Towards a Comprehensive Developmental Model of Pathological Gambling

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Abstract

Aims—To develop a comprehensive etiological model of pathological gambling (PG) for men and women based on Kendler's development model for major depression, which groups 22 risk factors in 5 developmental tiers (childhood, early adolescence, late adolescence, adulthood, last year). We hypothesized that: 1) All risk factors would be significantly associated with PG; 2) The effect of risk factors in earlier developmental tiers would be accounted for by later tiers; and, 3) There would be few gender differences.

Design—Separate models were built for lifetime gambling and for 12-month PG among those with lifetime gambling.

Setting—Data drawn from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) in the USA.

Participants—Respondents to NESARC Wave 1 (n= 43093).

Measurements—Odds ratios (OR) and Adjusted OR (AOR) were used to determine the risk factors in multiple models.

Findings—After mutually adjusting for other risk factors, family history of substance use disorders (SUD) or depression, impulsivity, childhood-onset anxiety, number of Axis I and II disorders, history of SUD, nicotine dependence, social deviance in adulthood, and past-year history of SUD, nicotine dependence, and independent stressful life events predicted lifetime gambling. Past history of PG, number of personality disorders and past year nicotine dependence were significantly associated with 12-month PG (all p<.05). There were no significant gender interactions for 12-month PG.

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Conclusions—A modification of Kendler's model for major depression provides a foundation for the development a comprehensive developmental model of pathological gambling. Lifetime history of gambling and 12-month pathological gambling appear to be determined by risk factors in several developmental levels, with the effect of earlier development tiers accounted for by later ones.

Keywords

NESARC; Pathological Gambling; Addictive Disorders; Developmental Model

Introduction

Pathological gambling (PG), recently renamed gambling disorder [1-3], is characterized by preoccupation with gambling, decreased control over gambling, and recurrent maladaptive gambling behavior [4]. The lifetime prevalence of PG ranges from 0.4% to 2.0% in North America [5-7], with age of onset generally in adolescence or early adulthood [6,8]. Previous research has documented gender differences in prevalence, age of onset, gambling attitudes, time course, motivation to gamble, types of gambling preferred, and treatment outcome [9-14].

PG is frequently associated with a wide spectrum of adverse consequences, such as significant financial losses, legal problems, and progressive disruptions in interpersonal relationships [10,14-17]. Furthermore, PG is often comorbid with other psychiatric syndromes, including mood and anxiety disorders [18-23], substance use disorders (SUD) [18,24-26], general medical conditions [15,17], and suicidality [27,28.

A substantial body of research has documented a broad range of risk factors for PG, including demographic characteristics such as male gender, younger age, racial minority and low socioeconomic status (SES) [29-31], psychiatric comorbidity [32-34], early exposure to gambling opportunities [35,36], impulsivity [6,37,38], childhood sexual abuse [6,20], and family history of PG or SUD [29,39-43].

Because risk factors seldom occur in isolation [44], a few studies have started to develop comprehensive models that incorporate several predictive factors for other psychiatric disorders. For example, Kendler and colleagues [45,46] proposed a developmental model for the etiology of major depression based on the Virginia Adult Twin Study of Psychiatric and Substance Use Disorders. The model posits that: 1) the etiology of major depression is multifactorial; 2) contemporary risk factors are interlinked; and, 3) the effect of earlier risk factors such as childhood sexual abuse is partially accounted for by subsequent risk factors such as childhood-onset anxiety and psychiatric comorbidity. In Kendler's model, potential risk factors are divided into five developmental tiers: childhood, early adolescence, late adolescence, adulthood, and the last year. This model, which is intended to be comprehensive yet parsimonious, rather than exhaustive, has recently shown to be highly predictive of cannabis use disorders [47] and nicotine dependence [48].

While previous studies on PG have focused on a single set of risk factors, a thorough understanding of the etiology of PG requires an integrative developmental perspective.

Given the multifactorial etiology of PG, the diversity of associated risk factors and its similarities with SUD [4,49,50], we sought to build on previous work by examining the applicability of Kendler's model in elucidating pathways in the etiology of PG. Specifically, the present study aims to develop a conceptual model that integrates several risk factors and investigates their independent and combined effects in predicting PG. A better understanding of the etiology of PG could guide the efforts in establishing more effective prevention and treatment programs.

Prior to our analyses, Kendler's model was modified to incorporate variables that are more salient in the etiology and course of PG than that of major depression or cannabis use disorders. Specifically, we substituted impulsivity given its central role in PG [37,51,52] for neuroticism, which is more strongly associated with internalizing disorders than gambling. We also included in the analyses history of PG (instead of history of major depression or cannabis use disorder) in the adulthood tier due to the focus of the current model.

The focus of our model was PG, but because gambling is a common activity and as a precondition to having PG, we first examined predictors of lifetime gambling in the general population. Then, we evaluated predictors of PG among those with a lifetime gambling. We also evaluated main effects of variables across developmental tiers, as well as interaction effects with gender, taking into consideration gender differences in the onset and course of PG [8-10,13,53]. Based on prior research [46-48], we hypothesized that: 1) In bivariate models, all predictors would be significantly associated with PG; 2) In multivariable models, the effect of earlier tiers would be accounted for by later tiers; and, 3) There would be few significant interactions with gender.

Method

Sample and procedures

The 2001-2002 National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) [54,55] is a nationally representative survey of non-institutionalized adults aged 18 and older, residing in households and group quarters in the US. Data were collected in face-to-face, computer-assisted personal interviews conducted by experienced lay interviewers in the respondents' homes on 43,093 respondent [54-56]. The research protocol, including informed consent, received full human subjects review and approval from the US Census Bureau and the US Office of Management and Budget. All potential NESARC respondents were informed in writing about the nature of the survey, the statistical uses of the survey data, the voluntary aspect of their participation, and the Federal laws that rigorously provide for the confidentiality of identifiable survey information. Respondents who consented to participate after receiving this information were interviewed. All other individuals were considered non-respondents. The overall survey response rate was 81%. Data were adjusted to account for oversampling and nonresponse. The weighted data were then adjusted using the 2000 Decennial Census, to be representative of the U.S. civilian population for a variety of sociodemographic variables. The goal of the NESARC was to examine the prevalence, correlates and course of substance-related and other psychiatric disorders [57-59]. The large sample size of the NESARC allows for very precise estimates of those disorders, as indicated by the narrow 95% confidence intervals (CIs) of the

estimates. In particular, the 12-month prevalence of PG was 0.16% (95% CI=0.12-0.20%) [60].

Measures

The Alcohol Use Disorder and Associated Disabilities Interview Schedule-DSM-IV Version (AUDADIS-IV) [56,61,62] was used to generate DSM-IV diagnoses. The AUDADIS-IV has demonstrated good validity [56,61,63,65] and test-retest reliability [56,61,63,64,66].

All respondents who indicated that they had gambled at least five times in any one year of their life were classified as engaging in lifetime gambling and further asked about the symptoms of DSM-IV PG. Fifteen symptom items operationalized the 10 PG criteria. Consistent with DSM-IV, an AUDADIS-IV diagnosis of PG required the respondent to meet at least five of the 10 DSM-IV diagnostic criteria. Internal consistency reliability of the symptom items (α=0.92) and criteria for PG (α=0.80) were excellent [6,9]. Individuals who met criteria for PG at some point in their lives were classified as having lifetime history of PG. Those meeting criteria for PG in the year preceding the interview were additionally classified as having past-year PG.

Model Variables

Kendler's model for major depression was adapted to examine lifetime experience with gambling and with having a past year diagnosis of PG. Variables related to tiers approximated five developmental periods: childhood, early adolescence, late adolescence, adulthood, and past year.

Childhood tier included family history of SUD (lifetime history of alcohol or drug use disorders in the biological parents or siblings), family history of major depressive disorder (MDD), childhood sexual abuse, vulnerable family environment. The later was assessed using the childhood emotional neglect scale from the Childhood Trauma Questionnaire; CTQ [67] and parental loss (parent's divorce or death of at least one parent before age 18 years old).

Early adolescence tier involved variables addressing impulsivity (dichotomous variable, scored 1 if the respondents indicated that they "had often done things impulsively"), low self-esteem (dichotomous variable, scored 1 if respondents reported believing that they were "not as good, smart, or attractive as most other people"), age of onset of anxiety disorders (with childhood onset before age 18), and social deviance (the number of conduct disorder or antisocial personality disorder (ASPD) behaviors, ranging between 0 to 33, in which the respondent engaged in before age 15).

Late adolescence tier related to educational attainment (measured in years), number of Axis I disorders (excluding PG) with onset before age 18, and number of personality disorders.

Adulthood tier consisted of history of divorce, history of SUD, history of nicotine dependence, history of PG, and social deviance (number of ASPD behaviors in which the individual engaged after age 15).

Past year tier included past year SUD, past year nicotine dependence, number of past year Axis I disorders excluding PG, marital problems (whether the respondent got separated, divorced or broke off a steady relationship in the last 12 months), and number of stressful life events divided into independent (those the respondent is unlikely to have caused such as a death of a family member, range: 0-9) and dependent (those in which the respondent is likely to play an active role such as serious problems with a neighbor, range 0-5) stressful life events.

Statistical Analyses

To obtain a thorough understanding of the relative importance of independent variables and groups of variables in the final model, we conducted the analysis in two stages. First, we identified predictors of lifetime gambling, and then predictors of 12-month PG among lifetime gamblers.

To identify predictors of lifetime gambling we compared data from respondents with lifetime gambling (operationalized as having gambled five or more times in a single year) and that from respondents with no lifetime gambling. We used odds ratios (ORs) to examine bivariate relationships between each predictor and lifetime gambling (Table 1; Model 1). We then examined the interactions of each predictor with sex (using men as the reference group), by constructing logistic regression models for each tier, including age and ethnicity as covariates in each model and testing for gender by predictor interactions (Table 2; Model 2). In the last step we constructed one logistic regression model with the variables that were significant in the prior step and also tested for gender by predictor interactions (Table 2; Model 3). Because this last model contained variables in all tiers, but gambling could have occurred prior to the year preceding the interview, we constructed two additional models: one contained the first four tiers, and another contained the first three tiers.

The second stage of model development involved identifying predictors of 12-month PG from the subsample with a lifetime gambling. We followed procedures similar to those used to construct our model of lifetime gambling (Table 3; Model 4, Table 4; Model 5, and Model 6 respectively), and an additional model that included as predictor PG in adulthood but did not included PG in the past-year tier to identify predictors that could be otherwise overshadowed by this variable (Table 4; Model 7).

Predictive accuracy of lifetime gambling and 12-month PG across the different models was assessed using the c-index [68], a measure of concordance between the predicted and the observed outcome. The c-index equals the area under the receiver operating characteristic (ROC) curve such that values of 0.5 represent prediction no better than chance, while values of 1.0 represent perfect prediction [69].

Finally, to examine whether the magnitude of the effect of the predictors was the same on the risk of lifetime gambling initiation or the risk of 12-month PG conditional on having gambled at least five times, we tested the continuation ratio (CR) with an ordinal logistic regression with three levels: no lifetime gambling, lifetime gambling with no PG, and 12-month PG [61]. A positive CR indicates that the predictor is more strongly associated with

the more severe category (in this case 12-month PG) than with the less severe one (i.e., lifetime gambling).

As in previous analyses of the NESARC [47,70, 71], all analyses including odd ratios (ORs) and 95% confidence intervals (95% CI) were estimated using SUDAAN (Research Triangle Institute, 2007) to adjust for the design effects of the NESARC survey, including weighting and clustering of observations. In complementary analyses, we examined our final models without taking into account the weights. Because the results of the models are very similar, we focus on the weighted results but mention the differences between the weighted and unweighted models.

Results

Lifetime gambling

Table 1 presents the bivariate analyses of variables included in our theoretical model in the sample with and without lifetime gambling (Model 1). Most variables were significantly associated with increased odds of lifetime gambling, although some (being younger than 50, Black, Asian or Hispanic) were associated with decreased odds of lifetime gambling.

When examining the effects of each variable adjusted for age, gender, race/ethnicity, and other variables in the same tier, 15 of 22 variables had significant main effects (Model 2; Table 2). The strongest association with lifetime gambling was history of SUD in adulthood, followed by past-year nicotine dependence and past-year history of SUD. There were no significant gender interactions with any of the variables in the model.

In Model 3 (Table 2), which included all significant predictors from Model 2, only family history of SUD, family history of MDD, impulsivity, childhood-onset anxiety, number of Axis I disorder excluding PG, number of personality disorders, history of SUD, nicotine dependence, social deviance in adulthood, and past-year history of SUD, past-year nicotine dependence, and past-year independent stressful life events had significant main effects in predicting lifetime gambling. There were significant gender interactions with past-year SUD, number of Axis I disorders, and independent stressful life events. The interactions indicated that the association of these variables with lifetime gambling was stronger in men than in women, except for past-year SUD, for which the opposite was true. These results were robust to model specification. There were no changes in the results when past-year tier was not included in the model. When the model was restricted to the first three tiers social deviance in late adolescent became significant, whereas number of axis I and II disorders were no longer significant (full results available on request).

12-month pathological gambling

Similarly to the bivariate models of lifetime gambling, 12-month PG among individuals with lifetime gambling was significantly associated with most predictors in the model (Model 4; Table 3). Prior history of PG and past-year nicotine dependence had the strongest association with 12-month PG.

After adjusting for age and race/ethnicity and other variables within their tier, in Model 5 family history of MDD, social deviance in early adolescence, number of personality disorders, past history of PG, and past-year nicotine dependence were significant predictors of 12-month PG. There were no significant gender interactions in the model.

When past history of PG was included in the full model (Table 4; Model 6), no other variable remained significant and there were no gender interactions in the model. Because of the strong effect of history of PG in the bivariate analysis and in model 6, this variable was excluded from Model 7 (Table 4). When past history of PG was excluded from the model, number of personality disorders and past year history of nicotine dependence were significantly associated with 12-month PG. When Models 6 and 7 were estimating without applying the weights, the only difference was that number of personality disorders reached significance (OR=1.34, 95% CI=1.09-1.64).

Differential effects of predictors on lifetime gambling and PG

Number of personality disorders had a positive continuation ratio, indicating that number of personality disorders is more strongly associated with PG than with lifetime gambling. No other continuation ratio was significant (Table 5).

Discussion

In a nationally representative sample of US adults, an array of variables across varying developmental tiers predicted lifetime gambling and 12-month PG in univariate analyses. However, the number of significant predictors substantially decreased in multivariable analyses which adjusted for the effects of all the predictors. The predictive power of the models for lifetime gambling and for 12-month PG was high. Further, despite gender differences in gambling and gender-related theories about progression to PG [8-10,49], few gender differences emerged in the models for lifetime gambling and none for 12-month PG.

In accord with previous research [13,30-32,32,37,72], the current study indicates that a broad range of variables, when examined individually, increased the likelihood of lifetime gambling. However, after adjusting for the effect of covariates, a more restricted set of variables remained significant. In accord with the findings on lifetime gambling, we also found that although multiple variables predicted 12-month PG in the bivariate and within-tier analyses, distal predictors were no longer significant after adjusting for the effect of more proximal ones, suggesting that the effects of distal risk factors appear to be mediated through effects of more proximal factors. Our results are consistent with the findings of Kendler and colleagues on the etiology of major depression and AUD [45,46], and Blanco and colleagues on the etiology of cannabis use disorders [73]. Our study also converges with previous work, such as Blaszczynski and Nower's Pathways model [74,12], in documenting the multiple etiological determinants of PG. However, whereas the Pathways model emphasizes the existence of different subtypes of pathological gamblers, our model is focused on providing a developmental framework to PG. Overall, these findings highlight the utility of integrated developmental etiological models, and confirm the applicability of Kendler's model beyond major depression and SUD. Future research should examine the shared and specific risk factors on different psychiatric disorders, and whether earlier risk

factors convey a general level of liability for psychopathology that is later shaped by more proximal risk factors [73,75,76].

As expected, past history of PG was the single most significant predictor for 12-month PG. PG, like other addictions, is often conceptualized as a chronic disorder with an episodic course [77,78]. Therefore, the genetic predisposition [32,42,43,79], developmental factors [6,9,37], and environmental cues [35,36,72] that make individuals vulnerable to PG at one point in their lives are also likely to increase the risk of current PG. Despite the large proportion of variance accounted for by lifetime history of PG, past-year nicotine dependence and mean number of personality disorders were also significantly associated to 12-month PG. These findings emphasize the multifactorial etiology of PG and may help inform the implementation of effective interventions, and guide policies regarding preventive measures. The robust association of nicotine dependence and PG also raises important questions regarding their shared etiological factors as well as the potential benefits from prohibiting nicotine use in gambling venues [80].

A novel contribution of this study was that, by using the continuation ratio, we were able to identify differences in the predictors of lifetime gambling versus 12-month PG. Specifically, number of personality disorders decreased the probability of lifetime gambling, whereas it increased the odds of current and life PG. These findings are consistent with prior studies documenting that the risk factors for drug initiation and dependence partially differ [46,48,69,81], and suggest these findings may also hold for behavioral addictions [42]. The differences in predictors of lifetime gambling and 12-month PG show the potential complexity of pathways from gambling initiation to PG and that some risk factors may be shared while others may have an inverse effect. Interventions targeted at preventing the development of PG may need to pay more attention to the role of personality disorders that those focused on reducing exposure to gambling.

An examination of sex interactions revealed very few variables in which the models differed by gender: 3 out of 23 in the bivariate analyses of lifetime gambling and none in the analyses of 12-PG, not much above than the 5% that could be expected only by chance. Our findings suggest that the risk factors for both lifetime gambling and 12-month PG do not differ much by gender. Similar findings of few gender differences across models have been documented for comprehensive developmental models of the etiology of major depression [45,46] and cannabis use disorders [47], although there may be some variability by sample [82].

Limitations

While the findings of this study contribute to our understanding of PG, certain limitations should be noted. First, information on gambling behavior was based on self-report and not confirmed by collateral informants. Second, while predictors were organized into structurally five discrete developmental periods, it is important to note the considerable overlap and between-subject variability across periods. Some of the constructs, particularly those of earlier tiers, such as impulsivity, may vary over the life of the individual. Further, in order to be parsimonious, the number of variables incorporated in the models was limited. Even with a limited number of variables, our models were quite accurate. Nevertheless,

alternative models could be developed to examine specific aspects not included in this study. Future studies should consider the inclusion of environmental factors such as geographical proximity to gambling venues and residence or family size. They should also consider the use of structural equation modeling techniques, which may further improve our understanding of the moderating and mediating effects of the variables in the different tiers. Third, there were differences in the recency of some risk factor for younger groups compared to older groups in sample. Future studies may allow the examination of these age-cohort effects. Fourth, to decrease respondent burden, the NESARC did not query about past-year gambling behaviors. Individuals who did not meet criteria for past-year PG may have been abstinent from gambling in the year preceding the interview, while other may have been gambling without meeting PG criteria.

Conclusions

A modification of Kendler's model for major depression offered the foundation for the development a comprehensive developmental model of PG. The model incorporated five developmental tiers in which the effect of distal tiers was accounted for by the effect of proximal ones, with only few significant differences across gender. We hope this findings can serve as the foundation for further etiological research and for the development of empirically-based prevention policies.

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Table 1

Bivariate associations of risk factors and prevalence of lifetime gambling in the general population. NESARC Wave 1 (n= 43,093).

	Ever Gambled (n=11,153, 27.17%)			Never Gambled (n=31,940, 72.83%)			Model 1 Bivariate Association
	%mean	95% CI		%mean	95% CI		OR (CI 95%)
Age							
18-29	17.28	16.27	18.35	23.49	22.68	24.31	**0.61 (0.56-0.66)**
30-39	18.75	17.93	19.61	20.60	19.99	21.22	**0.75 (0.70-0.81)**
40-49	21.15	20.17	22.16	20.63	20.04	21.23	**0.85 (0.78-0.91)**
>50	42.81	41.54	44.10	35.29	34.30	36.29	1.00 (1.00-1.00)
Race/Ethnicity							
White, non-Hispanic	75.18	72.45	77.72	69.29	65.76	72.60	1.00 (1.00-1.00)
Black, non-Hispanic	10.78	9.47	12.26	11.17	9.93	12.55	**0.89 (0.82-0.97)**
Native American	2.52	2.09	3.05	1.97	1.67	2.33	1.18 (0.96-1.45)
Asian	3.50	2.56	4.77	4.69	3.7	5.92	**0.69 (0.58-0.82)**
Hispanic	8.02	6.41	9.97	12.88	10.37	15.89	**0.57 (0.51-0.65)**
Childhood							
Family history of SUD	45.55	44.13	46.97	36.55	35.25	37.87	**1.45 (1.37-1.54)**
Family history of MDD	37.29	35.82	38.78	29.50	28.10	30.94	**1.42 (1.32-1.53)**
Sexual abuse	8.52	7.80	9.31	8.54	8.01	9.11	1.00 (0.90-1.11)
Vulnerable family environment	29.78	28.66	30.93	28.68	27.86	29.52	1.05 (0.99-1.12)
Parental loss	24.97	23.93	26.03	22.30	21.58	23.03	**1.16 (1.09-1.23)**
Early Adolescence							
Impulsivity	17.72	16.80	18.68	12.41	11.82	13.02	**1.52 (1.41-1.64)**
Low self-esteem	12.43	11.61	13.30	10.66	10.01	11.35	**1.19 (1.09-1.29)**
Childhood-onset anxiety[a]	11.62	10.76	12.54	8.29	7.65	8.97	**1.46 (1.34-1.59)**
Social deviance (mean)	0.82	0.78	0.87	0.45	0.42	0.47	**1.18 (1.15-1.20)**
Late adolescence							
Education years (mean)	13.74	13.64	13.84	13.68	13.56	13.80	1.00 (0.99-1.01)
Number of Axis I disorders excluding PG (mean)[b]	0.35	0.33	0.37	0.25	0.24	0.27	**1.20 (1.15-1.25)**
Number of personality disorders (mean)	0.31	0.29	0.33	0.21	0.19	0.22	**1.23 (1.18-1.27)**
Adulthood							

	Ever Gambled (n=11,153, 27.17%)			Never Gambled (n=31,940, 72.83%)			Model 1 Bivariate Association
	%mean	95% CI		%mean	95% CI		OR (CI 95%)
Ever divorced	35.37	33.99	36.78	30.08	29.07	31.11	**1.27 (1.20-1.35)**
History of SUD[c]	45.26	43.54	47.00	26.15	24.68	27.67	**2.34 (2.18-2.50)**
Nicotine dependence[d]	24.95	23.73	26.22	13.64	12.79	14.54	**2.11 (1.96-2.26)**
Social deviance (mean)	2.76	2.65	2.88	1.50	1.42	1.14	**1.14 (1.12-1.15)**
Past year							
SUD	13.99	13.14	14.89	7.62	7.15	8.13	**1.97 (1.80-2.16)**
Nicotine dependence	18.75	17.68	19.87	10.53	9.78	11.32	**1.96 (1.80-2.13)**
Number of Axis I disorders (no PG[e])(mean)	0.62	0.59	0.65	0.41	0.38	0.43	**1.28 (1.24-1.33)**
Marital problems	5.70	5.17	6.28	5.33	5.02	5.65	1.07 (0.95-1.22)
Stressful life events (mean)	1.82	1.78	1.87	1.56	1.51	1.6	**1.10 (1.08-1.12)**
Independent (mean)	0.88	0.86	0.91	0.75	0.73	0.78	**1.18 (1.14-1.21)**
Dependent (mean)	0.88	0.85	0.92	0.75	0.72	0.78	**1.09 (1.07-1.12)**

[a] Anxiety disorders with onset prior to age of 16;

[b] Axis I disorder onset by age of 17;

[c] Alcohol and Drug Use Disorders prior to past year;

[d] Nicotine dependence prior to past year;

[e] no past year PTSD, ADHD, PG at Wave 1.

Abreviations: OR, odds ratio; AUD, alcohol use disorders; DUD, drug use disorders; SUD, substance use disorders; MDD, major depressive disorder; PG, pathological gambling.

Significant results are bolded (p<0.05).

Table 2

Multivariable associations of risk factors and lifetime gambling. NESARC Wave 1 (n= 43,093).

	Model 2 (Across Tiers Analysis)		Model 3 (Within Tiers Analysis)	
	Main Effects	**Interactive Effects**	**Main Effects**	**Interactive Effects**
	AOR[a] (CI 95%)	**AOR[b] (CI 95%)**	**AOR[c] (CI 95%)**	**AOR[d] (CI 95%)**
Childhood				
Family history of SUD	**1.33 (1.25-1.41)**	1.05 (0.93-1.19)	**1.09 (1.02-1.16)**	1.10 (0.97-1.25)
Family history of MDD	**1.36 (1.27-1.46)**	1.03 (0.90-1.19)	**1.16 (1.08-1.24)**	1.00 (0.86-1.16)
Sexual abuse	1.03 (0.93-1.14)	1.02 (0.82-1.27)		
Vulnerable family environment	1.02 (0.95-1.10)	1.11 (0.95-1.30)		
Parental loss	**1.10 (1.02-1.18)**	1.00 (0.85-1.17)	1.03(0.97-1.10)	1.09 (0.96-1.24)
	c-index = 0.633	c-index = 0.633		
Early adolescence				
Impulsivity	**1.36 (1.26-1.47)**	**1.18 (1.01-1.37)**	**1.19 (1.09-1.29)**	1.15 (0.98-1.35)
Low self-esteem	1.08 (0.99-1.18)	1.13 (0.95-1.35)		
Childhood-onset anxiety[e]	**1.40 (1.28-1.53)**	0.93 (0.77-1.13)	**1.61 (1.41-1.84)**	0.89 (0.68-1.15)
Social deviance (mean)	**1.15 (1.12-1.17)**	1.02 (0.98-1.06)	1.01 (0.99-1.04)	1.00 (0.95-1.05)
	c-index = 0.640	c-index = 0.641		
Late adolescence				
Education years (mean)	1.00 (0.99-1.01)	1.00 (0.98-1.01)		
Number of Axis I disorders excluding PG (mean)[f]	**1.19 (1.14-1.25)**	0.97 (0.89-1.06)	**0.82 (0.77-0.88)**	0.93 (0.82-1.05)
Number of personality disorders (mean)	**1.18 (1.13-1.23)**	0.98 (0.89-1.07)	**0.95 (0.90-0.99)**	1.00 (0.90-1.12)
	c-index = 0.626	c-index = 0.627		
Adulthood				
Ever divorced	1.03 (0.96-1.10)	1.01 (0.89-1.14)		
History of SUD[g]	**1.55 (1.43-1.68)**	0.87 (0.75-1.01)	**1.49 (1.37-1.62)**	0.89 (0.76-1.05)
Nicotine dependence[h]	**1.36 (1.26-1.46)**	**1.18 (1.02-1.37)**	**1.26 (1.13-1.40)**	1.18 (0.94-1.48)
Social deviance (mean)	**1.09 (1.08-1.11)**	1.02 (0.99-1.04)	**1.09 (1.07-1.10)**	1.01 (0.98-1.03)
	c-index = 0.671	c-index = 0.671		
Past year				

	Model 2 (Across Tiers Analysis)		Model 3 (Within Tiers Analysis)	
	Main Effects	Interactive Effects	Main Effects	Interactive Effects
	AOR[a] (CI 95%)	AOR[b] (CI 95%)	AOR[c] (CI 95%)	AOR[d] (CI 95%)
SUD	**1.49 (1.33-1.66)**	0.85 (0.68-1.07)	**1.27 (1.13-1.43)**	**0.72 (0.56-0.92)**
Nicotine dependence	**1.50 (1.36-1.65)**	0.97 (0.80-1.17)	**1.15 (1.00-1.33)**	0.77 (0.59-1.01)
Number of Axis I disorders (exluding PG) (mean)	**1.09 (1.05-1.14)**	1.08 (0.99-1.18)	0.96 (0.91-1.02)	**1.19 (1.07-1.33)**
Marital problems	0.94 (0.82-1.08)	0.89 (0.68-1.17)		
Stressful life events				
Independent (mean)	**1.11 (1.08-1.14)**	1.05 (0.99-1.12)	**1.06 (1.03-1.09)**	**1.08 (1.01-1.15)**
Dependent (mean)	**1.09 (1.06-1.12)**	1.03 (0.98-1.09)	1.02 (0.99-1.05)	1.03 (0.97-1.09)
	c-index = 0.645	c-index = 0.646	c-index = 0.679	c-index = 0.680

[a] Adjusted for age, gender, race and other factors in the same tier;

[b] Adjusted for age, gender, race, main effects and other gender by-predictor interactions in the same tier;

[c] Adjusted for age, gender, race and other significant factors in model 2;

[d] Adjusted for age, gender, race, main effects and gender-by-predictor interactions of significant factors in model 2 and model 3;

[e] Anxiety by age of 16, no PTSD;

[f] Axis I disorder onset by age of 17;

[g] AUD & DUD before past year;

[h] Nicotine dependence before past year.

Areviations: AOR, adjusted odds ratio; AUD, alcohol use disorders; DUD, drug use disorders; SUD, substance use disorders; MDD, major depressive disorder; PG, pathological gambling.

Significant results are bolded (p<0.05). Reference group= no gambling. Reference group for sex interactions=males.

Table 3

Bivariate associations of risk factors and prevalence of 12-month pathological gambling among the population who ever gambled. NESARC Wave 1 (n= 11,153).

	Pathological Gambling (n=79)			No Pathological Gambling (n=11,074)			Model 4 Bivariate Association		
	%mean	95% CI		%mean	95% CI		OR	95% CI	
Age									
18-29	30.05	18.45	44.93	17.21	16.19	18.27	**3.06**	**(1.44- 6.48)**	
30-39	25.33	14.65	40.13	18.71	17.90	19.56	**2.37**	**(1.07- 5.27)**	
40-49	20.09	11.80	32.10	21.16	20.18	22.17	1.66	(0.82- 3.38)	
>50	24.53	15.14	37.19	42.92	41.64	44.21	1.00	(1.00- 1.00)	
Race/Ethnicity									
White, non-Hispanic	64.42	52.07	75.11	75.24	72.50	77.80	1.00	(1.00- 1.00)	
Black, non-Hispanic	21.80	13.72	32.83	10.72	9.41	12.19	**2.38**	**(1.33- 4.25)**	
Native American	1.75	0.35	8.26	2.53	2.09	3.05	0.81	(0.16- 4.10)	
Asian	3.29	0.45	20.42	3.50	2.55	4.77	1.10	(0.14- 8.48)	
Hispanic	8.74	4.45	16.44	8.01	6.40	9.98	1.27	(0.60- 2.71)	
Childhood									
Family history of SUD	63.08	49.63	74.77	45.44	44.04	46.85	**2.05**	**(1.19- 3.53)**	
Family history of MDD	60.02	46.21	72.40	37.15	35.68	38.65	**2.54**	**(1.45- 4.43)**	
Sexual abuse	11.49	5.31	23.08	8.51	7.78	9.29	1.40	(0.61- 3.21)	
Vulnerable family environment	47.52	33.96	61.46	29.68	28.56	30.83	**2.15**	**(1.22- 3.77)**	
Parental loss	34.77	23.47	48.09	24.91	23.88	25.97	1.61	(0.93- 2.79)	
Early Adolescence									
Impulsivity	25.87	15.13	40.58	17.68	16.75	18.64	1.63	(0.83- 3.19)	
Low self-esteem	26.09	16.21	39.18	12.35	11.54	13.21	**2.51**	**(1.38- 4.56)**	
Childhood-onset anxiety[a]	27.45	17.23	40.74	11.52	10.67	12.44	**2.91**	**(1.60- 5.28)**	
Social deviance (mean)	2.50	1.60	3.39	0.81	0.77	0.86	**1.22**	**(1.15- 1.29)**	
Late adolescence									
Education years (mean)	12.75	12.09	13.42	13.74	13.65	13.84	0.90	(0.83- 0.97)	
Number of Axis I disorders excluding PG (mean)[b]	0.87	0.55	1.18	0.35	0.32	0.37	**1.62**	**(1.36- 1.93)**	

	Pathological Gambling (n=79)			No Pathological Gambling (n=11,074)			Model 4 Bivariate Association	
	%mean	95% CI		%mean	95% CI		OR	95% CI
Number of personality disorders (mean)	1.32	0.98	1.67	0.31	0.29	0.33	**1.90**	**(1.65- 2.18)**
Adulthood								
Ever divorced	32.04	21.32	45.05	35.39	34.00	36.81	0.86	(0.49- 1.51)
History of SUD[c]	66.70	52.57	78.35	45.14	43.40	46.88	**2.43**	**(1.34- 4.43)**
Nicotine dependence[d]	60.93	47.57	72.83	24.74	23.52	26.01	**4.74**	**(2.75- 8.20)**
History of PG[e]	71.31	58.53	81.40	0.98	0.78	1.24	**251.22**	**(139.1- 453.57)**
Social deviance (mean)	6.89	5.48	8.29	2.74	2.62	2.86	**1.17**	**(1.13- 1.21)**
Past year								
SUD	41.11	28.52	54.99	13.83	12.98	14.73	**4.35**	**(2.47- 7.65)**
Nicotine dependence	54.28	41.15	66.85	18.54	17.47	19.67	**5.22**	**(3.04- 8.95)**
Number of Axis I disorders (no PG)[f] (mean)	1.78	1.38	2.19	0.62	0.59	0.65	**1.72**	**(1.53- 1.92)**
Marital problems	12.39	6.09	23.56	5.66	5.12	6.25	**2.36**	**(1.06- 5.23)**
Stressful life events (mean)	3.23	2.55	3.90	1.82	1.77	1.86	**1.38**	**(1.23- 1.53)**
Independent (mean)	1.32	1.03	1.62	0.88	0.86	0.90	**1.58**	**(1.20- 2.09)**
Dependent (mean)	1.78	1.31	2.25	0.88	0.84	0.91	**1.49**	**(1.28- 1.73)**

[a] Anxiety by age of 16, no PTSD;

[b] Axis I disorder onset by age of 17;

[c] AUD & DUD before past year;

[d] Nicotine dependence before past year;

[e] PG before past year;

[f] excluding past year PTSD, ADHD, PG at NESARC Wave 1.

OR, odds ratio; AUD, alcohol use disorders; DUD, drug use disorders; SUD, substance use disorders; MDD, major depressive disorder; PG, pathological gambling; significant results are bolded (p<0.05).

Table 4

Multivariable associations of risk factors and 12-month gambling disorder among individuals with lifetime gambling. NESARC Wave 1 (n= 11,153).

	Model 5 (Within Tiers Analysis)				Model 6 (Across Tiers Analyses)				Model 7 (Across Tiers Analyses)			
	Main Effects		Interactive Effects		Main Effects		Interactive Effects		Main Effects		Interactive Effects	
	AOR[a]	95% CI	AOR[b]	95% CI	AOR[c]	95% CI	AOR[d]	95% CI	AOR[c]	95% CI	AOR[d]	95% CI
Childhood	c-index=0.680		c-index=0.683		c-index=0.933		c-index=0.922		c-index=0.786		c-index=0.792	
Family history of SUD	1.61	(0.91- 2.88)	1.74	(0.50- 6.05)								
Family history of MDD	**2.34**	**(1.35- 4.07)**	1.01	(0.34- 3.02)	1.10	(0.52- 2.34)	1.82	(0.40- 8.34)	1.64	(0.88- 3.08)	1.40	(0.37- 5.25)
Sexual abuse	1.02	(0.44- 2.38)	2.83	(0.37- 21.69)								
Vulnerable family environment	1.67	(0.86- 3.24)	0.50	(0.15- 1.63)								
Parental loss	0.89	(0.47- 1.69)	0.97	(0.25- 3.76)								
Early Adolescence	c-index=0.714		c-index=0.728									
Impulsivity	1.17	(0.57- 2.42)	0.74	(0.21- 2.60)								
Low self-esteem	1.91	(0.98- 3.73)	0.52	(0.14- 1.93)								
Childhood-onset anxiety[e]	1.96	(0.99- 3.88)	1.12	(0.28- 4.53)								
Social deviance (mean)	**1.17**	**(1.10- 1.25)**	1.04	(0.90- 1.22)	1.04	(0.91- 1.18)	0.94	(0.63- 1.41)	1.05	0.96 1.14	0.98	(0.79- 1.21)
Late adolescence	c-index=0.745		c-index=0.748									
Education years (mean)	0.91	(0.83- 1.01)	1.05	(0.86- 1.28)								
Number of Axis I disorders excluding PG (mean)[f]	1.11	(0.82- 1.51)	1.11	(0.63- 1.97)								
Number of personality disorders (mean)	**1.70**	**(1.38- 2.09)**	1.02	(0.68- 1.52)	1.25	(0.96- 1.62)	0.99	(0.59- 1.66)	**1.48**	**(1.22- 1.8)**	1.09	(0.75- 1.59)
Adulthood	c-index=0.922		c-index=0.916									
Ever divorced	0.83	(0.37- 1.85)	1.70	(0.28- 10.53)								
History of SUD[g]	0.64	(0.29- 1.41)	1.19	(0.30- 4.65)								
Nicotine dependence[h]	1.99	(0.92- 4.30)	0.75	(0.17- 3.35)								
History of PG[i]	232.44	(92.23- 585.8)	6.76	(0.83- 55.25)	191.10	(83.82- 435.69)	5.15	(0.82- 32.45)				
Social deviance (mean)	1.04	(0.96- 1.14)	0.92	(0.77- 1.11)								
Past year	c-index=0.767		c-index=0.787									
SUD	1.72	(0.70- 4.25)	0.85	(0.14- 4.97)								
Nicotine dependence	**2.71**	**(1.35- 5.45)**	1.21	(0.30- 4.85)	1.79	(0.79- 4.03)	0.86	(0.20- 3.8)	**3.38**	**(1.71- 6.68)**	2.44	(0.62- 9.59)

	Model 5 (Within Tiers Analysis)				Model 6 (Across Tiers Analyses)				Model 7 (Across Tiers Analyses)			
	Main Effects		Interactive Effects		Main Effects		Interactive Effects		Main Effects		Interactive Effects	
	AOR[a]	95% CI	AOR[b]	95% CI	AOR[c]	95% CI	AOR[d]	95% CI	AOR[c]	95% CI	AOR[d]	95% CI
Number of Axis I disorders (no PG)[j] (mean)	1.25	(0.95- 1.64)	1.34	(0.81- 2.21)								
Marital problems	0.87	(0.35- 2.14)	0.34	(0.05- 2.35)								
Stressful life events (mean)												
Independent (mean)	1.26	(0.95- 1.67)	0.50	(0.32- 0.80)	1.33	(0.91- 1.93)	0.60	(0.30- 1.22)	1.25	(0.95- 1.65)	0.63	(0.41- 0.96)
Dependent (mean)	1.13	(0.90- 1.42)	1.41	(0.92- 2.16)								

[a] Adjusted for age, gender, race and other factors in the same tier.

[b] Adjusted for age, gender, race, main effects and other gender-by-predictor interactions in the same tier;

[c] Adjusted for age, gender, race and other significant factors in model 5;

[d] Adjusted for age, gender, race, main effects and other gender-by-predictor interactions of significant factors in model 5;

[e] Anxiety by age of 16, no PTSD;

[f] Axis I disorder onset by age of 17;

[g] AUD & DUD before past year;

[h] Nicotine dependence before past year;

[i] PG before past year;

[j] excluding past year PTSD, ADHD, PG at NESARC wave 1.

AOR, adjusted odds ratio; AUD, alcohol use disorders; DUD, drug use disorders; SUD, substance use disorders; significant variables are bolded (p<0.05). Reference group= individuals with lifetime gambling, but not with diagnosis of pathological gambling. Reference group for sex interactions=males.

Table 5

Differential effects of predictors on lifetime gambling and 12-months pathological gambling (ND). NESARC wave 1 (43,093).

	Initiation		Disorder		Continuation ratio (Interaction with threshold)	
	OR	p-value	OR	p-value	beta	p-value
Childhood						
Family history of SUD	1.10	0.0062	1.08	0.7933	-0.01	0.9664
Family history of MDD	1.16	0.0001	1.54	0.1765	0.28	0.3791
Sexual abuse	0.87	0.0147	0.72	0.4562	-0.19	0.6649
Vulnerable family environment	0.92	0.0379	1.41	0.2834	0.43	0.1861
Parental loss	1.09	0.0336	0.87	0.6492	-0.23	0.4735
Early adolescence						
Impulsivity	1.21	<0.0001	0.92	0.8322	-0.27	0.4709
Low self-esteem	1.05	0.3439	1.14	0.7521	0.08	0.8358
Childhood-onset anxiety	1.61	<0.0001	2.02	0.2283	0.23	0.7003
Social deviance[c]	1.02	0.2172	1.00	0.9771	-0.01	0.8032
Late adolescence						
Education years	1.00	0.9652	0.94	0.3153	-0.06	0.3166
Number of Axis I disorders excluding PG	0.82	<0.0001	0.78	0.2832	-0.05	0.8224
Number of Personality disorders	0.94	0.0182	1.38	0.0088	**0.39**	**0.0023**
Adulthood[d]						
Ever divorced	1.02	0.6171	0.79	0.5051	-0.25	0.4820
History of SUD	1.49	<0.0001	1.03	0.9418	-0.37	0.3735
Nicotine Dependence	1.26	0.0001	1.96	0.1180	0.44	0.2993
Social deviance[c]	1.09	<0.0001	1.06	0.1885	-0.03	0.4773
Past year						
SUD	1.28	0.0001	2.00	0.2716	0.45	0.4823
Nicotine Dependence	1.16	0.0472	1.63	0.3297	0.34	0.5022
Number of Axis I disorders excluding PG	0.96	0.1237	0.98	0.9305	0.02	0.9374
Marital problems	0.92	0.2491	0.88	0.8043	-0.04	0.9316
Stressful life events						
Independent	1.06	0.0002	1.21	0.1764	0.13	0.3559

	Initiation		Disorder		Continuation ratio (Interaction with threshold)	
	OR	p-value	OR	p-value	beta	p-value
Dependent	1.02	0.1082	1.02	0.8642	0.00	0.9855