1.000	0.830	0.000	0.675
PGSI-Short Form (3+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	48	5	15	769	0.906	0.981	0.762	0.994	0.019	0.094	0.976
	Volberg & Williams, 2012	General population	Adult	6329	Past year	PGSI; 8+	354	21	344	5610	0.944	0.942	0.507	0.996	0.058	0.056	0.942
	Volberg & Williams, 2012	General population	Adult	11,331	Past year	PGSI; 8+	74	7	61	11,189	0.912	0.995	0.576	0.999	0.005	0.088	0.994
	Volberg & Williams, 2012	General population	Adult	11,012	Past year	PGSI; 8+	38	1	65	10,908	0.974	0.994	0.369	1.000	0.006	0.026	0.994
RSPG-I (1+)	Challet-Bouju et al., 2016	General population	Adult	425	Past year	Interview based on the DSM-5; 4+	118	6	66	235	0.952	0.781	0.641	0.975	0.219	0.048	0.831
4-item screening instruments																	
BPGS-4 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	53	0	105	679	1.000	0.866	0.335	1.000	0.134	0.000	0.875
	Volberg & Williams, 2011	General population	Adult	6523	Past year	Clinical assessment (pathological)	396	2	1956	4169	0.995	0.681	0.168	1.000	0.319	0.005	0.700
NODS-PERC (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	52	1	86	698	0.981	0.890	0.377	0.999	0.110	0.019	0.896
	Himelhoch et al., 2015	Alcohol or other drug use service	Adult	299	Lifetime	DSM-5; 4+	121	0	76	102	1.000	0.573	0.614	1.000	0.427	0.000	0.746
	Stinchfield, 2014 [d]	Case-control [e]	Adult	282	Past year	Case-control [e]	227	5	1	49	0.980	0.980	0.996	0.910	0.020	0.020	0.980
	Stinchfield, 2014[d]	Case-control [e]	Adult	569	Past year	Case-control [e]	280	6	14	269	0.980	0.950	0.950	0.980	0.050	0.020	0.960
	Stinchfield, 2014 [d]	Case-control [e]	Adult	1062	Past year	Case-control [e]	256	3	24	779	0.990	0.970	0.910	0.996	0.030	0.010	0.970
	Stinchfield, 2014	Case-control [e]	Adult	390	Past year	Case-control [e]	121	0	24	245	1.000	0.910	0.830	1.000	0.090	0.000	0.940
	Stinchfield, 2014 [d]	Case-control [e]	Adult	175	Past year	Case-control [e]	149	2	4	21	0.990	0.840	0.970	0.950	0.160	0.010	0.970
	Stinchfield, 2014 [d]	Case-control [e]	Adult	135	Past year	Case-control [e]	90	1	4	40	0.990	0.910	0.960	0.980	0.090	0.010	0.960
	Stinchfield, 2014 [d]	Case-control [e]	Adult	212	Past year	Case-control [e]	92	0	74	46	1.000	0.380	0.550	1.000	0.620	0.000	0.650
	Stinchfield, 2014 [d]	Case-control [e]	Adult	422	Past year	Case-control [e]	199	1	89	133	0.995	0.600	0.690	0.990	0.400	0.005	0.790
	Volberg & Williams, 2011[d]	General population	Adult	4292	Past year	Clinical assessment (pathological)	362	17	1430	2483	0.955	0.635	0.202	0.993	0.365	0.045	0.663
	Volberg & Williams, 2011[d]	General population	Adult	2193	Past year	Clinical assessment (pathological)	18	0	181	1994	1.000	0.917	0.090	1.000	0.083	0.000	0.917
	Volberg et al., 2011	Clinical (gambling service - recruited from substance abuse and medical treatment settings)	Adult	375	Lifetime	NODS; 5+	228	0	120	27	1.000	0.184	0.655	1.000	0.816	0.000	0.680

(*continued on next page*)

Table B.1 (*continued*)

Brief screening instrument and cut-off [b,c]	Study ID	Setting	Sample type	Sample size	Time-frame	Reference measure and cut-off	TP	FN	FP	TN	Sens	Spec	PPV	NPV	FPR	FNR	Overall DA
RSPG-SA (1+)	Challet-Bouju et al., 2016	General population	Adult	416	Past year	Interview based on the DSM-5; 4+	115	6	107	188	0.950	0.637	0.518	0.969	0.363	0.050	0.728
5-item screening instruments																	
BPGS-5 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	53	0	106	678	1.000	0.865	0.333	1.000	0.135	0.000	0.873
	Stinchfield, 2014	Case-control [e]	Adult	282	Past year	Case-control [e]	230	2	14	36	0.990	0.720	0.940	0.920	0.280	0.010	0.940
	Stinchfield, 2014	Case-control [e]	Adult	569	Past year	Case-control [e]	286	0	23	260	1.000	0.920	0.930	1.000	0.080	0.000	0.960
	Stinchfield, 2014	Case-control [e]	Adult	1062	Past year	Case-control [e]	254	5	64	739	0.980	0.920	0.800	0.990	0.080	0.020	0.930
	Stinchfield, 2014	Case-control [e]	Adult	390	Past year	Case-control [e]	121	0	75	194	1.000	0.720	0.620	1.000	0.280	0.000	0.810
	Stinchfield, 2014	Case-control [e]	Adult	175	Past year	Case-control [e]	150	0	14	11	1.000	0.440	0.910	1.000	0.560	0.000	0.920
	Stinchfield, 2014	Case-control [e]	Adult	135	Past year	Case-control [e]	90	1	23	21	0.990	0.480	0.800	0.950	0.520	0.010	0.820
	Stinchfield, 2014	Case-control [e]	Adult	212	Past year	Case-control [e]	92	0	83	37	1.000	0.310	0.530	1.000	0.690	0.000	0.610
	Stinchfield, 2014	Case-control [e]	Adult	422	Past year	Case-control [e]	199	1	109	113	0.995	0.510	0.650	0.990	0.490	0.005	0.740
	Volberg & Williams, 2011	General population	Adult	6523	Past year	Clinical assessment (pathological)	396	2	1995	4130	0.995	0.674	0.166	1.000	0.326	0.005	0.694
NODS-CLiP2 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 8+	52	1	113	671	0.981	0.856	0.315	0.999	0.144	0.019	0.864
	Volberg & Williams, 2011 [e]	General population	Adult	4292	Past year	Clinical assessment (pathological)	369	10	1644	2269	0.974	0.580	0.183	0.996	0.420	0.026	0.615
	Volberg & Williams, 2011	General population	Adult	2193	Past year	Clinical assessment (pathological)	18	0	239	1936	1.000	0.890	0.070	1.000	0.110	0.000	0.891
QUIP (2+)	Weintraub et al., 2009	Clinical (Parkinson's disease)	Adult	157	Anytime during Parkinson's disease	Semi-structured interview for compulsive gambling	10	1	4	142	0.910	0.970	0.710	0.990	0.030	0.090	0.966
Short SOGS (2+)	Stinchfield, 2014	Case-control [e]	Adult	282	Past year	Case-control [e]	218	14	0	50	0.940	1.000	1.000	0.790	0.000	0.050	0.950
	Stinchfield, 2014	Case-control [e]	Adult	569	Past year	Case-control [e]	280	6	11	272	0.980	0.960	0.960	0.980	0.040	0.020	0.970
	Stinchfield, 2014	Case-control [e]	Adult	1062	Past year	Case-control [e]	246	13	32	771	0.950	0.960	0.880	0.980	0.040	0.050	0.960
	Stinchfield, 2014	Case-control [e]	Adult	390	Past year	Case-control [e]	117	4	30	239	0.970	0.890	0.810	0.980	0.110	0.030	0.920
	Stinchfield, 2014	Case-control [e]	Adult	175	Past year	Case-control [e]	150	0	5	20	1.000	0.800	0.970	1.000	0.200	0.000	0.970
	Stinchfield, 2014	Case-control [e]	Adult	135	Past year	Case-control [e]	90	1	12	32	0.990	0.730	0.890	0.970	0.270	0.010	0.910
	Stinchfield, 2014	Case-control [e]	Adult	212	Past year	Case-control [e]	92	0	42	78	1.000	0.650	0.690	1.000	0.360	0.000	0.800
	Stinchfield, 2014	Case-control [e]	Adult	422	Past year	Case-control [e]	196	4	31	191	0.980	0.860	0.860	0.980	0.140	0.020	0.910

TP: True positive; FN: False negative; FP: False positive; TN: True negative; Sens: Sensitivity; Spec: Specificity; PPV: Positive predictive value; NPV: Negative predictive value; FPR: False positive rate; FNR: False negative rate; Overall: Overall diagnostic accuracy.

[a] While additional data was available across the included articles, only data included in the synthesis of findings has been included.

[b] BPGS = Brief Problem Gambling Screen (2–5 item versions); QUIP/QUIP-S = Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease (and Short Form); BAGS = Brief Adolescent Gambling Screen; BBGS = Brief Biosocial Gambling Screen; CSPG = Consumption Screen for Problem Gambling; NODS-CLiP/NODS-CLiP2 = National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation; PGSI-Short Form = Problem Gambling Severity Index Short Form; RSPG = Rapid Screener for Problem Gambling (self-assessment & interview versions); NODS-PERC = National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships; Short SOGS = Short South Oaks Gambling Screen.

[c] Numbers in parentheses represent the cut-off scores for each brief screening instrument recommended by the developers.

[d] Wording of items employed is not based on original and validated brief screening instrument.

[e] Case-control refers to the comparison of a group known to have the disorder (i.e., clinical sample from gambling service) with a group without the disorder (i.e., general population).

Table B.2
Raw data for at-risk gambling diagnostic accuracy meta-analysis [a].

Brief screening instrument and cut-off [b,c]	Study ID	Setting	Sample type	Sample size	Timeframe	Reference measure and cut-off	TP	FN	FP	TN	Sens	Spec	PPV	NPV	FPR	FNR	Overall DA
2-item screening instruments																	
BPGS-2 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 3+	83	40	12	702	0.675	0.983	0.874	0.946	0.017	0.325	0.938
	Volberg & Williams, 2011	General population	Adult	6523	Past year	Clinical assessment (problem and pathological)	717	78	1188	4540	0.902	0.793	0.376	0.983	0.207	0.098	0.806
CHAT (1+)	Goodyear-Smith et al., 2009	Clinical (primary care)	Adult	688	Current	SOGS; 4+	4	1	13	670	0.800	0.980	0.235	0.999	0.019	0.200	0.980
Lie/Bet (1+)	Colasante et al., 2013	General population	Adult	5102	Lifetime	PGSI; 3+	226	68	400	4408	0.769	0.917	0.361	0.985	0.083	0.231	0.908
	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 3+	75	48	13	701	0.610	0.982	0.852	0.936	0.018	0.390	0.927
	Gotestam et al., 2004	General population	Adolescent	894	Lifetime	DSM-IV; 3+	180	14	104	596	0.928	0.851	0.634	0.978	0.149	0.072	0.868
	Gotestam et al., 2004	General population	Adult	1382	Lifetime	DSM-IV; 3+	11	1	42	1328	0.917	0.964	0.204	0.999	0.031	0.083	0.969
	Rossow & Molde, 2006	General population (school)	Adolescent	14,439	Lifetime	SOGS-RA; 2+	1041	570	706	12,122	0.646	0.945	0.596	0.955	0.055	0.354	0.912
	Volberg & Williams, 2011[d]	General population	Adult	4292	Past year	Clinical assessment (problem and pathological)	504	233	543	3012	0.684	0.847	0.481	0.928	0.153	0.316	0.819
	Volberg & Williams, 2011[d]	General population	Adult	2193	Past year	Clinical assessment (problem and pathological)	32	22	54	2085	0.593	0.975	0.372	0.990	0.025	0.407	0.965
3-item screening instruments																	
BBGS (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 3+	91	32	22	703	0.740	0.985	0.892	0.956	0.015	0.260	0.949
	Volberg & Williams, 2011[d]	General population	Adult	4292	Past year	Clinical assessment (problem and pathological)	523	214	268	3287	0.710	0.925	0.661	0.939	0.075	0.290	0.888
	Volberg & Williams, 2011 [d]	General population	Adult	2193	Past year	Clinical assessment (problem and pathological)	35	19	43	2096	0.648	0.980	0.449	0.991	0.020	0.352	0.972
BPGS-3 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 3+	114	9	40	674	0.927	0.944	0.740	0.987	0.056	0.073	0.941
	Volberg & Williams, 2011	General population	Adult	6523	Past year	Clinical assessment (problem and pathological)	778	17	1430	4298	0.979	0.750	0.352	0.996	0.250	0.021	0.778
NLCLiP (1+)	Lepper & Haden, 2013	General population (school)	Adolescent	8958	Past year	DSM-IV-MR-J; 2+	222	181	149	8381	0.551	0.981	0.598	0.979	0.017	0.449	0.963
NODS-CLiP (1+)	Cowlishaw, McCambridge, & Kessler, 2018	Primary care	Adult	1058	Past year	PGS1; 1+	19	36	16	987	0.345	0.984	0.543	0.965	0.016	0.655	0.951
	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 3+	111	12	37	677	0.902	0.948	0.750	0.983	0.052	0.098	0.941
	Toce-Gerstein et al., 2009	General population	Adult	8867	Lifetime	NODS; 3+	327	13	836	7691	0.962	0.902	0.281	0.998	0.098	0.038	0.904
	Volberg & Williams, 2011[d]	General population	Adult	4292	Past year	Clinical assessment (problem and pathological)	592	145	631	2924	0.803	0.823	0.484	0.953	0.177	0.197	0.819
	Volberg & Williams, 2011[d]	General population	Adult	2193	Past year	Clinical assessment (problem and pathological)	47	7	121	2018	0.870	0.943	0.280	0.997	0.057	0.130	0.942
	Volberg et al., 2011	Clinical (gambling service - recruited from substance abuse and medical treatment settings)	Adult	375	Lifetime	NODS; 3+	304	5	46	20	0.984	0.303	0.869	0.800	0.697	0.016	0.864
	Volberg & Williams, 2012	General population	Adult	6329	Past year	PGSI; 3+	1506	32	1058	3733	0.979	0.779	0.588	0.992	0.221	0.021	0.828

(continued on next page)

Table B.2 (*continued*)

Brief screening instrument and cut-off [b,c]	Study ID	Setting	Sample type	Sample size	Timeframe	Reference measure and cut-off	TP	FN	FP	TN	Sens	Spec	PPV	NPV	FPR	FNR	Overall DA
PGSI-Short Form (1+)	Volberg & Williams, 2012	General population	Adult	11,331	Past year	PGSI; 3+	284	24	407	10,616	0.921	0.963	0.419	0.998	0.037	0.079	0.962
	Volberg & Williams, 2012	General population	Adult	11,012	Past year	PGSI; 3+	177	9	280	10,546	0.952	0.974	0.391	0.999	0.026	0.048	0.974
4-item screening instruments																	
BPGS-4 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 3+	115	8	43	671	0.935	0.940	0.728	0.988	0.060	0.065	0.939
	Volberg & Williams, 2011	General population	Adult	6523	Past year	Clinical assessment (problem and pathological)	789	6	1563	4165	0.993	0.727	0.335	0.999	0.273	0.007	0.759
NODS-PERC (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 3+	105	18	33	681	0.854	0.954	0.761	0.974	0.046	0.146	0.939
	Volberg & Williams, 2011[d]	General population	Adult	4292	Past year	Clinical assessment (problem and pathological)	617	120	1175	2380	0.837	0.669	0.344	0.952	0.331	0.163	0.698
	Volberg & Williams, 2011[d]	General population	Adult	2193	Past year	Clinical assessment (problem and pathological)	44	10	155	1984	0.815	0.928	0.221	0.995	0.072	0.185	0.925
	Volberg et al., 2011	Clinical (gambling service - recruited from substance abuse and medical treatment settings)	Adult	375	Lifetime	NODS; 3+	308	1	40	26	0.997	0.394	0.885	0.963	0.606	0.003	0.891
5-item screening instruments																	
BPGS-5 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 3+	116	7	43	671	0.943	0.940	0.730	0.990	0.060	0.057	0.940
	Volberg & Williams, 2011	General population	Adult	6523	Past year	Clinical assessment (problem and pathological)	788	7	1604	4124	0.991	0.720	0.329	0.998	0.280	0.009	0.753
NODS-CLiP2 (1+)	Dowling et al., 2018/ Lubman et al., 2017	Mental health service	Adult	837	Past year	PGSI; 3+	113	10	52	662	0.919	0.927	0.685	0.985	0.073	0.081	0.926
	Volberg & Williams, 2011[d]	General population	Adult	4292	Past year	Clinical assessment (problem and pathological)	667	70	1346	2209	0.905	0.621	0.331	0.969	0.379	0.095	0.670
	Volberg & Williams, 2011[d]	General population	Adult	2193	Past year	Clinical assessment (problem and pathological)	50	4	207	1932	0.926	0.903	0.195	0.998	0.097	0.074	0.904

TP: True positive; FN: False negative; FP: False positive; TN: True negative; Sens: Sensitivity; Spec: Specificity; PPV: Positive predictive value; NPV: Negative predictive value; FPR: False positive rate; FNR: False negative rate; Overall DA: Overall diagnostic accuracy.

[a] While additional data was available across the included articles, only data included in the synthesis of findings has been included.

[b] BPGS = Brief Problem Gambling Screen (2–5 item versions); CHAT = Case Finding and Help Assessment Tool; BBGS = Brief Biosocial Gambling Screen; NLCLiP = National Lottery screen – Loss of Control, Lying and Preoccupation; NODS-CLiP/NODS-CLiP2 = National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation; PGSI-Short Form = Problem Gambling Severity Index Short Form; NODS-PERC = National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships.

[c] Numbers in parentheses represent the cut-off scores for each brief screening instrument recommended by the developers.

[d] Wording of items employed is not based on original and validated brief screening instrument.

Appendix C

C.1. Decision rules

1. Where a single study sample examined the diagnostic accuracy of a brief screening instrument across multiple cut-offs, the original and validated cut-off was used.
2. Where a single study sample examined the diagnostic accuracy of numerous variations of items to determine the best-performing combination of items, only the best performing combination of items according to the included study were used.
3. Where a single study sample examined the diagnostic accuracy of a brief screening instrument across multiple reference standard measures, preference was given to reference standard measures independent of the brief screening instrument, followed by structured clinical interviews and the most frequently employed reference standard.
4. Where a single study sample employed one cut-off on a reference standard to examine the diagnostic accuracy of a brief screening instrument for detecting problem gambling and one cut-off on the same reference standard to examine the diagnostic accuracy of a brief screening instrument for detecting at-risk/problem gambling, the problem gambling cut-off was employed in the problem gambling meta-analysis and the at-risk/problem gambling cut-off was employed in the at-risk/problem gambling meta-analysis.
5. Where a single study sample employed multiple cut-offs on a single reference standard to examine the diagnostic accuracy of a brief screening instrument for detecting problem gambling, the following reference standard measure cut-offs were preferred for inclusion in the problem gambling (including pathological gambling) meta-analysis. These are based on defined cut-offs by the development articles.
   a. A score of 5 or more on any self-report measure or interview-based on the DSM-IV criteria
   b. A score of 4 or more on any self-report measure or interview-based on the DSM-5 criteria
   c. A score of 8 or more on the PGSI
   d. A score of 5 or more on the NODS
   e. A score of 5 or more on the SOGS
   f. A score of 4 or more on the SOGS-RA
   g. Any structured interview where pathological gambling was assessed (not including sub-clinical problem gambling)
6. Where a single study sample employed multiple cut-offs on a single reference standard to examine the diagnostic accuracy of a brief screening instrument for detecting at-risk/problem gambling, the following reference standard measure cut-offs were preferred for inclusion in the at-risk/problem gambling meta-analysis. These are based on defined cut-offs by the development articles. Where the below cut-offs were not available, any available cut-off (as close as possible) lower than the problem gambling cut-off was employed.
   a. A score of 3 or more on any self-report measure or interview-based on the DSM-IV criteria
   b. A score of 3 or more on the PGSI
   c. A score of 3 or more on the NODS
   d. A score of 3 or more on the SOGS
   e. A score 2 or more on any self-report measure or interview based on the DSM-IV-MR-J criteria
   f. A score of 2 or more on the SOGS-RA
   g. Any structured interview where pathological and sub-clinical problem gambling was assessed

Appendix D

Table D.1
Summary description of available brief screening instruments for problem gambling.

Brief screening instrument	Development information	Intended setting	No. of items	Intended age-group	Intended timeframe	Items	Response options	Scoring information
Lie/Bet Questionnaire (Johnson et al., 1997)	Items from a 12-item questionnaire measuring the DSM-IV diagnostic criteria that best discriminated between male Gamblers Anonymous members and non-problem gambling controls (Veterans Administration Medical Centre employees) in the US.	Not reported	2	Adult	Lifetime	(1) Have you ever had to lie to people important to you about how much you gambled? (2) Have you ever felt the need to bet more and more money?	Binary: (1) Yes, (0) No	Positive endorsement of one or both items is indicative of problem gambling
Short South Oaks (SOGS) Gambling Screen (Room et al., 1999)	Derived from the 20 SOGS items in a Canadian population survey.	Not explicitly reported; but impetus for development was because "the SOGS is lengthy for use in a general population telephone survey"	5	Adult	Past year	(1) Was there ever a time when you gambled more than you intended to? (2) Have people criticised your gambling?; (3) Have money arguments centred on your gambling?; (4) Have you felt guilty about the way you gamble or what happens when you gamble; and (5) Have you claimed to be winning money gambling when you were not?	Binary: (1) Yes, (0) No	Positive endorsement of two or more items is indicative of problem gambling
One item screen (Thomas et al., 2010)	Developed in Australia for use in medical practice but was validated in an adult age- and sex-representative community sample.	Primary care	1	Adult	Lifetime	Have you ever had an issue with your gambling?	Binary: (1) Yes, (0) No	Positive endorsement of the item is indicative of problem gambling
Case Finding and Help Assessment Tool (CHAT) (Goodyear-Smith et al., 2008)	Developed in New Zealand, the 24-item CHAT is a composite health screen that screens for nine current lifestyle and mental health conditions (tobacco use, alcohol and other drug misuse, problem gambling, depression, anxiety and stress, abuse, anger problems, inactivity, and eating disorders).	Primary care	2 (3 items administered on positive endorsement on 2 items)	Adult	Current	(1) Do you sometimes feel unhappy or worried after a session of gambling? (2) Does gambling sometimes cause you problems? Patients asked the following item if they have indicated problem gambling on the first two items (to improve specificity): If yes to either or both of these 2 questions, do you want help with this? (No; Yes, but not today; Yes)	Binary: (1) Yes, (0) No	Positive endorsement of one or more items is indicative of problem gambling
National Opinion Research Center Diagnostic Screen for Gambling Disorders – Loss of Control, Lying and Preoccupation (NODS-CLiP: (Toce-Gerstein et al., 2009)/NODS-CLiP2: (Volberg & Williams, 2011)	Derived from the NODS, which is a 17-item measure based on the DSM-IV criteria for pathological gambling. NODS-CLiP comprises the 3 NODS items that best identified problem gambling across eight separate community surveys in the US. The NODS-CLiP2 adds Chasing and Escape to the 3 NODS-CLiP items. Developed in a problem gambling treatment sample recruited from alcohol and other drug and medical treatment settings in the U.S.	NODS-CLiP: Epidemiological research and clinical settings NODS-CLiP2: Not explicitly reported	NODS-CLiP: 3 NODS-CLiP2: 5	Adult	Lifetime	(1) Have there ever been periods lasting 2 weeks or longer when you spent a lot of time thinking about your gambling experiences, or planning out future gambling ventures or bets? (2) Have you ever tried to stop, cut down, or control your gambling? (3) Have you ever lied to family members, friends, or others about how much you gamble or how much money you lost on gambling? The two additional NODS-CLiP2 items are: (1) Has there ever been a period when, if you lost money gambling one day, you would return another day to get even? (2) Have you ever gambled as a way to escape from personal problems?	Binary: (1) Yes, (0) No	Positive endorsement of one or more items is indicative of problem gambling

(continued on next page)

Table D.1 (*continued*)

Brief screening instrument	Development information	Intended setting	No. of items	Intended age-group	Intended timeframe	Items	Response options	Scoring information
Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease (QUIP)/Shortened version (QUIP-S) (Weintraub et al., 2009)	Developed in the US, the 30-item QUIP screens for four impulse-control disorders (gambling, sex, buying and eating), and includes introductory questions relating to other compulsive behaviours and questions relating to compulsive medication use. The items were derived from a combination of existing screening and diagnostic instruments, input from experts in the field and was preliminarily structured to be consistent with diagnostic criteria described by the DSM-IV-TR.	Clinical settings (Parkinson's disease)	QUIP: 5 QUIP-S: 2	Adult	Anytime during Parkinson's Disease	Not reported	Binary: (1) Yes, (0) No	QUIP: Positive endorsement of two or more items is indicative of problem gambling QUIP-S: Positive endorsement of one or more items is indicative of problem gambling
Brief Biosocial Gambling Screen (BBGS) (Gebauer et al., 2010)	Derived from the DSM-IV diagnostic criteria for pathological gambling as measured by the Alcohol Use Disorder and Associated Disability Interview Schedule (AUDADIS) in the US National Epidemiologic Survey on Alcohol and Related Conditions (NESARC).	General population; but also indicates the objective was to develop a screen "for clinicians to use with treatment seekers" and that it is suited to "clinical applications in various settings"	3	Adult	Past year	During the past 12 months: (1) Have you become restless, irritable, or anxious when trying to stop and/or cut down on gambling? (2) Have you tried to keep your family or friends from knowing how much you gambled? (3) Did you have such financial trouble as a result of gambling that you had to get help with living expenses from family, friends, or welfare?	Binary: (1) Yes, (0) No	Positive endorsement of one or more items is indicative of problem gambling
Brief Problem Gambling Screen (BPGS) (Volberg & Williams, 2011)	Best-performing 2–5 items selected from a pool of 30 items from the four most widely used problem gambling assessment measures (South Oaks Gambling Screen; National Opinion Research Center Diagnostic Screen for Gambling Disorders; Problem Gambling Severity Index; Problem and Pathological Gambling Measure) that best captured the largest proportions of pathological, problem, and at-risk gamblers identified via clinical assessment in North American (US and Canada) community and online samples.	Both clinical settings and population research	2–5 item versions	Adult	Past year	In the past 12 months: (1) Would you say you have been preoccupied with gambling? (2) Have you often gambled longer, with more money or more frequently than you intended to? (3) Have you needed to gamble with larger amounts of money to get the same feeling of excitement? (4) Have you made attempts to either cut down, control or stop gambling? (5) Have people criticised your betting or told you that you had a gambling problem, regardless of whether or not you thought it was true? (6) Have you borrowed money or sold anything to get money to gamble? 2-item: Items 1–2 3-item: Items 2–4 4-item: Items 2–5 5-item: Items 1–4 and 6	Binary: (1) Yes, (0) No	Positive endorsement of one or more items is indicative of problem gambling

(*continued on next page*)

Table D.1 (*continued*)

Brief screening instrument	Development information	Intended setting	No. of items	Intended age-group	Intended timeframe	Items	Response options	Scoring information
National Opinion Research Centre Diagnostic Screen for Gambling Disorders – Preoccupation, Escape, Chasing and Risked Relationships (NODS-PERC) (Volberg et al., 2011)	Comprised of the four NODS items that best identified problem gambling in a problem gambling treatment sample recruited from alcohol and other drug and medical treatment settings, in the U.S.	Alcohol and other drug treatment and other clinical settings	4	Adult	Lifetime	(1) Have there ever been periods lasting 2 weeks or longer when you spent a lot of time thinking about your gambling experiences or planning out future gambling ventures or bets? (2) Have you ever gambled as a way to escape from personal problems? (3) Has there ever been a period when, if you lost money gambling one day, you would return another day to get even? (4) Has your gambling ever caused serious or repeated problems in your relationships with any of your family members or friends?	Binary: (1) Yes, (0) No	Positive endorsement of one or more items is indicative of problem gambling
Problem Gambling Severity Index (PGSI) Short Form (Volberg & Williams, 2012)	Developed for the purpose of tracking the prevalence of problem gambling in the general population. Comprised of three items from the PGSI. The PGSI short form was developed across English-speaking countries, including the U.S., Canada, U.K., Australia and New Zealand.	Population research; not recommended for clinical settings	3	Adult	Past year	Thinking about the last 12 months: (1) Have you bet more than you could really afford to lose? (2) Have people criticised your betting or told you that you had a gambling problem, regardless of whether or not you thought it was true? (3) Have you felt guilty about the way you gamble or what happens when you gamble?	Multiple: (0) Never; (1) Sometimes; (2) Most of the time; and (3) Almost always	Scores range from 0 to 9; Cut-offs: 3+ = problem gambling, 1–2 = at-risk gambling, 0 = non-problem gambling.
Consumption Screen for Problem Gambling (-CSPG) (Rockloff, 2012)	A conceptual analogue of the Alcohol Use Disorders Identification Test – Consumption. It was developed in an adult community (email panel) sample in Australia and measures consumption rather than harm. Although it was developed and validated in a community sample, the authors suggest that the CSPG may most useful in clinical settings, such as general practice, as items about consumption may be less intrusive than those about gambling harms.	Clinical settings, such as general practice	3	Adult	Past year	The questions and response options are: Item 1: How often did you gamble in the past 12 months? (0) I have NEVER gambled OR I have not gambled at all in the past 12 months (1) Monthly or less (2) 2 to 4 times a month (3) 2 to 3 times a week (4) 4 to 5 times a week (5) 6 or more times a week Item 2: How much time did you spend gambling on a typical day in which you gambled in the past 12 months? (0) < 30 min (1) > 30 min but < 1 h (2) > 1 h but < 2 h (3) > 2 h but < 3 h (4) > 3 h. Item 3: How often did you spend > 2 h gambling (on a single occasion) in the past 12 months? (0) Never (1) Less than monthly (2) Monthly (3) Weekly (4) Daily or almost daily.	Like the AUDIT-Consumption, the CSPG has different response options for each item	A score of 4 or more is indicative of problem gambling
National Lottery screen – Loss of Control, Lying and Preoccupation (-NLCLiP) (Lepper & Haden, 2013)	Designed in the U.K. to assess changes in problem gambling prevalence and harms in children and adolescents over time. An adaptation of the NODS-CLiP, in which the wording of CLiP items was simplified for use among children and multiple response options were provided for each item.	Population research; not developed for clinical settings	3	Adolescence	Past year	In the past 12 months: (1) How often have you found yourself thinking about gambling or planning to gamble? (2) How often have you tried to cut down how much you gamble? (3) How often have you lied to your family, friends, or anyone else about how much you gamble?	Multiple: (3) Quite a lot; (2) Only sometimes; (1) Don't know; and (0) Not at all	A score of 3 or more is indicative of problem gambling

(*continued on next page*)

Table D.1 (*continued*)

Brief screening instrument	Development information	Intended setting	No. of items	Intended age-group	Intended timeframe	Items	Response options	Scoring information
Rapid Screener for Problem Gambling (RSPG) – Interview version (-Challet-Bouju et al., 2016)	The aim was to perform a systematic search of the best combinations of items from several gambling scales, to develop a brief screen for use in interview-based epidemiological surveys (i.e., telephone or face-to-face surveys), in France. Items for the interview-based tool came from testing combinations of the 10 DSM-IV diagnostic criteria and 3 interview questions designed to evaluate gambling history and habits (lifetime history of problem gambling, monthly expenses in gambling, and abstinence of 1 month or more).	Population research	3	Adult	Past year	(1) Have you had a gambling practice over the past 12 months? (2) During the past 12 months, have you needed to gamble with increasing amounts of money in order to achieve the desired excitement? (3) During the past 12 months, have you made repeated unsuccessful efforts to control, cut back or stop gambling?	Binary: (1) Yes, (0) No	A score of 1 or more is indicative of the need for a deeper interview to establish a final diagnosis of a gambling disorder
Rapid Screener for Problem Gambling (RSPG) – self-assessment version (Challet-Bouju et al., 2016)	The aim was to perform a systematic search of the best combinations of items from several gambling scales, to develop a brief screen for use in self-report-based epidemiological surveys (i.e., internet-based surveys), in France. Items for the self-report tool came from testing combinations of 25 items from the SOGS and the 35 items from the Gambling Attitudes and Beliefs Scale (GABS)	Population research	4	Adult	Past year	(1) Have you had a gambling practice over the past 12 months? (2) When you gamble, how often do you go back another day to win back money you have lost? (3) Have you ever felt guilty about the way you gamble, or what happens when you gamble? (4) Have you ever felt like you would like to stop betting money on gambling, but didn't think you could?	Binary (items 1, 3 and 4): (1) Yes, (0) No; Multiple (item 2): (1) Every time I lose, (1) Most of the time I lose, (0) Some of the time (less than half the time I lost), (0) Never	A score of 1 or more is indicative of the need for a deeper interview to establish a final diagnosis of a gambling disorder
Brief Adolescent Gambling Screen (BAGS) (Stinchfield et al., 2017)	The aim was to develop a brief screen for adolescent problem gambling based on items from the Canadian Adolescent Gambling Inventory (CAGI), the only assessment tool developed specifically for adolescents.	NR	3	Adolescence	Past 3 months	Over the past 3 months, how often have you: (1) Skipped hanging out with friends who do not gamble/bet (2) Felt that you might have a problem with gambling/betting (3) Hidden your gambling/betting from your parents, other family members or teachers	Multiple: (3) Almost always; (2) Most of the time; (1) Sometimes; (0) Never.	A score of 4 or more is indicative of a very high likelihood of gambling disorder.

Appendix E

Table E.1
Characteristics of included studies.[a]

Study ID	Jurisdiction	Sample type	Setting	Sample size	Brief screening instrument	Reference measure
Brett et al. (2014)	USA	Adult	Clinical (gambling service)	2750	BBGS	Semi-structured interview based on DSM-IV
Challet-Bouju et al. (2016)	France	Adult	General population	416; 425	BBGS; Lie/Bet; One-Item Screen; RSPG-I; RSPG-SA	Interview based on the DSM-5
Colasante et al. (2013)	Italy	Adult	General population	5102	Lie/Bet	PGSI
Cowlishaw et al. (2018)	England	Adult	Clinical (primary care)	1058	NODS-CLiP	PGSI
Dowling et al. (2018) / Lubman et al. (2017)	Australia	Adult	Clinical (mental health service)	837	BBGS; BPGS-2; BPGS-3; BPGS-4; BPGS-5; Lie/Bet; NODS-CLiP; NODS-CLiP2; NODS-PERC; PGSI-Short Form	PGSI
Gebauer et al. (2010)	USA	Adult	General population	11,106	BBGS; Lie/Bet	DSM-IV-TR criteria
Goodyear-Smith et al. (2009)	New Zealand	Adult	Clinical (primary care)	688	CHAT	SOGS
Gotestam et al. (2004)	Norway	Adult	General population	1382	Lie/Bet	DSM-IV criteria
Gotestam et al. (2004)	Norway	Adolescent	General population	894	Lie/Bet	DSM-IV criteria
Himelhoch et al. (2015)	USA	Adult	Clinical (AOD service)	299	BBGS; Lie/Bet; NODS-CLiP; NODS-PERC	DSM-5 criteria
Johnson et al. (1997)	USA	Adult	Case-control (general population and clinical (gambling service))	362	Lie/Bet	Case-control
Johnson et al. (1998)	USA	Adult	Case-control (general population and clinical (gambling service))	423	Lie/Bet	Case-control
Langan, Wall, Potts, and Himelhoch (2018)	USA	Adult	Clinical (HIV)	100	BBGS	DSM-5 criteria
Lepper and Haden (2013)	England, Wales and Scotland	Adolescent	General population (school)	8958	NLCLiP	DSM-IV-MR-J criteria
Rockloff et al. (2011)	Australia	Adult	General population	1292	One-Item Screen	PGSI
Rockloff (2012)	Australia	Adult	General population	1396	CSPG	PGSI
Rossow and Molde (2006)	Norway	Adolescent	General population (school)	14,439	Lie/Bet	SOGS-RA
Stinchfield and McCready (2014)(from Jimenez-Murcia et al., 2012)	Spain	Adult	Case-control (general population and clinical (gambling service))	282	BBGS; BPGS-5; Lie/Bet; One-Item Screen; NODS-CLiP; NODS-PERC; Short SOGS	Case-control
Stinchfield and McCready (2014) (from Jimenez-Murcia et al. 2009)	Spain	Adult	Case-control (general population and clinical (gambling service))	569	BBGS; BPGS-5; Lie/Bet; One-Item Screen; NODS-CLiP; NODS-PERC; Short SOGS	Case-control
Stinchfield and McCready (2014) (from Stinchfield, 2003)	USA	Adult	Case-control (general population and clinical (gambling service))	1062	BBGS; BPGS-5; Lie/Bet; One-Item Screen; NODS-CLiP; NODS-PERC; Short SOGS	Case-control
Stinchfield and McCready (2014) (from Stinchfield et al. 2005)	Canada	Adult	Case-control (general population and clinical (gambling service))	390	BBGS; BPGS-5; Lie/Bet; One-Item Screen; NODS-CLiP; NODS-PERC; Short SOGS	Case-control
Stinchfield, Winters, Botzet, Jerstad, and Breyer (2017) (from Stinchfield et al., 2007)	USA	Adult	Case-control (general population and clinical (gambling service))	175	BBGS; BPGS-5; Lie/Bet; One-Item Screen; NODS-CLiP; NODS-PERC; Short SOGS	Case-control
Stinchfield et al. (2007) (from Stinchfield et al., 2007)	USA	Adult	Case-control (general population and clinical (gambling service))	135	BBGS; BPGS-5; Lie/Bet; One-Item Screen; NODS-CLiP; NODS-PERC; Short SOGS	Case-control

(*continued on next page*)

Table E.1 (*continued*)

Study ID	Jurisdiction	Sample type	Setting	Sample size	Brief screening instrument	Reference measure
Stinchfield and McCready (2014) (from Stinchfield et al. 2012)	USA	Adult	Case-control (general population and clinical (gambling service))	212	BBGS; BPGS-5; Lie/Bet; One-Item Screen; NODS-CLiP; NODS-PERC; Short SOGS	Case-control
Stinchfield and McCready (2014) (from Stinchfield et al. 2012)	Canada	Adult	Case-control (general population and clinical (gambling service))	422	BBGS; BPGS-5; Lie/Bet; One-Item Screen; NODS-CLiP; NODS-PERC; Short SOGS	Case-control
Stinchfield et al. (2017)	Canada	Adolescent	General population (schools) and clinical (problem behaviour and substance abuse treatment services)	105	BAGS	Self-report and clinician administered DSM-5 criteria
Tanaka et al. (2013)	Japan	Adult	Clinical (Parkinson's disease)	93	QUIP-S	DSM-IV criteria
Toce-Gerstein et al. (2009)	USA	Adult	General population	8867	NODS-CLiP	DSM-IV criteria
Volberg et al. (2011)	USA	Adult	Clinical (gambling service - recruited from substance abuse and medical treatment settings)	375	NODS-CLiP; NODS-PERC	NODS
Volberg and Williams (2011) – Best Practices sample[a]	Canada	Adult	General population	2193	BBGS; Lie/Bet; NODS-CLiP; NODS-CLiP2; NODS-PERC	Clinical assessment (pathological)
Volberg and Williams (2011) – Internet Online sample[a]	USA and Canada	Adult	General population	4292	BBGS; Lie/Bet; NODS-CLiP; NODS-CLiP2; NODS-PERC	Clinical assessment (pathological)
Volberg and Williams (2011) – Combined sample[a]	USA and Canada	Adult	General population	6523	BPGS-2; BPGS-3; BPGS-4; BPGS-5	Clinical assessment (pathological)
Volberg and Williams et al. (2012) – British Gambling Prevalence Survey sample	UK	Adult	General population	11,331	PGSI-Short Form	PGSI
Volberg and Williams et al. (2012) – Omnibus sample	UK	Adult	General population	11,012	PGSI-Short Form	PGSI
Volberg and Williams et al. (2012) – Combined Best Practices and Internet Online sample[a]	USA, Canada, UK, Australia and New Zealand	Adult	General population	6329	PGSI-Short Form	PGSI
Weintraub et al. (2009)	USA	Adult	Clinical (Parkinson's disease)	157	QUIP; QUIP-S	Semi-structured interview for compulsive gambling

[a] There may be overlap in the samples employed in Volberg and Williams (2011) and Volberg & Williams et al. (2012), however, they have been treated as separate samples as the methodologies, sample size, and brief screening instruments assessed differed.

Appendix F. QUADAS-2 Risk of Bias by Item

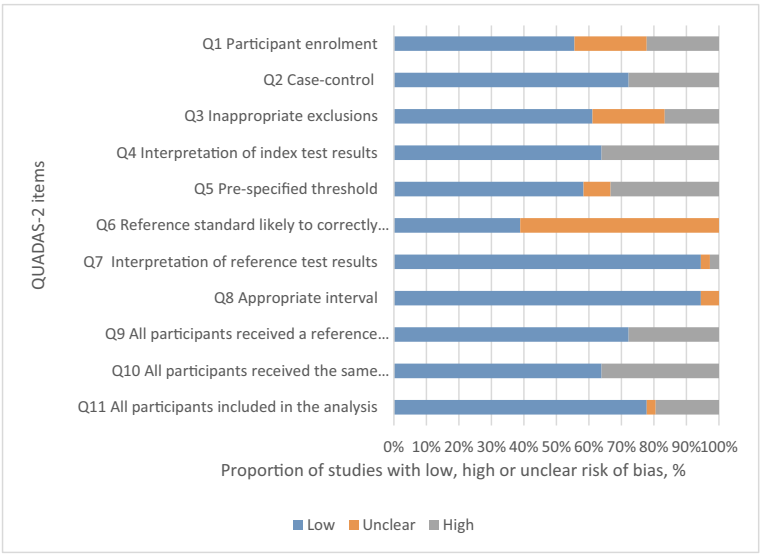

Fig. F.1. QUADAS-2 risk of bias assessment results by signalling items.

References

Achab, S., Chatton, A., Khan, R., Thorens, G., Penzenstadler, L., Zullino, D., & Khazaal, Y. (2014). Early detection of pathological gambling: Betting on GPs' beliefs and attitudes. *BioMed Research International, 2014*. https://doi.org/10.1155/2014/360585.

American Psychiatric Association (2013). *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.). Arlington, VA: American Psychiatric Association.

Aragay, N., Roca, A., Garcia, B., Marqueta, C., Guijarro, S., Delgado, L., ... Valles, V. (2012). Pathological gambling in a psychiatric sample. *Comprehensive Psychiatry, 53*(1), 9–14. https://doi.org/10.1016/j.comppsych.2011.02.004.

Bailey, L., Vardulaki, K., Langham, J., & Chandramohan, D. (2006). *Introduction to epidemiology* (1st ed.). London, United Kingdom: Open University Press.

Biddle, D., Hawthorne, G., Forbes, D., & Coman, G. (2005). Problem gambling in Australian PTSD treatment-seeking veterans. *Journal of Traumatic Stress, 18*(6), 759–767. https://doi.org/10.1002/jts.20084.

Brett, E. I., Weinstock, J., Burton, S., Wenzel, K. R., Weber, S., & Moran, S. (2014). Do the DSM-5 diagnostic revisions affect the psychometric properties of the Brief Biosocial Gambling Screen? *International Gambling Studies, 14*(3), 447–456. https://doi.org/10.1080/14459795.2014.931449.

Browne, M., Greer, N., Rawat, V., & Rockloff, M. (2017). A population-level metric for gambling-related harm. *International Gambling Studies, 17*(2), 163–175.

Calado, F., Alexandre, J., & Griffiths, M. D. (2017). Prevalence of adolescent problem gambling: A systematic review of recent research. *Journal of Gambling Studies, 33*(2), 397–424.

Challet-Bouju, G., Perrot, B., Romo, L., Valleur, M., Magalon, D., Fatseas, M., ... Grall-Bronnec, M. (2016). Harmonizing screening for gambling problems in epidemiological surveys – development of the rapid screener for Problem Gambling (RSPG). *Journal of Behavioral Addictions, 5*(2), 239–250. https://doi.org/10.1556/2006.5.2016.030.

Chou, K. L., & Afifi, T. O. (2011). Disordered (pathologic or problem) gambling and axis I psychiatric disorders: Results from the National Epidemiologic Survey on Alcohol and Related Conditions. *American Journal of Epidemiology, 173*(11), 1289–1297. https://doi.org/10.1093/aje/kwr017.

Colasante, E., Gori, M., Bastiani, L., Siciliano, V., Giordani, P., Grassi, M., & Molinaro, S. (2013). An assessment of the psychometric properties of Italian version of CPGI. *Journal of Gambling Studies, 29*(4), 765–774. https://doi.org/10.1007/s10899-012-9331-z.

Corney, R. (2011). Continuing professional development for general practitioners in the United Kingdom. *Journal of Gambling Issues, 25*(4), 108–112. https://doi.org/10.4309/jgi.2011.25.8.

Cowlishaw, S., Hakes, J. K., & Dowling, N. A. (2016). Gambling problems in treatment for affective disorders: Results from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). *Journal of Affective Disorders, 202*, 110–114. https://doi.org/10.1016/j.jad.2016.05.023.

Cowlishaw, S., McCambridge, J., & Kessler, D. (2018). Identification of Gambling Problems in Primary Care: Properties of the NODS-CLiP Screening Tool. *Journal of Addiction Medicine, 12*(6), 442–446. https://doi.org/10.1097/ADM.0000000000000429.

Cowlishaw, S., Merkouris, S., Chapman, A., & Radermacher, H. (2014). Pathological and problem gambling in substance use treatment: a systematic review and meta-analysis. *Journal of Substance Abuse Treatment, 46*(2), 98–105.

Cowlishaw, S., Merkouris, S. S., Dowling, N. A., Anderson, C., Jackson, A., & Thomas, S. (2012). Psychological therapies for pathological and problem gambling. *Cochrane Database of Systematic Reviews, 11*, CD008937. https://doi.org/10.1002/14651858.CD008937.pub2.

Crockford, D. N., & el-Guebaly, N. (1998). Psychiatric comorbidity in pathological gambling: a critical review. *The Canadian Journal of Psychiatry, 43*(1), 43–50.

Derevensky, J. L., Gupta, R., & Winters, K. C. (2003). Prevalence rates of youth gambling problems: Are the current rates inflated? *Journal of Gambling Studies, 19*(4), 405–425.

Di Nicola, M., Tedeschi, D., Mazza, M., Martinotti, G., Harnic, D., Catalano, V., & Janiri, L. (2010). Behavioural addictions in bipolar disorder patients: role of impulsivity and personality dimensions. *Journal of Affective Disorders, 125*(1–3), 82–88. https://doi.org/10.1016/j.jad.2009.12.016.

DiStefano, C., & Morgan, G. (2011). Examining classification criteria: a comparison of three cut score methods. *Psychological Assessment, 23*(2), 354–363. https://doi.org/10.1037/a0021745.

Doebler, P. (2017). Mada: meta-analysis of diagnostic accuracy. R package version 0.5.8. Retrieved from https://CRAN.R-project.org/package=mada.

Dowling, N. A., Jackson, A. C., Suomi, A., Lavis, T., Thomas, S. A., Patford, J., & Bellringer, M. E. (2014). Problem gambling and family violence: prevalence and patterns in treatment-seekers. *Addictive Behaviors, 39*(12), 1713–1717.

Dowling, N. A., Merkouris, S. S., Manning, V., Volberg, R., Lee, S. J., Rodda, S. N., & Lubman, D. I. (2018). Screening for problem gambling within mental health services: a comparison of the classification accuracy of brief instruments. *Addiction, 113*(6), 1088–1104.

Dussault, F., Brendgen, M., Vitaro, F., Wanner, B., & Tremblay, R. E. (2011). Longitudinal links between impulsivity, gambling problems and depressive symptoms: A transactional model from adolescence to early adulthood. *Journal of Child Psychology and Psychiatry, 52*(2), 130–138. https://doi.org/10.1111/j.1469-7610.2010.02313.x.

Edgren, R., Castrén, S., Mäkelä, M., Pörtfors, P., Alho, H., & Salonen, A. H. (2016). Reliability of instruments measuring at-risk and problem gambling among young individuals: A systematic review covering years 2009–2015. *Journal of Adolescent Health, 58*(6), 600–615. https://doi.org/10.1016/j.jadohealth.2016.03.007.

Eusebi, P. (2013). Diagnostic accuracy measures. *Cerebrovascular Diseases, 36*, 267–272.

Gebauer, L., LaBrie, R., & Shaffer, H. (2010). Optimizing DSM-IV-TR classification accuracy: A brief biosocial screen for detecting current gambling disorders among gamblers in the general household population. *Canadian Journal of Psychiatry, 55*(2), 82–90. https://doi.org/10.1177/070674371005500204.

Glascoe, F. P. (2005). Screening for developmental and behavioral problems. *Mental Retardation and Developmental Disabilities Research Reviews, 11*(3), 173–179. https://doi.org/10.1002/mrdd.20068.

Gooding, P., & Tarrier, N. (2009). A systematic review and meta-analysis of cognitive-behavioural interventions to reduce problem gambling: Hedging our bets? *Behaviour Research and Therapy, 47*(7), 592–607. https://doi.org/10.1016/j.brat.2009.04.002.

Goodyear-Smith, F., Arroll, B., & Coupe, N. (2009). Asking for help is helpful: Validation of a brief lifestyle and mood assessment tool in primary health care. *Annals of Family Medicine, 7*(3), 239–244. https://doi.org/10.1370/afm.962.

Goodyear-Smith, F., Arroll, B., Kerse, N., Sullivan, S., Coupe, N., Tse, S., ... Perese, L. (2006). Primary care patients reporting concerns about their gambling frequently have other co-occurring lifestyle and mental health issues. *BMC Family Practice, 7*, 1–6.

Goodyear-Smith, F., Coupe, N. M., Arroll, B., Elley, C. R., Sullivan, S., & McGill, A. T. (2008). Case finding of lifestyle and mental health disorders in primary care:

Validation of the "CHAT" tool. *British Journal of General Practice, 58*(546), 26–31. https://doi.org/10.3399/bjgp08X263785.
Gotestam, K. G., Johansson, A., Wenzel, H. G., & Simonsem, I. E. (2004). Validation of the Lie/Bet screen for pathological gambling on two normal population data sets. *Psychological Reports, 95*(3), 1009–1013. https://doi.org/10.2466/pr0.95.3.1009-1013.
Haydock, M., Cowlishaw, S., Harvey, C., & Castle, D. (2015). Prevalence and correlates of problem gambling in people with psychotic disorders. *Comprehensive Psychiatry, 58*, 122–129. https://doi.org/10.1016/j.comppsych.2015.01.003.
Henderson, M. J. (2004). Psychological correlates of comorbid gambling in psychiatric outpatients: A pilot study. *Substance Use & Misuse, 39*(9), 1341–1352. https://doi.org/10.1081/ja-120039391.
Himelhoch, S. S., Miles-McLean, H., Medoff, D. R., Kreyenbuhl, J., Rugle, L., Bailey-Kloch, M., & Brownley, J. (2015). Evaluation of brief screens for gambling disorder in the substance use treatment setting. *The American Journal on Addictions, 24*(5), 460–466. https://doi.org/10.1111/ajad.12241.
Hodgins, D. C., Peden, N., & Cassidy, E. (2005). The association between comorbidity and outcome in pathological gambling: A prospective follow-up of recent quitters. *Journal of Gambling Studies, 21*(3), 255–271. https://doi.org/10.1007/s10899-005-3099-3.
Jimenez-Murcia, S., Stinchfield, R., Alvarez-Moya, E., Jaurrieta, N., Bueno, B., Granero, R., Aymami, M. N., Gomez-Pena, M., Gimenez-Martinez, R., Fernandez-Aranda, F., & Vallejo, J. (2009). Reliability, validity and classification accuracy of a Spanish translation of a measure of DSM-IV diagnostic criteria for pathological gambling. *Journal of Gambling Studies, 25*(1), 93–104.
Jimenez-Murcia, S., Stinchfield, R., Alvarez-Moya, E., Jaurrieta, N., Bueno, B., Granero, R., Aymami, M. N., Gomez-Pena, M., Gimenez-Martinez, R., Fernandez-Aranda, F., & Vallejo, J. (2012). *Unpublished data from the Gambling Behavior Interview (GBI) collected in Barcelona, Spain*.
Johnson, E. E., Hamer, R. M., & Nora, R. M. (1997). The Lie/Bet Questionnaire for screening pathological gamblers. *Psychological Reports, 80*(1), 83–88. https://doi.org/10.2466/pr0.1997.80.1.83.
Johnson, E. E., Hamer, R. M., & Nora, R. M. (1998). The lie/bet questionnaire for screening pathological gamblers: A follow-up study. *Psychological Reports, 83*, 1219–1224.
Jones, L., Metcalf, A., Gordon-Smith, K., Forty, L., Perry, A., Lloyd, J., & Rogers, R. D. (2015). Gambling problems in bipolar disorder in the UK: Prevalence and distribution. *British Journal of Psychiatry, 207*(4), 328–333. https://doi.org/10.1192/bjp.bp.114.154286.
Kennedy, S. H., Welsh, B. R., Fulton, K., Soczynska, J. K., McIntyre, R. S., O'Donovan, C., & Martin, N. (2010). Frequency and correlates of gambling problems in outpatients with major depressive disorder and bipolar disorder. *Canadian Journal of Psychiatry, 55*(9), 568–576. https://doi.org/10.1177/070674371005500905.
Kessler, R. C., Hwang, I., LaBrie, R., Petukhova, M., Sampson, N. A., Winters, K. C., & Shaffer, H. J. (2008). DSM-IV pathological gambling in the national comorbidity survey replication. *Psychological Medicine, 38*(9), 1351–1360. https://doi.org/10.1017/S0033291708002900.
Langan, K., Wall, M., Potts, W., & Himelhoch, S. (2018). Prevalence and potential predictors of gambling disorder among people living with hiv. *AIDS Care*. https://doi.org/10.1080/09540121.2018.1499858.
Langham, E., Thorne, H., Browne, M., Donaldson, P., Rose, J., & Rockloff, M. (2016). Understanding gambling related harm: A proposed definition, conceptual framework, and taxonomy of harms. *BMC Public Health, 16*, 80. https://doi.org/10.1186/s12889-016-2747-0.
Langan, K., Wall, M., Potts, W., & Himelhoch, S. (2019). Prevalence and potential predictors of gambling disorder among people living with HIV. *AIDS Care, 31*(4), 421–426.
Lepper, J., & Haden, B. (2013). Testing NLCLiP: Validation of estimates of rates of non-problematic and problematic gambling in a sample of British schoolchildren. *Journal of Gambling Studies, 29*(1), 15–27. https://doi.org/10.1007/s10899-012-9294-0.
Lesieur, H. R., & Blume, S. B. (1987). The South Oaks Gambling Screen (SOGS): A new instrument for the identification of pathological gamblers. *The American Journal of Psychiatry, 144*(9), 1184–1188. https://doi.org/10.1176/ajp.144.9.1184.
Levens, S., Dyer, A. M., Zubritsky, C., Knott, K., & Oslin, D. W. (2005). Gambling among older, primary-care patients: An important public health concern. *American Journal of Geriatric Psychiatry, 13*(1), 69–76. https://doi.org/10.1097/00019442-200501000-00010.
Lubman, D., Manning, V., Dowling, N. A., Rodda, S., Lee, S., Garde, E., & Volberg, R. (2017). *Problem gambling in people seeking treatment for mental Illness.* Melbourne: Victorian Responsible Gambling Foundation.
Macaskill, P., Gatsonis, C., Deeks, J., Harbord, R., & Takwoingi, Y. (2010). *Cochrane handbook for systematic reviews of diagnostic test accuracy. Version 0.9. 0.* London: The Cochrane Collaboration.
Manning, V., Dowling, N. A., Lee, S., Rodda, S., Garfield, J. B. B., Volberg, R., & Lubman, D. I. (2017). Problem gambling and substance use in patients attending community mental health services. *Journal of Behavioral Addictions, 6*(4), 678–688. https://doi.org/10.1556/2006.6.2017.077.
McCambridge, J., & Cunningham, J. (2007). Against the odds: Should GPs have any involvement with gambling problems. *British Journal of General Practice, 57*(537), 327.
McIntyre, R. S., McElroy, S. L., Konarski, J. Z., Soczynska, J. K., Wilkins, K., & Kennedy, S. H. (2007). Problem gambling in bipolar disorder: Results from the Canadian Community Health Survey. *Journal of Affective Disorders, 102*(1–3), 27–34. https://doi.org/10.1016/j.jad.2006.12.005.
Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Annals of Internal Medicine, 151*(4), 264–269. https://doi.org/10.1371/journal.pmed.1000097.
Morasco, B. J., Vom Eigen, K. A., & Petry, N. M. (2006). Severity of gambling is associated with physical and emotional health in urban primary care patients. *General Hospital Psychiatry, 28*(2), 94–100.
Neal, P., Delfabbro, P., & O'Neil, M. (2005). *Problem gambling and harm: Toward a national definition.* Melbourne: Office of Gaming and Racing.
Nehlin, C., Gronbladh, L., Fredriksson, A., & Jansson, L. (2013). Alcohol and drug use, smoking, and gambling among psychiatric outpatients: A 1-year prevalence study. *Substance Abuse, 34*(2), 162–168. https://doi.org/10.1080/08897077.2012.728991.
Parhami, I., Mojtabai, R., Rosenthal, R. J., Afifi, T. O., & Fong, T. W. (2014). Gambling and the onset of comorbid mental disorders: A longitudinal study evaluating severity and specific symptoms. *Journal of Psychiatric Practice, 20*(3), 207–219. https://doi.org/10.1097/01.pra.0000450320.98988.7c.
Pasternak, A., & Fleming, M. F. (1999). Prevalence of gambling disorders in a primary care setting. *Archives of Family Medicine, 8*, 515–519.
Pilver, C. E., Libby, D. J., Hoff, R. A., & Potenza, M. N. (2013). Problem gambling severity and the incidence of axis I psychopathology among older adults in the general population. *Journal of Psychiatric Research, 47*(4), 534–541. https://doi.org/10.1016/j.jpsychires.2012.12.013.
Quilty, L. C., Watson, C., Robinson, J. J., Toneatto, T., & Bagby, R. M. (2011). The prevalence and course of pathological gambling in the mood disorders. *Journal of Gambling Studies, 27*(2), 191–201. https://doi.org/10.1007/s10899-010-9199-8.
R Core Team (2013). R: A language and environment for statistical computing. *Vienna*. Austria: R Foundation for Statistical Computing.
Reitsma, J. B., Glas, A. S., Rutjes, A. W., Scholten, R. J., Bossuyt, P. M., & Zwinderman, A. H. (2005). Bivariate analysis of sensitivity and specificity produces informative summary measures in diagnostic reviews. *Journal of Clinical Epidemiology, 58*(10), 982–990. https://doi.org/10.1016/j.jclinepi.2005.02.022.
Rockloff, M. J. (2012). Validation of the Consumption Screen for Problem Gambling (CSPG). *Journal of Gambling Studies, 28*(2), 207–216. https://doi.org/10.1007/s10899-011-9260-2.
Rockloff, M. J., Ehrich, J., Themessl-Huber, M., & Evans, L. G. (2011). Validation of a one item screen for problem gambling. *Journal of Gambling Studies, 27*(4), 701–707. https://doi.org/10.1007/s10899-010-9232-y.
Rodda, S. N., Manning, V., Dowling, N. A., Lee, S., & Lubman, D. I. (2018). Barriers and facilitators of screening for problem gambling: Perspectives of Australian mental health services. *Journal of Gambling Studies, 34*(1), 307–320. https://doi.org/10.1007/s10899-017-9713-3.
Room, R., Turner, N. E., & Ialomiteanu, A. (1999). Community effects of the opening of the Niagra Casino. *Addiction, 94*(10), 1449–1466. https://doi.org/10.1046/j.1360-0443.1999.941014492.x.
Rossow, I., & Molde, H. (2006). Chasing the criteria: Comparing SOGS-RA and the Lie/Bet screen to assess prevalence of problem gambling and 'at-risk' gambling among adolescents. *Journal of Gambling Issues,* (18), 57–72. https://doi.org/10.4309/jgi.2006.18.9.
Rowan, M. S., & Galasso, C. S. (2000). Identifying office resource needs of Canadian physicians to help prevent, assess and treat patients with substance use and pathological gambling disorders. *Journal of Addictive Diseases, 19*(2), 43–58. https://doi.org/10.1300/J069v19n02_04.
Sanju, G., & Gerada, C. (2011). Problem gamblers in primary care: Can GPs do more? *British Journal of General Practice, 61*(585), 248–249. https://doi.org/10.3399/bjgp11X567027.
Scholes-Balog, K. E., Hemphill, S. A., Dowling, N. A., & Toumbourou, J. W. (2014). A prospective study of adolescent risk and protective factors for problem gambling among young adults. *Journal of Adolescence, 37*(2), 215–224. https://doi.org/10.1016/j.adolescence.2013.12.006.
Scholes-Balog, K. E., Hemphill, S. A., Toumbourou, J. W., & Dowling, N. A. (2015). Problem gambling and internalising symptoms: a longitudinal analysis of common and specific social environmental protective factors. *Addictive Behaviors, 46*, 86–93. https://doi.org/10.1016/j.addbeh.2015.03.011.
Scholes-Balog, K. E., Hemphill, S. A., Toumbourou, J. W., & Dowling, N. A. (2016). Problem gambling patterns among Australian young adults: Associations with prospective risk and protective factors and adult adjustment outcomes. *Addictive Behaviors, 55*, 38–45. https://doi.org/10.1016/j.addbeh.2015.12.016.
Séguin, M., Robert, M., DiMambro, M., Lesage, A., Reidi, G., Roy, M., ... Dutrisac, S. (2013). Gambling over the life course and treatment-seeking. *International Gambling Studies, 13*(3), 302–318. https://doi.org/10.1080/14459795.2013.812675.
Shaffer, H. J., & Korn, D. A. (2002). Gambling and related mental disorders: a public health analysis. *Annual Review of Public Health, 23*, 171–212. https://doi.org/10.1146/annurev.publhealth.23.100901.140532.
Šimundić, A. M. (2009). Measures of diagnostic accuracy: Basic definitions. *EJIFCC, 19*(4), 203–211.
Slutske, W. S., Eisen, S., Xian, H., True, W. R., Lyons, M. J., Goldberg, J., & Tsuang, M. (2001). A twin study of the association between pathological gambling and antisocial personality disorder. *Journal of Abnormal Psychology, 110*(2), 297.
Specker, S. M., Carlson, G. A., Edmonson, K. M., Johnson, P. E., & Marcotte, M. (1996). Psychopathology in pathological gamblers seeking treatment. *Journal of Gambling Studies, 12*(1), 67–81. https://doi.org/10.1007/BF01533190.
Stinchfield, R. (2003). Reliability, validity, and classification accuracy of a measure of DSM-IV diagnostic criteria for Pathological Gambling. *American Journal of Psychiatry, 160*, 180–182.
Stinchfield, R. (2010). A critical review of adolescent problem gambling assessment instruments. *International Journal of Adolescent Medicine and Health, 22*(1), 77–93.
Stinchfield, R. (2014). In D. C. S. Richard, A. Blaszcynski, & L. Nower (Eds.). *A review of problem gambling assessment instruments and brief screens*The Wiley-Blackwell handbook of disordered gambling: John Wiley & Sons (Ltd).
Stinchfield, R., Govoni, R., & Frisch, R. G. (2005). DSM-IV diagnostic criteria for Pathological Gambling: Reliability, validity, and classification accuracy. *American*

Journal on Addictions, 14, 73–82.
Stinchfield, R., Govoni, R., & Frisch, G. R. (2007). A review of screening and assessment instruments for problem and pathological gambling. In G. Smith, D. C. Hodgins, & R. J. Williams (Eds.). *Research and measurement issues in gambling research* (pp. 180–217). New York: Elsevier.
Stinchfield, R., & McCready, J. (2014). *Cross-validation and comparison of seven brief problem gambling screens.* Canada: Retrieved from Ontario.
Stinchfield, R., McCready, J., & Govoni, R. (2012). *Cross-validation of the Windsor Ontario Gambling Scale (unpublished raw data)*.
Stinchfield, R., Winters, K. C., Botzet, A., Jerstad, S., & Breyer, J. (2007). Development and psychometric evaluation of the Gambling Treatment Outcome Monitoring System (GAMTOMS). *Psychology of Addictive Behaviors, 21*(2), 174–184.
Stinchfield, R., Wynne, H., Wiebe, J., & Tremblay, J. (2017). Development and psychometric evaluation of the Brief Adolescent Gambling Screen (BAGS). *Frontiers in Psychology, 8*, 2204. https://doi.org/10.3389/fpsyg.2017.02204.
Sullivan, S. (2011). Impulse control disorders in medical settings. In J. E. Grant, & M. N. Potenza (Eds.). *The oxford handbook of impulse control disorders*. Oxford University Press: US.
Sullivan, S., Arroll, B., Coster, G., Abbott, M., & Adams, P. (2000). Problem gamblers: Do GPs want to intervene? *New Zealand Medical Journal, 113*(1111), 204–207. https://doi.org/10.3399/bjgp11X567027.
Sullivan, S., McCormick, R., Lamont, M., & Penfold, A. (2007). Problem gambling: Patients affected by their own or another's gambling may approve of help from general practitioners. *The New Zealand Medical Journal, 120*(1257), U2605.
Suurvali, H., Hodgins, D., Toneatto, T., & Cunningham, J. (2008). Treatment seeking among Ontario problem gamblers: Results of a population survey. *Psychiatric Services, 59*(11), 1343–1346. https://doi.org/10.1176/ps.2008.59.11.1343.
Tanaka, K., Wada-Isoe, K., Nakashita, S., Yamamoto, M., & Nakashima, K. (2013). Impulsive compulsive behaviors in Japanese Parkinson's disease patients and utility of the Japanese version of the Questionnaire for Impulsive-Compulsive Disorders in Parkinson's disease. *Journal of the Neurological Sciences, 331*(1–2), 76–80. https://doi.org/10.1016/j.jns.2013.05.013.
Temcheff, C. E., Derevensky, J. L., St-Pierre, R. A., Gupta, R., & Martin, I. (2014). Beliefs and attitudes of mental health professionals with respect to gambling and other high risk behaviors in schools. *International Journal of Mental Health and Addiction, 12*(6), 716–729. https://doi.org/10.1007/s11469-014-9499-9.
Thomas, S. A., Jackson, A. C., Browning, C. J., & Piterman, L. (2010). *A one-item screening tool for problem gambling for use in primary care settings.* Melbourne, Australia: Monash University.
Tiet, Q. Q., Finney, J. W., & Moos, R. H. (2008). Screening psychiatric patients for illicit drug use disorders and problems. *Clinical Psychology Review, 28*(4), 578–591. https://doi.org/10.1016/j.cpr.2007.08.002.
Toce-Gerstein, M., Gerstein, D. R., & Volberg, R. A. (2009). The NODS-CLiP: A rapid screen for adult pathological and problem gambling. *Journal of Gambling Studies, 25*(4), 541–555. https://doi.org/10.1007/s10899-009-9135-y.
Volberg, R. A., Munck, I. M., & Petry, N. M. (2011). A quick and simple screening method for pathological and problem gamblers in addiction programs and practices. *The American Journal on Addictions, 20*(3), 220–227. https://doi.org/10.1111/j.1521-0391.2011.00118.x.
Volberg, R. A., & Williams, R. J. (2011). *Developing a brief problem gambling screen using clinically validated samples of at-risk, problem and pathological gamblers.* Boston, MA: Report to the Alberta Gambling Research Institute.
Volberg, R. A., & Williams, R. J. (2012). *Developing a short form of the PGSI.* Birmingham, United Kingdom: Report to the Gambling Commission.
Weintraub, D., Hoops, S., Shea, J. A., Lyons, K. E., Pahwa, R., Driver-Dunckley, E. D., & Voon, V. (2009). Validation of the questionnaire for impulsive-compulsive disorders in Parkinson's disease. *Movement Disorders, 24*(10), 1461–1467. https://doi.org/10.1002/mds.22571.
Whiting, P. F., Rutjes, A. W., Westwood, M. E., Mallett, S., Deeks, J. J., Reitsma, J. B., & Bossuyt, P. M. (2011). QUADAS-2: A revised tool for the quality assessment of diagnostic accuracy studies. *Annals of Internal Medicine, 155*(8), 529–536. https://doi.org/10.7326/0003-4819-155-8-201110180-00009.
Williams, R. J., Volberg, R. A., & Stevens, R. M. G. (2012). *The population prevalence of problem gambling: methodological influences, standardized rates, jurisdictional differences, and worldwide trends.* Canada: Retrieved from Ontario.
Yakovenko, I., Quigley, L., Hemmelgarn, B. R., Hodgins, D. C., & Ronksley, P. (2015). The efficacy of motivational interviewing for disordered gambling: Systematic review and meta-analysis. *Addictive Behaviours, 43*(11), 72–82. https://doi.org/10.1016/j.addbeh.2014.12.011.
Zimmerman, M., Chelminski, I., & Young, D. (2006). Prevalence and diagnostic correlates of DSM-IV pathological gambling in psychiatric outpatients. *Journal of Gambling Studies, 22*(2), 255–262. https://doi.org/10.1007/s10899-006-9014-8.

Dowling NA is an Associate Professor of Psychology at Deakin University and an honorary Principal Research Fellow at the University of Melbourne. She is a registered clinical psychologist and has considerable experience in the treatment of people with gambling problems and their affected others.

Dr. Merkouris SS, PhD, is a Research Fellow in the School of Psychology at Deakin University. Her main research interests relate to the prospective examination of factors associated with gambling problems and treatment outcomes.