ONLINE GAMBLING: NEW DEVELOPMENTS

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ONLINE GAMBLING: NEW DEVELOPMENTS

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Gambling Phenotypes in Online Sports Betting

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Background and Objectives: The Internet provides easy access to multiple types of gambling and has led to changes in betting habits. A severe rise in problematic gambling has been predicted among all sectors of the population, and studies are required to assess the emerging phenotypes related to the new structures of gambling activities. This study aimed to explore the existence of latent classes associated with gambling habits among treatment-seeking gamblers due to Online Sports Betting (OSB).

Method: Initial sample included *n* = 4,516 patients consecutively admitted for treatment in a hospital unit specialized in behavioral addictions. Two-step clustering analysis was used within the subsample of *n* = 323 patients who reported problems related with OSB, within a set of indicators including sociodemographics, psychopathological distress, personality, and severity of the gambling activity.

Results: The prevalence of OSB as a main type of gambling problem in the study was 7.2% (95% confidence interval: 6.4 to 7.9%). Two latent clusters were identified, with differences in sociodemographics and clinical status. Cluster 1 (*n* = 247, 76.5%) grouped patients that were more affected due to the OSB behaviors, and it was characterized by non-married patients, lower socioeconomic position index, higher comorbidity with other substance related addictions, younger age, and early onset of the gambling activity, as well as higher debts due to the OSB, higher psychopathological distress, and a more dysfunctional personality profile. Cluster 2 (*n* = 76, 23.5%) grouped patients that were less affected by OSB, mostly married (or living with a stable partner), with higher social position levels, older age and older onset of the gambling activity, as well as a more functional psychopathological and personality profile.

Conclusion: The increasing understanding of latent classes underlying OSB phenotypes is essential in guiding the development of reliable screening tools to identify individuals

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highly vulnerable to addictive behaviors among Internet gamblers, as well as in planning prevention and treatment initiatives focused on the precise profiles of these patients.

Keywords: clustering, gambling disorder, internet, online sports betting, phenotype

INTRODUCTION

Despite the extensive research on the involvement in gambling related problems, a new phenomenon has recently emerged which is causing concern among specialists: Online Sports Betting (OSB). The expansion of this gambling modality in developed countries has significantly increased in parallel with opportunities to participate in online gambling services. Some experts advice that the characteristics of this betting modality could make it potentially more addictive and dangerous than other gambling activities, or even than betting at physical locations [online gambling sites are permanently accessible from anywhere there's an Internet connection (24 hour-day, 7 day-week), gamblers can play *via* computer or mobile device at different sites (such as work, home), and online provides greater convenience, anonymity and comfort than other offsite platforms]. But although the potential unhealthy consequences associated with OSB, little research has been centered on this behavior. This study contributes to developing empirical knowledge regarding the phenotypes of the OSB, classically included as a subtype of the problematic or disordered gambling.

Gambling Disorder (GD) is a behavioral addiction involving a repeated and uncontrolled urge to gamble, with the consequence of clinical impairment or distress [DSM-5; (1)]. The DSM-5 taxonomy allows specifying the gambling severity level based on the number of criteria (mild, moderate, or severe gambling), while the ICD-11 (2) adds the subdivision into the subtypes of predominantly offline versus predominantly online.

Epidemiological studies regularly update worldwide prevalences for problem gambling, which estimates they were between 0.1% and 5.8% across five continents during the year before the survey, and between 0.7% and 6.5% during lifetime (3). The noteworthy increase in the incidences reported in meta-analytical data during the last decades has led to a large volume of studies aimed at increasing the understanding of the mechanisms explaining the onset and the progression of the GD (4). Much of the pioneer research in the gambling area had often contended that individuals who engage excessively in gambling behaviors experience a common set of symptoms, which are the result of shared risk factors, and which lead to similar treatment outcomes (5, 6). This assumption involved the grouping of different gambling types within a theoretical homogeneous condition, failing to take into account subtypes of gamblers based on how they engage in gambling activity and avoiding exploring how the mode of access could affect the latent phenotypes.

But in the recent years the gambling subtypes and the new emerging gambling modes have increased clinical and research interest, due to their supposed relevant role in the pathways of the gambling picture (7, 8). At present, multiple gambling modalities exist that differ in several aspects, such as the range of stakes involved, the odds of the winning, or the level of mental/physical skills required. The advances in technology and the universalization of Internet access have facilitated fast and easy access to almost all traditional manners of gambling globally. It has been observed that when gamblers can choose, they tend to select Internet instead of land-based modes, arguing, as the main reasons, convenience, higher fun-excitement-entertainment, greater comfort (online is accessible in their own homes), perception of greater capacity to win money, faster play speed, anonymity, and privacy (9). As a result, online gambling (also referred to as Internet, interactive, or remote gambling) is currently a particular area of interest, and many studies have emerged to investigate the characteristics and motivations of the growing population of Internet gamblers.

Online gambling does not represent a new gambling modality, since Internet is only a mode of access to multiple gambling platforms. Evidence suggests that the same activity experienced in online modalities versus venue/land-based forms may have particular features that can lead to different harms (10, 11). A relationship also exists, albeit complex, between the availability of the gambling activities and the level of the related problems (12). It seems that fast, easy, and constant access to gambling, as well as the ability to bet for uninterrupted periods in private settings, may contribute to the early onset of the gambling activities, and the high progression of the gambling related problems (10, 11). The particular structural characteristics and the interactive and immersive Internet environment could also adversely affect the gambling related harms (13). For example, the payment methods: compared to the cash procedure typical of many land/based games, the digital forms of money used through Internet system (e.g. credit cards, electronic funds transfers, or e-wallets) appear to lead to greater expenditures and increased gambling and losses (14). It has also been stated that online gambling environments contribute to problems with self-regulation and self-control on spending decisions (11, 15, 16), and that the rapid-sequential choice typical of computerized environments facilitates transactions and significantly contributes to gamblers' decision to continue and intensify gambling behavior (17).

But the results on the differences between online and offsite gambling outcomes are still controversial. Some studies outline that adjusting by the gambling preference and other variables (such as the frequency of participation), the contribution of online access does not achieve the predictive capacity of the gambling impairment (18–20). It has also been observed that the dichotomy of online versus offline access to gambling is far too limited to appropriately understand differences in the subgroups of gamblers, and that considering the individuals' life cycle by combining chronological age, socioeconomic position and

marital status, should provide better insights into groups (21). It has also been postulated that it should be the mixed-mode of gambling (using both Internet and land-based modes, compared to internet-only and land-based only) that predicts the greatest overall involvement in gambling and the greatest level of gambling problems (22). Among clinical treatment-seeking samples, online pathological gamblers (compared to landed-based pathological gamblers) have shown limited differences, focused on slightly higher educational levels, higher socioeconomical positions, and larger amounts of bets and debts related to Internet forms (23). And even considering the legal status of Internet gambling (with great differences between countries), studies carried out across different European jurisdictions (ranging from prohibition of online gambling to broad legal access) have found no relevant differences in the prevalence rates of GD depending on the mode of access (24).

One of the most popular types of Internet gambling is OSB. It is heavily marketed and successfully targeted at the young adult male, with the consequence of hundreds of websites facilitating access to sportsbooks and fastest developing forms internationally. OSB represents an example of the potential interaction between the mode of access to the gambling activity (Internet versus land-based) and the presence and severity of the gambling related problems. One study has obtained a great difference in the prevalence of impairment related to the sports betting among Internet gamblers (67%) compared to land-based gamblers (23%) (25). Based on a large online survey, it has also been observed that, compared to non-Internet gamblers (both moderate-risk and problem gamblers), Internet gamblers that experience gambling-related harms are characterized by younger age individuals, engaged in a greater number of gambling behaviors, and more likely to bet on sports (26). Finally, it has been postulated that OSB gamblers (compared to non-sports Internet GD patients and GD patients who did not gamble online) represent a particular vulnerable subgroup characterized by distinct personality traits (higher persistence levels), riskier betting behavior, and higher debt levels (27).

But although there is cumulated evidence regarding OSB phenotype compared to other gambling types, most studies have been planned under the assumption that OSB constitutes a unique homogeneous phenotype, grouping mostly young, male, single, with medium to high education levels, employed, or full-time student (15). Although, lower income, minor ethnicity groups, immigrant situation, and engaging in multiple different gambling forms have also been reported as distinctive characteristics of the OSB profile (28). To the best of our knowledge no study has been conducted to identify latent empirical classes within OSB groups in a clinical treatment-seeking population.

Objectives

To summarize, although there is increasing interest in online gambling, little has been reported in the scientific literature about the heterogeneity of the OSB profiles regarding demographic characteristics and other clinical features. This study aimed to explore the existence of empirical latent classes in a large sample of OSB treatment-seeking patients, using a broad set of indicator variables, including sociodemographics, problem gambling severity, psychological distress, and personality functioning. Based on the available empirical evidence obtained in different modes of gambling, we hypothesized that OSB constitute a mixed group in which latent underlying subgroups with different gambling profiles can be recognized. Since no previous study using this approach is available for OSB samples, we made no *a priori* assumptions about the number of expected groups.

Identifying the variables related to these empirical classes would facilitate the development of measurement tools with good discriminative ability and the planning of effective and precise prevention and treatment programs.

METHOD

Participants

The initial sample comprised n = 4,516 treatment-seeking patients consecutively attended to at the Pathological Gambling Unit and other Behavioral Addictions situated in the Bellvitge University Hospital (Barcelona), between January 2005 and August 2019. This hospital oversees the treatment of cases with behavioral addiction-related problems, and it is certified as a tertiary care center for the treatment of these psychiatric conditions. Data analyzed in the study corresponded to the first assessment before starting treatment. A total of 3,982 (88.2%) men were attended to, versus 534 women (11.8%). Most of the participants had achieved a primary or less (57.1%) education level, were single (41.9%) or married (44.8%), belonged to low socioeconomic levels (51.5%), and were employed (55%). The mean chronological age was 42.0 years old (SD = 13.9), and the mean duration of the gambling was 6.1 years (SD = 6.2). The most prevalent reason for seeking treatment in this behavioral addictions unit was GD (n = 3,987; 88.3%). The first block of **Table 1** contains the description of the initial complete sample.

A subsample of n = 323 patients who reported OSB related problems as the main reason for treatment-seeking was selected for exploring the existence of latent classes based on a set of indicators, including sociodemographic and clinical variables. The mean chronological age was 32.2 years old (SD = 9.7), and the mean duration of the betting behavior was 3.7 years (SD = 3.7). Most patients in this subsample were single (61.0%), employed (67.2%), and had achieved secondary education levels (49.2%). The second block of **Table 1** contains the description of the OSB subsample.

Measures

Diagnostic Questionnaire for Pathological Gambling (according to DSM criteria) (29). This is a self-report questionnaire developed to identify the presence of GD using 19 items based on the DSM criteria [diagnoses are available for the DSM-IV-TR (30) and the DSM-5 versions (1)]. The psychometrical Spanish adaptation of this tool achieved adequate properties (Cronbach's

TABLE 1 | Characteristics of the patients in the study.

		Total sample (n = 4,516)			OSB subsample (n = 323)		
Sociodemographics		**n**		**%**	**n**		**%**
Sex	Women	534		11.8	13		4.0
	Men	3,982		88.2	310		96.0
Education	Primary or less	2,577		57.1	106		32.8
	Secondary	1,615		35.8	159		49.2
	University	324		7.2	58		18.0
Marital status	Single	1,892		41.9	197		61.0
	Married-couple	2,023		44.8	99		30.6
	Divorced-Separated	601		13.3	27		8.4
Social status	High	65		1.4	10		3.1
	Mean-high	224		5.0	34		10.5
	Mean	484		10.7	49		15.2
	Mean-low	1,418		31.4	126		39.0
	Low	2,325		51.5	104		32.2
Employment	Unemployed	2,032		45.0	106		32.8
	Employed	2,484		55.0	217		67.2
Age and evolution		*Min*	*Max*	*Median*	*Min*	*Max*	*Median*
Chronological age (yrs-old)		15	88	40	15	80	30
Onset of the addiction (yrs-old)		14	80	27	14	58	23
Duration of the addiction (yrs)		1	46	4	1	23	2

OSB, online sports betting; Min, minimum; Max, maximum.

alpha α= 0.81 for a population-based sample and α=0.77 for a clinical sample) (31). The internal consistency achieved in this study was good (α=0.814).

Symptom Checklist-Revised (SCL-90-R) (32). This is a self-report questionnaire developed to assess the psychological state using 90 items factorized into nine primary (first order) dimensions (somatization, obsessive-compulsive, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism), and three global indices [global severity index (GSI), total positive symptoms (PST), and positive symptoms discomfort index (PSDI)]. The psychometrical Spanish adaptation of this tool obtained adequate properties (the mean Cronbach's alpha was α = 0.75) (33). The internal consistency in our sample was also in the adequate to good range (α = 0.790, for the paranoid ideation scale, to α = 0.981 for the global indices).

Temperament and Character Inventory-Revised (TCI-R) (34). This is a self-report questionnaire developed to assess personality traits using 240 items based on the Cloninger's multidimensional model, and structured into seven factors [four for temperament (novelty seeking, harm avoidance, reward dependence, and persistence), and three for character (self-directedness, cooperation, and self-transcendence)]. The psychometrical Spanish adaptation of the tool obtained adequate properties (the mean Cronbach's alpha was α = 0.87) (35). The internal consistency in the sample of the study was in the adequate to good range (α = 0.703, for novelty seeking, to α = 0.868 for persistence).

Other variables. This study also analyzed additional data assessed using a semi-structured interview. This tool covered socio-demographic characteristics (sex, marital status, education level, employment status), as well as the socio-economic position index, according to Hollingshead's scale (based on the participants' level of education and profession) (36). Patients also completed questions related to OSB problem-related variables (age of onset, duration, bets per gambling/episode, and cumulated debts due to the gambling addiction) and substance use (no vs. at least sometimes).

Procedure

The study was carried out in accordance with the Declaration of Helsinki principles, and approved by the Ethics Committee of University Hospital of Bellvitge (Barcelona). All patients provided signed informed consent for participating in the research. There was no financial or other compensation for being part of the sample of the study.

The assessment process took place in a single session lasting about 90 min. Data for the semi-structured interview were collected by psychologists and psychiatrists with high experience in the treatment of behavioral addictions. The clinicians also helped participants to complete the self-report questionnaires in order to guarantee that no data were missing (for example, due the lack of understanding).

Statistical Analysis

The statistical analysis was carried out with SPSS24 for windows (37). The identification of the latent empirical classes was based on a two-step cluster procedure, a method used to explore the existence of natural groupings within a dataset of categorical and continuous variables. This method uses an agglomerative hierarchical clustering system and allows automatic determination of the optimal number of groups. This study used the log-likelihood distance and the Schwarz Bayesian Information Criterion (BIC), and Akaike's Information

Criterion (AIC) to determine the best model (the optimal number of latent classes was considered for the model with the largest ratio of changes for the BIC and AIC, as well as the largest ratio of distances measured comparing the current number of clusters against the previous number).

The indicator variables in the two-step clustering included sociodemographic features (sex, marital status, and social position index), global psychopathological distress (SCL-90R GSI), personality profile (TCI-R scales), OSB severity (number of the DSM-5 criteria for gambling), and substances use. The quality of the clustering was measured using the Silhouette index, a cohesion-separation measurement interpreted as how similar individuals are to their own cluster compared to other clusters) (38). Silhouette values are into the range −1 to +1, and high values are indicative of adequate matching in one's own cluster and of poor matching in other clusters (values lower than 0.30 are interpreted as poor fits, between 0.30 and 0.50 as fair, and higher than 0.50 as good).

The comparison between the latent empirical clusters was based on Chi-square tests (χ^2) for categorical variables and on *t*-Test procedures for quantitative measurements. The effect sizes for the proportion and mean differences were based on the standardized Cohen's-*d* coefficient, considering poor-low effect size for $|d| > 0.20$, moderate-medium for $|d| > 0.5$, and large-high for $|d| > 0.80$ (39). The increase in the Type-I errors due to the multiple statistical tests for comparing the clusters was controlled with the Finner method (included in the stepwise familywise error rate procedures) (40).

RESULTS

Prevalence of OSB in the Study

Within the initial complete sample (N = 4,516), the number of patients who reported OSB as primary or secondary reason for treatment-seeking was *n* = 323 [prevalence = 7.2%; 95% confidence interval (95%CI): 6.4 to 7.9%]. **Figure 1** shows the line-plot for the prevalence of consultations due to OSB during the recruitment of the data in the study (obtained for the complete sample, N = 4,516). This plot displays an upward trend over time, with rates of 0.3% during 2005 to 16.1% during 2019.

OSB was the reason for treatment-seeking in *n* = 323 patients (prevalence = 7.2%; 95%CI: 6.4 to 7.9%). A number of *n* = 230 patients reported the presence of OSB concurrent with other secondary comorbid forms of gambling or behavioral addiction [prevalence within the total sample: 5.1% (95%CI: 4.5 to 5.7%); prevalence within the OSB subsample: 71.2% (95%CI: 66.3 to 76.1%)]. The number of OSB patients with substance use was *n* = 161 [prevalence within the total sample: 3.6% (95%CI: 3.0 to 4.1%); prevalence within the OSB subsample: 49.8% (95%CI: 44.4 to 55.3%)]. **Table S1** (**Supplementary Material**) contains the distribution of the secondary comorbid forms of gambling and behavioral addictions within the OSB subsample, as well as the substances use.

Clustering Procedure

Table S2 (**Supplementary Material**) shows the results of the auto-clustering in the OSB subsample. The optimal number of clusters chosen by the system was two: it achieved the largest ratio changes for BIC and AIC (1.00 in both estimations), the highest ratio distance (1.60) and the highest cohesion/separation measurement (Silhouette = 0.30, into the fair range). Since this two-cluster model also achieved good clinical interpretation, it was selected as the best.

The first panel in **Figure 2** shows the ordered bar-chart with the relative predictor importance in the clustering, and provides a measure of the discriminative capacity of each variable. Relative relevance is reported in a range 0 to 1: the greater the relevance of the indicator, the less likely it is that changes between clusters for the variable are attributable to chance. The predictor with the greatest significance in the study was the marital status, followed by the onset of the gambling, the novelty seeking score, tobacco use, and novelty seeking (these variables are plotted with the darkest color bars). The remaining predictors achieved lower significance, as they

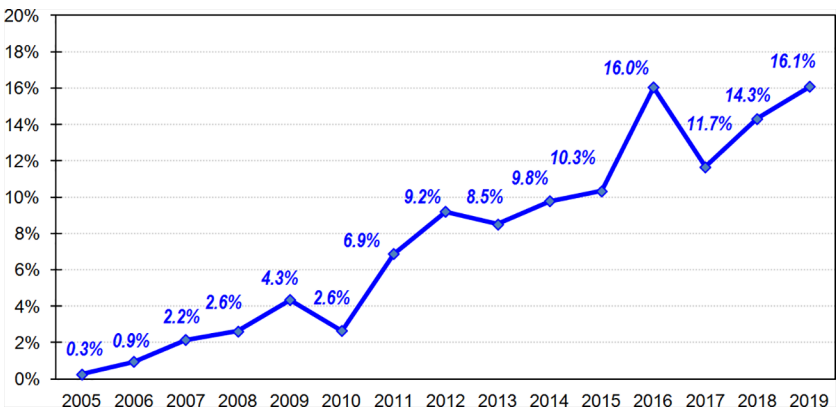

FIGURE 1 | Prevalence of the prevalence of consultation due to OSB during the recruitment of data (n=4,516).

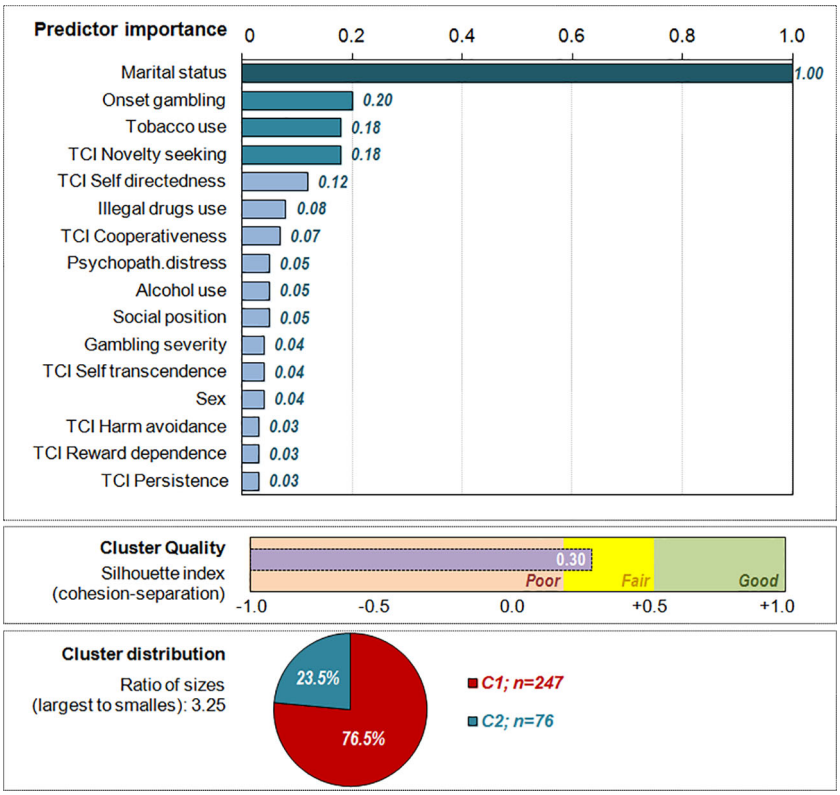

FIGURE 2 | Results of the clustering procedure within the sports betting online subsample (n = 323).

were the variables with the poorest contribution to harm avoidance, reward dependence, and persistence levels. The second panel contains the graphic representation of the Silhouette index in the study, and the third panel the cluster distribution (the ratio of sizes was 3.25, since cluster 1 achieved nearly one third of the OSB subsample).

Comparison Between the Latent Empirical Clusters

Table 2 shows the comparison between the empirical clusters identified in the study. Cluster 1 grouped $n = 247$ patients, which represented 76.5% of the OSB patients. This latent cluster was characterized by unmarried marital status, poorer socioeconomic levels, higher prevalence of substances use (tobacco, alcohol, and other illicit drugs), younger age, early onset of the OSB activity, higher severity of the betting activity, higher psychopathological distress and more dysfunctional personality profile (higher scores in novelty seeking and lower levels in self-directedness and cooperativeness). Cluster 2 grouped the remaining $n = 76$ patients (23.5% of the OSB subsample), and it was characterized by married marital status (or living with a stable partner), higher social position levels, older age and older onset of the OSB activity, lower severity associated with the OSB, and a more functional psychopathological and personality profile. The prevalence of substance use was also lower.

Figures 3 and **4** graphically show the results of the comparison between the clusters, which contribute to the understanding of the two latent classes within the OSB patients. **Figure 3** displays the line-chart with the prevalence of patients outside the normal range in the SCL-90R (psychopathological state) and the TCI-R scales (personality traits). As a whole, compared to Cluster 2 a higher percentage of patients within Cluster 1 reported mean scores within the clinical range in the SCL-90R, being the highest impairing level in the depression scale and in the global indexes GSI and PST; regarding the personality traits, the highest deviances from normal ranges were for self-directedness and novelty seeking. **Figure 4** displays the radar-plot with the main variables analyzed in the study (proportions area plotted for categorical variables and z-standardized means for quantitative variables, to allow easy interpretation due the difference in the metric scale of the variables). As a whole, Cluster 1 represented the profile of OSB patients that are more affected, while Cluster 2 represented the profile of those less affected.

DISCUSSION

The current study estimated the prevalence of the OSB among a large clinical sample of patients attended in a hospital unit

TABLE 2 | Comparison between the latent clusters identified within the OSB subsample.

		Cluster 1 (n = 247; 76.5%)		Cluster 2 (n = 76; 23.5%)		p	|d|
		n	%	n	%		
Sex	Women	12	4.9	1	1.3	.169	0.21
	Men	235	95.1	75	98.7		
Education	Primary or less	76	30.8	30	39.5	.150	0.18
	Secondary	129	52.2	30	39.5		0.26
	University	42	17.0	16	21.1		0.10
Marital status	Single	197	79.8	0	0.0	**.001***	**2.21†**
	Married-couple	26	10.5	73	96.1		**2.08†**
	Divorced-Separated	24	9.7	3	3.9		0.23
Social position index	High	6	2.4	4	5.3	**.012***	0.15
	Mean-high	25	10.1	9	11.8		0.06
	Mean	29	11.7	20	26.3		0.38
	Mean-low	103	41.7	23	30.3		0.24
	Low	84	34.0	20	26.3		0.17
Employment	Unemployed	90	36.4	16	21.1	**.012***	0.34
	Employed	157	63.6	60	78.9		
Other behavioral addictions		177	71.7	53	69.7	.746	0.04
Tobacco		133	53.8	13	17.1	**< .001***	**0.80†**
Alcohol		29	11.7	1	1.3	**.006***	**0.52†**
Other drugs		36	14.6	0	0.0	**< .001***	**0.78†**
		Mean	*SD*	*Mean*	*SD*	*p*	*|d|*
Chronological age (yrs-old)		30.41	9.33	37.95	8.76	**< .001***	**0.83†**
Age of onset of gambling (yrs-old)		23.66	6.91	29.58	8.22	**< .001***	**0.78†**
Duration of the addiction (yrs)		3.89	3.76	3.15	3.27	.125	0.21
Number of DSM-5 criteria		7.32	1.79	6.82	1.85	**.032***	0.28
[1]Maximum bets (euros-episode)		800	1700	700	1775	.795	0.03
[1]Mean bets (euros-episode)		40	140	35	190	.430	0.10
[1]Debts due to the OSB		6500	20250	2300	14000	**.023***	0.23
SCL-90R GSI		1.07	0.69	0.82	0.55	**.005***	0.40
Novelty seeking		113.91	13.43	103.64	13.39	**< .001***	**0.77†**
Harm avoidance		99.96	17.21	97.55	14.52	.270	0.15
Reward dependence		96.54	14.21	98.57	13.87	.276	0.14
Persistence		106.30	20.84	105.84	18.26	.863	0.02
Self-directedness		126.27	21.59	139.21	21.59	**< .001***	**0.60†**
Cooperativeness		126.62	17.95	134.37	14.14	**< .001***	0.48
Self-transcendence		60.39	14.57	57.38	13.55	.111	0.21

OSB, online sports betting; SD, standard deviation.

[1]Median and interquartile range.

**Bold: significant comparison.*

[†]Bold: effect size into the mild-moderate (|d| > 0.50) to large-high range (|d| > 0.80).

specialized in the treatment of GD and other behavioral addictions. The clustering analysis then examined the variance within the OSB subsample, with the aim of identifying latent homogeneous subgroups. The phenotypical differences between the two empirical clusters of OSB as regards sociodemographics, gambling severity, psychopathological state, and personality, provided reliability and validity to the clustering.

Earlier studies fueled concerns that online gambling significantly contributes to the onset and progression of the gambling related problems, with the result of prompting research into the characteristics and associated risks of this mode of access to gambling activities (7, 41). But while the insights provided by these studies into the profiles of problem gamblers that gamble online, they did not account for the relevant issue of the heterogeneity and within-subjects variance among the samples. This paper is the first, to our knowledge, to explore latent subgroups in a clinical sample of OSB patients. The rationales of this study were: a) the assumption that not all problematic online gamblers form a homogeneous group with common features and shared vulnerabilities, and therefore to automatically attribute the global Internet gambling habits and traits amongst OSB patients is inaccurate; and b) the requisite to distinguish modes of gambling (online versus land-based) and gambling forms (e.g., slot-machines, lottery, sports betting, …) to adequately characterize gambling related profiles, as well as more specific and personalized treatment approaches for each type of patient.

The clustering analysis in this work revealed that two distinctive latent subgroups was the optimal grouping solution for the study that, respectively, represented latent phenotypes of OSB. The characterization of these subgroups seemed to suggest a dimensional factor varying in the psychological and functional

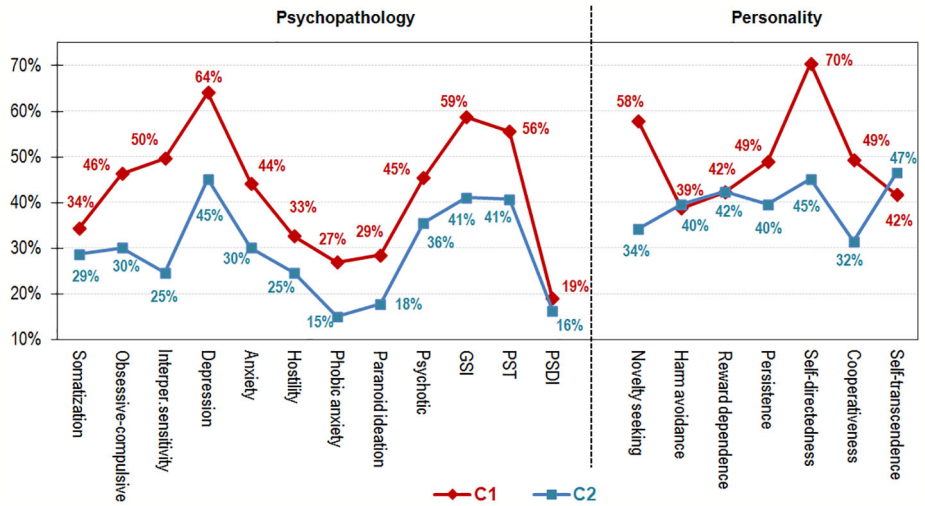

FIGURE 3 | Line-chart within the sports betting online subsample (n = 323).

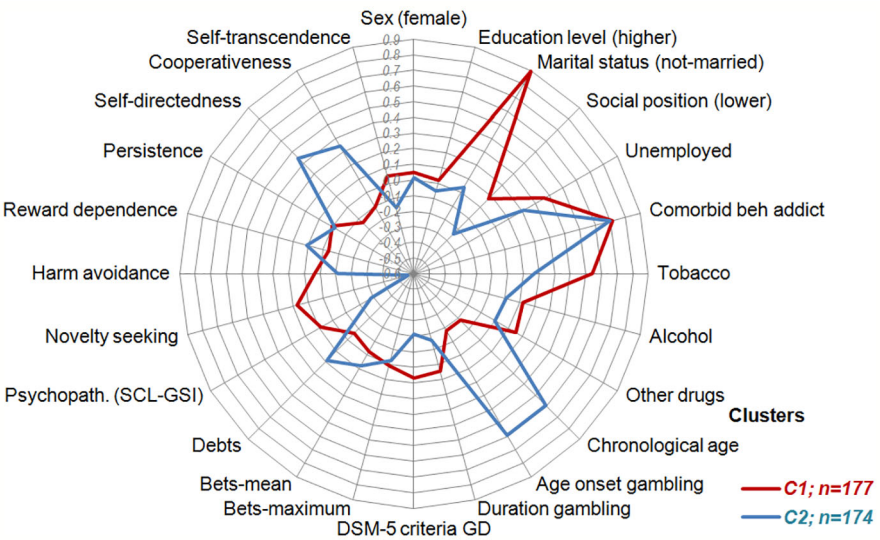

FIGURE 4 | Radar-chart within the sports betting online subsample (n = 323).

affectation. This result is in line with previous studies, which have published a higher likelihood for experiencing psychological distress among problematic online gamblers compared to non-problematic online gamblers (42). To explain these results, it has been argued that online access to gambling may become particularly motivating for escaping and alleviating negative emotional states, since Internet provides privacy, is less socially demanding than many land-based gambling activities, and allows gambling sessions without distractions and interruptions. This results in a vicious circle: individuals with high risk of negative mood and anxiety states should find in online gambling an easy way to escape and control emotional distress (43), but the higher the immersion in online gambling activity the higher are the increases in the gambling harms and their correlates (including the general psychopathological state).

Associated with the worse mental state among the patients within the cluster with the higher affectation, this latent subgroup also reported higher comorbidity with substance use (tobacco, alcohol, and other drugs). In fact, the tobacco consumption was one predictor with high importance in the clustering, after the marital status and the onset of the OSB activity. This finding is also consistent with previous studies, which have related a higher likelihood of substance use while gambling (mainly for alcohol and illicit drugs) among people with online gambling habits (44).

Increased prevalences of substance-related disorders among Internet problematic gamblers compared with other gambling forms and with non-gamblers have also been reported (45). Epidemiological and etiological research has also shown the relevance of the co-occurrence between online gambling and substances consumption (mainly with tobacco), as well as the relationship between substances status with more severe gambling habits (46). Our results, together with this set of findings, should again suggest that the solitary and private settings allowed by Internet gambling may undermine rational decision-making and increase the ease of substance use. Online access at home may also facilitate gambling alone at any time of the day for long continuous sessions, and these contextual features should make substances more likely to be consumed. Future research should assess how gambling alone, timing, and duration of online play contribute to the gambling severity among OSB.

As regards the comorbid concurrence of OSB with other addictive behaviors, previous studies have shown a strong relationship between online gambling and engaging in a wide range of other behavioral addictions (land-based and online activities) (47). In our study, both latent empirical clusters achieved high prevalences of comorbid forms of gambling and/or other behavioral addictions (71.7% and 69.7%, with a low difference of 2.0% between the classes). The strong links (co-occurrences) within addictions obtained in the scientific studies have suggested the notion that some people are more prone to these problems, regardless of whether these involve substances or other behavioral activities (48). This higher vulnerability has been explained on the basis of a spectrum that grouped a number of disorders drawn from several diagnostic categories that share core impulsive-compulsive features. This construct has been supported by many studies (49–51), who have placed GD, substance use disorders and other behavioral addictions (sex, buying or gaming) toward the upper band of the impulsive trait in the spectrum (the opposite upper band of the compulsive trait in the spectrum included disorders such as obsessive-compulsive, body dysmorphic or restrictive-type anorexia nervosa). This theoretical assumption could explain the results of our study, which showed a joint association between the presence of OSB and the high likelihood of other multiple addictions.

Regarding personality traits, the higher affectation cluster was characterized by a more dysfunctional profile defined by higher scores in novelty seeking and lower scores in self-directedness and cooperativeness. Novelty seeking is a personality trait strongly related with the exploratory level of the individuals in response to novel situation and the impulsive decision making (52), and it has been considered in research and clinical settings as a measure of the individuals' (in)capacity to bring responses into standards and to support the pursuit of long-term goals and as a consequence a powerful risk factor for psychopathology (53, 54). High levels on the novelty seeking dimension has been linked to all stages of addictions, from the acquisition phase of a single addiction to the escalation to multiple concurrent addictive behaviors (51, 55, 56). This characteristic has also been systematically obtained by comparing problematic and disordered gamblers with non-gamblers controls, and it has also been identified as a strong predictor of the gambling severity (57). Self-directness is the ability to adapt-regulate owns' behavior to the demands of a situation in order to achieve personally chosen goals and values, while cooperativeness is described as the capacity of the individuals for being empathic, helpful, socially tolerant and compassionate. Adequate functioning in self-directedness and cooperativeness seem play a relevant role in fast and adaptive emotional responses and in the choice of cognitive regulation strategies (58), and its relevance in the stress response has also been consistently reported (59). Along this line, some researchers have suggested that a combination of both low self-directedness and low cooperativeness could form a general factor representing low psychological maturity, a temperamental vulnerability predictive of many psychiatric disorders (60, 61). This intrinsic aspect of the global mental health has also been interpreted as an epiphenomenon, a "marker" of the neuropsychiatric dysfunctions in individuals who show a lack of sense of responsibility, self-control, and social skills, which ultimately are part of the definitions of the addictive disorders (substance and non-substance) (62). Finally, our results regarding the personality profile related to the more affected cluster (higher novelty seeking score and lower self-directedness and cooperativeness) are consistent with previous studies which reported the contribution of these domains on the gambling area (63–65). A recent path-analysis study has also observed that at a young age, the combination of a profile defined by immature character (low self-directedness and cooperativeness) with extreme temperament (high novelty seeking) may be a predictor of substance addiction across sex (with direct and indirect effects on the mental health status) (66). Future research should analyze the longitudinal predictive capacity of this particular endophenotype on the onset and progression of the OSB related problems.

Previous research into the OSB area have also emphasized distinguishing demographic features for this gambling subtype, such as the individuals' male sex, young age, not-married marital status (mostly single), medium or higher education levels and employed as full-time student (11, 47). The results of this study are in line with these findings. The description of the OSB subsample revealed that most patients were male (96%), with secondary or university education levels (67.2%), unmarried (69.4%), and employed (67.2%). The mean of the chronological age among OSB subsample was also younger compared to the mean obtained among the total sample (32.2 versus 42.0 years-old), as well as the age of onset of the addictive gambling (25.1 versus 29.6 years-old), and the progression of the disorder (3.7 versus 6.1 years). The results obtained in the OSB clustering reinforced these findings as regards the contribution of the sociodemographic features in the variability of the phenotype. The higher affectation latent group was related to more deprived social positions, unemployed situation, unmarried marital status, younger age, and early age of onset of the gambling activity. Other studies have also showed a relationship between lower income and the severity of the problematic online gambling (67), and being divorced/separated or living common-law has been described as the marital status most predictive of the worse

harms related to the Internet gambling (68). Lastly, it should be emphasized that research studies focused on specific populations highly vulnerable to gambling problems have found that unemployed/low income/poverty, unmarried status, young age, and early age are powerful risk factors for experiencing the greatest severe consequences of the gambling activity, independent of the gambling forms/types and the online versus offline access (69).

Finally, our results are also consistent with previous research focused on the identification of separate profiles among sports betting. The secondary data analysis published by LaBrie and Shaffer on a longitudinal study among a large sample of subscribers to an Internet sports gambling site observed, using discriminant function analysis, a particular subgroup of individuals that made more and larger bets, bet more frequently, and were more likely to exhibit intense betting soon after enrollment (70). The results of our study, obtained in a clinical sample of treatment-seeking patients, adds empirical evidence about the heterogeneity of the gambling habit profiles among OSB, with a worse psychopathological state (higher distress and comorbid patterns with substance and non-substance behaviors), a higher affectation latent subgroup, also characterized also by a higher duration of the addiction patterns, higher debts related to the gambling activity, and personality traits defined by higher scores in novelty seeking, and lower self-directedness and cooperativeness.

Limitations and Strengths

Some limitations should be considered when interpreting the results of this study. Firstly, the analysis of cross-sectional data restricts the temporal analysis of causative associations, and future longitudinal studies should explore the predictive capacity of the identified phenotypes (for example in treatment outcomes or developmental trajectories of the gambling problem). Secondly, the low prevalence of women within the OSB subsample restricts generalization of the findings, and makes results potentially non-representative of the female population with OSB. It should be considered that the frequency of women in the study is consistent with the point prevalence estimates in clinical treatment-seeking samples in the gambling area (GD is highly more frequent among men). We decided retaining the women in the study to increase the ecological validity of the study, and to be able to provide pioneer results in the area for OSB women.

A strength of the current study is the use of clustering procedure to identify the latent empirical groups among OSB patients, based on a relatively large set of predictors, including sociodemographics and clinical features. Compared with usual analytical procedures, cluster analysis does not require *a priori* assumptions regarding the underlying profiles in the sample, and therefore it allows empirically identifying the systematic covariation of multiple features contributing to the inter-individual variance in the gambling habits. A second strength is the relatively large sample size for the two latent subgroups identified (247 and 76 patients), which suggest that the clusters adequately cover the variance of naturally occurring individual differences (likelihood of small extreme groups are minimized). The third strength is the assessment of other behavioral and substance related addictions different to OSB. The high comorbidity rates found in our study warn of the high vulnerability of the patients for the concurrent presence of multiple addictive problems and the need of early screening tools and prevention plans.

Conclusion and Implications

In conclusion, Internet gambling has become a relative newcomer to the world of gambling opportunities. The amount (in number and variety) of online applications has progressed with hasty speed during the last decades, offering changes and increases in sports betting opportunities. This study is the first to systematically analyze individual variance of OSB in a large clinical sample, and the clusters obtained provides empirical evidence about the existence of different latent phenotypes associated with the Internet sports betting habits. The identification of a latent subgroup of patients with higher affectation could suggest that OSB may be largely attractive for some highly vulnerable individuals, who can isolate and immerse in these activities in their home environment as an "escape problem" way, with the consequence of increased harms. The results of this work sought to provide a more accurate assessment of these patients in whom the gambling problems stemmed from OSB, as well as to identify highly vulnerable individuals from the general population. The findings of this work should also prove useful for planning effective prevention programs for developing effectiveness intervention therapies focused on the needs of the patients.

DATA AVAILABILITY STATEMENT

The datasets generated for this study will not be made publicly available because the data used in this study is part of the hospital database, and it is restricted to protect patients' confidentiality.

ETHICS STATEMENT

This study was carried out in accordance with the latest version of the Declaration of Helsinki principles. The Ethics Committee of the Bellvitge University Hospital approved the study and written informed consent was obtained and signed from all final participants.

AUTHOR CONTRIBUTIONS

Conceptualization: SJ-M, FF-A. Data curation: AP-G. Statistical analysis: RG. Investigation: BM, EM-V, IB-S, MG-P, LM, EC, HL-G, TM-M, GM-B, SV-S, SR, CV-A, ML-M. Project administration: SJ-M, FF-A, JM. Resources: AP-G, ZA. Writing of the first draft: SJ-M, RG. Review and critique: FF-A, JM.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2020.00482/full#supplementary-material

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Considering Motor Excitability During Action Preparation in Gambling Disorder: A Transcranial Magnetic Stimulation Study

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A lack of inhibitory control appears to contribute to the development and maintenance of addictive disorders. Among the mechanisms thought to assist inhibitory control, an increasing focus has been drawn on the so-called preparatory suppression, which refers to the drastic suppression observed in the motor system during action preparation. Interestingly, deficient preparatory suppression has been reported in alcohol use disorders. However, it is currently unknown whether this deficit also concerns behavioral, substance-free, addictions, and thus whether it might represent a vulnerability factor common to both substance and behavioral addictive disorders. To address this question, neural measures of preparatory suppression were obtained in gambling disorder patients (GDPs) and matched healthy control subjects. To do so, single-pulse transcranial magnetic stimulation was applied over the left and the right motor cortex to elicit motor-evoked potentials (MEPs) in both hands when participants were performing a choice reaction time task. In addition, choice and rapid response impulsivity were evaluated in all participants, using self-report measures and neuropsychological tasks. Consistent with a large body of literature, the MEP data revealed that the activity of the motor system was drastically reduced during action preparation in healthy subjects. Surprisingly, though, a similar MEP suppression was observed in GDPs, indicating that those subjects do not globally suffer from a deficit in preparatory suppression. By contrast, choice impulsivity was higher in GDPs than healthy subjects, and a higher rapid response impulsivity was found in the more severe forms of GD. Altogether, those results demonstrated that although some aspects of inhibitory control are impaired in GDPs, these alterations do not seem to concern preparatory suppression. Yet, the profile of individuals suffering of a GD is very heterogeneous, with only part of them presenting an impulsive disposition, such as in patients with alcohol use disorders. Hence, a lack of preparatory suppression may be only shared by this sub-type of addicts, an interesting issue for future investigation.

Keywords: gambling disorder, addiction, inhibitory control, impulsivity, transcranial magnetic stimulation, motor system, action preparation

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INTRODUCTION

Self-regulation is essential to behave in a goal-directed manner. In particular, the ability to suppress prepotent but inappropriate responses is a key component, preventing one to respond to stimulus-driven impulses (1, 2). Without the efficient operation of this inhibitory control, behavior becomes maladaptive, as evidenced in a range of psychiatric disorders, including addictive disorders (3, 4). As such, a core element of addiction is a loss of control over either the use of a substance or the engagement in a recurrent activity, despite awareness of negative consequences, which clearly interfere with long-term goals.

Among the different processes assisting inhibitory control, an increasing focus has been drawn on mechanisms allowing to downregulate the excitability of the motor system (5). Accordingly, a drastic suppression of motor activity has been reported when subjects are in the process of stopping an action (6, 7), but also during the preparation of motor acts (8, 9). In particular, by measuring motor-evoked potentials (MEPs) elicited by single-pulse transcranial magnetic stimulation (TMS) over the primary motor cortex (M1), studies have monitored changes in the excitability of the corticospinal pathway during instructed-delay choice reaction time (RT) tasks (10–14). Such tasks typically require participants to choose between responding with the left of the right hand according to an informative preparatory cue, and to withhold their response until the onset of an imperative signal. When TMS pulses are applied between the cue and the imperative, the amplitude of MEPs probed in both hands are strongly reduced relative to resting conditions (15–17). This phenomenon, referred to as preparatory suppression (or inhibition), is thought to help prevent premature or inappropriate motor responses and, more generally, to ensure some sort of impulse control (8, 18–20).

Consistent with this view, preparatory suppression appears to be deficient in individuals lacking inhibitory control, such as in addictive disorders. We have recently shown that alcohol-dependent patients (ADPs) display a reduced MEP suppression during action preparation relative to matched healthy participants (9), suggesting that a shortage of preparatory suppression might represent a newly identified feature of addictive disorders. Moreover, it might serve as an objective indicator of addiction severity, as the magnitude of this defect was linked to the subsequent propensity to relapse.

Chronic alcohol consumption has considerable neurotoxic effects, with the most pronounced damage reported in regions underpinning response inhibition, such as the frontal lobes and basal ganglia (21–23). In addition, the degree of brain atrophy is related to the amount of alcohol previously consumed (24). Hence, the deficit in preparatory suppression could be a consequence of brain damage induced by chronic alcohol exposure. Alternatively, a lack of inhibitory control might have been present before the pathology, predisposing individuals to early recreational experiences with alcohol, or facilitating their transition towards alcohol use disorder. For example, offspring of ADPs, known to be at higher risk of developing alcohol use disorders (25), display deficient inhibitory control (26, 27). In addition, impulsivity assessed during childhood or adolescence predicts substance use disorders later in life (28, 29).

Inhibitory control is also impaired in behavioral, substance-free, addictions, implying that it might act as a vulnerability factor common to both substance and behavioral addictive disorders (3, 30). This matter has been especially addressed in gambling disorder (GD), which shares considerable phenomenological parallels with substance addiction, including difficulties to control the urge to gamble despite awareness of its negative impact, unsuccessful attempts to cut back, or the emergence of craving in front of gambling-related cues (31). In particular, an increasing body of literature has highlighted that patients suffering from GD (GDPs) have higher levels of impulsivity and lower response inhibition abilities than control subjects (32–34). Moreover, several studies have reported an interesting association between those alterations and gambling severity (35–37).

The goal of the present study was to determine whether GDPs, who suffer from an addictive disorder but are preserved from the neurotoxic influence of drugs of abuse, display a lack of preparatory suppression in the motor system, similar to our findings in ADPs. To test this idea, we applied single-pulse TMS over the left and the right M1 to elicit MEPs in GDPs and matched healthy control subjects performing an instructed-delay choice RT task. The study also involved the examination of other aspects of inhibitory control, including trait impulsivity, choice impulsivity, and response inhibition. Based on the hypothesis that a lack of preparatory suppression represents a common feature to both substance and behavioral addictions, we expected preparatory suppression to be less pronounced in GDPs than in healthy subjects.

MATERIALS AND METHODS

Participants

Thirteen right-handed individuals with a diagnosis of GD were included in the study. All patients were recruited through advertisements in several gambling areas, such as in casinos and sports betting facilities, and through a collaboration with the psychiatry unit of the Saint-Luc Academic Hospital (Université catholique de Louvain, Brussels, Belgium). Gambling dependence severity was assessed before the experiment using the South Oaks Gambling Scale (SOGS); a score higher than 5 was required to participate, indicating probable pathological gambling (38). Based on this criterion, we selected 16 participants. Moreover, on the day of the experiment, a face-to-face clinical interview was conducted by an experienced psychologist, and only patients who met DSM-5 criteria for GD (39) were kept in the final sample (n = 13). All patients gambled at least more than once a week; the mean duration of gambling behavior was 6.1 years (SD = 3.86). Their main gambling activity was either sports betting (n = 7) or online casino games (n = 6). GDPs were matched for age, gender, and education level with 13 right-handed healthy control subjects (HCs); all controls had a SOGS score of 0. Exclusion criteria for

both groups included major neurological or psychiatric disorder, any drug treatment that could influence performance or neural activity (including benzodiazepine), and no history of substance use disorder (except nicotine). Nicotine dependence was more prevalent among GDPs (n = 4) than controls (n = 0). Finally, in order to avoid any confounding effects due to a problematic consumption of alcohol, subjects from both groups had to complete the Alcohol Use Disorder Test (AUDIT); a score higher than 10 was considered as an exclusion criterion (40). All participants gave written informed consent, following a protocol approved by the Biomedical Ethic Committee of the Saint-Luc University Hospital, Université catholique de Louvain. All the experimental procedures occurred at the Institute of Neuroscience of the Université catholique de Louvain, and a 50-euro voucher was provided at the end of the experiment as a financial compensation.

Experimental Procedure

Self-Reported Measures

Current clinical status was measured using French versions of the Spielberger State Trait Anxiety Inventory [STAI Trait and State; (41, 42)] and the Beck Depression Inventory [BDI; (43, 44)]. To evaluate trait impulsivity, both the Barratt Impulsiveness Scale Version 11 [BIS-11; (45, 46)] and the UPPS Impulsive Behavior Scale (47, 48) were used. While the former is composed of three subscales, namely attentional, motor, and non-planning impulsivity, the latter allows to assess four different dimensions of impulsivity, referred to as urgency, lack of premeditation, lack of perseverance, and sensation seeking. Finally, choice impulsivity was measured using the Monetary Choice Questionnaire [MCQ; (49)]. This tool consists of 27 dichotomous choices between smaller-immediate and larger-delayed monetary rewards to provide individual's delay discounting rate, i.e. the *k*-value. Three magnitudes are assessed, resulting in separate discounting rates for small, medium, and large reward; an overall discounting rate was also obtained. *K*-values can range from 0 (consistent selection of the delayed reward) to 0.25 (consistent selection of the immediate reward); hence, the higher the *k* is, the more the individual discounts delayed reward.

Behavioral Measures of Motor Inhibition

Stop-Signal Task

The STOP-IT software was used to assess action stopping (50). Overall, the task consisted of 32 practice trials, followed by three experimental blocks of 96 trials. On each trial, participants were presented with an arrow (go signal); their task was to press the left arrow key of a keyboard with the left index finger when they saw a left arrow, and to press the right arrow key with the right index finger when they saw a right arrow. However, on 25% of the trials (stop trials), the arrow became blue after a variable delay (stop-signal delay; SSD), notifying participants to abort their response. The SSD was initially set at 250 ms, and was continuously adjusted *via* a standard adaptive tracking procedure (i.e. decrease of 50 ms after a successful stop and increase of 50 ms after an unsuccessful stop); this converges on a response rate to a stop trial of ±50%. Importantly, participants were instructed to respond as accurately and as fast as possible (maximal reaction time [RT] set at 1,250 ms), and not to delay their response to wait for the potential onset of a stop-signal. The stop-signal reaction time (SSRT), which corresponds to the latency of the stop process, was estimated with the integration method (with replacement of go omissions, i.e. 0.007% of the trials in the current study), such as recently recommended by Verbruggen et al. (51). In addition to the SSRT, we measured the RTs on Go trials, RTs on unsuccessful stop trials, and the SSDs.

Anti-Saccade Task

In this task [adapted from (52)], participants performed three different blocks, all of them involving a similar procedure. Each trial started with the presentation of a fixation cross in the middle of the screen for 1,500 to 3,500 ms, followed by the onset of a target stimulus. This stimulus was an arrow inside a square displayed for 150 ms on the left or the right side of the screen, before being masked by a gray cross-hatching square. The participant's task was to indicate the orientation of the arrow (towards the left, the right, or upwards) by pressing the corresponding key on a keyboard. The first two blocks corresponded to control conditions, whereas the third one was the experimental condition. In the first block (No cue [NC]; 40 trials), the sequence of events for each trial occurred as described above. In the second type of block (Congruent cue [CC]; 40 trials), a visual cue (a black square) was presented for 225 ms between the fixation cross and the target stimulus on the same side as the arrow. Finally, the last block involved trials in which the visual cue was systematically displayed on the side opposite to the target stimulus (Incongruent cue [IncC]; 80 trials). Given that the arrow appeared for only 150 ms, participants had to inhibit the automatic response triggered by the IncC in order to correctly identify the orientation of the arrow. The critical measure was the anti-saccade cost, which was computed for both RTs and percentage of correct responses, by calculating the difference between the average scores obtained in the IncC block and the average scores recorded in the two other NC and CC blocks.

Neural Measures of Preparatory Suppression

The "Rolling Ball" Task

Participants performed an instructed-delay choice RT task, which was implemented with Matlab 7.5 (Mathworks, Natick, Massachusetts, USA) using the Psychophysics Toolbox extensions (53, 54). It consists in a virtual "rolling ball" game previously used in other studies [(8, 9, 17, 55); see **Figure 1A**]. In this task, a ball and a goal appear on a computer screen and participants must virtually "shoot the ball into the goal" by performing an abduction movement with the left or right index finger, which requires the activation of the left or right first dorsal interosseous (FDI) muscle, respectively.

The sequence and timing of events are shown in **Figure 1B**. Each trial started with the presentation of a preparatory cue, consisting of a ball and a goal separated by a gap. Participants had to prepare an abduction of the left index finger when the ball was displayed on the left side of the screen, and an abduction of

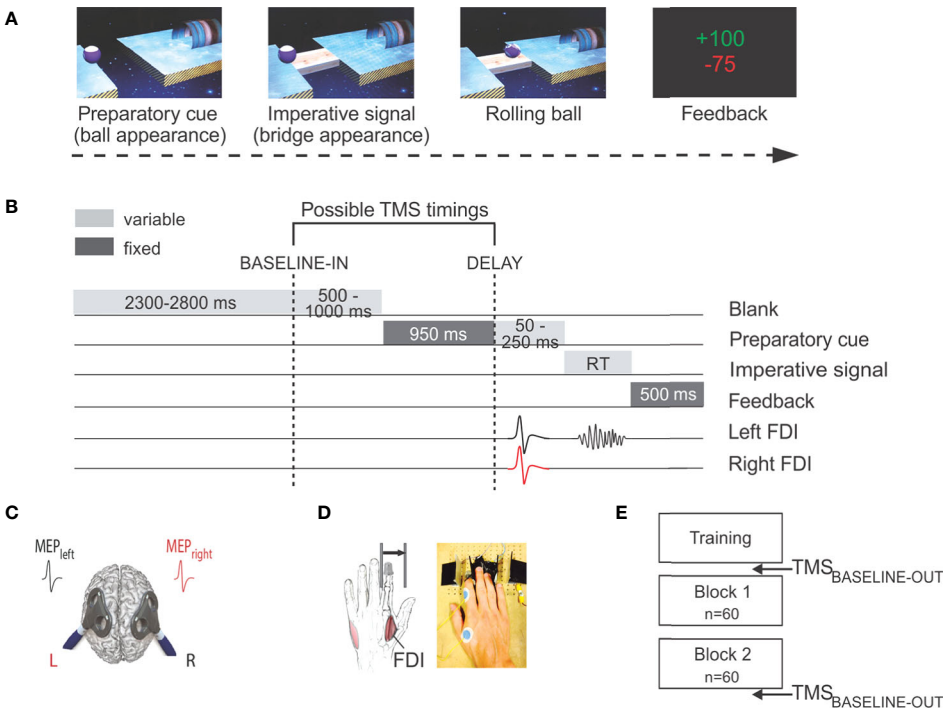

FIGURE 1 | Experimental procedure to measure preparatory suppression. **(A)** Rolling ball task. Subjects performed an instructed-delay choice reaction time task, requiring them to choose between an abduction movement of the left or right index finger (left in the current example) depending of the position of a preparatory cue (i.e., the ball). They had to withhold their response until the onset of an imperative signal (i.e., the bridge). Once the bridge appeared, they were required to release their response as fast as possible. If they answered correctly, the ball then rolled over the bridge and reached the goal located on the other side. A feedback reflecting how fast and accurate subjects had been concluded each trial. **(B)** Time course of a trial. Each trial started with the preparatory cue (random duration; 1,000–1,200 ms) followed by the imperative signal, which remained visible until the subject responded (maximum duration of 700 ms). The feedback was presented at the end of each trial for 500 ms. Transcranial magnetic stimulation (TMS) was used to elicit motor-evoked potentials (MEPs) in the first dorsal interosseous (FDI) of both hands. TMS pulses could occur either during the inter-trial interval (between 2300 and 2800 ms after the blank screen onset; $TMS_{BASELINE\text{-}IN}$), or during the delay period (950 ms after the preparatory cue onset; TMS_{DELAY}). **(C)** TMS protocol. Two figure-of-eight coils were placed over the subject's primary motor cortex, eliciting near simultaneous MEPs (1ms delay) in the left and right FDIs. **(D)** Response device. Index finger responses were recorded using a home-made response device positioned under the left (graphic representation) and right (photographic representation) hands. **(E)** Time course of the experiment. After a training block, subjects performed two blocks of 60 trials. Moreover, MEPs were elicited before and after the two experimental blocks to obtain a measure of corticospinal excitability outside the context of the task ($TMS_{BASELINE\text{-}OUT}$).

the right index finger when it appeared on the right. Subjects were explicitly told to withhold their prepared response until the onset of an imperative signal (i.e., the bridge), which appeared 1,000 to 1,200 ms later. We purposely varied the duration of the delay period to decrease the subjects' tendency to respond prematurely (i.e., before the imperative signal). For the same reason, each block involved a few trials in which the bridge did not appear (i.e., catch trials—4 per block). In these trials, subjects were required not to respond and were penalized if they did so. Once the bridge was on the screen, subjects had to respond as fast as possible to make the ball roll over it, within a maximum time of 700 ms. The imperative screen disappeared once a response was detected (or after 700 ms) and a feedback was presented for 500 ms. Following a correct response, the feedback consisted of a positive score depicted in green, which ranged from 1 to 100 and was inversely proportional to the trial's RT ($\text{Score} = \frac{100*(0,8*250)}{(0,8*250)+(\frac{RT-(0,8*250)}{10})^{2,4}}$). By contrast, incorrect responses (i.e., responses provided prematurely, that is before the onset of the imperative, responses provided too late, that is more than 700 ms after the imperative onset, or responses that were provided with the incorrect finger) were penalized by a negative score (−75) displayed in red. Note that when subjects succeeded not to respond on a catch trial, they received +75 points. Finally, each trial ended up with a blank screen, lasting between 2,800 and 3,800 ms (inter-trial interval).

TMS Protocol

TMS was always delivered using a double-coil TMS method recently developed in our laboratory (17, 56–58), where both M1 are stimulated with a 1 ms inter-pulse interval, eliciting MEPs in both hands at a near simultaneous time (**Figure 1C**). Adding an interval between both pulses allows to avoid direct electromagnetic interference between the two coils, while keeping it short prevents transcallosal interactions to occur between motor areas. The MEPs obtained using this double-coil approach are comparable to those

elicited using single-coil TMS, regardless of the pulse order or the intensity of stimulation (17, 56); here, the first pulse was systematically applied over right M1. Both pulses were delivered through small figure-of-eight coils (wing internal diameter 35 mm), each connected to a stimulator delivering monophasic pulses. The coils were placed tangentially on the scalp with the handle pointing backward and laterally at 45° angle away from the midline, approximatively perpendicular to the central sulcus. For each M1, the optimal coil position for eliciting MEPs in the contralateral FDI was identified and marked on a head cap placed on the participant's scalp to provide a reference mark throughout the experiment (8, 18, 59).

The resting motor threshold (rMT) was determined at the hotspot for each M1 as the minimal TMS intensity required to evoke MEPs of 50 μV peak-to-peak in the relaxed FDI muscle in 5 out of 10 consecutive stimulations. Across control subjects, the rMTs corresponded to 41.92 ± 2.56% and 41.46 ± 2.65% of the maximum stimulator output for the left and right M1, respectively. In GDPs, the rMTs equaled 41.77 ± 2.58% and 41.53 ± 2.79% in the corresponding conditions. The intensity of TMS used throughout the experiment was always set at 115% of the individual rMT for each hemisphere.

Experimental Design

Participants sat in front of the computer screen with forearms resting in a semi-flexed position and hands placed palms down on a home-made response device developed in our laboratory to detect any horizontal movement of the index fingers (**Figure 1D**). This setup provides us with a very precise measure of the RT (precision = 1 ms) and allows us to control the initial index finger position at the beginning of each trial [for more details regarding this device, please refer to (60)].

As illustrated in **Figure 1E**, the testing always began with a training block in order to familiarize the subjects with the task, followed by two experimental blocks of 60 trials. During those blocks, TMS pulses were delivered at one of two possible timings (**Figure 1B**). To establish a baseline measure of corticospinal excitability (CSE), TMS pulses fell during the inter-trial interval, between 2,300 and 2,800 ms after the blank screen onset (i.e., 500 to 1,000 ms before the onset of the preparatory cue), eliciting MEPs at rest but in the context of the task ($TMS_{BASELINE\text{-}IN}$; 18 MEPs per block). In other trials, TMS pulses were delivered 950 ms after the onset of the preparatory cue, when subjects were withholding their response (TMS_{DELAY}; 18 MEPs per responding side and per block). The remaining trials (six per block) did not include any TMS pulse, preventing participants from anticipating TMS pulses at TMS_{DELAY} when it had not occurred at $TMS_{BALSINE\text{-}IN}$. Finally, 18 TMS pulses were applied before and after the two experimental blocks to obtain a baseline measure of CSE at rest outside the context of the task ($TMS_{BASELINE\text{-}OUT}$).

Electromyography (EMG) Recording

EMG activity was recorded from surface electrodes (Ambu Blue Sensor NF-50-K Neuroline, Medicotest, Oelstykke, Denmark) placed over the FDI muscle of the left and right hands. EMG data were collected for 3,200 ms on each trial, starting 200 ms before the TMS pulse. The raw EMG signals were amplified (gain, 1 K), bandpass filtered online (10–500 Hz, NeuroLog; Digitimer) and digitized at 2,000 Hz for offline analysis. The latter consisted in extracting the peak-to-peak amplitude of MEPs recorded in both FDIs. In order to prevent contamination of MEP measurements by significant fluctuations in background EMG, trials with EMG activity (root mean square computed in the 200 ms windows preceding the TMS pulse) exceeding 2.5 standard deviations (SD) around the mean were discarded from the following analyses (8, 17). The remaining MEPs were classified according to the experimental condition within which they had been elicited. Trials in which subjects made an error were also removed from the data set; the task was so easy that these trials remained rare and errors were not analyzed. For each condition, we excluded trials with peak-to-peak MEP amplitudes exceeding 2.5 SD around the mean. Following data cleaning, a mean of 30.7 ± 3.5 trials per condition were left.

Statistical Analyses

Self-Reported Measures

Demographic variables and current clinical status were compared in HCs and GDPs using independent sample t-tests. Trait impulsivity was analyzed by conducting two separate multivariate analyses of variance (MANOVAs) on scores reported at the different subscales of the BIS-11 and the UPPS questionnaire, with GROUP (HCs, GDPs) as the between-subject factor. To analyze choice impulsivity, a two-way ANOVA was computed on *k*-values obtained at the MCQ, with MAGNITUDE (small, medium, large) as the within-subject factor and GROUP (HCs, GDPs) as the between-subject factor. Importantly, as several works reported that using the natural log (nlog) transformation allows to approximately normalize the distribution of *k*-values (61, 62), analyses were performed on *nlog k*-values.

Behavioral Measures of Motor Inhibition

To compare motor inhibition in both groups, independent sample t-tests were performed on the critical measures specific to each task, i.e. the SSRT and the anti-saccade cost. In addition, RTs on Go trials, RTs on unsuccessful stop trials and SSDs were compared using Welch's t-tests, because of unequal variances in HCs and GDPs.

Neural Measures of Preparatory Suppression

First, we focused on CSE at rest, by considering MEPs probed outside the blocks ($TMS_{BASELINE\text{-}OUT}$) and those recorded within the blocks ($TMS_{BASELINE\text{-}IN}$). The raw amplitude of those MEPs (mV) was analyzed using a three-way ANOVA, with MEP-SIDE (Left, Right) and TMS-TIMING ($TMS_{BASELINE\text{-}OUT}$, $TMS_{BASELINE\text{-}IN}$) as within-subject factors and GROUP (HCs, GDPs) as the between-subject factor. Then, we considered MEPs at TMS_{DELAY}; those MEPs were expressed in percentage of MEPs elicited at $TMS_{BASELINE\text{-}IN}$. To assess the presence of preparatory suppression in each sub-condition, one-sample t-tests (Bonferroni-corrected) were carried out to compare these values to 100 (i.e. to $TMS_{BASELINE\text{-}IN}$). Furthermore, the

strength of preparatory suppression was compared between both groups by performing a three-way ANOVA, using MEP-SIDE (Left, Right) and CONDITION (Selected, Non-Selected) as the within-subject factors and GROUP (HCs, GDPs) as the between-subject factor. Finally, to analyze behavior during the rolling ball task, a three-way ANOVA was computed on RTs, with RESPONDING-SIDE (Left, Right) and TMS-TIMING ($TMS_{BASELINE-IN}$, TMS_{DELAY}) as within-subject factors and GROUP (HCs, GDPs) as the between-subject factor.

Exploratory Analyses on the Relationships With Gambling Severity

In order to assess the potential link between the total number of DSM-V criteria and psychopathological variables as well as our different measures of inhibition in GDPs, partial Pearson's correlations were performed in these subjects, using the factor AGE as a covariate.

The Fisher's Least Significant Difference (LSD) method was used to run post-hoc comparisons. All of the data are expressed as mean ± SE and the statistical significance was set at $p < 0.05$. Analyses were carried out using Statistica 10 (StatSoft, Cracow, Poland).

RESULTS

Demographics and Current Clinical Status

As illustrated in **Table 1**, analyses confirmed that both groups were matched for age (t24 = −0.21, p = 0.67) and education level (t24 = 1.92; p = 0.07). In addition, they did not significantly differ for state anxiety (t24 = −1.29; p = 0.74), trait anxiety (t24 = 0.97; p = 0.45), and depression (BDI, t24 = −1.67; p = 0.11). Finally, the AUDIT score was not significantly different between HCs and GPDs (t24 = 1.71; p = 0.10).

Trait Impulsivity

The MANOVA performed on scores at the BIS-11 questionnaire showed a significant main effect of the factor GROUP ($\lambda_{3,22}$ = 0.49; $p < 0.01$). As shown in **Table 2**, univariate results obtained for each subscale reveal that the significant difference between both groups was due to higher scores on the non-planning impulsiveness subscale in GDPs relative to HCs ($F_{1,24} = 21.21$; $p < 0.001$). Moreover, scores on the motor subscale also tended to be higher in GDPs, even if it did not reach significance ($F_{1,24} = 3.31$; $p = 0.08$).

Surprisingly, the main effect of GROUP was not significant for the UPPS scale (λ34,21 = 0.70; p = 0.10). Nonetheless, it is interesting to note that univariate analyses still reveal a significant difference between both groups for the lack of premeditation subscale (F1,24 = 6.79; p < 0.05), consistent with the results regarding the BIS-11 questionnaire

TABLE 1 | Demographic and psychopathological measures for healthy controls (HCs) and gambling disorder patients (GDPs) (Mean [SE]).

	HCs (n = 13)	GDPs (n = 13)
Age[NS]	27.8 *(2.4)*	28.6 *(2.7)*
Education level[1,NS]	15.5 *(0.48)*	14.1 *(0.6)*
Trait anxiety[NS]	35.3 *(2.9)*	40.5 *(2.7)*
State anxiety[NS]	43.3 *(3.2)*	43.5 *(2.6)*
BDI[NS]	3.6 *(1.0)*	6.8 *(1.6)*
AUDIT[NS]	6.1 *(0.7)*	4.2 *(0.9)*
Tobacco (n smokers)	0	4
SOGS	0	9.1 *(0.6)*
DSM-V criteria	0	5.8 *(0.4)*

[1]The education level reflects the number of years of education completed since starting primary school. BDI, Beck Depression Inventory; AUDIT, Alcohol Use Disorders Identification Test; SOGS, South Oaks Gambling Screen; DSM, Diagnostic and Statistical Manual; NS, non-significant.

TABLE 2 | Trait impulsivity measures for healthy controls (HCs) and gambling disorder patients (GDPs) (Mean [SE]).

	HCs (n = 13)	GDPs (n = 13)
BIS-11**		
Attentional	17.1 *(1.2)*	17.3 *(0.9)*
Motor	20.5 *(1.0)*	23.3 *(1.2)*
Non-planning***	21.2 *(1.0)*	27.2 *(0.8)*
UPPS Scale[NS]		
Urgency	26.6 *(1.5)*	29.7 *(1.8)*
Lack of premeditation	20.1 *(1.1)*	23.9 *(0.9)*
Lack of perseverance	19.1 *(1.5)*	21.4 *(1.4)*
Sensation seeking	35.2 *(1.8)*	35.3 *(2.5)*

*NS, non-significant. **p < 0.01 and ***p < 0.001.*

Choice Impulsivity

The ANOVA performed on the *nlog k*-values of HCs and GDPs revealed a significant main effect of GROUP ($F_{1,24} = 22.17$; $p <$

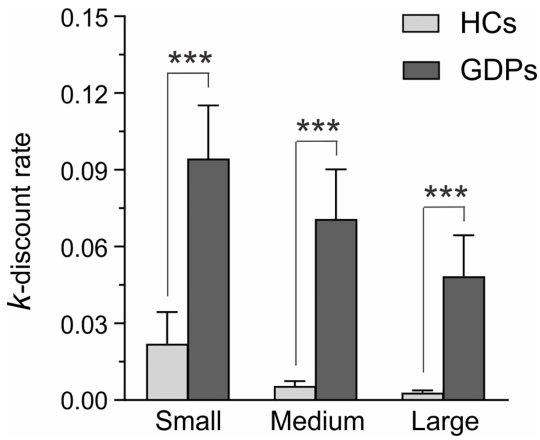

FIGURE 2 | Self-reported measures for choice impulsivity. K-values estimated from the Monetary Choice Questionnaire (MCQ) are shown for HCs (light gray) and GDPs (dark gray) when the delayed reward was small, medium, or large. Higher k-values reflect higher discounting rates. Please note that statistical analyses were performed on nlog k-values, although this figure depicts the raw data. Those results highlight the higher discount rate in GDPs relative to HCs, regardless of the magnitude of the delayed reward. ***p < 0.001: significantly different.

0.001). Hence, and as evident on **Figure 2**, GDPs discounted reward at a significantly higher rate than HCs did. Furthermore, the main effect of MAGNITUDE was significant ($F_{2,48}$ = 15.03; $p < 0.001$), which reflected a decrease in discounting rates as the amount of the delayed reward increased. Interestingly, the interaction between both factors was not significant (F2,48 = 0.13; p = 0.73), indicating that GDPs had higher discounting rates relative to controls regardless of the reward amount. Accordingly, further analyses performed on the mean discounting rate estimated for the whole questionnaire (i.e. 0.006 ± 0.002 and 0.056 ± 0.018 for HCs and GDPS, respectively) revealed a significant difference between both groups (t24 = −4.47; p < 0.001).

Behavioral Measures of Motor Inhibition

In the stop-signal task, two GDPs did not properly follow the instructions—i.e. probability of responding on a stop trial higher than 0.75—and were consequently excluded from the subsequent analyses, as recommended (51). In the remaining subjects, the mean response rate on stop trials equaled 49.17 and 47.76% in HCs and GDPs, respectively, indicating that the tracking procedure was successful, which should allow a valid interpretation of the SSRT. As shown on the left panel of **Figure 3A**, the t-test performed on this index revealed no significant difference between both groups (t22 = 0.18; p = 0.86), suggesting similar abilities to abort an ongoing action in HCs and GDPs. However, GDPs seemed to be slower than controls when performing the task, such as indicated by longer RTs on Go trials (t22 = −2.23; p = 0.06; see right panel of **Figure 3A**). This overall slowness was also reflected in measures of the SSD (243.7 ± 23.9 and 396.3 ± 75.6 ms in HCs and GDPs, respectively; t22 = −1.92; p = 0.07) and of RTs on unsuccessful stop trials (393.9 ± 10.9 and 523.5 ± 60.1 ms in HCs and GDPs, respectively; t22 = −2.12; p = 0.06).

Regarding the anti-saccade task, even though the figures suggest a larger cost in GDPs than in controls, our analyses did not reveal any significant difference between both groups, neither for the percentage of correct responses (t24 = −1.71; p = 0.10; left panel of **Figure 3B**) nor for the RTs (t24 = −0.57; p = 0.57; right panel of **Figure 3B**). Hence, GDPs did not significantly display more difficulties than HCs to inhibit the initial reflexive saccade towards the incongruent visual cue.

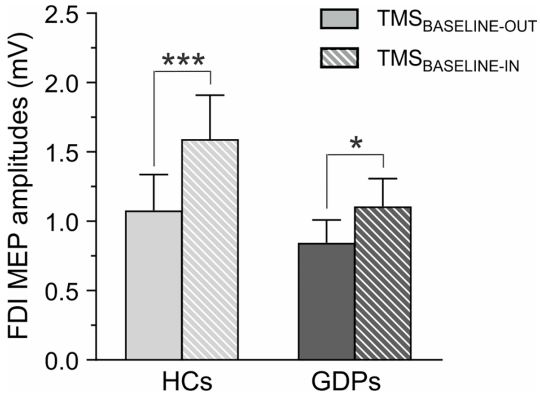

FIGURE 4 | Measures of corticospinal excitability (CSE) at rest. Raw amplitude of motor-evoked potentials (MEPs, in mV) recorded in the FDI at rest, either outside ($TMS_{BASELINE-OUT}$; open bars) or within ($TMS_{BASELINE-IN}$; dashed bars) the blocks. MEPs are shown for HCs (light gray) and GDPs (dark gray). Such as revealed by the significant GROUP X TMS-TIMING interaction, the increase in CSE during the task was larger in HCs than in GDPs. *p < 0.05 and ***p < 0.001: significantly different.

Neural Measures of Preparatory Suppression

MEP Measurements

First, we considered MEPs acquired at rest, either outside or within the blocks ($TMS_{BASELINE-OUT}$ and $TMS_{BASELINE-IN}$). Overall, the amplitude of MEPs probed at $TMS_{BASELINE-OUT}$ was 1.06 ± 0.26 mV and 0.84 ± 0.16 mV in HCs and GDPs, respectively. When elicited at $TMS_{BASELINE-IN}$, MEPs equaled 1.64 ± 0.34 mV and 1.06 ± 0.21 mV in the corresponding groups. In line with previous studies (8, 17, 55), MEPs were globally larger at $TMS_{BASELINE-IN}$ relative to $TMS_{BASELINE-OUT}$ (F1,24 = 39.14; p < 0.001), reflecting an increase in the level of CSE in the context of the task. However, consistent with the significant GROUP X TMS-TIMING interaction (F1,24 = 8.07; p < 0.01) and as shown on **Figure 4**, this increase was more pronounced in controls (p < 0.001) than in GDPs (p < 0.05).

Then, we evaluated the amplitude of MEPs elicited during action preparation (expressed in percentage of MEPs at

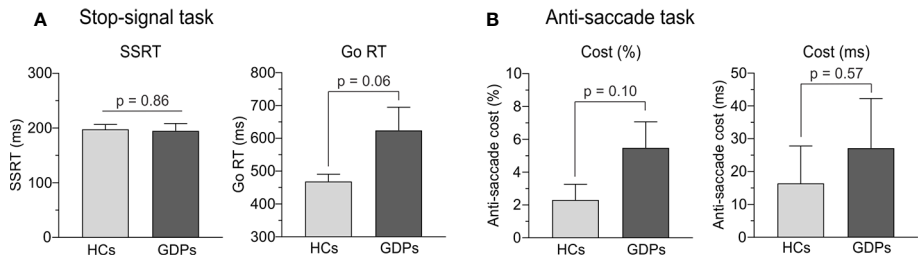

FIGURE 3 | Behavioral measures of motor inhibition. **(A)** Stop-signal reaction time (SSRT) and reaction time (RT) on go trials during the stop-signal task in HCs (light gray) and GDPs (dark gray). **(B)** Anti-saccade cost, defined as the difference between the scores (% of errors and RTs) in incongruent and control trials, in HCs and GDPs (same color code).

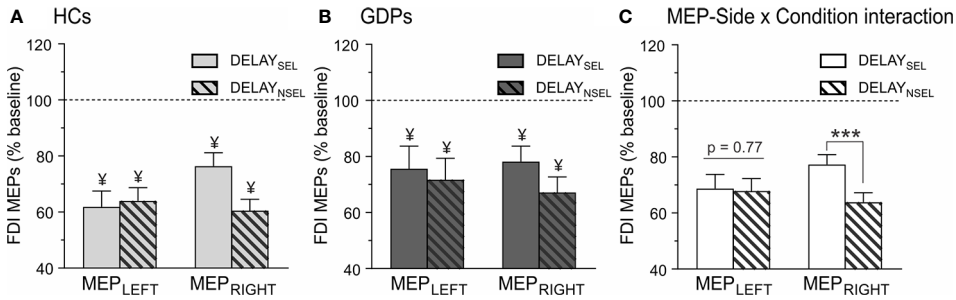

FIGURE 5 | Neural measures of preparatory suppression. Amplitude of motor-evoked potentials (MEPs) recorded at TMS_{DELAY}, expressed in percentage of MEPs elicited at $TMS_{BASELINE\text{-}IN}$, shown for the left (MEP_{LEFT}) and the right (MEP_{RIGHT}) FDI, which was either selected ($DELAY_{SEL}$; open bars) or non-selected ($DELAY_{NSEL}$; dashed bars) for the forthcoming response in HCs **(A)** and GDPs **(B)**. ¥ = significantly different from MEPs probed at $TMS_{BASELINE\text{-}IN}$. **(C)** MEP-Side x Condition interaction. MEPs were larger in the selected relative to the non-selected condition only in the right FDI, regardless of the group. ***$p < 0.001$: significantly different.

$TMS_{BASELINE\text{-}IN}$). As evident on **Figure 5A**, MEPs probed in control subjects were drastically decreased at TMS_{DELAY} when compared to $TMS_{BASELINE\text{-}IN}$. This effect occurred for MEPs in both the left and the right FDIs, regardless of whether the muscle was selected or non-selected for the forthcoming response (all $t12 < -4.92$ and all $p < 0.0125$). Hence, HCs displayed a strong MEP suppression during action preparation, such as extensively shown in many other works (15, 59, 63). Interestingly, MEPs at TMS_{DELAY} were also significantly suppressed in all conditions in GDPs (all $t12 < -3.02$ and all $p < 0.0125$), indicating that those subjects displayed preparatory suppression as well (**Figure 5B**). Moreover, as revealed by the ANOVA computed on these data, the strength of this MEP suppression was comparable in both groups ($F1,24 = 1.58$; $p = 0.22$).

Besides, analyses showed a significant main effect of CONDITION ($F1,24 = 4.46$; $p < 0.05$), due to a weaker MEP suppression in an effector that was selected for the forthcoming response relative to when the effector was non-selected. However, and as shown on **Figure 5C**, this effect depended on the hand within which the MEPs were elicited (CONDITION x MEP-SIDE interaction $F1,24 = 7.64$; $p < 0.05$), as it concerned the right ($p < 0.001$) but not the left ($p = 0.78$) hand, regardless of the group (GROUP X MEP-SIDE X CONDITION interaction, $F1,24 = 1.44$; $p = 0.24$).

Behavior

The RTs measured during the rolling ball task are shown in **Figure 6**. The ANOVA computed on these data revealed a main effect of TMS-TIMING ($F1,24 = 13.05$; $p < 0.01$): RTs were faster with TMS_{DELAY} than with $TMS_{BASELINE\text{-}IN}$, consistent with many previous reports showing that a TMS pulse applied close to the imperative signal can speed up the release of a motor response (11, 17, 59). By contrast, RTs were comparable in both groups ($F1,24 = 0.71$; $p = 0.41$), regardless of the TMS timing (GROUP X TMS-TIMING interaction; $F1,24 = 1.38$; $p = 0.25$), indicating that HCs and GDPs performed equally in the task.

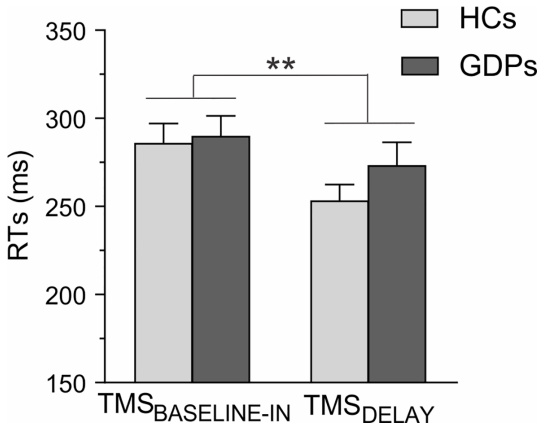

FIGURE 6 | Reaction times (RTs) during the rolling ball task. The RTs are shown for trials in which the TMS pulses were applied either at baseline ($TMS_{BASELINE\text{-}IN}$) or during action preparation (TMS_{DELAY}) for HCs (light gray) and GDPs (dark gray). Data from responses performed with both hands are pooled together, as the main effect of RESPONDING-SIDE was not significant ($F_{1,24} = 0.02$; $p = 0.89$). Please note the shortening of RTs at TMS_{DELAY}. **$p < 0.01$: significantly different.

Exploratory Analyses on the Relationships With Gambling Severity

Regarding the psychopathological variables, the total number of DSM-V criteria significantly correlated with the scores for state anxiety ($r = 0.84$; $p < 0.001$) and BDI ($r = 0.62$; $p < 0.05$), which indicates that more severe GDs were associated with higher anxiety and depression. Moreover, we observed a significant positive correlation between the DSM-V criteria and the anti-saccade cost in terms of RTs ($r = 0.65$; $p < 0.05$; **Figure 7**), suggesting lower motor inhibition abilities in more severe GDs. Nonetheless, note that only the relationship between gambling severity and state anxiety remained after correction for multiple comparisons. None of the other correlations was significant (all $-0.37 < r < 0.55$ and $p > 0.06$).

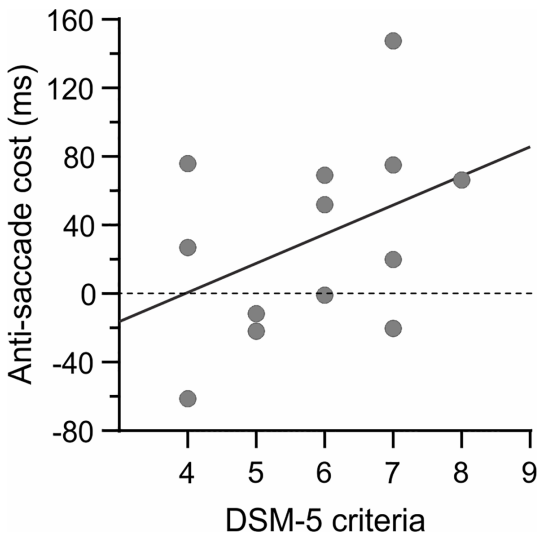

FIGURE 7 | Relationship with gambling severity. A positive correlation (r = 0.65) was observed between the number of DSM-V criteria and the anti-saccade cost (in terms of RT), suggesting lower motor inhibition abilities in more severe GDs. However, note that the correlation did not survive Bonferroni correction.

DISCUSSION

The fifth edition of the DSM recently reclassified pathological gambling from the "Impulse Control Disorder" category to the newly established "Substance-related and Addictive Disorders" section (39). Such a decision implies that this substance-free gambling addiction shares many features with addictions to substances (64–66). In this context, extensive work is being dedicated to understanding these similarities and to identifying vulnerability markers that may be common to all addictive disorders, with one particularly promising candidate being a lack of inhibitory control. In the present study, we addressed this question by assessing preparatory suppression, a specific facet of inhibitory control, in a group of GDPs and in matched HCs. Contrary to our hypothesis, GDPs did not lack any preparatory suppression, though they had some deficits in other aspects of inhibitory control, such as a steeper delay discounting rate and a higher trait impulsivity than HCs.

In control subjects, MEPs elicited during the rolling ball task were globally smaller at TMS_{DELAY} than at $TMS_{BASELINE\text{-}IN}$, consistent with the literature reporting a lower corticospinal excitability during action preparation (5). Also, in line with some previous studies [(57, 59); but see also (17)], this preparatory suppression was less prominent in the dominant hand, especially when it was selected for the subsequent movement, possibly reflecting a higher readiness of effectors from the dominant hand to initiate actions (57, 58). Interestingly, the same pattern of results was found in GDPs, suggesting that those subjects did not suffer from a deficit in preparatory suppression. In fact, the only group difference that we found during the rolling ball task concerns MEPs elicited during the inter-trial interval, at $TMS_{BASELINE\text{-}IN}$. In both groups, these MEPs were larger than those elicited outside the blocks, at $TMS_{BASELINE\text{-}OUT}$, in agreement with previous studies (17, 55, 63). Yet, this increase was more pronounced in HCs than in GDPs. This difference might be the result of dissimilarities at the level of attention, vigilance, or arousal (2, 67). As such, one possibility is that GDPs are less motivated by a task in which the sole reward consisted in a feedback score, leading to a blunted resting excitability during the blocks. Accordingly, fMRI studies have reported a diminished sensitivity towards small or non-monetary rewards in gamblers relative to control subjects (68, 69). Nevertheless, this plausible reduced vigilance in GDPs did not impact the level of preparatory suppression or even the performance in the rolling ball task.

While we did not observe an alteration of preparatory suppression in GDPs, there were some differences between both groups regarding some aspects of impulsivity, substantiating the presence of a deficit as expected in these patients. Although multiple theoretical models have been put forward (70–72), impulsivity is commonly divided into two primary components, called *choice impulsivity* and *rapid response impulsivity* (73, 74). In line with the relative independence of those two types of impulsivity, GDPs were affected differently depending on the assessed component. Our findings at the MCQ revealed that GDPs had significantly steeper discounting rates than HCs, highlighting a higher choice impulsivity in this group of patients, as shown previously (35, 75, 76). This predisposition to prefer smaller-sooner rewards over larger-delayed ones was also supported by our measures of trait impulsivity. Indeed, GDPs obtained higher scores than controls on the "non-planning" and "lack of premeditation" subscales of the BIS-11 questionnaire and the UPPS Impulsive Behavior Scale, respectively, implying that those individuals are more oriented to the present rather than the future and tend to act without consideration of the consequences. In this line, an association between scores on both subscales and discounting rates has been previously reported (61, 76, 77). Altogether, this pattern of results is likely to contribute to the tendency of GDPs to favor immediate bets, despite the negative consequences of their gambling behavior.

By contrast, GDPs and HCs did not seem to differ at the level of rapid response impulsivity. This lack of group effect concerned not only behavioral motor inhibition, such as assessed by the stop-signal and the anti-saccade tasks, but also impulsivity trait, as scores at the motor subscale of the BIS-11 questionnaire were not significantly different between both groups. This result contrasts with recent meta-analyses suggesting higher rapid response impulsivity in subjects suffering from pathological gambling (30, 78), although some studies failed to identify a deficit (79, 80). Nonetheless, the present results need to be put into perspective in several ways. First, while the SSRT was similar in HCs and GDPs, it is noteworthy that other task variables estimated in the stop-

signal task, such as the RTs on Go trials and unsuccessful stop trials, as well as the SSDs, indicated a general slowness to respond in GDPs. Hence, it might be that GDPs strategically slowed down in anticipation of the stop-signals to compensate for a potential inhibitory deficit, even though blocks without stop-signals would have been required to ascertain this hypothesis. Besides, the slowness reported in GDPs might have prevented us from highlighting a lack of response inhibition. Indeed, while the tracking procedure was efficient, the SSD had to drastically increase to adapt to the slower responses of GDPs. Consequently, the number of trials was probably insufficient in the present study to allow the SSD to reach a relatively steady value at which the SSRT can be computed reliably. Hence, future studies should use initially longer SSDs to observe a potential deficit in GDPs (35). Moreover, despite the overall lack of group effect in the anti-saccade task, we found an interesting positive correlation between the number of DSM-V criteria and the anti-saccade cost, which was quite variable in GDPs. In fact, and in line with previous works (35, 36, 81), this association indicates that a deficit in rapid response impulsivity only concerned the most severe forms of pathological gambling, contrary to choice impulsivity, which was higher regardless of gambling severity. Finally, it is worth noting that GDPs tended to score higher at the motor subscale of the BIS-11 questionnaire, and that the lack of significant difference is likely to result from our small sample size.

The current findings in GDPs contrast considerably with our prior observations in alcohol-dependent patients (ADPs), which revealed a major lack of preparatory suppression, especially in the patients who relapsed during the year following the testing (9). As GDPs are preserved from the neurotoxic influence of drugs of abuse, one straightforward interpretation of the discrepancy between both studies is that the lack of preparatory suppression observed in ADPs arises as a consequence of chronic alcohol consumption. Accordingly, it has been shown that the lateral prefrontal cortex—i.e., the region of the alcoholic brain in which the decrease in gray matter volume is the most significant (82)—generates at least part of the preparatory suppression effect (11, 83). Hence, it is plausible that this prefrontal source of preparatory suppression is specifically reduced in ADPs after years of alcohol abuse. Future studies, combing structural magnetic resonance imaging to quantify the brain damage and TMS to assess preparatory suppression in ADPs, are required to conclude on this point. Moreover, it would be interesting to investigate whether the lack of preparatory suppression extends to other substance use disorders. Yet, it is noteworthy that structural and functional prefrontal alterations still exist in GDPs (84–88), even in the absence of any substance use disorder comorbidity (89). In particular, an increasing literature has led to consider the neuromodulation of the dorsolateral prefrontal cortex, using high-frequency repetitive TMS, as a potential treatment for GD (66), with encouraging results in terms of craving reduction (90–92), but not regarding inhibitory control (93). That being said, the absence of deficit in preparatory suppression reported in GDPs makes it an unlikely common vulnerability marker of whether one is going to develop an addiction or not.

The present finding that preparatory suppression was comparable in GDPs and HCs should be interpreted with caution and requires further evidences as the current study suffer from several limitations. First, GDPs represent a highly heterogeneous group, characterized by different impairments depending on the form of gambling in which they engage (32, 94). Although impulsivity is an important ethiological factor for GD, the recognized pathway model of Blaszczynski and Nower (95) posits that it represents only one of the three routes than can lead to pathological gambling. Hence, it is likely that our results reflect the average of different GD profiles, and that our findings would have been more similar to those observed in ADPs if we had only included GDPs from the impulsivity pathway. Second, the power of our study is rather low given our small sample sizes. Yet, this is the best we could do in view of the real challenge of recruiting patients suffering of GD *only*. Indeed, many GDPs show high extent of comorbidity with alcohol and substance use disorders (96), preventing them from participating in experiments aiming at assessing the neuropsychological profile exclusively associated with GD. Finally, our sample was entirely male. Although this is consistent with gender biases in the GD population (30, 76, 94), this limits the generalizability of our findings to females.

In summary, although we found some alterations in several aspects of inhibitory control in the sample of GDPs tested in the current study, preparatory suppression was not deficient in these patients. This finding contrasts with prior observations reported in subjects suffering from an alcohol use disorder, suggesting that a lack of preparatory suppression does not represent a common feature shared by behavioral and substance-related addictions. Critically, future studies would gain from taking into account the large heterogeneity in GDP profiles and possibly focus on patients that are part of the impulsivity pathway. Moreover, extending investigations of preparatory suppression to other "Substance-related and Addictive Disorders" should further our understanding of inhibitory control as a vulnerability marker underlying these conditions.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

This study was reviewed and approved by Biomedical Ethic Committee of the Saint-Luc University Hospital, Université catholique de Louvain. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CQ, JG, and JD: designed the experiment. CQ and JG: performed the experiments. CQ and JG: analyzed data. CQ and JD: wrote the article.

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The Relationship Between In-Play Betting and Gambling Problems in an Australian Context of Prohibited Online In-Play Betting

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Internationally, Internet gambling is increasingly permitted under regulated licensing conditions; however, the specific products that are legal varies between jurisdictions. Online sports and race wagering are now legal in many jurisdictions, but in-play betting (also referred to as "live action" or "in-the-run" betting) is often restricted. In-play betting enables bets to be placed on an event after it has commenced. Prohibitionist policies often cite the potential for this type of betting to increase risk of gambling problems. This study aimed to identify which online bettors are most likely to engage in in-play betting, and to investigate the relationship between in-play betting and gambling problems. Online survey responses were collected from 501 Australian past-month online sports bettors in the context of in-play betting only being available on offshore gambling sites or via telephone betting. Thirty-four percent of participants had placed a bet in-play in the past month. Participants placing in-play bets differed from those who had not in terms of education, employment status, ethnicity, age, and gambling involvement. Those who bet in-play had higher problem gambling severity scores than those who did not bet in-play. Problem gambling severity significantly predicting in-play betting, holding other variables constant. Findings are consistent with previous research indicating that the relationship between in-play gambling and problems holds across jurisdictions which have prohibited and legalized in-play betting. The findings suggest that in-play betting should warrant specific regulatory attention and interventions to minimize gambling harms among individuals that engage with this activity.

Keywords: in-play betting, live action betting, regulation, online gambling, internet gambling, problem gambling, disordered gambling, gambling addiction

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INTRODUCTION

In-play betting (also termed "live," "live action," or "in-the-run" betting) refers to betting markets that allow bets to be wagered after an event, such as a race or sporting matches, have commenced. In-play betting is becoming an increasingly popular feature of contemporary gambling markets (1). Statistics on the prevalence of in-play betting are scarce as it is common for the activity not to be specifically measured in prevalence studies. However, one UK-based survey conducted in 2018 found that 45.4% of bettors surveyed (aged 18–54 years) had bet in-play (2). Another UK study found that in-play betting among 18- to 24-year-olds rose from 38% in 2015 to 45% in 2016 (3).

In-play betting, combined with online and mobile betting availability, has fueled the growth of sports betting. For example, tennis is the third most profitable market for betting companies despite its relatively low fan base. Eighty percent of wagers on tennis events are reportedly placed after the match begins (4).

It is important for policy makers to understand the impact of specific gambling activities on harms to guide regulatory approaches to minimizing gambling problems. The structural features of in-play betting, including the short delay between the bet and the outcome, the small window for decisions to place a bet, variability in outcomes, and continuous options for bets are speculated to contribute to gambling-related harms (5). This paper aims to increase understanding of the types of individuals participating in in-play betting and to explore the potential association between this betting activity and gambling problems. Greater understanding of in-play betting and the subgroup of individuals who engage in this activity is essential to inform policy decisions and design targeted interventions to enhance well-being and minimize potential harms associated with in-play betting.

The Regulatory Context

Gambling policy has a significant impact on the rates of harm experienced within communities. For example, jurisdictions with less stringent regulations regarding advertising of online gambling have higher rates of sub-clinical disordered gambling (6). There are three main types of in-play betting: (i) betting on the final outcome of an event after it has started (e.g., which team will win a sporting match); (ii) exotic wagering, betting on contingencies that may or may not happen during the course of an event (e.g., a specific player will score the next goal in a football game); and (iii) micro-betting, betting on a subset of an event (e.g., the outcome of the next point in a tennis match) (7, 8).

Internationally, the United Kingdom and Italy allow in-play betting (including micro-betting), whereas France prohibits micro-betting but allows in-play betting on match outcomes and some forms of exotic wagering (e.g., goals scored, goal scorers) (8). In the United States, gambling and betting is legislated at the state level, so in-play betting (commonly referred to as proposition or "prop" bets) rules differ across the nation and mode of access permissions follow general sports betting rules. In Nevada, for example, in-play betting is permitted for a variety of wagers, such as point spreads, money lines, and totals (9). Online betting is permitted following in-person registration, which involves initial account deposits made in-person at a sportsbook or registered location (10). In Iowa, in-play wagering is permitted except for wagers involving in-state collegiate teams (11). Online betting is permitted from anywhere in the state once an individual has registered in-person at a casino [a requirement that ends in 2021; (11)].

In Australia, online in-play sports betting is prohibited under the Interactive Gambling Act (12) (IGA); however, in-play race and sports betting are permitted when bets are placed on-site (in a venue) or over the telephone [i.e., by way of voice calls to customer service centers, but not VoIP (Voice over Internet Protocol) or "click to call" where consumers use handheld Internet-connected devices to speak to an automated system to place their bets]. This approach was intended to reduce the risk to individuals vulnerable to experiencing gambling problems, particularly for higher risk variants of in-play betting (e.g., those involving very short-term, repetitive betting). Various arguments have been made for the legalization of online in-play betting in addition to on-site and telephone in-play betting (essentially, platform neutrality). These arguments typically relate to the ability of licensed operators to compete with offshore gambling providers and to the increasingly obsolete distinction between online and telephone in-play betting (7, 13).

Interviews conducted with community respondents and industry and sporting body stakeholders indicate that most in-play betting within Australia occurs in sports due to the opportunities to place bets on a greater range of outcomes as compared to racing (1). Online in-play betting has raised issues in relation to sports integrity because the outcomes of subsets of events, as opposed to the event itself, can be manipulated relatively easily (7, 8).

Structural Characteristics of Online In-Play Betting

Structural characteristics of gambling—inherent features of games—can contribute to the acquisition, maintenance, and development of problem gambling behaviors (14). Structural features of online in-play betting may have greater potential for causing gambling-related harm than telephone or in-venue in-play betting. Online in-play betting has been likened to "continuous gambling" (5, 15). Continuous forms of gambling are characterized by a short duration of time between the bet being placed and the outcome becoming known, providing a structure that allows gamblers to immediately reinvest money in a rapid sequence, resulting in fast and repetitive betting (16, 17). The rapid speed of play tends to encourage more bets, longer gambling sessions, loss-chasing, and impaired self-control (18). Furthermore, the nature of in-play betting means that there is limited time to make the decision about placing a bet. An experimental French study found that participants used more heuristic than analytical processes when placing bets under time constraints, theoretically leading to less reasonable bets (19). However, there remains very limited empirical and ecologically valid research to justify claims regarding the potential of online in-play betting to cause gambling-related harm.

The Association Between Online In-Play Betting and Problem Gambling

A series of studies have been conducted using customer account data on *bwin*, a predominately European gambling site. Live action online sports betting was the only form of gambling associated with potential gambling-related problems when assessments were made on screen-based activity and after controlling for participation in another 15 gambling activities (20). These results are confirmed by several separate analyses of customer data. In the first month after opening an account, customers characterized by high intensity and frequency of live action gambling and by high variability of wager sizes were more likely to report gambling-related problems upon account closure

than other customers who placed live action bets (21). Greater intensity of gambling activity, such as a greater number of bets placed per day, appears to clearly distinguish customers who trigger a responsible gambling alert from controls, particularly in relation to live action sports betting (22). Customers who played at least two games and demonstrated high variability in live action wager amounts were identified as a high-risk group when controlling for first deposit date (23). Participating at least three times in live action betting was a significant predictor of increased risk of experiencing gambling-related problems after controlling for involvement in multiple gambling activities (24). Although these studies provide some evidence of a link between in-play betting and gambling problems, several relied on proxy indicators of gambling harm or subsets of customers reporting problems, thereby not capturing all gamblers experiencing problems. Additionally, these studies provide limited insight into the typical characteristics of individuals placing in-play bets, such as severity of gambling problems, associated gambling activity, and demographic factors.

A prospective longitudinal study of Internet sports gamblers from 85 countries found that participants betting in-play on sports, relative to those betting before matches, were categorized more often as heavily involved gamblers (25). The prototypical bettor was a 31-year old male betting for longer periods of time than females. Data from the UK gambling prevalence survey indicates that online gamblers who bet in-play are more likely to be classified as having a gambling problem and are at greater risk of harm from gambling than those who do not bet in-play (26). In a Spanish sample of sports gamblers, in-play betting was more prevalent among those with a gambling problem than any other group (27). Furthermore, those with a gambling problem bet more heavily in-play compared to before games commenced. Analysis of customer account data from a small sample of individuals classified as having gambling problems found that live betting increased betting opportunities and motivated loss chasing, resulting in persistent and extended betting sessions (28). In-play betting created fewer natural breaks in play due to short periods between a bet being placed and the outcome being determined, thus reducing the opportunity for reductions in arousal and other emotional responses stimulated by betting, winning, and losing.

An Australian study of 1,816 sports bettors found that men aged between 18 and 34 years were most likely to have participated in in-play betting (29). More highly engaged bettors, including those with gambling problems, were more likely to bet on micro events, and were more likely to place a higher proportion of their bets on micro events (15). Micro-event bettors tended to be younger, well-educated, single, and to have high trait impulsivity. They engaged in a higher number of different gambling forms in addition to sports betting, bet on a higher number of different sports, had more accounts with different operators, and used a higher number of different sports betting promotions. Of those who bet on micro events, 78% met the criteria for problem gambling, whereas only 5% met the criteria for non-problem gambling (vs. 29 and 28%, respectively, for non-micro event bettors). Moreover, placing a higher proportion of bets on micro-events was related to problem gambling. Within an Australian sample, respondents were more likely to bet on in-play sporting events than on pre-match outcomes if they were characterized by having higher trait impulsivity, more frequent sports betting behavior, higher problem gambling severity and a shorter history of sports betting (30). However, these studies either focus on a subset of in-play betting (15) or examine sports betting across an aggregation of online, telephone, and retail betting channels (15, 29–31) and several of the separately published results are based on the same dataset, limiting the differential conclusions drawn.

Taken together, these studies indicate that intensity and frequency of live action sports betting is associated with gambling-related problems among individuals who place online bets. However, many of the previous studies fail to control for overall gambling involvement and use proxy behaviors as indicators of level of harm, making it difficult to ascertain the extent to which in-play betting is predictive of current or future experience of gambling harm. Given that online in-play betting may be associated with gambling-related harms over and above that of telephone or on-site in-play betting (15, 18), it is imperative to examine the relationship between problem gambling and online in-play betting specifically.

The Current Study: Aims and Hypotheses

This study aimed to understand the association between online in-play betting and gambling problems in the context of online in-play betting being prohibited on licensed domestic gambling sites. Specifically, the study sought to determine: (i) the proportion of regular online gamblers who engage in in-play sports betting; (ii) the characteristics this sub-group; and (iii) whether there is an association between online in-play betting and increased risk for gambling problems. The findings contribute to existing knowledge concerning participation in online in-play betting and clarify whether individuals who participate in online in-play betting are at increased risk of experiencing gambling problems. Moreover, this research is needed to inform international policy debates regarding the legalization of online in-play betting. Given the relative lack of research on this area, the study was largely exploratory. However, we hypothesized that use of in-play wagering would be associated with higher problem gambling severity.

METHODS

Recruitment occurred using market research online panel sampling. To participate, respondents had to be 18 years of age or older and have gambled online during the past 4 weeks. Potential respondents received an email from the market research company providing a brief outline of the study and a URL to access the online questionnaire. Participation was voluntary and respondents could withdraw at any time. Ethics approval for this research was received from the [deidentified] University Human Research Ethics Committee.

A total of 1,001 were responses collected and our initial sample was a subset of $N = 501$, consisting of all participants who indicated they had wagered on sports during the prior 4 weeks. Respondents were mostly male (67.8%), married (52.6%), and

employed full-time (53.6%). Age ranged from 18 to 83, with a significant difference in mean age for males ($M = 45.5$, $SD = 14.8$) and females ($M = 38.1$, $SD = 12.7$), $t_{(362.98)} = 5.74$, $p < 0.001$, $d = 0.53$.

Measures

Gambling Frequency and Behaviors

Fixed choice questions assessed frequency of spending real money on seven types of Internet gambling activities: lottery-type games, slot machines, race wagering, esports betting[1], sports betting, poker, casino card or table games, and other. Response options were at least once per day, at least once per week, or at least once in the last 4 weeks. Respondents were also asked to indicate (yes/no) if they had placed a wager on an event after it had started (i.e., an in-play bet). Questions assessed age at which participants had first gambled and modes used to place bets (smartphone, computer, tablet, wearable device, telephone, in venue).

Demographics

Age, gender, education, work status, family household income, language spoken at home, country of birth, and ethnic background.

Gambling Problems

The nine-item Problem Gambling Severity Index (PGSI) (32) assessed the extent of gambling-related harm experienced over the previous 12 months. Total scores range from 0 to 27 and are used to classify respondents into the following categories: non-problem gambling (PGSI = 0), low-risk gambling (PGSI = 1–2), moderate-risk gambling (PGSI = 3–7), and problem gambling (PGSI = 8–27). Cronbach's alpha in this sample was 0.95. The PGSI has been independently validated and shown to have excellent reliability, dimensionality, external/criterion validation, item variability, practicality, applicability, and comparability (33).

Statistical Analysis

The data were analyzed using SPSS 26.0. Assumptions testing was conducted on all measured variables, including skewness and kurtosis, univariate outliers, and multivariate outliers (Mahalnobis distance). Where instances of homogeneity of variance is violated, a Satterthwaite approximation for degrees of freedom is applied. One multivariate outlier was found and removed from the database, resulting in a sample of $N = 500$ for further analysis. Age first gambled was highly skewed and leptokurtic, which was corrected with a log transformation. Missing values for the in-play betting variable were excluded on a list wise basis.

Chi-square tests and *t*-tests were used to investigate if group differences existed between sports bettors who participate in in-play betting and those who do not for single-response demographic and gambling behavior variables. Following these comparisons, a logistic regression was conducted to determine which characteristics differentiate in-play bettors from non-in-play bettors. Twelve predictor variables were used in the logistic regression: gender, age, education level, employment status, income, ethnic background, country of birth, language other than English spoken at home, number of gambling behaviors (other than sports betting), age first gambled, highest reported gambling frequency for any gambling game, and PGSI classification (binary variable, classified as problem gambling for scores of 8 or higher). These variables were selected based on established validity from other studies [see, e.g., (34–36)].

For comparison testing, an alpha of 0.05 was used and effect sizes are reported for all *t*-tests and chi-squares. For *t*-tests, Cohen's *d* is reported (small effect = 0.2, medium effect = 0.5, and large effect = 0.8). For chi-square comparisons, the ϕ (phi) coefficient was used (small effect = |0.1|, medium effect = |0.3|, and large effect = |0.5|). Where measurement of certain variables is not conducive to certain analytical procedures (i.e., questions offered multiple response options and thus percentage responses sum to more than 100%), these frequency percentages are provided without statistical comparisons. Following the omnibus tests, standardized residuals (±2) were examined to determine where cell differences lie.

RESULTS

Just over one third of the participants (34.4%) reported having placed a wager on an event after it had started (i.e., participated in in-play betting) during the prior 4 weeks and were classified as in-play bettors.

Demographics

As shown in **Table 1**, participants who bet in-play were significantly younger than those who did not bet in-play; those aged 50 years and over particularly more likely to not bet in-play than those under the age of 40 years, χ^2 (4, $N = 500$) = 42.80, $p < 0.001$, $\phi = 0.29$. Participants that bet in-play were statistically more also likely to have completed higher education levels (e.g., university or college degree, post graduate qualification) χ^2 (3, $N = 500$) = 24.45, $p < 0.001$, $\phi = 0.22$. In terms of employment status, a higher proportion of participants that bet in-play were employed full-time, and a lower proportion were the recipient of welfare, χ^2 (3, $N = 500$) = 28.89, $p < 0.001$, $\phi = 0.24$. There were no significant differences in terms of reported household income. Participants who bet in-play were more likely to be of Asian or Middle Eastern backgrounds than those who did not, who were more likely to be from European backgrounds, χ^2 (3, $N = 500$) = 40.70, $p < 0.001$, ϕ =0.29. In-play betting participants were more likely to speak a language other than English at home, χ^2 (1, $N = 500$) = 10.55, $p < 0.001$, ϕ =0.15, although there was no significant difference in country of birth ($p > 0.05$). The difference in gender proportions between groups approached significant levels, but was not statistically significant ($p = 0.053$).

Gambling Involvement

Table 2 displays reported gambling behaviors and history. In terms of game preference, the most popular form of gambling among participants who bet on sports was lottery-type games.

[1]Esports refers to professional video game tournaments.

TABLE 1 | Comparison of the demographic profiles of participants who bet in-play vs. those who did not bet in-play ($N = 500$).

Demographic characteristic	In-play betting ($N = 172$) (%)	No in-play betting ($N = 328$) (%)
Gender		
Male	62.2	70.7
Female	37.8	29.3
$p = 0.053$ ($\chi^2 = 3.75$, df = 1)		
Age		
18–19	2.3	1.2
20–29	27.3	12.5
30–39	33.1	22.6
40–49	22.7	24.1
50 and over	14.5	39.6
$p < 0.001$ ($\chi^2 = 42.80$, df = 4)		
Education		
Year 12 or equivalent	24.4	31.7
Trade/technical certificate/diploma	16.9	31.7
University or college degree	43.6	25.6
Post graduate qualification	15.1	11.0
$p < 0.001$ ($\chi^2 = 24.45$, df = 3)		
Employment status		
Work full time	65.3	48.6
Work part time or casual	20.0	17.3
Non-salaried	10.0	10.8
Welfare recipient	4.7	23.2
$p < 0.001$ ($\chi^2 = 28.89$, df = 3)		
Family household annual income		
<$25,000	6.3	5.6
$25,000–$49,999	16.5	23.8
$50,000–$74,999	17.7	17.2
$75,000–$99,999	19.6	18.8
$100,000–$124,999	15.2	13.9
$125,000–$149,999	14.6	9.6
$150,000–$174,999	4.4	3.6
$175,000–$199,999	2.5	3.6
$200,000 or more	3.2	4.0
$p > 0.05$		
Country of birth		
Australia	80.2	84.5
Not Australia	19.8	15.5
$p > 0.05$		
Language other than English		
Yes	18.0	8.2
No	82.0	91.8
$p = 0.001$ ($\chi^2 = 10.55$, df = 1)		
Ethnic origin		
European	57.0	79.6
Asian (including East, Southeast, and South Asian)	30.2	10.1
Middle Eastern	4.7	1.2
Other	8.1	9.1
$p < 0.001$ ($\chi^2 = 40.70$, df = 3)		

TABLE 2 | Comparison of gambling behaviors and history of profiles of participants who bet in-play vs. those who did not bet in-play ($N = 500$).

	In-play betting ($N = 172$) (%)	No in-play betting ($N = 328$) (%)
Games played (past 4 weeks involvement)		
Lottery-type games	81.4	68.3
Slot machines, pokies, electronic gaming machines	76.7	50.3
Esports betting	58.7	17.7
Race wagering	79.1	64.0
Poker	59.3	28.0
Casino card or table games (not including poker)	61.6	28.7
Highest gambling frequency*		
At least once per day	36.0	13.4
At least once per week	54.1	68.3
At least once in the last 4 weeks	9.9	18.3
$p < 0.001$ ($\chi^2 = 36.04$, df = 2)		
Years of age when first gambled		
17 and under	6.4	14.5
18–19	32.6	41.0
20–29	44.2	29.9
30–39	13.4	8.6
40–49	2.3	3.1
50 and over	1.2	2.8
$p = 0.002$ ($\chi^2 = 18.98$, df = 5)		

Chi-square values are not displayed where the question allowed multiple responses to be selected.
**Highest gambling frequency taken as highest response to any form of gambling.*

Participants that bet in-play engaged in all forms of gambling at a higher frequency than those who did not bet in-play, with a notably large difference for esports betting (58.7 vs. 17.7%), poker (59.3 vs. 28.0%), and casino card or table games (61.6 vs. 28.7%). Participants that bet in-play engaged in 4.17 ($SD = 1.97$) of the six additional reported forms of gambling (not including sports betting, for which the entire sample indicated they had played) in the past 4 weeks, which was significantly higher than the 2.55 ($SD = 1.86$) mean forms for those who did not place in-play bets, $t_{(493)} = 9.02$, $p < 0.001$, $d = 0.84$.

Participants that bet in-play were more likely to gamble at least once per day [χ^2 (2, $N = 500$) = 36.04, $p < 0.001$, $\phi = 0.27$] and were more likely to be older ($M = 23.12$, $SD = 6.78$) when they first gambled compared to those who did not bet in-play ($M = 22.02$, $SD = 7.87$), $\chi^2(5, \mathrm{N} = 500) = 18.98$, $p = 0.002$, $\phi = 0.20$.

Participants that bet in-play had a significantly higher average PGSI score ($M = 8.76$, $SD = 6.65$) than those who did not bet in-play ($M = 3.68$, $SD = 5.17$), $t_{(281.76)} = 8.72$, $p < 0.001$, $d = 0.85$.

Of those who indicated that they had placed in-play bets, the most popular mode of access was using online websites and apps via smartphone (50.0%), followed by personal computer (48.8%), tablet (11.6%), and wearable device (2.9%), none of which are permitted by gambling sites licensed in Australia. In-play bettors placed their bets via legal, regulated modes of access, including speaking over the telephone (10.5%) and in-venue at fixed betting

TABLE 3 | Logistic regression results for characteristics differentiating participants who bet in-play vs. those who did not bet in-play ($N = 500$).

Predictor variable	B	S.E. (B)	Wald	Significance level	Odds ratio	95% CI (lower)	95% CI (upper)
Gender	0.170	0.254	0.447	0.504	1.185	0.721	1.948
Age	**−0.039**	**0.011**	**13.085**	**<0.001**	**0.962**	**0.942**	**0.983**
Education level			3.743	0.291			
University or college degree	0.514	0.380	1.826	0.177	1.672	0.793	3.525
Trade/technical diploma	0.019	0.428	0.002	0.965	1.019	0.440	2.358
Year 12 or equivalent	0.120	0.418	0.083	0.773	1.128	0.497	2.558
Employment status			7.215	0.065			
Work part-time or casual	−0.202	0.308	0.432	0.511	0.817	0.447	1.493
Non-salaried	−0.514	0.394	1.702	0.192	0.598	0.276	1.295
Welfare recipient	**−1.154**	**0.462**	**6.249**	**0.012**	**0.315**	**0.128**	**0.779**
Language other than English at home	−0.491	0.337	2.118	0.146	0.612	0.316	1.186
Number of gambling behaviors	**0.183**	**0.066**	**7.644**	**0.006**	**1.201**	**1.055**	**1.367**
Age first gambled (ln)	**1.387**	**0.450**	**9.512**	**0.002**	**4.003**	**1.658**	**9.666**
Highest gambling frequency			**8.109**	**0.017**			
At least once per week	**−0.777**	**0.295**	**6.950**	**0.008**	**0.460**	**0.258**	**0.819**
At least once in the last 4 weeks	**−0.991**	**0.417**	**5.637**	**0.018**	**0.371**	**0.164**	**0.841**
PGSI classification	**−1.036**	**0.258**	**16.177**	**<0.001**	**0.355**	**0.214**	**0.588**

Significant predictors are identified in bold.

terminals (11.0%), at lower frequencies than the online modes of access.

Predictors of In-Play Betting Behavior

An initial logistic regression was applied to assess which predictor variables statistically differentiated participants who bet in-play from those who did using the 12 predictor variables described in the Methods.

Income and country of birth predictor variables were removed from analysis due to lack of significance and poor contribution to model fit statistics. Ethnic background was also excluded from the final model because sparse data effects both reduced the model fit and led to uninterpretable odds ratios. As a robustness check, the model was run with these variables included, but the model fit improved with their removal.

The test of the final overall model with 9 predictors was significant, χ^2 (22, $N = 500$) = 168.3, $p < 0.001$, indicating that, all together, these predictors reliably distinguished between in-play and non-in-play betting participants in the sample. The Hosmer and Lemeshow Test was not significant ($p > 0.05$), indicating a good model fit. Overall prediction success was 77.1%, with moderate predictive success for in-play betting participants (60.6%) and stronger accuracy for non-in-play betting participants (85.9%). The regression variables were assessed for multicollinearity using Variance Inflation Factor diagnostics, which were under 1.6 for all variables, well under the threshold of an indication of multicollinearity issues (37).

Table 3 displays regression coefficients, coefficient standard errors, Wald statistics, significance level, odds ratio, and 95% confidence intervals for each of the 10 predictor variables. Categorical variables used the following reference groups: gender (male), education level (post-graduate qualification), employment status (work full-time), language other than English spoken at home (yes), highest gambling frequency (at least once per day), and PGSI classification (score 8 or higher).

Controlling for all other variables in the model, the significant predictors ($\alpha = 0.05$) were: age, employment status (for Welfare recipient, compared to Work full-time), age first gambled, number of gambling behaviors, gambling frequency, and PGSI score.

DISCUSSION

This study makes a significant contribution by providing insight into the characteristics of those who place in-play bets, overcoming limitations of previous studies which focus on analyzing gambling behaviors without controlling for significant personal variables and betting across different modes and activities. The results of this study show that among the sample of participants who regularly gamble online, in-play betting is relatively common. Three in 10 participants had placed bets after an event had started, and this occurred mostly via online methods which are prohibited under Australian regulations. Demographic differences were found between those who placed bets in-play and those who did not: in-play bettors were more likely to be more highly educated, employed, younger, and from culturally and ethnically diverse backgrounds (albeit not country of birth). Individuals who received income from welfare sources including a pension, unemployment, or disability benefits, were less likely to bet in-play than respondents who work full time. As in-play betting was associated with younger age, however, this finding may reflect a likelihood of older participants to be retired. No specific differences were found in relation to gender although the different approached significance with a greater proportion

of females engaged in in-play betting. The relationship between gender and in-play betting and gambling problems warrants additional investigation particularly as several previous studies have been based on almost entirely male samples (20, 25).

Those who placed bets in play were more involved in gambling overall in terms of frequency and number of activities. This is consistent with previous studies (15, 20, 25). Higher levels of problem gambling severity were observed among those who placed in-play bets, which is a novel finding as our results control for a greater range of relevant factors than previous research including individual characteristics, gambling behavior, and gambling history. Several of the characteristics of those who bet in-play are similar to the profile of Australians who use offshore (as opposed to only domestic) online gambling sites, suggesting there may be some confound or overlap given in-play betting is only available via offshore gambling sites (34). Our hypothesis was supported as after adjusting for gambling involvement, participants who had placed bets in-play were approximately three times more likely to be classified as having a gambling problem than those who had not placed this bet type, indicating an association between in-play betting and gambling problems. These findings are consistent with previous research (24) which is important as it demonstrates the consistency of findings across jurisdictions despite policy differences in prohibition and legalized in-play betting.

As with previous studies, our results are based on cross-sectional data and we cannot draw conclusions regarding causality. The structural characteristics of in-play betting mean that these bets require a rapid decision based on quick reactions to within-game events and are more similar to continuous and rapid gaming than most other forms of wagering which is typically discontinuous with low event frequency. These characteristics may make in-play betting more appealing and potentially problematic. For example, individuals with gambling problems are more likely to consume impulsively, using immediate forms of gambling in which the time period between bet and outcome is shorter (5, 27, 38). This is likely related to findings that higher trait impulsivity is common among those with gambling problems (39, 40). As such, online in-play betting products may be particularly harmful for individuals who are vulnerable to experiencing gambling problems.

In addition to the lack of evidence regarding causality, our methodology included other limitations. To be eligible to participate in the study, respondents had to have gambled online in the past month, meaning that respondents were likely more frequently engaged in gambling than the broader population of online gamblers. Further, the survey was described as a gambling study, making it more likely to catch the attention of potential respondents with a specific interest in gambling. As such, the results should be interpreted in relation to this specific sample of online gamblers rather than as an accurate level of gambling involvement or gambling problems among all those who have made in-play bets.

In terms of implications, our findings support the prohibition of online in-play betting in Australia based on the principle of limiting the availability of gambling products that are strongly associated with gambling-related harm. It is crucial to note that the association between in-play betting and gambling problems is independent of involvement in other gambling activities and is consistently found across jurisdictions regardless of policies to legalize or prohibit this gambling activity. The findings suggest that further regulatory attention needs to be paid to this gambling activity and efforts made to identify those who bet in-play to assess for gambling harms as well as to develop specific prevention interventions for in-play betting.

Since the time of data collection, efforts have been made in Australia to reduce the availability of and demand for offshore gambling sites, by which in-play betting can be accessed. The extent to which restricting in-play betting may encourage consumers to use offshore gambling sites should be continuously evaluated due to the risks associated with this activity. Further research on the mechanisms by which in-play betting may cause harm is warranted, including consideration of other gambling products that allow continuous bets to be placed within short decision periods, such as electronic gaming machines. How to differentiate between different variants of in-play betting and whether particular variants of in-play betting should be regulated, such as those involving longer time periods for decision-making, is a matter for further research.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because this would be a violation of the conditions of ethics approval. Requests to access the datasets should be directed to sally.gainsbury@sydney.edu.au.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Sydney Human Research Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SG and AB designed and conducted the survey. BA led the data analysis. SG led the manuscript preparation. BA and AB contributed to the manuscript editing and refining. All authors contributed to the article and approved the submitted version.

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Impact of Wagering Inducements on the Gambling Behaviors, Cognitions, and Emotions of Online Gamblers: A Randomized Controlled Study

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Wagering inducements are part of loyalty/reward programs implemented by online gambling operators to retain or attract consumers. They constitute incentives to bet that are offered to gamblers provided that they perform certain betting-related activities. They are often considered risk factors for gambling problems, but studies exploring the actual impacts of such incentives are scarce. The objective of the present study was to assess the actual impact of wagering inducements on gambling behaviors, cognitions, and emotions of online gamblers. One hundred seventy-one adults (18–65 years old) who gamble on a regular basis on the Internet, including at-risk and recreational gamblers, were recruited through media announcements and in panels from survey institutes. Participants were randomly assigned to one of four experimental conditions, in which a defined amount of money was given to the gambler with a bank e-card system during an experimental gambling session to simulate a wagering inducement (€10, €50, €100, or €200), or the control condition, in which no incentive was given. The experimental gambling session was designed to be as natural as possible (participants gambled with their own gambling account and their own money). Participants completed a pretest interview, took part in the experimental gambling session, and then completed a post-test interview. The impact of wagering inducements was estimated on objective (money wagered and time spent gambling during the gambling session) and subjective (cognitive distortions, enjoyment of gambling, loss of control, and respect of usual gambling habits) gambling endpoints that were compared between conditions. Two-thirds of participants reported having already received wagering inducements at some point of their gambling course. Although no effect was demonstrated on time spent gambling, inducements increased money wagered, gambling-related expectancies and perceived loss of control. In particular, it seems that wagering inducements could lead to extreme expenses, especially for at-risk gamblers. This research suggests that regulating wagering inducements could be helpful for prevention and early intervention. Future research on the impacts of wagering inducements is still needed, especially

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more ecological studies based on behavioral tracking data and studies assessing the differential impacts of various incentive types.

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Keywords: online gambling, wagering inducement, gambling expectancies, loss of control, gambling disorder, responsible gambling, addiction, prevention

INTRODUCTION

Gambling problems concern only a minority of gamblers (from 0.1 to 5.8%, depending on country) (1). However, the Internet was identified as a risk factor for problem gambling due to its high accessibility, anonymity, high frequency of gambling outcomes, and digital payment modes (2–4). Gambling on the Internet leads to higher risk for and higher severity of gambling problems for online gamblers compared to offline gamblers (5–9). For example, in France, where Internet gambling was legalized in 2010, the prevalence of past-year gambling problems has continuously increased since 2010 to reach 6% of past-year gamblers in 2019 (10), with Internet gamblers being twice as likely to be excessive gamblers (11). Indeed, a survey conducted exclusively on Internet gamblers revealed a prevalence of gambling problems of 22.4% in 2017 (12).

As for other markets, gambling operators implement marketing strategies to boost sales and generate loyalty among their customers (13). In particular, the use of loyalty/reward programs is widespread among online gambling operators (13). Such marketing strategies include both loyalty programs and instant reward programs. Loyalty programs include incentives that are given to consumers in response to repeated consumption and are expected to reinforce consumption in those consumers in the long term (14, 15). In contrast, instant reward programs are short-term programs including one-off advantages that reward consumers instantly with incentives (15, 16). In the framework of gambling, instant reward programs include wagering inducements, presented as sales promotions. According to Hing et al., wagering inducements are defined as incentives to bet that are given to gamblers in addition to what is normally received as part of the core wagering product; wagering inducements are conditional upon certain betting-related activities and/or redeemed in a form that encourages betting and aim to trigger specific consumer responses (such as inducing an immediate sale, retaining consumers, prompt brand switching, and intensify purchasing) (17). Wagering inducements can take different forms, such as sign-up and referral offers, matching deposits with bonus bets, refund/stake back offers, and bonus or better odds (17). They may also vary according to the type of gambling (race or sports betting, poker, lotteries, etc.). In the French online gambling market, wagering inducements are very common and represented 179 million euros during 2019 for online sports betting, horse betting and poker alone (18).

Little research has been performed on loyalty programs in the framework of gambling (13, 15). For example, a report commissioned by Gambling Research Australia in 2014 found only 16 articles about loyalty programs specific to the gambling industry, which were exclusively focused on casinos, and none from France (15). The large majority of articles on loyalty programs in gambling are from a marketing perspective (15). As an illustration, only one qualitative study identified by the report commissioned by Gambling Research Australia explored the impact of loyalty programs on vulnerable and at-risk gamblers (15). This study explored the way in which gamblers interpret and respond to marketing strategies, including incentives (19). Gamblers were influenced by incentives in various ways, mainly depending on their age and sex. Older women without problem gambling appreciated the social benefits and free meals offered through incentives but were realistic about the associated risks. In contrast, younger men, gamblers with low socioeconomic backgrounds and problem gamblers mainly focused on the benefits associated with the incentives but did not take into account their long-term risks. They described the impact on their gambling behavior (shift toward online activities, opening new accounts, or gambling on multiple websites) but considered incentives as "no lose" benefits, especially for problem gamblers. However, a recent study has demonstrated that gamblers tend to underestimate the true cost of bonus bets (20). Indeed, bonus bets often have conditions of use that imply additional gambling expenditures from gamblers, which are not always clearly stated in advertisements and, by extension, understood by gamblers. This may lead one to question the principle of informed choice for responsible gambling consumption. In a qualitative study performed in 2014, the same team reported increased gambling in response to bonus offers in treatment-seekers but not in general population gamblers, with treatment-seekers feeling strongly tempted to drop resolutions of controlled gambling (21). Another qualitative study on sports betters, also conducted in Australia, indicated that incentives such as bonus bets were considered by gamblers among the most effective marketing strategies (22). They conceptualized these incentives as safety bets or free money, which led them to open multiple accounts (for long-term use rather than short-term use as initially intended), gamble at moments when they would normally not do so, and feel greater control over their gambling, even if they are aware that inducements are a marketing strategy. An online survey of 1,813 sports bettors also reported that the consumption of wagering inducements may lead to impulsive in-play betting patterns, especially among problem gamblers, and frequent sports viewers (23). More recently, another online survey from the same team highlighted the impact of incentives, including bonus bets, on increasing risk taking in a simulation of sports betting (24).

Those studies, while being very instructive on the potential impact of wagering inducements, relied mainly on qualitative designs, self-reported data or online surveys, which suffer from poor ecological validity. A recent study on the impact of exposure

to inducements on betting behaviors included an ecological momentary assessment design with higher ecological validity (25). In this study, almost 600 gamblers completed up to 15 ecological momentary assessments to report their exposure to different types of wagering advertisements and inducements, along with intended and actual betting expenditure. The results indicated that wagering inducements and advertisements were associated with more frequent and more intense betting. However, such a design may suffer from problems of chronology because of the dynamic interrelation between closely interrelated outcomes that may influence each other over time; that is, the attribution of wagering inducements depends on previous gambling behaviors, and gambling behaviors may be influenced by inducements, the latter being the causal dynamic of interest from a gambling prevention perspective. The authors of this study thus recommended measuring betting behavior that occurs strictly after exposure to inducements to capture a causal interpretation.

The objective of the present study was thus to assess the actual impact of wagering inducements on gambling behaviors in experimental research with both objective (money wagered, time spent gambling) and subjective (cognitions, emotions) gambling endpoints and high ecological validity (real money, real gambling websites). We hypothesized that wagering inducements would lead to increased gambling behavior and gambling-related cognitions and emotions during a gambling session. More specifically, we made the assumption that the impact of wagering inducements would be stronger for participants at risk for gambling disorder compared to low-risk controls, and would vary depending on preferred gambling activities. This hypothesis was tested by manipulating wagering inducements in a sample composed of at-risk gamblers and recreational gamblers with various favorite types of gambling activity, and monitoring betting behavior during an experimental gambling session in which participants were able to wager on their own preferred websites.

MATERIALS AND METHODS

The present work is part of the MOD&JEU research program (trial registration number: NCT01789580), previously described in a study protocol available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4448208/ (26). The MOD&JEU research program is composed of four randomized controlled studies assessing the effectiveness of various types of Internet gambling protection tools [self-limitation, pop-up messages, and self-exclusion (27)] and the impact of wagering inducements on gambling behaviors. The present work reports the results of the study dedicated to wagering inducements.

Participants

Participants were volunteers gambling regularly and currently on the Internet. To represent a wide range of gambling profiles in the sample, half of volunteers were at-risk gamblers, and half were recreational gamblers [according to the scoring of the Problem Gambling Severity Index (PGSI) (28)].

The inclusion criteria were as follows: only adults (18–65 years old) gambling at least once per month on a licensed French website who agreed to give the research team access to their gambling account information (to provide access to their gambling history, making it possible for the research team to objectively collect data on changes in gambling behavior during the period of interest) and who have set their deposit limit to at least €200 (in order to be able to implement any of the experimental conditions set out in the study). Non-inclusion criteria were being a problem gambler according to the PGSI (scoring 8 or more), being currently treated for a gambling problem, being indebted, being pregnant, being under protective measures (guardianship or curatorship), having used psychoactive substances on the day of the experiment, participating in another clinical study during the week preceding the experiment, and having a history of psychosis or severe cognitive impairment. Problem and treated gamblers were not included to prevent the amplification of their gambling problems by putting them in a gambling situation as part as this research.

Procedure

The recruitment took place between March 2013 and February 2018. Participants were recruited through media announcements (newspapers, radio, and websites) and in panels from survey institutes. Volunteers were requested to contact the research team by email to obtain details on the study and arrange a telephone appointment to complete the pre-selection questionnaire to assess eligibility. Eligible participants were invited to come to the research center for a half day to perform the research procedure.

First, participants were randomly assigned to one study from the MOD&JEU research program (wagering inducements, self-limitation, pop-up messages, or self-exclusion) and then to one of the experimental conditions of the assigned study. In the case of the wagering inducements study, participants were randomly assigned to four experimental conditions (€10, €50, €100, or €200, with an expected sample size of 30 each) or the control condition [expected sample size of 60, calculated as $30^*\sqrt{(k)}$, where k was the number of experimental conditions]. The graduated amount of money used for the experimental conditions was chosen to estimate the impact of wagering inducements depending on the amount of money. The randomization was stratified according to the gambler's status (recreational or at-risk) and to the favorite type of gambling activity (pure chance games: lottery and scratch cards; skill and chance bank games: horserace and sports betting; and skill and chance social games: poker).

All participants completed a pretest interview prior to the experiment to provide the following information: sociodemographic characteristics, previous knowledge, use and opinion on Internet gambling protection tools, gambling habits and course, gambling problems, cognitive distortions, and gambling account information.

Then, all participants were requested to gamble at their favorite gambling website, on their favorite type of gambling, in their usual way (as if they were at home) in a quiet room specifically dedicated to the study. The room did not contain any gambling-related cues or other stimuli that might promote

gambling. To be as naturalistic as possible, participants gambled with their own gambling account and their own money. The gambling session could last up to 3 h, and there was no minimum duration defined *a priori*. The screen was video recorded to be able to monitor all bets made during the gambling session. Participants were advised of this specific feature of the assessment beforehand, and have expressly consented for this. Participants were instructed at the beginning of the session that they could gamble as long as they want and just had to inform the interviewer when they wanted to end the session. If participants wanted to smoke, they had to leave the room (as the experimental room was in a hospital).

In the experimental conditions, a defined amount of money was given to the gambler during the gambling session with a bank e-card system to simulate a wagering inducement. Participants were not aware that they would receive this inducement. The time when the inducement was given was defined as the middle of the gambling session, whose duration was estimated equal to the mean duration of the session declared by the gambler in the pretest interview (and maximum after 1:30 of gambling). In the control condition, the participants received no wagering inducement.

Finally, a post-test interview was conducted at the end of the gambling session to collect the following information: subjective impact of the wagering inducement (for gamblers in the experimental conditions), cognitive distortions, enjoyment of gambling, loss of control, and gambling account information.

Measures

We used a combination of quantitative and qualitative measures. Qualitative measures were used to collect the subjective perspective of the participants regarding Internet gambling protection tools in general (pretest) and the impact of the experimental wagering inducement on their gambling behaviors (post-test).

Sociodemographic Characteristics

We collected data on age, sex, living conditions, education level, and employment status during the pretest only.

Gambling Habits and Course

During the pretest only, we collected data on the age of gambling initiation, gambling habits (types of game, frequency, etc.) and motives for gambling. Moreover, participants were asked to indicate how much money and time they usually spent during a gambling session.

Previous Experience With Wagering Inducements

During the pretest only, participants were requested to report on their previous experience with wagering inducements (whether they previously received some, the usual amount of money) and their opinion (qualitative data) about the limitation of wagering inducements as a possible Internet gambling protection tool (interest in reducing the risks of problem gambling, view of the operator if he/she implemented this measure).

Gambling Problems

During the preselection questionnaire, participants completed the PGSI, which is a 9-item self-report questionnaire derived from the Canadian Problem Gambling Index originally developed by Ferris and Wynne (28). The total score indicates the status of the gambler: non-problem gambler (score 0), low-risk gambler (score 1–2), moderate-risk gambler (score 3–7), and problem gambler (score 8+). In the present study, the result of the PGSI was only used for eligibility and to define two categories of interest: at-risk gamblers (ARGs) were those with a moderate risk (score 3–7), and recreational gamblers (RGs), including both non-problem gamblers and low-risk gamblers, had a score of 0–2. Moreover, during the post-test, they completed a 10-point Numerical Rating Scale (NRS) to assess their feeling of losing control over gambling during the experimental gambling session.

Cognitive Distortions

During both the pretest and post-test, participants completed the French version of the Gambling Related Cognitions Scale (GRCS) (29, 30). The GRCS is a 23-item self-report questionnaire exploring five dimensions of cognitive distortions associated with gambling: interpretative bias (GRCS-IB), illusion of control (GRCS-IC), predictive control (GRCS-PC), gambling-related expectancies (GRCS-GE), and perceived inability to stop gambling (GRCS-IS). Moreover, participants were asked to estimate their probability of winning the next gambling session (percentage) at the pretest and post-test.

Enjoyment of Gambling

During the post-test, participants were requested to estimate their level of enjoyment of gambling during the experimental gambling session using a 10-point NRS.

Gambling Account Information

Information gathered from the participant's gambling account history was used to ensure eligibility. Moreover, as the screen was video recorded, we were able to monitor precisely all the gambling actions performed during the experimental gambling session, so that an objective and prospective record of measures of gambling (money wagered and time spent gambling) was possible. Money wagered was defined as the sum of bets during the gambling session. Time spent gambling was defined as the time during which the participant wanted to continue the gambling session, whether to place bets, prepare bets, look at sports/horse race events, etc. Thus, the beginning of the session was the moment when the participant connected to his/her account, and the end was the moment when he/she indicated that he/she wanted to end the experimental gambling session.

Subjective Impact (Qualitative Data Collection)

During the post-test, participants in the experimental conditions were asked about the subjective impact of the wagering inducement on their gambling behavior during the gambling session.

Data Reduction

We used the raw value of money wagered and time spent gambling during the experimental gambling session as the two main outcomes of the study to objectively estimate the impact of wagering inducements on gambling behavior.

Moreover, we used secondary outcomes to investigate the effects of wagering inducements on gambling-related cognitions, emotions, and behaviors. We computed change scores to express variations between the pretest and post-test on GRCS scores and the subjectively rated probability of winning. Two variables (enjoyment of gambling NRS and loss of control NRS) were used as is. Finally, we created two binary variables to estimate whether the pattern of betting (money wagered and time spent gambling) during the experimental gambling session conformed to the participant's usual gambling behavior outside the laboratory. These variables were determined by comparing the objective money wagered and time spent gambling during the gambling session (gathered from the gambling account information) collected in the post-test with the baseline money wagered and time spent gambling defined in the pretest (i.e., subjective indication from the participant of how much money and time they usually spend during a gambling session).

For qualitative data, reported quotes are French excerpts of the participants' responses, translated into English.

Statistical Analysis

We first described all variables by their number and percentage for categorical variables and by their mean and standard deviation for quantitative variables. We also graphically described the dispersion of the two main outcomes with box plots, including the median, the first and third quartiles, the non-outlier range, and the identification of outliers and extremes, to observe the relative heterogeneity of the distribution in each condition. The normality of quantitative variables was tested using the Shapiro-Wilk test, and transformations were applied whenever needed.

We then conducted a series of independent three-way ANOVAs, Poisson's regressions or logistic regressions, depending on the distribution and type of the outcome variable. These analyses were performed to compare the four experimental conditions with the control condition on the main and secondary outcomes (or their transformed equivalents), taking into account the stratification variables, i.e., the status of the gambler (recreational or at-risk), and the type of preferred gambling activity (pure chance games, skill and chance bank games and skill and chance social games). The analyses included both the effect of the condition, the effects of the stratification variables and the interaction between them. When the interactions were not significant, they were removed from the final models. When an effect was significant, pairwise comparisons were performed with Dunnett's tests only for the significant effects, by comparing each experimental condition to the control condition and controlling for the Type 1 experimentwise error.

All statistical analyses were performed using SAS® software version 9.4 (SAS Institute Inc., Cary, NC, USA).

Ethics

The participants were informed about the research and gave their written informed consent prior to their inclusion in the study. As the procedure involved that participants, including at-risk gamblers, gambled with their own funds, several safeguards were discussed with the ethics committee and put in place to ensure financial safety of the procedure for participants. These safeguards were:

- A maximum bet limit defined for each participant before the gambling session (equal to 4 times the amount that the participant declared to bet on average per gambling session in the pretest, minus the amount of the inducement if applicable); the protocol provided the session to be stopped if the participant reached this limit.
- A maximum gambling duration of 3 h; the protocol provided the session to be stopped if the participant reached this limit.
- A compensation fund in order to partially reimburse participants for losses incurred during the experimental gambling session, when they reached a certain amount. We indemnified participants if the losses reached at least the amount that the participant declared to bet on average per session of gambling during the pretest, up to the amount lost beyond this limit (minus the amount of the inducement if applicable).
- The *a posteriori* exclusion of participants who have bet more than € 2,000 during the experimental gambling session. If this threshold was reached, the protocol provided for the session to be stopped and the participant's data not to be used in the data analysis.

As 2 of these safeguards relied on the amount of the average bets per gambling session declared by the participants, and to ensure this amount was not biased, we checked the relevance of this subjective estimate based on objective data gathered from the participants' accounts: in the event of a difference of more than 20% between the declared amount and the objective amount, the amount was re-evaluated in agreement with the participants.

Participants were not aware of these safeguards during the procedure in order not to bias their gambling behavior during the gambling session, and were only informed at the end of their participation if applicable. Moreover, although they were aware of the overall process, they were not informed beforehand that they would receive (for experimental conditions) a wagering inducement. This choice was made in order not to bias the gambling behavior during the experimental session. At the end of the post-test interview, participants were debriefed in order to investigate, after having received knowledge about the entire procedure and being aware of the safeguards (if applicable), if they wished to maintain or withdraw their consent to participate. No participant wanted to withdraw his/her consent.

This study was approved by the French Research Ethics Committee (CPP) on January 8, 2013.

RESULTS

As described in **Table 1**, we included 171 gamblers out of the 180 expected gamblers, but the sample sizes of each group

TABLE 1 | Sample size of each condition according to the stratification variables (status of gambler and type of preferred gambling activity).

	Control	€10	€50	€100	€200	Whole sample
Sample size	55	28	29	30	29	171
Status of gambler						
Recreational gamblers	30 (54.5%)	15 (53.6%)	15 (51.7%)	15 (50.0%)	15 (51.7%)	90 (52.6%)
At-risk gamblers	25 (45.5%)	13 (46.4%)	14 (48.3%)	15 (50.0%)	14 (48.3%)	81 (47.4%)
Type of preferred gambling activity						
Pure chance games	16 (29.1%)	8 (28.6%)	9 (31.0%)	10 (33.3%)	8 (27.6%)	51 (29.8%)
Skill and chance bank games	20 (36.4%)	10 (35.7%)	10 (34.5%)	10 (33.3%)	10 (34.5%)	60 (35.1%)
Skill and chance social games	19 (34.5%)	10 (35.7%)	10 (34.5%)	10 (33.3%)	11 (37.9%)	60 (35.1%)

TABLE 2 | Gambling habits of the sample ($n = 171$).

	N (%)
Gambling activity exclusively online	52 (30.4%)
Gambling activity centered on only one type of game	94 (55.0%)
Type of gambling played online	72 (42.1%)
Poker	
Sports betting	64 (37.4%)
Lotteries	58 (33.9%)
Horse-race betting	47 (27.5%)
Scratch cards	34 (19.9%)
Black Jack	4 (2.3%)
Slots	2 (1.2%)
Roulette	2 (1.2%)
Video poker	1 (0.6%)
Frequency of online gambling	28 (16.4%)
Once per month or more	
Once per week or more	96 (56.1%)
Almost everyday	47 (27.5%)
Motives for gambling online	104 (60.8%)
Money	
Fun and excitement	90 (52.6%)
Convenience of online gambling (compared to offline gambling)	30 (17.5%)
Strategy or competition	22 (12.9%)
Avoid loneliness or boredom	16 (9.4%)
Speed and diversity of online gambling (compared to offline gambling)	9 (5.3%)
Convivial aspect of gambling	8 (4.7%)
Escapism from worries or everyday problems	3 (1.8%)
Anonymity of online gambling	3 (1.8%)
Create another life online	1 (0.6%)

were well-balanced. No participant stopped gambling before they received their assigned inducement.

Description of the Sample

Sociodemographic Characteristics

Participants were mainly men (78.9%), with a mean age of 38 ($SD = 11.1$). Age ($F = 0.9$, $p = 0.47$) and sex ($\chi^2 = 2.8$, $p = 0.58$) did not differ between conditions. The participants were mainly professionally active (69.6%), with only a small proportion being either professionally inactive (18.7%), students (7.6%), or retired (4.1%). The majority of participants had an educational level that was higher than or equal to that of a high school graduate (which corresponds to 12 years of education in France) (80.7%). Finally, approximately two-thirds of the sample lived as a couple (61.4%), and the remaining third lived either alone (31.0%) or with parents or another legal representative (7.6%).

Gambling Habits and Course

Participants began gambling at an average age of 15 years old ($SD = 5.6$). All the participants also had an offline gambling practice, and the large majority (94.7%) of participants were initiated into gambling through offline gambling. Among the 171 participants, 66 (38.6%) reported being introduced to online gambling through promotional offers (advertising, sign-up offers, etc.).

The gambling habits of the sample are described in **Table 2**. Participants mainly had mixed gambling activities, combining offline and online gambling (69.6%). Just under half of the participants played multiple games on the Internet (45.0%). They mainly participated in poker, sports betting, lotteries, horse-race betting, and scratch cards. The majority of participants (83.6%) played very regularly, i.e., once per week or almost every day. Finally, the large majority of participants reported gambling for *money* and *fun and excitement*.

Previous Experience With Wagering Inducements

Approximately two-thirds (67.3%) of participants declared having already received wagering inducements. When asked about the usual amount of money, the large majority declared having received wagering inducements of less than €10 (70.2%). Other participants declared amounts between €11 and €50 (21.1%), between €51 and €100 (6.1%), and between €101 and €200 (2.6%). Within the sample, opinions were mixed about the value of limiting wagering inducements as a possible Internet gambling protection tool. Indeed, a third of participants (33.9%) thought that there was no interest in the limitation of wagering inducements for reducing the risks of problem gambling, a third declared a low (11.1%) or medium (23.4%) interest, and a third declared a high (25.7%) or very high (5.9%) interest. More than half of the sample thought that wagering inducements represent an incentive to gamble (54.4%): to wager more money, to experiment with new gambling activities, to register on new gambling websites, and to return to gambling after cessation, among others. Moreover, just over half of the participants reported that they would have a good (38.24%), a very good

TABLE 3 | Description of the two main outcomes (averaged money wagered and time spent gambling during the gambling session), according to the experimental condition.

	Control $N = 55$	€10 $N = 28$	€50 $N = 28$	€100 $N = 30$	€200 $N = 29$
Money wagered (€)—*Mean (SD)*	17.18 (22.71)	33.15 (69.45)	37.13 (51.18)	37.27 (40.69)	40.63 (60.87)
Time spent gambling (min)—*Mean (SD)*	40.96 (46.30)	54.82 (55.82)	53.29 (57.73)	48.67 (51.77)	52.90 (50.14)

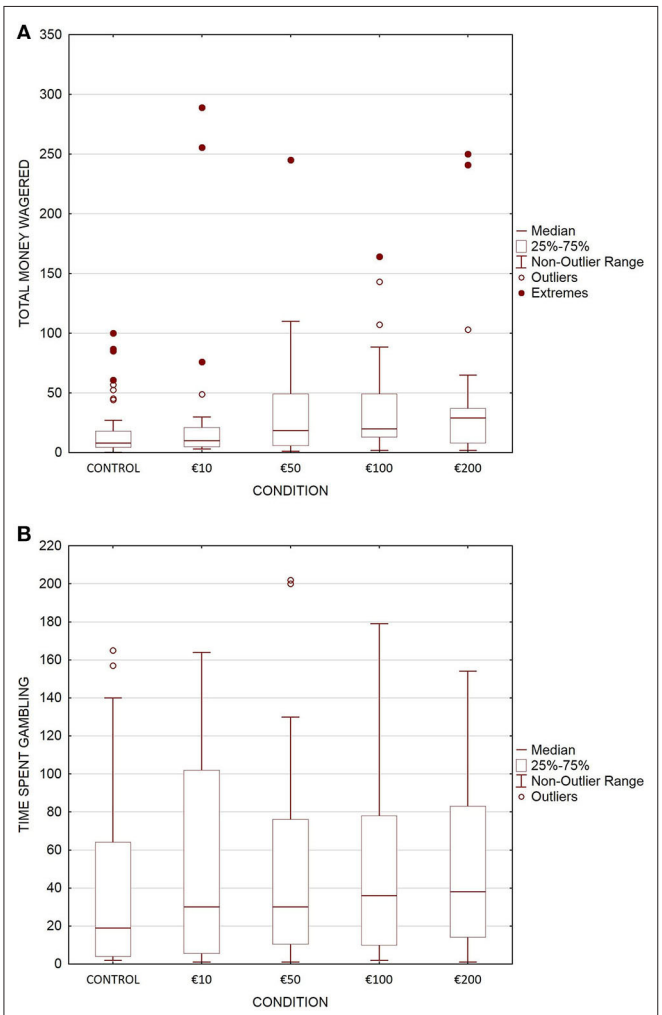

FIGURE 1 | Box plots of total money wagered **(A)** and time spent gambling **(B)** during the experimental gambling session, according to the condition.

(13.53%), or an excellent (1.76%) opinion of the operator if he/she would implement the limitation of wagering inducements.

Description and Dispersion of the Two Main Outcome Variables (Money Wagered and Time Spent Gambling During the Gambling Session)

Table 3 describes the two main outcomes (money wagered and time spent gambling during the gambling session) according to conditions (control or experimental conditions), without taking into account the type of gambling or the status of the gambler.

The amount of money wagered is, on average, twice as high for all experimental conditions (regardless of the amount of inducement) than for the control condition. Moreover, as depicted in **Figure 1A**, the dispersion of money wagered is highly variable depending on the condition. Indeed, the dispersion of the values for the control group is much smaller than that of the experimental groups, regardless of the amount of inducement. Extreme values of money wagered were predominantly observed for at-risk gamblers (of the 11 extremes identified, 9 were at-risk gamblers). Within the control group, extremes ranged from €60 to €100, whereas they ranged from €75 to €290 in the experimental conditions (and from €160 to €290 when considering only €50, €100 and €200 groups).

As depicted in **Figure 1B**, time spent gambling increased slightly (in the range of 8–15 min more) for the experimental conditions compared to the control condition. In contrast to the money wagered, relatively similar dispersions of values as a function of the condition are observed for the time spent gambling.

Effect of Wagering Inducements Adjusted for the Status of Gamblers and the Type of Preferred Gambling Activity

The results of the analyses adjusted for the status of gamblers and the type of preferred gambling activity are displayed in **Table 4**. All interactions were not significant, so they were all removed from the final models.

Regarding the stratification variables, a significant effect of status of gambler was demonstrated on the two main outcomes (money wagered and time spent gambling), with at-risk gamblers wagering more money and spending more time gambling compared to recreational gamblers, as expected. A significant effect of type of preferred gambling activity was also demonstrated on time spent gambling, with a gradient of time spent gambling from pure chance games (lowest length) to skill and chance social games (highest length) (each type differed significantly from the others in pairwise comparisons). Money wagered did not differ according to type of preferred gambling activity.

Regarding the two main outcomes, an effect of wagering inducements on money wagered has been evidenced. The pairwise comparisons indicated that this effect was significant from the amounts of €100, and there was a trend toward significance ($p = 0.07$) for amount of €50. On the contrary, no effect of inducement on time spent gambling was evidenced.

TABLE 4 | Results of the ANOVAs and regressions adjusted for the status of gamblers and the type of preferred gambling activity, comparing the 4 experimental conditions with the control condition on main and secondary outcome variables.

	ANOVA effects						Pairwise comparisons for significant effects of the inducement conditions with Dunnett's tests‡
	Inducement		Status of gambler		Type of gambling		
	F	*p*-value	*F*	*p*-value	*F*	*p*-value	
Money wagered	3.47	**0.0095**	14.26	**0.0002**	0.18	0.8320	a^{NS}; b^{NS}; c^{***}; d^{***}
Time spent gambling	1.04	0.3893	6.20	**0.0138**	107.60	**<0.0001**	NA
Change score GRCS_GE	4.01	**0.0039**	0.05	0.8189	4.62	**0.0111**	a^{***}; b^{***}; c^{NS}; d^{NS}
Change score GRCS_IS	0.51	0.7255	0.02	0.8917	0.09	0.9143	NA
Change score GRCS_IC	0.81	0.5191	1.01	0.3169	3.34	**0.0378**	NA
Change score GRCS_PC	1.43	0.2267	0.91	0.3420	0.43	0.6502	NA
Change score GRCS_IB	0.90	0.4636	0.40	0.5279	0.90	0.4085	NA
Change score subjectively rated probability of winning	0.47	0.7596	0.08	0.7720	1.26	0.2855	NA
Pleasure to gamble NRS	2.27	0.0640	0.00	0.9668	0.95	0.3893	NA

	Poisson's regression effects			
	Estimate	**95% Wald confidence limits**		***p*-value**
Loss of control NRS				
Inducement				**<0.00001**
€10 vs. control	−0.1818	−0.6713	0.3076	0.4665
€50 vs. control	0.1792	−0.2555	0.6138	0.4191
€100 vs. control	0.2459	−0.1713	0.6630	0.2480
€200 vs. control	0.8263	0.4668	1.1858	**<0.0001**
Status of gambler				
ARGs vs. RGs	0.9266	0.6331	1.2201	**<0.0001**
Type of gambling				**<0.0001**
Skill and chance bank games vs. pure chance games	−0.0444	−0.4463	0.3575	0.8285
Skill and chance social games vs. pure chance games	0.7133	0.3623	1.0643	**<0.0001**

	Logistic regression effects			
	OR	**95% Wald confidence limits**		***p*-value**
Respect of the usual money wagered per gambling session (binary)				
Inducement				0.1828
€10 vs. control	1.499	0.424	5.308	0.5300
€50 vs. control	2.097	0.526	8.358	0.2938
€100 vs. control	1.259	0.386	4.109	0.7029
€200 vs. control	0.444	0.158	1.252	0.1247
Status of gambler				
ARGs vs. RGs	1.440	0.645	3.214	0.3732
Type of gambling				0.1477
Skill and chance bank games vs. pure chance games	1.250	0.504	3.098	0.6306
Skill and chance social games vs. pure chance games	2.744	0.972	7.744	0.0566
Respect of the usual time spent per gambling session (binary)				
Inducement				0.3594
€10 vs. control	0.170	0.383	3.571	0.7824
€50 vs. control	0.961	0.326	2.835	0.9432
€100 vs. control	0.407	0.153	1.084	0.0722
€200 vs. control	0.836	0.294	2.379	0.7376
Status of gambler				
ARGs vs. RGs	1.152	0.569	2.334	0.6940
Type of gambling				**0.0265**
Skill and chance bank games vs. pure chance games	0.701	0.312	1.575	0.3900
Skill and chance social games vs. pure chance games	2.402	0.937	6.158	0.0681

NRS = 10-point Numerical Rating Scale; Change scores: variations between pretest and post-test.
p-value in bold: significant effect ($p < 0.05$).
‡*a. €10 vs. control; b. €50 vs. control; c. €100 vs. control; d. €200 vs. control. NS, non-significant. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. NA, not applicable (no effect of the inducement condition).*
ARGs, at-risk gamblers; RGs, recreational gamblers.
Pure chance games: lottery and scratch cards; skill and chance bank games: horserace and sports betting; and skill and chance social games: poker.

Regarding the secondary outcomes, a significant effect of inducement was demonstrated on the change score of the "gambling expectancies" subscale of the GRCS (GRCS-GE). Indeed, in the control condition, the change score of the GRCS-GE was negative (mean value: −1.79), which indicated that gambling expectancies decreased during the gambling session. In the experimental conditions (with inducement), the mean value ranged from −1.57 to +0.43, which indicated that gambling expectancies decreased less or even increased after the gambling session. Pairwise comparisons indicated that this effect was significant for amounts of €10 and €50, and there was a trend toward significance for amount of €200.

Moreover, a significant effect of inducement was also demonstrated on the change score of the loss of control NRS. The loss of control rating was low (under 1) for the control group and the €10 group and higher for other experimental conditions (1.18–2.34). Pairwise comparisons indicated that the effect of inducement on the loss of control NRS was significant for amounts of €200.

Subjective Impact of Wagering Inducements on the Gambling Session

Of those who had a wagering inducement during the gambling session (experimental conditions), regardless of its amount, just over half of the sample reported that the inducement had an impact on their gambling practice (50.4%), the majority of whom found this effect to be high (32.8%) or very high (25.9%). The majority of gamblers who reported that the inducement had no impact on their gambling practice were from the €10 group (35.1%). Examples of impacts spontaneously reported by the participants were "*I took more risks after receiving the bonus*" (at-risk gambler of sports betting, randomized into the €10 group), "*I bet more than I originally planned and I used gambling options that I do not usually use*" (recreational gambler of lotteries, randomized into the €100 group), "*I played on more expensive tables than usual*" (recreational gambler of poker, randomized into the €50 group), and "*I wagered during the session what I usually wager in a month*" (at-risk gambler of horse betting, randomized into the €200 group).

DISCUSSION

The objective of the present study was to compare the impacts of different levels of wagering inducements on objective (money wagered, time spent gambling) and subjective (cognitions, emotions) gambling-related outcomes to those of no inducements in a control group.

Regarding money wagered, a significant effect of wagering inducements was demonstrated from the amount of €100, with twice the money wagered compared to the control condition. This is in favor of an effect of wagering inducements on money wagered. A lack of power may explain why we were not able to demonstrate any significant differences (or only trends) for lower amounts.

Moreover, observed values of money wagered were very scattered for experimental conditions, regardless of the amount of inducement, contrary to the control condition. This is an interesting result *per se*, which may indicate that individuals who have received a wagering inducement have very heterogeneous gambling behaviors, which can lead to extreme expenses. We noted that extreme values of money wagered were predominantly observed for at-risk gamblers and that higher extreme values were observed for higher amounts of wagering inducements (€50–€200). In our sample, the large majority of gamblers reported gambling for money, which is consistent with previous literature on gambling (31–33). In particular, several structural equation modeling analyses identified that financial motives were central to explaining paths to gambling problems (34, 35). This may explain why at-risk gamblers seem to display more extreme responses to incentives.

Regarding the time spent gambling, no effect of wagering inducements was demonstrated. Contrary to money wagered, there did not seem to be variability in dispersion across conditions. As stated in the introduction, wagering inducements are supposed to encourage betting, especially to induce an immediate sale (17). Thus, it is not surprising that gamblers in the experimental conditions are more prone to gambling more money than more time.

Along with the effect of wagering inducements on money wagared, several effects of subjective outcomes were evidenced. More specifically, experimental inducements, from amounts as low as €10, seemed to prevent gambling expectancies from decreasing during the experimental gambling session, as was observed in the control group. According to expectancy theory, the decision to perform certain behaviors is related to the anticipation of an expected outcome of these behaviors (36). This theory was initially developed to explain the relation between motivation and work but has been largely adapted for addictive behaviors, especially substance-related, alcohol-related and gambling disorders, given the reinforcing effects expected from these addictive behaviors (37–40). The concept of gambling expectancies largely overlaps that of gambling motives, as expectancies represent the expected effects that motivate gambling initiation and maintenance despite persistent losses (30). In a recent study, Barrada et al. found that reward (and punishment) sensitivity was related to gambling behavior only through gambling motives, especially the affect regulation factor that corresponds to both positive and negative affect upregulation (41). This factor is quite similar to the GRCS-GE dimension from the GRCS, which includes gambling-related expectancies associated with both positive and negative affects ["*Gambling makes things seem better*" or "*Having a gamble helps reduce tension and stress*" (30)]. Therefore, wagering inducements hold a reward value that may have strengthened gambling expectancies during the gambling experimental session. It is important to highlight that in Barrada's study, the affect regulation factor was the strongest predictor of gambling severity (41). Although we were unable to demonstrate a significant inducement*status of gambler interaction in this single gambling session study, one may hypothesize that the repetition of wagering inducements in the long term may lead to a chronic increase in gambling expectancies and secondarily to gambling problems.

Moreover, an effect of wagering inducements on the feeling of losing control was revealed for amounts of €200. The loss of control is one of the key symptoms of addiction (42). The fact that wagering inducements lead to an increased perception of losing control over gambling behavior is consistent with the subjective impact reported by gamblers who were in the experimental conditions. On the scale of a gambling session, this effect on the loss of control could lead gamblers to experiment with more risky or unusual gambling options or to bet more than intended. Such behaviors may induce more damage, particularly for excessive gamblers.

According to our sample, wagering inducements are widespread, as the large majority of participants have already received some. The mixed opinion of gamblers about the possible limitation of wagering inducements was not surprising. Indeed, according to the qualitative study from Thomas et al., gamblers usually have a positive opinion of wagering inducements, especially in online gambling (19). In this study, and more specifically for younger men, those with low socioeconomic status and at-risk or problem gamblers, participants reported that such incentives represent benefits in the short term that they perceive as harmless free money. In our study, we demonstrated that wagering inducements increased gambling expectancies and loss of control, even on the scale of a single gambling session. As stated above, such emotional impacts may have long-term effects that could secondarily induce or exacerbate gambling problems. Such long-term risks are quite minimized by gamblers, especially at-risk gamblers (19). Finally, we can highlight that, contrary to what may have been expected intuitively, the enjoyment of gambling was not significantly accentuated in experimental conditions with wagering inducements.

The findings of this study may be considered in light of several limitations. *First*, as stated above, the limited sample size may have reduced the significant effects observed. Indeed, with the objective of being as naturalistic as possible, we decided to set up a procedure involving the presence of participants for half a day. This drastically reduced our capacity to include more participants in this exploratory study, and the results should be replicated in more ecological studies. This is planned in the framework of the EDEIN study (43), in which the impacts of wagering inducements will be assessed using behavioral tracking data in conjunction with self-reports of gambling problems, thus responding to the call for research launched by Wohl (13). However, the experimental methodology that we implemented in the present study allowed us to have access to more subjective aspects, such as gambling-related expectancies, which are of high interest in clarifying the mechanisms of wagering inducement effects. *Second*, in this study, we simulated a wagering inducement through a bank e-card system. This procedure was intended to free ourselves from the content of the advertising message going with the wagering inducement. However, such simulated incentives were not conditional upon certain gambling-related actions as they are in real conditions. This will limit the generalizability of our findings and again suggest the importance of carrying out more ecological studies. *Third*, excessive gamblers (scoring 8 or more on the PGSI) and treated gamblers were excluded from this study due to ethical reasons in relation to the procedure, including a gambling session. This may have inevitably reduced the effects of wagering inducements according to the status of gamblers. *Fourth*, participants who gambled on illegal websites, such as online slots and other casino game websites (which are forbidden in France), were not included in this study. Thus, the present results may not be generalizable to those participating in unregulated online gambling activities, which were found to be associated with the highest prevalence of excessive gambling in online French gamblers (12). However, the lack of a legislative framework for such online gambling activities provides an opportunity for more aggressive marketing practices from gambling operators, including wagering inducements programs, and future research should replicate the present study with online casino gamblers. *Fifth*, certain measure used in this study did not rely on psychometrically validated instruments, such as motives to gamble. Moreover, the GRCS was not specifically validated for a use as a state measure of gambling-related cognitions. *Sixth*, we used a between-group design rather than a within-group one, in order to take into account the potential disparity of time distribution of gambling events within a gambling session, independently of this experimental procedure. Future research may therefore investigate the effects of inducements in a before/after approach, with repeated gambling sessions to ensure the reproducibility of observed effects.

Despite these limitations, we must emphasize the strengths of this study. *First*, this study was focused on an innovative theme in the gambling literature. Indeed, despite the wealth of studies on responsible gambling, wagering inducements are rarely studied with respect to their impacts on gambling behaviors, cognitions, and emotions from an addictive perspective (15), although such findings would constitute an interesting method of informing policy regulations. The present study led to new findings using an experimental procedure that went beyond qualitative or self-reported methods used in previous studies. *Second*, the procedure was designed to be as naturalistic as possible; that is, participants gambled on their favorite gambling website in a usual way (as if they were at home) during a long-lasting gambling session, with their own gambling account and their own money. *Third*, the combination of objective and subjective data gave us access to a more in-depth understanding of the impacts of wagering inducements, rather than just focusing on their impacts on gambling behaviors. This design allowed us to highlight a potential mechanism of action of wagering inducements through the increase in gambling expectancies.

CONCLUSION

This study demonstrated that wagering inducements may have effects on gamblers by increasing money wagered, gambling-related expectancies and perceived loss of control. In particular, it seems that wagering inducements could lead to extreme expenses, especially for at-risk gamblers. These findings taken together indicate that wagering inducements may hold risks for certain gamblers, especially at-risk gamblers. It seems

important to implement preventive measures regarding wagering inducements from a responsible gambling perspective. An example of such measures would be that at-risk and problem gamblers should not be targeted by wagering inducements (19), which implies that they must previously be identified through an algorithm based of gambling tracking data for example. This is the aim of another research program called EDEIN (43). Beyond at-risk and problem gamblers, individuals who have implemented a self-exclusion measure should not receive such inducements even after the self-exclusion period to favor a gradual resumption of controlled gambling. Another possible measure would be to explain more explicitly to gamblers the true cost of wagering inducements, especially the play-through conditions that require the gambler to make further expenditures (20), which may limit the increase in gambling-related expectancies. Future research on the impacts of wagering inducements is still needed, especially more ecological studies based on behavioral tracking data and studies assessing the differential impacts of various incentive types.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because data generated in this study included sensitive data according to the French Data Protection Authority (CNIL), that could not be transferred to other researchers to guarantee participants' anonymity. Requests to access the datasets should be directed to Gaëlle Challet-Bouju, gaelle.bouju@chu-nantes.fr.

ETHICS STATEMENT

This study involved human participants and was reviewed and approved by the French Research Ethics Committee (CPP) OUEST IV. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

GC-B and JC designed the study, obtained funding, and were responsible for the project management and interpretation of data. GC-B wrote the first draft of the manuscript. MG-B included participants and provided the medical supervision of the study. AS, JL, and YD collected the data. MP performed the statistical analysis. All authors gave feedback on the first draft of the manuscript and approved the submitted manuscript.

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Gambling Despite Nationwide Self-Exclusion–A Survey in Online Gamblers in Sweden

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Background: Voluntary self-exclusion is a well-known harm reduction intervention in problem gambling, although primarily in operator-specific or venue-based systems. A nationwide overall self-exclusion system ("*Spelpaus"*) for all licensed gambling was introduced in Sweden in 2019. However, gambling in overseas companies despite national exclusion may be a concern in online gamblers. The present web survey study aimed to study self-reported self-exclusion and gambling despite exclusion in a nationwide multi-operator land-based/online exclusion system.

Methods: Web survey in web panel members of a market survey company, carried out in May, 2020 (co-occurring with the COVID-19 pandemic). Past-year online gamblers ($n = 997$) answered questions about gambling patterns, gambling problems, psychological distress, self-exclusion since "*Spelpaus"* introduction, and gambling despite self-exclusion.

Results: Seven percent reported ever self-excluded at *Spelpaus*, and this was associated with younger age, female gender, gambling problems, and chance-based games and online poker. In logistic regression, *Spelpaus* remained strongly associated with past-year online casino gambling, gambling problems, and absence of past-year sports betting. Among those having self-excluded, 38 percent reported gambling despite self-exclusion, most commonly online casino.

Conclusions: In online gamblers in a setting with a nationwide self-exclusion system, using this was associated with past-year online casino gambling and gambling problems. Gambling despite self-exclusion appears to be common, and more commonly involves online casino. Stakeholders should aim to increase rates of self-exclusion in high-risk online gamblers, both during and beyond the COVID-19 situation in which the study was carried out. Also, policy makers should use gambling regulation in order to decrease the risk of breaching self-exclusion online, such as through the prohibition of non-registered gambling operators. Further research should focus on in-depth analysis of the reasons for gamblers to enroll or not enroll in multi-operator self-exclusion.

Keywords: gambling disorder, problem gambling, online gambling, online casino, behavioral addiction, self-exclusion, harm reduction

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INTRODUCTION

Problem gambling is a condition known to have severe consequences on the mental well-being, social and financial situation of affected individuals, and has been reported to affect somewhere between less than one percent and almost six percent, across different studies and settings (1). Gambling disorder (2) is a criteria-based diagnosis recognized by the World Health Organization diagnostic system, ICD-11 (3), and the American Psychiatric Association's diagnostic manual (4), nowadays as one of the addictive disorders along with drug and alcohol use disorders. Gambling disorder is associated with a high degree of psychiatric comorbidity (5, 6), and typically severe financial difficulties (7).

Although there is growing scientific support in favor of treatment of gambling disorder, such as through cognitive-behavioral therapy (8) or brief (9) or motivational interventions (10), treatment seeking is known to be low and associated with different barriers (11). Besides formal treatment, and in particular for individuals with problem gambling even in the absence of formal treatment seeking, voluntary self-exclusion from gambling is a commonly used harm reduction instrument (12, 13). Such self-exclusion tools, however, have been scientifically studied in several land-based gambling settings (14–19), meaning that an individual self-excludes from entering one or several specific gambling venues, such as land-based casinos. Also, there are reports about self-exclusion tools on specific online gambling sites (20–22), i.e., where a gambler self-excludes from one specific gambling operator.

In recent years, online gambling plays an increasing role in gambling markets and in the patient population of individuals with gambling problems. Online gambling may present a number of particular hazards to the gambling population, mainly due to the characteristics of the online modality in itself, being rapid and highly accessible (23) to an extent which is difficult to compare to any land-based venues. In some settings, such as the one studied here, online gambling represents a very large proportion of treatment-seeking patients (24). Online gambling is known to be highly predominating in individuals with high-risk gambling in the present setting, and recent data have indicated that this may also confer changing gender patterns, with the percentage of women becoming larger in populations with gambling problems (25, 26). While a majority of people reporting self-exclusion are typically male (27, 28), as are typically a majority of individuals reporting problem gambling in most settings (1), there is so far less knowledge about the gender distribution in nationwide multi-operator self-exclusion services.

Online gambling presents particular challenges to gamblers who want to self-exclude from a problematic gambling behavior; gambling operators online are numerous, and the self-exclusion from one site may easily be followed by the registration and gambling on another site in order to enable continued gambling. Also, it has been shown that the risk of relapsing into gambling in other sites than the one excluded from is perceived as a major limitation to this method (27). Sweden, after a major change in the gambling market legislation from January 1st, 2019, has introduced a nationwide self-exclusion system from all types of licensed gambling types in the country, and administered by a government authority (29). Despite the theoretically broad coverage of such a system, there is limited knowledge about the extent to which overseas gambling and other non-regulated gambling opportunities may limit the performance of this self-exclusion system. A recent web survey from the present setting demonstrated that—unsurprisingly—respondents with problem gambling were more likely than the remaining respondents (who were not actively gambling or gambled but screened negative for problem gambling) to enroll in such a self-exclusion system (30). However, little is known about how such self-exclusion is influenced by the risk of gambling on gambling services not covered by the system, a theoretical risk particularly in settings with widespread online gambling opportunities.

As there is little research in the area of nationwide multi-operator self-exclusion from gambling, and given the particular challenges of online gambling, the present study aimed to increase knowledge about which online gamblers enroll in such a system, and about the risk of online gamblers breaching it. The present analysis uses a database of online gamblers assessed in a web survey in May, 2020, in order to study online behavior, problem gambling, indebtedness and self-exclusion. From this database, one prior study has been published (31), using the fact that the data were collected during the COVID-19 pandemic, and studying potential pandemic-related effects on gambling. Using the same population of past-year repeated-occasion online gamblers, the present analysis aimed to study the use of self-exclusion in a setting with an overall, combined land-based/online and multi-operator self-exclusion service. Specifically, the study aimed to assess, in online gamblers, variables associated with having self-excluded, such as specific gambling patterns, psychological distress, gender, age and living conditions, as well as to study potential gambling despite self-exclusion and correlates of such self-exclusion breaching.

METHODS

The present study is a web survey addressing online gamblers in Sweden, recruiting from members of a pre-existing web panel of the market survey company Ipsos. Members of the web panel regularly receive offers to participate in market surveys and political opinion polls, and the company also has carried out research studies within their web panel, such as in the area of research reported here (32, 33). In a previous gambling-related study using the same web panel, participants were seen to be skewed toward higher level of education and higher monthly income, compared to the general Swedish population (33).

The present project was reviewed by the Swedish Ethical Review Authority (file number 2020-00364), which expressed no ethical concerns with the project and stated that it formally did not require ethical approval as it does not include personal data possible to link to an identified individual.

Setting

Since January 1, 2019, a national self-exclusion instrument for gambling, *Spelpaus* (www.spelpaus.se) is in use in Sweden, as part of a new gambling market legislation (29). An individual, with

or without a current gambling behavior, can register voluntarily using an official online identification service and provided she/he is above 18 years of age (legal gambling age in Sweden), and is thereafter self-excluded for a period of the individual's own choice; 1, 3, 6 months, or for unlimited time but with the possibility of discontinuation after 12 months. One self-exclusion period can immediately be actively followed by another one, and the administration of this system does not require any registration or visit to a gambling operator's site. Upon every gambling occasion of an individual at any gambling licensed gambling site, an electronic control is made with the national *Spelpaus* register, such that an individual can be allowed to gamble only provided she/he is not currently self-excluded. Until now, around 50,000 individuals have so far self-excluded using this service, corresponding to slightly above half a percent of the adult population in Sweden. About 75 percent of these individuals who have self-excluded are reported to be men (34).

The *Spelpaus* system applies to licensed operators, which include the state-owned gambling operator AB Svenska Spel (providing sports betting, online poker, land-based electronic gambling machines, online bingo, online lotteries, and online casino games), the state-owned land-based casinos (four in total in Sweden, owned by a sub-division of AB Svenska Spel), and a large number of operators offering online casino games, sports or horse betting, online bingo, online poker, and online lotteries. Gambling types not included in the self-exclusion system include land-based lotteries such as lottery tickets bought in coffee shops, gas stations, grocery stores and similar, and so-called "restaurant casinos," which refer to smaller dealer-administered gambling services provided in bars and restaurants and limited to the deposit of smaller amounts.

Procedure

The present study applied the same recruitment method and the same criteria of inclusion as one previous study in online gamblers, carried out in the present setting in 2018 (33). The study was conducted from May 5 to May 12, 2020. Thus, the present study was conducted during the ongoing COVID-19 pandemic and the restrictions to society surrounding it, a situation recently highlighted as potentially affecting online gambling behavior (29). For example, a fear of a potential increase in some gambling types, typically online gambling, has been discussed, particularly during periods of lock-down of land-based gambling venues and sports events (35, 36). In addition to the purposes of the original project, the fact that is was carried out during the COVID-19 pandemic gave rise to a first publication, where past-30-day gambling was assessed as a measure of gambling habits during the pandemic (31). Both in that study and in another general population survey in Sweden, possible decreases have been seen in self-report data for a number of gambling types, such that more individuals in a survey study reported a decrease in gambling during the pandemic, compared to those reporting an increase (35). In the analyses of the present paper, past-30-day gambling habits were not assessed specifically, but instead, individuals were included because of reporting online gambling on ten occasions or more during the past year, and the gambling variables assessed were the full measure of having gambling on a particular gambling type at any time, either during the past 30 days, or during the past year prior to that.

Web panel members were asked about how many times during the past year they had gambled on online betting or online casinos, and respondents endorsing the option of 10 times or more, were further assessed in the study. The invitation to participate included written online information about the study, and informed consent was needed in order to open the survey. Participation in the web survey renders a monetary compensation in the form of credit points in the market survey company's own credit system, where the participation in the present kind of study provides credits of a value of around 1.50 Euros. The aim of the study was to include 1,000 individuals, and when inclusion was halted, 1,007 responses had been registered. For 10 individuals, data on gambling problem severity were missing, such that a total of 997 individuals were included in the final sample.

Measures

Self-exclusion was assessed with a brief introducing sentence about the new national system in used since January, 2019, and asked whether the respondent had ever—since the start of that system—used it for self-exclusion. If yes, the next question asked about the period of time chosen (1, 3, 6, or 12 months). Thereafter, questions were asked about whether the respondent had had any gambling of other types during the self-exclusion, and for each of the gambling types included, whether that had been gambled or not during the self-exclusion period.

Among those endorsing the self-exclusion item, one individual reported among "other" games gambled during self-exclusion that she/he mistakenly had chosen the "yes" option, and stated in free text that she/he had not self-excluded.

Problem Gambling Severity Index [PGSI, (37)] was used for the assessment of problem gambling, as in the previous study in online gamblers (33) and in other general population research from the present setting (25). As in previous studies, 0 point was regarded as no-risk gambling, 1–2 points as low-risk gambling, 3–7 points as moderate-risk gambling, and 8 points or above as problem gambling (25, 33). Other data used in the present study include gender, age (in age groups), living conditions (with several options which were *post-hoc* dichotomized as either living alone without children, or living with somebody), occupation (several options, dichotomized as either working/studying, or not), whether the respondent had ever felt a need to seek treatment for problem gambling, and questions about psychological distress. The measure of psychological distress was the Kessler-6 scale (38), consisting of six items describing mental health symptoms and scored 0–4 for each item, summarized to a total score of 0–24. The Kessler-6 scale assesses the past 6 months, and has been validated as a good measure of psychological distress (39, 40). In the present study, a total score of five or more was considered to represent psychological distress on at least a moderate level.

Gambling habits were assessed with questions about any gambling during the past 30 days for each of the gambling types displayed in **Table 1**, and for individuals denying each of the

TABLE 1 | Characteristics of the study sample ($N = 997$).

Male gender	75% (744)
Age group	
- 18–24 years	1% (11)
- 25–29 years	5% (45)
- 30–39 years	13% (134)
- 40–49 years	16% (162)
- 50–59 years	27% (265)
- 60–69 years	22% (217)
- 70+ years	16% (163)
Living alone without children	15% (246)
Employed/studying	62% (618)
Past-year gambling	
- Online casino	38% (381)
- Land-based casino	8% (81)
- Online horse betting	65% (646)
- Land-based horse betting	29% (291)
- Sports, live betting	48% (474)
- Sports, non-live betting	50% (495)
- Any sports betting	62% (619)
- Online poker	18% (178)
- Land-based poker	9% (87)
- Land-based electronic gambling machines	11% (113)
- Online bingo	22% (220)
Ever felt need to seek problem gambling treatment	
- Yes	5% (49)
- No	95% (945)
- Unsure/prefer not to answer	0% (3)
Gambling severity	
- No risk gambling	52% (514)
- Low-risk gambling	23% (230)
- Moderate-risk gambling	15% (154)
- Problem gambling	10% (99)

gambling types, the next question was asked about whether the individual had gambling on that form of gambling during the past year but prior to the last 30-day period. Here, gambling was reported as any past-year gambling, i.e., the endorsing of any of these two questions for each form of gambling. For sports betting, in the statistical analyses here, both sports live betting and non-live betting were collapsed.

Statistical Methods

Participants with and without a history of self-exclusion were compared using chi-square analyses. Among 17 cases with any missing data for psychological distress, four could be categorized as psychological distress as the available items summed up to a value of five or more, and three cases were categorized as non-psychological distress, as the sum was zero and only one item was missing. Variables with a statistically significant association ($p < 0.05$) with self-exclusion were entered simultaneously into a logistic regression analysis with self-exclusion as the dependent variable. In order to limit the number of variables entered into the model, moderate-risk/problem gambling (according to the PGSI) and perceived need for treatment seeking (both significantly associated with self-exclusion but also conceptually close to one another) were run against each other in a logistic regression, and here, moderate-risk/problem gambling was the strongest predictor, such that this variable was used in the overall regression model. In addition, within the smaller group of respondents having self-excluded, those with the longest time period chosen, and other respondents with self-exclusion, were compared with Fisher's exact test (as group sizes were small). Likewise, those reporting gambling during self-exclusion, and those who did not, were compared using the same method. Due to the low sample size in the specific comparisons within the group reporting self-exclusion, no regression analyses were carried out here.

RESULTS

Among 997 included individuals, six respondents (one percent) preferred not to answer the question about self-exclusion, whereas seven percent ($n = 65$, after correcting the option from the individual reporting a mistake) endorsed a history of self-exclusion, and 93 percent ($n = 926$) denied this. Among those having self-excluded, 57 percent ($n = 37$) were men, and 43 percent ($n = 28$) were women.

Correlates of Self-Exclusion

Individuals reporting self-exclusion were significantly younger, more likely to be female, and more likely to score above cut-off for psychological distress, whereas they did not differ with respect to living alone without children or current employment/studying. Respondents who had self-excluded were more likely to have ever felt a need to seek problem gambling treatment, and more likely to screen positive for moderate-risk/problem gambling, and specifically they were more likely to belong to the subgroup with problem gambling. With respect to gambling types, respondents who reported self-exclusion were significantly more likely to report past-year gambling on online casino, land-based casino, online poker, electronic gambling machines, and online bingo, and less likely to report any sports betting, whereas they did not differ with respect to online horse betting or land-based horse betting (**Table 2**).

In logistic regression, the reporting of self-exclusion remained significantly and positively associated with online casino gambling and level of gambling problems, and negatively associated with any sports betting, whereas age, gender, psychological distress and remaining gambling types did not remain significantly associated with self-exclusion (**Table 3**).

Self-Exclusion Time Periods

Among those reporting a self-exclusion history ($n = 65$), 23 percent ($n = 15$) reported having self-excluded for 1 month, 26 percent ($n = 17$) for 3 months, 22 percent ($n = 14$) for 6 months, 26 percent ($n = 17$) for at least 1 year, and three percent ($n = 2$) were uncertain or preferred not to report. Within the groups of individuals who had self-excluded, those reporting the longest time interval ($n = 17$) were not significantly different

TABLE 2 | Comparison of respondents with and without history of self-exclusion, chi-squared test ($N = 991$ after exclusion of six respondents with missing data for the self-exclusion item).

	Individuals reporting self-exclusion ($n = 65$)	Individuals not reporting self-exclusion ($n = 926$)	*p*-value
Age			<0.001[a]
- 18–24 years	2% (1)	1% (10)	
- 25–29 years	8% (5)	4% (39)	
- 30–39 years	29% (19)	12% (113)	
- 40–49 years	11% (7)	17% (155)	
- 50–59 years	29% (19)	26% (245)	
- 60–69 years	14% (9)	22% (208)	
- 70 years or older	8% (5)	17% (156)	
Female gender	43% (28)	24% (221)	<0.001
Psychological distress above cut-off	59% (38)	41% (373)	<0.01
Living alone without children	20% (13)	25% (231)	0.37
Employed/studying	69% (45)	61% (569)	0.21
Ever needed to seek treatment for gambling problems	22% (14)	4% (33)	<0.001
Moderate-risk/problem gambling	69% (45)	22% (202)	<0.001
-Problem gambling	40% (26)	7% (68)	<0.001
Past-year online casino gambling	89% (58)	34% (319)	<0.001
Past-year land-based casino gambling	18% (12)	7% (66)	0.001
Past-year online poker gambling	28% (18)	17% (157)	0.03
Past-year electronic gambling machines	23% (15)	10% (96)	0.01
Past-year online bingo	46% (30)	20% (188)	<0.001
Past-year sports betting (any)	43% (28)	63% (587)	0.001
Past-year online horse betting	53% (41)	65% (600)	0.78
Past-year land-based horse betting	22% (14)	30% (276)	0.16

[a]*Chi-square, linear-by-linear.*

TABLE 3 | Logistic regression of variables associated with self-exclusion ($N = 981$ after exclusion of respondents with any missing data for included variables).

	Odds ratio	95-percent confidence interval
Age	0.89	0.72–1.10
Male gender	1.20	0.63–2.29
Moderate-risk/problem gambling	3.99	2.08–7.64*
Online casino, past-year	8.02	3.34–19.29*
Land-based casino, past-year	1.39	0.58–3.33
Online poker, past-year	0.85	0.41–1.76
Land-based electronic gambling machines, past-year	0.92	0.42–2.03
Online bingo, past-year	1.40	0.76–2.60
Any sports betting, past-year	0.41	0.22–0.76*
Psychological distress	0.75	0.39–1.45

**significant association with self-exclusion.*

from others with respect to gender, age, employment, living conditions, psychological distress, or moderate-/risk or problem gambling. For gambling types, also, none reached a statistically significant association with self-excluding for the longest time interval, with the most marked differences in absolute numbers were for past-year online casino (76 percent of those reporting 1-year self-exclusion and 94 percent in other respondents reporting self-exclusion, $p = 0.07$, Fisher's exact test), electronic gambling machines (six vs. 29 percent, $p = 0.09$, Fisher's exact test), and any past-year sports betting (24 vs. 50 percent, $p = 0.09$, Fisher's exact test).

Gambling Despite Self-Exclusion

Thirty-eight percent ($n = 25$) reported gambling during their self-exclusion, 58 percent ($n = 38$) denied this, and three percent ($n = 2$) preferred not to answer. Among the 25 individuals reporting such gambling despite being self-excluded, 52 percent ($n = 13$) reported gambling during self-exclusion on online casino, 16 percent ($n = 4$) online sports betting, 36 percent ($n = 9$) land-based lotteries, 21 percent ($n = 3$) online lotteries, four percent ($n = 1$) "restaurant" casino gambling, four percent ($n = 1$) land-based gambling in private homes, four percent ($n = 1$) for illegal gambling establishments, and 20 percent ($n = 5$) other games (three of them reported horse race betting). One of the latter individuals reported having self-excluded only from casino gambling and not from horse race betting.

The respondents endorsing the "gambling despite self-exclusion" item did not differ from those denying it with respect to gender (60 vs. 55 percent men, $p = 0.71$) or problem gambling status (80 vs. 61 percent moderate-risk/problem gambling, $p = 0.10$), whereas they were marginally more likely to report ever having felt a need to seek problem gambling treatment (33 vs. 13 percent, $p = 0.06$) and tended to be more likely to report psychological distress (72 vs. 49 percent, $p = 0.07$).

DISCUSSION

The present study reports on self-exclusion in a sample of online gamblers, and in the context of a novel, multi-operator, nationwide self-exclusion system, including the variables correlating with such self-exclusion. In addition, it further elaborates on the occurrence of gambling despite self-exclusion in this context. A history of self-excluding, reported by seven percent in this sample of past-year online gamblers, was clearly more common than the figures reported from the whole general population in Sweden, where around 50,000 individuals (i.e., well-below one percent of the adult population) are so far self-excluded (34). Importantly, respondents reporting self-exclusion were more likely to have gambling problems and markedly more common to be online casino gamblers, whereas the opposite was seen for sports betting. Gambling despite being self-excluded was common, with online casino being the most common gambling form in this group. In total, the study adds to the knowledge about characteristics of individuals who choose self-exclusion from gambling, a potential harm reduction tool in a condition where treatment seeking is known to be low (11). In particular, the study adds a perspective from online gamblers specifically, and in a type of broad, nationwide self-exclusion system rarely documented in the literature.

The fact that women were more likely to self-exclude may be in contrast to meta-analysis data on land-based self-exclusion, where a majority of those who had self-excluded were reported to be men (28). Motka and co-workers summarized gender in land-based and online self-exclusions programs, separately. In land-based programs, the percentage of men varied from 45 to 72 percent, compared to the 57 percent in the present study. In online-based self-exclusion services, likely more comparable to the present system, as many as 69–95 percent were men (27). Thus, while the *Spelpaus* system can likely be more precisely compared to previous online services, the lower proportion of men among those who had self-excluded in the present study may be considered to be in contrast to previous data. Also, the percentage of women in this sample of online gamblers was higher than in the official *Spelpaus* statistics in Sweden; thus, gender differences in this online sample appear to be smaller than in gamblers in general.

Altogether, this finding from the present study, as in a previous study in online gambling (33) points to a novel trend in online gambling in the present setting, where gender differences have become narrower (25) with increasing gambling problems in women (26), and that male gender may not even be not as clearly associated with gambling problems as before (33), and where female gender is associated with the gambling types most commonly reported in populations with problem gambling. In addition, it cannot be ruled out that self-exclusion may attract women and men differently and in different phases of life. Gambling is known to have a later age of onset in women, although problem gambling in women has been described to develop more rapidly after onset, often referred to as the telescoping phenomenon (41, 42). It remains to be studied in other research whether these trajectories from gambling onset to voluntary self-exclusion may differ with respect to gender. Here, although female gender was associated with self-exclusion, this association disappeared when controlling for online casino and other correlates.

Comparisons between those who reported self-exclusion and other gamblers demonstrated a relatively clear difference with respect to the past-year gambling types included; horse race betting and sports betting were not more common (and sports betting even significantly less common) among those who had self-excluded, whereas they were instead more likely to report the online and land-based chance-based games, as well as online poker. This picture is in line with the fact that online casino is the type and modality of gambling most commonly reported by gambling disorder patients seeking treatment in the present setting (24), and in line with the overall impression of online gambling as being more hazardous (23, 43). The negative association between sports betting and self-exclusion should be seen as relative with respect to other gambling types within the present study sample; all included subjects had a certain amount of online gambling, and therefore, the negative association with sports betting still does not exclude sports betting being a risk factor of self-exclusion in comparison to the full general population, but as a negative association in comparison to online casino gamblers in the sample.

Due to the relatively low absolute numbers of individuals who had self-excluded in the study, it was not possible to fully conclude whether there are characteristics separating individuals who choose a longer time period, i.e., the longest possible *Spelpaus* which can be breached only after 1 year, in comparison to those choosing a 1, 3, or 6-month exclusion. However, socio-demographic characteristics and psychological distress were not significantly different across the groups self-excluding for 1 year vs. shorter time, suggesting that more research is needed in order to better understand mechanisms behind choosing a longer or shorter self-exclusion period. No gambling patterns differed significantly between the groups, and the non-significant trends toward lower past-year gambling for some gambling forms in the 1-year exclusion group may primarily be interpreted as an effect of the theoretically lower gambling during a year when a person is self-excluded, particularly as the study was carried out after only around 17 months of this national self-exclusion system. It is beyond the scope of the present study to assess whether a longer time period of exclusion is more efficient than shorter periods, and reasons for choosing a longer or shorter self-exclusion period will need further study, and similar research needs to be repeated in different geographical settings with diverse gambling markets. Thus, further research is needed in order to highlight whether certain gambling patterns or other characteristics are likely to

be associated with longer time periods chosen, and also, such future research may merit from studying self-exclusion systems in use for a longer time period, where, e.g., a 12-month exclusion period may also be preceded or followed by a longer period of non-exclusion than in the present relatively novel system.

It was expected that people with a history of self-exclusion had markedly more severe gambling habits, expressed both through the estimated gambling severity and through the item about perceived need for treatment. However, self-exclusion from gambling, particularly with the present system, may be chosen also by individuals who never gamble but who may want to feel safe from the risk of problem gambling, for example due to a previous gambling problem. Possibly, concerned significant others of individuals with problem gambling may potentially also decide to adhere to a non-gambling life-style and therefore to choose a self-exclusion in the absence of an own gambling problem. In addition, the present system makes direct marketing (such as through mail, e-mails or text messages) prohibited for operators to send to self-excluded individuals. As the present studied included past-year online gamblers with at least 10 occasions of such gambling, it does not give information about self-exclusion for such reasons. However, as participants were recruited from the general population due to their gambling practices, and not specifically due to a clinically diagnosed gambling problem, the present data may be a relatively good indicator of self-exclusion practices among online gamblers in this setting, regardless of the cause.

Interestingly, the significant difference in psychological distress between those reporting self-exclusion and other gamblers did not remain when controlling for other variables in the logistic regression analysis. Thus, for example due to the inclusion of problem gambling severity in the model, psychological distress did not demonstrate an association with self-exclusion over and above the difference explained by gambling patterns and other factors. However, it remains of interest to note that people who had ever chosen to self-exclude from gambling scored higher on psychological distress, again pointing to self-exclusion as a measure used to cope with problem gambling or as a harm reduction tool with or without formal treatment seeking. It remains to be studied, in other more in-depth study designs, whether specific mental health problems or psychological features may predict a willingness to self-exclude, and whether such mechanisms may remain even when controlling for the gambling pattern itself.

Gambling despite self-exclusion was relatively common in the group of gamblers reporting self-exclusion. Continued gambling despite self-exclusion has been shown to limit the effects of the intervention (44), and may seem particularly alarming given the severe consequences in an ongoing problematic gambling behavior, such as financial loss and severe mental health symptoms. There are likely no corresponding figures available for comparisons, as the present *Spelpaus* system involves all licensed gambling in the country, and therefore comparisons to more operator-specific or venue-based self-exclusions practices may be difficult. In the meta-analysis of self-exclusion interventions summarized by Kotter and co-workers, rates of "breaching" the self-exclusion (at the sites excluded from) ranged from 8 to 55 percent in exclusion systems of casinos, and 9 to 59 percent from exclusion systems from other land-based venues. As to the percentage gambling in other sites during self-exclusion, these figures ranged from 12 to 75 percent for casino self-exclusion programs, and from 23 to 59 percent for programs from other land-based venues (28). Although the programs summarized by Kotter and co-workers are all land-based, such that the comparison with the present study is difficult, a 38 percent rate of all-gambling breaching could be considered to be within the range of what can be expected from land-based self-exclusion systems. In studies assessing online self-exclusion systems, there is limited data of breaching patterns, while effects of short-term exclusion periods have been seen to be modest and in particular, self-exclusion may be less effective in individuals with the most pronounced gambling habits (45). Also, breaching self-exclusion on the present type of overall self-exclusion service involving major parts of the legal gambling market is previously undocumented, and analyses should be repeated in the present and other corresponding systems. Also, it merits further investigation whether such breaching involves illegal gambling or legal (but non-regulated in the own setting) offshore gambling operators which may theoretically involve higher risks and less of consumer protection compared to gambling occurring in the same context as available prevention and treatment tools. Likewise, it remains to be understood whether breaching self-exclusion in online gamblers can be seen as particularly hazardous or norm-breaking, given the fact that such gambling may occur in overseas sites beyond the regulatory systems of one's own setting.

In the study by McCormick and collaborators, self-exclusion violators were described not to differ substantially from those adhering to gambling abstinence; however, PGSI scores proved to be improved after a period of self-exclusion, although with less of a reduction in those breaching the exclusion (44). Although the field requires more research in different settings and across different self-exclusion program designs, it may be reasonable to hypothesize that individuals with problem gambling reporting continued gambling despite self-exclusion in the present study may represent a group corresponding to McCormick's and co-workers' description of the group improving partly but to a lesser extent than those not breaching the self-exclusion. In this sense, self-exclusion could indeed be seen as a harm reduction measure, i.e., a tool improving the clinical course although full abstinence is not achieved. While the present study is not an interventional or longitudinal study, such studies may be needed in order to further describe trajectories after exclusion from gambling.

The present study may have a number of implications for policy makers and for clinical settings, despite the relatively low absolute number of respondents with self-exclusion history and gambling despite self-exclusion. As this self-exclusion service is new, involving all licensed operators in a nationwide, authority-managed system hitherto not described, findings could be seen as preliminary and should both inform policy makers and suggest researchers to further studies in larger samples and with more in-depth study designs. However, from these findings

so far, it can at least be concluded that even an official and nationwide self-exclusion from gambling does not rule out a risk of gambling to some extent during periods of self-exclusion, at least not in the sub-population of gamblers who have a relatively pronounced online gambling pattern as in the present study. Second, the risk of continued gambling, even though the study cannot establish the exact extent of such breaching of the self-exclusion, merits further research and potentially policy changes. Thus, screening for problem gambling, in mental health treatment settings, social services or by customer credit counselors, should continue to be emphasized even in the context of self-exclusion, as the latter cannot be assumed to provide a full protection against continued gambling. Third, the present study provides further data on the link between specific gambling types and gambling problems, in particular for online casino, which had by far the strongest association to a history of self-exclusion here, even when controlling for the gambling severity measure. Online casino gamblers demonstrated higher self-exclusion than sports bettors, even within this sample of online gamblers, a finding consistent with previous findings using the same methodology as here (33); rapid, chance-based games may be particularly problematic with respect to the risk of addictive behaviors, measured here through the choice to self-exclude. These issues are of importance to assess in future studies also with larger total samples and larger numbers of individuals having breached their self-exclusion, allowing for conclusions to be drawn with greater statistical power.

The present study has limitations, which are mainly related to the use of self-reported data, and because the actual temporal association between self-exclusion periods and gambling patterns, treatment needs or mental health could not be detected. The sample included depends on the population enrolled with an online web panel, and as shown in a previous study using the same methodology, this may include respondents with higher levels of income or education, than in the general population (33). Also, as the present study assessed online gamblers specifically, as the aim was to do so, conclusions cannot be drawn about how self-exclusion is used by gamblers who use exclusively land-based gambling types. Likewise, in addition to the present, first findings from a novel multi-operator self-exclusion service, further studies should provide more in-depth knowledge about gamblers' reasons for self-excluding with this particular type of system, and other qualitative aspects on how self-exclusion is perceived. While such study aims go beyond the ones of the present study, these aspects are likely to be of great relevance in order to optimize self-exclusion systems and increase their availability.

In addition, the study was carried out during the COVID-19 pandemic, and it is difficult to know whether that has an impact on data collection and findings in the study. Concerns have been raised about potential changes in gambling habits due to COVID-19, for example due to home confinement, time spent online, or lock-down of sports events (46), and these fears have led politicians to harm-reducing policy changes (although occurring in Sweden at a later date than the present data collection, 35). Theoretically, inclusion criteria, which referred to a gambling patterns on ten times or more during the past year, should not be severely affected by the COVID-19 and its impact on sports events. Within the present dataset, several land-based and sports-related gambling types could be suspected to be lower during the past 30 days than in a similar study carried out with the same inclusion criteria in 2018 (33), whereas online horse race betting appeared instead to be more common than in the comparison study from 2018. Likewise, individuals still reporting to gamble recently on the gambling types theoretically affected by the pandemic (i.e., those likely affected by lower attendance to land-based contexts and the short-term shortfall of sports events) appeared to have more gambling problems than other study respondents (31). Although COVID-19-related change in gambling has been reported to be modest (35), it cannot be excluded that the halted sports betting opportunities during the recruitment period may have influenced web panel members' perception of their own gambling habits. In addition, the study is conducted in only one country, and in a sample of active past-year online gamblers, such that rates of gambling problems in the whole study sample are naturally higher than in the general population, and generalizability to other countries or to populations of exclusively land-based gamblers may be limited.

Thus, while the potential impact of COVID-19 on study recruitment and past-30-day gambling reports is a limitation, this limitation should not be exaggerated, as the data reported in the study include any gambling on each specific gambling type, *either* during the past 30 days, *or* during the year prior to that. Also, a fully reliable sensitivity analysis, with respect to non-recent gambling in order to exclude the COVID-19-affected period, could not be conducted, as the data referring to the year prior to the most recent 30-day period was reported only for those denying each of the gambling types during the past 30 days. However, altogether, the choice to address each gambling type with a time frame ranging from either a very recent one, or a more longstanding one (far prior to the pandemic), should make the findings of the study more reliable. Also, it should be born in mind that the present study aimed to analyze gambling behaviors in online gamblers, defined with at least ten gambling sessions online such as on online casino or online betting. Thus, the gambling pattern for which they were included in the study was not primarily affected by the COVID-19 pandemic; although the content of the gambling during the most recent period may have changed, the possibility to gamble online was not technically affected by the pandemic, and consequences are likely more related to land-based gambling opportunities (31).

Also, an online survey necessarily limits the possibility to use longer or more extensive diagnostic tools, although problem gambling and psychological distress were measured using established tools. Another limitation, partly related to the necessarily brief format of a web survey, is that some further individual characteristics could not be investigated, such as a more thorough picture of the respondents' socio-demographic situation. For example, the present study in online gamblers did not address the geographical location,

including the urbanicity or socio-economic situation of the respondents. Socio-economic situation is likely to affect the risk of problem gambling in general, as demonstrated in previous research (25, 47), including the geographical area of residence (47). Although it is less known whether this affects online gambling patterns as much as land-based gambling, more in-depth information about the living situation of the participants would have been of value. In addition, future research should assess similar broad self-exclusion systems after being in use for a longer time, as a person self-excluded a year prior to the study has been excluded from gambling for a large proportion of the time the system has been up and running, making it less likely for such a person to be included in the study. Still, however, the present study provides a broad picture of a relatively large sample of online gamblers, but future research may need to assess either larger samples or specifically recruited individuals with experience of self-exclusion.

In conclusion, assessments of multi-operator official self-exclusion systems are previously lacking, and the present study is therefore the first to elaborate of risk of breaching such a multi-operator self-exclusion. The present study concludes that online casino was strongly associated with a self-exclusion history, in contrast to sports betting, and that individuals with self-exclusion expectedly had higher degrees of gambling problems. The study also concludes that gambling despite self-exclusion, even in a broad nationwide multi-operator system, remains a challenge in online gamblers. Thus, while self-exclusion is a promising tool for prevention and harm reduction, more research is needed in order to evaluate and optimize its effects.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because Datasets are available after review by the ethics authority. Requests to access the datasets should be directed to anders_c.hakansson@med.lu.se.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Etikprövningsmyndigheten (Swedish Ethical Review Authority). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AH and CW both contributed to the overall research idea. AH was the main responsible of the data collection, and wrote the first draft of the paper. CW made substantial contributions to the text of the manuscript and its overall design. Both authors approved the final version of the paper, results were interpreted, and discussed.

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Reducing Internet Gambling Harms Using Behavioral Science: A Stakeholder Framework

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Internet gambling provides a unique environment with design mechanics and data-driven opportunities that can impact gambling-related harms. Some elements of Internet gambling including isolation, lack of interruption, and constant, easy access have been argued to pose specific risks. However, identifiable player accounts enable identification of behavioral risk markers and personalized private interfaces to push customized messages and interventions. The structural design of the Internet gambling environment (website or app) can have a strong influence on individual behavior. However, unlike land-based venues, Internet gambling has few specific policies outlining acceptable and unacceptable design practices. Harm minimization including responsible gambling frameworks typically include roles and responsibilities for multiple stakeholders including individual users, industry operators, government regulators, and community organizations. This paper presents a framework for how behavioral science principles can inform appropriate stakeholder actions to minimize Internet gambling-related harms. A customer journey through internet gambling demonstrates how a multidisciplinary nexus of collaborative effort may facilitate a reduction in harms associated with Internet gambling for consumers at all stages of risk. Collaborative efforts between stakeholders could result in the implementation of appropriate design strategies to assist individuals to make decisions and engage in healthy, sustainable behaviors.

Keywords: gambling (gaming), online, internet, technology, addictive behaviors, nudge design, behavioral science, persuasive design

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INTRODUCTION

Gambling is a relatively common activity, however, for a minority of people gambling can lead to the development of gambling disorder, a mental disorder categorized as a behavioral addiction. Gambling disorder is highly co-morbid with other mental disorders and is characterized by a preoccupation with gambling and persistence and lack of control despite wide-spread negative consequences (1). Gambling problems may include sub-clinical but serious harms, which are experienced by 0.4–2.0% of adults

internationally (2). Of those who experience gambling problems, the minority (7–29%) will seek treatment for these problems (3). The global online gambling market is expected to grow 13.2% between 2019 and 2020, from USD$58.9 billion to USD$66.7 billion (4). This growth appears to be due to COVID-19, which is limiting access to land-based gambling opportunities and resulting in more people gambling online.

Internet gambling occurs in a unique environment containing design mechanics and data-driven opportunities, with the potential to impact gambling-related harms. Just as the layout of land-based venues has been shown to influence gambling behavior (5–7), the design of websites has been shown to influence general ecommerce behavior (8). However, there has been minimal research investigating the impact of the design of Internet gambling websites. Some elements of Internet gambling, including isolation, lack of interruption, and constant, easy access, have been argued to pose specific risks (9). There is minimal research to guide evidence-based policies to design a sustainable online gambling environment in which individuals gamble at a level that is affordable for them and free from coercion or undue influence. We present here a framework for the role each key stakeholder can play in reducing harms from Internet gambling.

Persuasive design combines the theory of behavioral design with computer technology (10) and has been popularized by nudge theory (11). Nudge theory uses choice architecture and choice framing to ask questions in a way that nudges individuals' behavior in certain directions without restricting the available options–such as through opt-out default retirement funds. Systems of rewards and punishments in online gambling products are designed to encourage continued use and attention, additional payments, or other behaviors that are not always beneficial to the user, or consistent with their own plans and values. Examples include push notifications of time-limited promotional offers or matched deposits with complicated terms and conditions and limited benefits for users; excessive friction creating difficulty in withdrawing deposited funds; targeted push messages promoting a betting or spending options matching the user's profile ("people like you bet on…,"); and encouraging continuous use by eliminating natural breaks in play or the ability to pause (e.g., infinity scrolling). Most of these features are effective as they exploit natural human weaknesses in exercising self-control (12). In the heat of the moment, people often make decisions that favor immediate pleasure over later costs, in a way that is not consistent with their initial plans. Online gambling providers exploit this universal feature of human behavior to encourage more time and money spent on gambling.

On a positive side, behavioral science can identify nudges that steer users toward healthier levels of engagement with online gambling (which, for some people, may not include any gambling). Technological nudges are adaptable across settings with varying political and societal preferences around autonomy and paternalism, as the strength of the nudges can be adjusted accordingly. Software has been developed to monitor gambling and user activity, identify risk indicators, and enable well-timed interventions, including personalized, normative feedback, and encouragement to moderate play through pre-commitment devices (13–15). Dynamic messages can create a break in play and encourage self-appraisal (16, 17). Electronic gaming machines have been developed with customisable alarm clocks and ring-fenced winnings to prevent re-gambling (18). Digital wallets can limit gambling expenditure and provide personal feedback on gambling spend (19). Design options may include "plain packaging" for gambling sites (minimizing color and graphics), increasing friction by requiring users to click through different pages to access different betting/game options, creating pauses to slow the betting speed, reducing defaults bets, and requiring users to confirm bets and manually entering the amount, using default automated withdrawals of winnings, and default opt-out of notifications and marketing.

Policies based on behavioral science principles have been shown to be effective in influencing consumer behavior, including where personal risks are possible (20), although these have only recently been considered for gambling policies (21–23). This paper aims to present a framework for how behavioral science principles can inform appropriate stakeholder actions to minimize Internet gambling-related harm, with a focus on how technology can impact harms.

FRAMEWORK

There is a web of interacting factors that influence gambling related harms—including individual cognitive and personality characteristics of gambling users; various enticements and subtle influences used by gambling providers; cultural and social factors; availability of alcohol; and of course, individual choice. Opinions differ on who among those involved in the gambling experience ought to be responsible for reducing those harms. However, all those involved can, if they wish to, implement measures to do so.

Customer journey maps visually represent user experiences in using services such as gambling websites (24). We use this method in **Figure 1** to illustrate (1) a hypothetical journey of escalating harms from online gambling that a customer, "Joshua" could take, and (2) the roles different stakeholders could play at each step of the journey in order to alter its course toward a lower level of harm. We intend this map to highlight pivotal points from a user perspective and provide tangible calls to action for all stakeholders.

Individual Users

There is a range of actions that individuals can take to decrease the chance that their online gambling behaviors cause harms for themselves, their families, and their communities. Individuals should inform themselves about the risks and persuasion associated with website features. With such knowledge, individuals will be better placed to select regulated websites that employ responsible design, to turn off any default persuasive design elements, and to select the settings they prefer. This could include disabling features that nudge users toward continued gambling. At the same time, some individuals will find it difficult to make informed decisions about gambling due to factors such as comorbid conditions, addiction, or impulsivity that make it more difficult to exercise self-control. This speaks to

Joshua, 20s, male

Once Joshua begins online gambling, he moves along a trajectory of increasing harms. First, he begins gambling recreationally without experiencing problems. Then he begins to experience occasional negative consequences (low-risk gambling), increasingly loses track of time and spends more than he can afford (moderate-risk gambling), before experiencing significant problems and feeling very distressed and guilty (problem gambling).

Observe the actions that Joshua and other stakeholders could take at each step to prevent this escalation and help Joshua gamble recreationally or not at all.

No gambling

Individual considers the reputability, terms, conditions, and default settings of any gambling website before joining

Financial institutions enable accounts and cards to be automatically blocked from gambling sites

Regulators create policies to restrict the content, location, and timing of advertisements for gambling websites to non-users

Recreational gambling

Individual easily opts out of personalised advertising

Gambling industry immediately verifies new users for age and against a centralised self-exclusion database

Researchers quantify the degree of impact of each website design feature and identify 'healthy' nudges

Regulators ensure products are verified to have no features that could encourage excessive use

Low-risk gambling

Researchers identify factors that predict or lead to escalation of harm to enable well-timed interventions

Community groups increase awareness of user-friendly resources on available consumer protection tools and self-regulation strategies

Financial institutions provide regular digital summaries of gambling spending across operators and over time

Moderate-risk gambling

Individual uses available tools such as pre-commitment and self-imposed limits on time on site

Gambling industry uses play monitoring with algorithms to detect risky play and lead customised, targeted interventions including pop-ups with information about consumer protection tools

Problem gambling

Financial institutions identify individuals with markers of risk gambling and stop access to credit and encourage them to self-imposed spending limits or blocks

Community groups facilitate access to treatment for those individuals seeking this support

Regulators commission ongoing research to identify factors associated with problem gambling and trial policies to prevent harms

FIGURE 1 | Hypothetical customer pathway illustrating appropriate stakeholder interventions according to level of gambling behavior and harm. For context, on average, 60–70% of individuals fall into some category of gambling behavior per year, with 1–2% falling in the "problem" category; however this varies between jurisdictions (25).

the necessity of this broader framework that identifies roles for multiple stakeholders.

Similarly, individuals should inform themselves about tools available to reduce harms. These include consumer protection tools such as self-exclusions and limits (26), but may include more general self-regulation tools that can be implemented in any behavioral domain to reduce the need to exercise self-control in the moment (27). Apps and software can be used to limit and restrict access to specific apps/websites, and limits can be placed on payments and access to credit. Users may avoid features that minimize friction to provide greater opportunities for self-reflection. For example, by avoiding options to remain signed-in to accounts for betting and avoiding saved passwords, requiring manual entry of passwords. At the beginning of a gambling session, an individual may set a timer on their device with an alarm to subsequently signal the planned end of the gambling session. Such strategies are only likely to be adopted by individuals who are motived to regulate or reduce their gambling (27, 28). Other individuals will likely view these strategies as a hindrance toward their goal of gambling, which might be meeting needs for relatedness, competency, or mood modulation (29–31). Knowledge of available tools combined with a desire or willingness to use them might be helpful to minimize the intention-behavior gap and self-control issues (27, 28). There are many tools available to assist individuals to enforce their planned behaviors if they have the knowledge and motivation to use these and autonomy to make informed choices.

Community Groups

Community groups are typically non-profit organizations (may be large or small and focus on broad or specific issues or target groups) that are established and operated independently from governments and are typically funded from a range of stakeholders, commonly governments or charity donations. These groups have the capacity to provide education and outreach to communities, mobilize resources, advocate for citizens, challenge policy, and conduct various projects to

impact communities. Community groups can collaborate with other stakeholders to reach shared goals, such as working with researchers to create and disseminate up-to-date communication materials about risks and protective strategies in formats that are accessible to individuals. In collaboration with researchers, community groups might also provide tools to individuals to help them understand their own personal risks of gambling harms, such as self-assessment quizzes with personalized feedback. These strategies might help to shift their individual attitudes toward gambling (28). Community groups can work in an advocacy role to convey the needs and concerns of individuals to regulators. Efforts are needed to ensure funding received from stakeholders is provided in an independent manner without restrictions and involvement by the funding body to minimize conflicts of interest and funding should not be reliant on gambling expenditure.

Gambling Industry

The gambling industry is responsible for ensuring that websites, apps, products, offers, marketing, and communication are designed to facilitate the customer's need for autonomy (31), encourage gambling only at personally affordable levels, and reduce the risk of foreseeable harms. Operators should avoid using overly persuasive design elements as this violates the principles of autonomy and informed choice. Features to avoid could include those which create a sense of urgency (e.g., countdown timers on bets and promotions), that distort attitudes by creating overly optimistic perceptions of the chance of winning or reduce the perceived likelihood of losing (e.g., dynamic leader boards of recent winners, money back guarantee bets) (28), providing irrelevant information that perpetuate erroneous beliefs (e.g., providing details of previous wins in independent events such as winning lottery or roulette numbers, time since last jackpot, location winning lottery tickets were sold) (28), promoting irrelevant information to perpetuate social norms (e.g., most popular bets, number of active users) (28), or that act to reduce the opportunity to reflect on the decision to place a bet or make a deposit (e.g., prompted bet size, frictionless betting).

Gambling industry operators have a responsibility to "know their customer," to verify a customer's identity prior to accepting any bets, and to avoid exacerbating any harms experienced by customers who are identified as at-risk or already experiencing gambling-related problems. Verified player accounts enable identification of behavioral risk markers and personalized private interfaces to push customized messages and interventions (32, 33). For example, operators could delay sending promotional offers until they have a good understanding of their customers and use continuous monitoring programs and algorithms to identify customers with risk indicators and respond appropriately with messages to encourage use of consumer protection tools, phone calls to check in with customers, or automatic blocking of promotions and marketing materials (26).

In addition to the avoidance of harm (principle of nonmaleficence), website operators also have the opportunity to do good for their customers (principle of beneficence) (34). The gambling industry could implement consumer protection tools as the (modifiable) default option. For example, a time "limit" could be placed on all users, whereby a message alerts users when they have gambled for the limited time, and requires users to change the default settings if they wish to gamble for longer. Users could be shown pop up displays summarizing their behavior in comparison to that of other users (personalized, normative feedback) thereby potentially shifting their attitudes and social norms (28), directing the user to information about consumer protection tools that are available to them (e.g., spending limits and self-exclusion), and creating friction by using pop-up messages and breaks in play to prompt the user to pause and reflect (e.g., please confirm that you want to place your xth bet for this week) (35, 36). To preserve autonomy (31), customers should be able to turn on (opt-in to) notifications and marketing and turn down (opt-out of) restrictions such as deposit limits; however, by making these active choices operators are prompting sustainable gambling–that is, gambling within their financial means and without associated harm/s. To ensure they are effective and well-received, the exact content and delivery of interventions should be negotiated in collaboration with other stakeholders–particularly users and researchers.

Government and Regulators

Like industry operators, governments and regulators have a responsibility to ensure that all legalized products and activities contribute to the public good and do no harm. Governments should consider approving non-exploitative forms of gambling, as well as consumer protections. Regulators and policy makers have a responsibility to commission research to guide the development of policy options, review evidence to inform these, and seek consultation from other stakeholders and the public, to ensure that industry standards conform to social expectations. As technology continues to evolve, it is likely that commissioned research will be needed to analyse of the impacts of individual website features and assess those impacts for harm. Experience from venue-based gambling regulation could also be expected to inform online gambling regulation where the former includes regulation of ambient and other factors that create unacceptable risks for gambling users. Regulatory and policy direction is increasingly focusing on online gambling as it steadily increases as a proportion of gambling activity. As with all tech regulation, the challenge will be to create policies that are specific enough to be effective, but also future proof. As the gambling environment is impacted by multiple layers of regulation, across jurisdictions, inter-governmental coordination on the relevant issues will also be critically important.

Financial Institutions

Financial institutions including banks and credit providers are able to contribute to reducing harms from online gambling by providing consumer tools to assist individuals to manage their online gambling spending and using algorithms to identify indicators of risky gambling (37). Financial institutions could

provide individuals with comprehensive activity and expenditure statements collating all gambling spending in one place and as a proportion of income and discretionary expenditure. Statements could be an easily accessible way to communicate to customers evidence of risk indicators such as increased gambling spend or frequency in relation to previous time periods and relative to income and other expenses. Financial institutions could provide products with voluntary or default gambling spend limits or blocks and notify customers as they are approaching their limits. Non-gambling products could be developed and marketed to those who wish to opt-out of gambling completely, such as for adolescents and those who identify themselves as at-risk due to their personal situations. It is difficult for financial institutions to limit customers in spending their own money; however, there may be a duty of care implication related to offering credit to customers for the purposes of gambling given the demonstrated relationship between consumer debt and gambling problems (38, 39).

Researchers

There is a role for researchers across academic disciplines in working together to ensure the evidence supporting each element involved in reducing harms from online gambling is robust. Research should focus both on the elements of the online environment (and their interactions with user characteristics) that can cause harm, as well as mechanisms of harnessing technology to prevent harm. Research should investigate mental health issues specifically associated with online gambling. These can contribute to functional impairment and include depression, suicidal behavior and proneness to psychoactive substance misuse, among other issues. Cross-disciplinary researchers can use behavioral economics theory and apply a variety of methods to identify the existing persuasive elements of the online gambling design, identifying nudges that will help maintain healthy levels of gambling without restricting autonomy of the players (31), as well as quantifying the degree of impact of persuasive design features on gambling behavior and harms. Reliable indicators of the size of effects of different features are needed to inform good policy about their use and to identify priority areas for policy development. Specific attention could be paid to those features already in use, such as financial incentives (40), time-sensitive promotions (41), targeted advertising, default site settings, and displays of "latest winners" (41).

Researchers can use the existing data to create models that will identify at-risk individuals from their usage patterns before life-changing harm occurs. In collaboration with industry operators and financial institutions, this research could inform algorithms to identify at-risk individuals in practice and deliver automatised, personalized intervention or prevention strategies. Research should focus on the multiple harms related to online gambling. The intersection between online gambling, fraud, theft, and violence-related offenses, for example, could usefully be explored by criminologists. Such insights will help in arguments regarding policy and regulatory responses required to minimize harms.

For maximal real-world impact, researchers across disciplines must be responsive to the needs and opinions of the other stakeholders with respect to priority research areas. This could involve proactive involvement of stakeholders into research design and dissemination and implementation of findings, as well as reactive design of research to address issues identified by other stakeholders. This will ensure that the research being conducted continues to address evolving real-world problems. All stakeholders should work with researchers to develop, test, and evaluate policies and strategies designed to minimize harms and to check for any unintended negative consequences.

CONCLUSION

This paper aimed to describe a framework of opportunities by which different stakeholder groups can contribute to the shared goal of reducing harm associated with online gambling. The value of this framework is that it makes explicit the roles and responsibilities of each stakeholder. In addition to those roles listed above we propose open and transparent collaborative communication between stakeholder groups as a role for all stakeholders. This is particularly important in the field of (Internet) gambling when stakeholders can hold competing interests. For example, operators' commercial imperatives compete with their need for corporate social responsibility and duty of care. Taxation revenue benefits must be balanced against governments' need to minimize harm caused by legal activities. Users face a conflict between possible long-term harms and short-term enjoyments. Community groups need to balance the needs of a minority who experience significant gambling-related harms with those who enjoy gambling and want to make autonomous choices. We intend this framework to be a step toward acknowledging and mediating these competing interests. This framework is intended to be preliminary and to facilitate discussion. As such, we welcome comments on further roles not described here that any of these stakeholder groups could play as well as suggestions of other stakeholder groups who could play a role in reducing online gambling harms. We also hope that it will serve as a structured outline of the types of harm-reduction strategies that warrant further investigation to determine their effectiveness, as this empirical evidence is somewhat limited with respect to Internet gambling.

Practical steps can be taken to achieve collaboration between stakeholders to reduce Internet-gambling-related harms. Actions that facilitate communication between stakeholders could include conferences and roundtables dedicated to this purpose. Such events will increase the knowledge held by each stakeholder of the others' roles, values, and motivations, which will ultimately lead to more effective communication. Co-funding, co-design, and co-evaluation of projects are further ways in which stakeholders could make tangible strides toward the shared goal. Behavioral science principles respect individual autonomy, allowing modifiable restrictions to be used to protect the at-risk minority. They may be imposed by regulators

or implemented by operators as a form of self-regulation and corporate social responsibility, or even a marketing strategy to attract customers. In any case, design strategies can assist individuals to make decisions and act in ways that contribute to a healthy and sustainable lifestyle and overall wellbeing.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

SG and AB conceived of the paper idea. SG and NB drafted the manuscript. All authors contributed to and revised the manuscript critically and approved the final version for submission.

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ORIGINAL RESEARCH
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Effects on Gambling Activity From Coronavirus Disease 2019—An Analysis of Revenue-Based Taxation of Online- and Land-Based Gambling Operators During the Pandemic

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Background: Concerns have been raised about increased gambling problems during the coronavirus disease (COVID-19) crisis, particularly in settings with high online gambling and risks of migration from land-based to riskier online-based gambling types. However, few non-self-reported data sources are hitherto available. The present study aimed to assess changes in the online- and land-based gambling markets in Sweden during the first months affected by the societal impact of COVID-19.

Methods: Data were derived from national authority data describing monthly taxations of all licensed Swedish gambling operators, whose monthly tax payments are directly based on gambling revenue. Subdivisions of the gambling market were followed monthly from before COVID-19 onset in Sweden (mainly February 2020) through June 2020, when the sports market was restarted after COVID-19 lockdown.

Results: Overall revenue-based taxations in the licensed gambling decreased markedly from February to March, but stabilized onto an overall modest decrease through June. Commercial online casino/betting, despite some decrease in March, was maintained on a relatively stable level through June. However, within this category, horse betting increased steeply during the pandemic but returned to prepandemic levels later during the period. The state-owned operator in betting/online casino decreased markedly throughout the pandemic. The remaining commercial operators, mainly in online casino and online betting, demonstrated no change during the pandemic and ended on a June level 14% above the February level. Throughout the pandemic, the smaller restaurant casinos decreased markedly, while major state-owned casinos also closed entirely. State-owned lotteries and electronic gambling machines decreased markedly but were rapidly normalized to prepandemic levels.

Conclusions: Commercial online gambling operators' revenues remained stable throughout the pandemic, despite the dramatic lockdown in sports. Thus, chance-based online games may have remained a strong actor in the gambling market despite the

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COVID-19 crisis, in line with previous self-report data. A sudden increase in horse betting during the sports lockdown and its decrease when sports reopened confirm the picture of possible COVID-19-related migration between gambling types, indicating a volatility with potential impact on gambling-related public health.

Keywords: gambling disorder, online gambling, behavioral addiction, COVID-19, sports betting, online casino, land-based casinos

BACKGROUND

Emerging research has highlighted that the coronavirus disease (COVID-19) pandemic may cause or worsen mental health problems (1) and that this may include addictive behaviors and addiction-like online behaviors (2, 3). Among the latter, problem gambling has been mentioned as a potential consequence of the pandemic and the restrictions surrounding it (4, 5).

Mechanisms potentially increasing gambling behavior during COVID-19 may include effects from the financial crisis and unemployment caused by the pandemic, but also, home confinement and changes in employment and everyday habits may enhance people's time at home and increase the time spent online. Likewise, the nearly total lockdown in sports events in most parts of the world during the early phases of the pandemic changed the gambling market significantly, logically leading to decreased gambling on sports events otherwise popular in gamblers (4). In March 2020, several countries took action in order to prevent a transfer to potentially more addictive types of gambling. Policy makers have expressed fear of gamblers switching to other gambling types, and that such a transfer in gambling habits may push gamblers or subpopulations of gamblers toward more rapid, online-based gambling types (6).

A self-report survey study in Sweden demonstrated that only a relatively limited minority of the population reported an increased gambling behavior during the early phases of the pandemic, but also that this subgroup had markedly higher rates of problem gambling than those reporting decreased or unaffected gambling (7). Likewise, another recent survey study from the same setting displayed findings in line with this; past-month gambling during the spring of 2020 was markedly lower for some gambling types compared to a previous report from the same setting, whereas some other gambling types appeared to be more preserved despite the pandemic. Typically, the more land-based gambling types were more affected by COVID-19-related lockdown and restrictions, whereas online gambling types appeared to be less affected (8). While such findings rely on self-reported data from survey respondents, objective data on gambling activities are needed, in order to demonstrate possible changes and transfers of gambling habits within the gambling market and between different types and modalities of gambling. One study on measured gambling data from one (anonymous) gambling operator demonstrated a modest impact from COVID-19 on gambling behavior, such that migration from sports betting to online casino within that specific operator could not be demonstrated (9). In contrast, however, a different study conducted in Ontario, Canada, demonstrated that some migration was likely between gambling types, due to the pandemic (10). Thus, findings are hitherto diverse with respect to the pandemic's consequences on gambling behavior, and further data are needed, if possible from objective sources of non-self-report gambling data.

Thus, the present study used official, national authority data on revenue-based taxation from gambling operators, aiming to study measures of financial activity in the overall legal gambling market in Sweden and the activity of specific subsections of the market. In the study, it was hypothesized that activity in the gambling market would have decreased in the gambling types related to sports events and other land-based gambling and that an increase may be possible in online-based gambling involving other types of gambling. Also, the study aimed to study whether decreases in some gambling types may be fully or partly counteracted by increases in other gambling types.

METHODS

Variables

Data were derived from the Swedish Gambling Authority and included figures describing the monthly taxation of each of the gambling operators licensed for operation in Sweden. Gambling taxation equals 18% of the net revenue of the gambling operator (11) and is paid on a monthly basis to the Swedish national taxation authority. The data included in the present analysis can be applied for by individuals, media, and other organizations from the gambling authority or from the taxation authority and are available under the act making a broad range of governmental and authority documents and correspondence publicly available upon request. Data include no information on individual gamblers. Taxation from private companies in Sweden can be corrected up to 6 years later, for example in order to correct errors in the total revenue reported, but monthly revenue, and thereby the taxation level calculated from it, is considered a reliable source of gambling activity in the market, such that it is used by the Swedish Gambling Authority for the reporting of national gambling data.

Data were derived from the Swedish Gambling Authority during August 2020, when full monthly taxation data were available for all months from January 2019 (onset of the current regulation and taxation practices) through June 2020. Data used here included the months from January 2020 through June 2020. Data represented the full monthly taxation for each of the months, in Swedish currency (Swedish krona, 1 krona corresponding to around 0.10 Euros). For the best comparison possible, data were also reported for the same months of 2019, although direct comparisons are likely difficult, as the current gambling license system was introduced in January 2019 (11),

such that the first months of 2019 may have been affected by the recency of new regulations at that time.

Setting

Gambling operators are obliged to be licensed in Sweden in order to operate physically within the borders of Sweden or in order to operate online with their seat in Sweden. The registration in Sweden is mandatory for the use of Swedish money transfer instruments to a gambling account and for broadcasting in Swedish media sources (11). This legislation was initiated on January 1, 2019, and before that date, a large number of operators in the Swedish market were overseas companies operating from other EU countries but advertising and offering gambling in Swedish media channels and attracting a substantial proportion of Swedish gamblers. Thus, even before the introduction of the present legislation, online casinos were all operating from abroad while formally prohibited within Sweden, but still represented the most common gambling type reported by treatment-seeking gambling disorder patients (12) and the most common gambling type seen in television advertisements (13). Legal gambling types in Sweden, according to the updated legislation, are online casinos, land-based and online betting on sports and horse races, charity-based and other land-based and online lotteries (commercial and carried out by a large number of operators), land-based casinos in four major state-owned casinos across Sweden, and land-based electronic gambling machines (all state-owned in a monopoly situation), as well as a more limited market involving private restaurant-based casino games under a stricter regulation with limited deposits. In addition, relatively limited gambling activities in funfairs and similar events are legal but regulated. In the present study, charity-based lotteries are not included in the data. One state-owned gambling operator (*AB Svenska Spel*) operates in three subdivisions: in the monopoly position involving the four major land-based casinos and land-based gambling machines, and in two commercialized subdivisions operating in sports betting and online casino, and in lotteries and other chance-based number games, respectively. Thus, this state-owned company acts in a monopoly situation in some of these sectors (major land-based casinos and electronic gambling machines) and as one of the competing operators in the market of online casinos and sports betting. In the latter market, one further operator is the major organization of the Swedish horse racing industry (ATG, *Aktiebolaget Trav & Galopp*), which offers sports betting and online casino as well, but which traditionally plays a predominating role in land-based and now also online-based horse race betting.

An overall impression from the Swedish gambling market is the large share of online-based gambling in its exposition in advertisements (13) and in problem gamblers (12, 14). Trends in recent years have described a decreasing number of people reporting any past-year gambling (15), but a growing subgroup who fulfills the criteria of problem gambling in public health surveys. In total, between 1 and 1.5% of the adult population are believed to be moderate-risk problem gamblers, and the percentage of women among problem gamblers has been reported to increase in recent years (16). Also, while a majority of treatment-seeking patients with gambling problems are men (12), among online gamblers, female gamblers even have shown to have a higher risk of having gambling problems (14).

COVID-19 started to affect the Swedish society substantially during the month of March 2020 after a first case was detected in late January and the second case reported in late February. A series of events in mid-March marked the most dramatic impact of the pandemic, with travel restrictions, work-at-home recommendations, severe effects on financial markets, and restrictions on public gatherings. In parallel with this, during March, several major soccer leagues and other sports events were canceled or postponed, such that at the end of March, only a very limited number of less-known soccer leagues in the world were still operating. Thus, to an increasing extent throughout the month of March, in Sweden, the impression of COVID-19 consequences on society is likely to have been at its peak, with April leaving early recommendations unaltered and with a peak daily number of COVID-19-related deaths reported on April 7. In May, some major soccer leagues restarted and the opening of further European leagues was announced and thereafter took place in June. In mid-June, the Swedish soccer league reopened (**Table 1**).

While online casinos (and similar chance-based games, such as online bingo and similar games) and online sports betting represent different kinds of gambling, companies involved in any of them typically have a license for both, making it possible to offer gambling services in both these commercialized products, such that their respective share of the market cannot be easily separated from national market statistics. Thus, in the present analyses, and due to the large involvement of online gambling in Sweden, the subdivisions of the gambling market are reported as follows: state-owned land-based casino (one operator, state monopoly), limited-deposit land-based restaurant casinos (29 private operators), state-owned lotteries and electronic gambling machines (one state-owned operator), and commercial operators in online casino and online/land-based sports/horse betting (77 operators, including one state-owned operator, one private and predominating horse betting operator including land-based horse betting, and 75 private companies operating in online casino or online betting). The limited number of funfair games and similar events (three operators), lotteries and bingo operators without taxation data, and one private non-profit association organizing card games are not displayed in the table.

Statistical Methods

Taxation data were compared, month by month, with respect to the full gambling taxation for the entire Swedish licensed gambling market and, also, with respect to the specific subtypes of gambling. In addition, data from minor gambling activities in festivals, funfairs, and similar events were reported for descriptive purposes. For each month of reported taxation, this was compared descriptively to the month of February, considered to be the last full month during which sports events, national financial markets, and public health were considered virtually unaffected by the COVID-19 pandemic (**Table 2**). As a comparison, the corresponding comparisons (each of the months, March through June, compared to the February levels) were also reported (**Table 3**). However, further statistical analyses

TABLE 1 | Time schedule of major COVID-19-related events in society and sports affecting Sweden.

Month, 2020	Date and event
January	January 31st—first confirmed case reported in Sweden
February	February 26th—second confirmed case reported in Sweden
March	March 9th—Italian male soccer league canceled March 10th—restriction of public gatherings to a maximum of 500 people in Sweden March 11th—first confirmed COVID-19 death in Sweden March 12th—historic baisse in the Stockholm stock market (−11%) March 13th—French male soccer league suspended March 14th—Swedish government advice not to travel to other countries March 15th—decision to suspend remaining ice hockey season in Sweden March 16th—advice to work at home, advice for elderly 70+ to stay at home in Sweden March 17th—advice to all high schools and universities in Sweden to conduct their studies online March 17th—decision to postpone Euro soccer 2020 for men March 19th—decision to postpone Swedish top-two leagues of male and female soccer March 20th—Volvo cars stop all production in Sweden March 20th—new crisis intervention from government to businesses in Sweden and a support intervention for sports and culture in Sweden March 24th—decision to postpone the 2020 summer Olympics in Tokyo March 27th—public gatherings of more than 50 people prohibited in Sweden March 30th—Swedish business newspaper *Dagens Industri* reports that the only soccer leagues still playing are Belarus, Nicaragua, Burundi, Turkmenistan, and Myanmar.
April	April 1st—international media report unexpected attention to low-tier Swedish soccer leagues due to lockdown of more established sports in Sweden April 7th—top number (through September, 2020) of COVID-19 deaths in Sweden
May	May 6th—announcement that male Bundesliga starts on May 16th May 9th—Korean soccer league started May 16th—start of German Bundesliga May 29th—decision that the highest league in male soccer in Sweden can start June 14th, other soccer leagues later May 29th—decision that La Liga Spain will start on June 11th
June	June 11th—start of Spanish La Liga June 14th—first game in Swedish top league in male soccer June 17th—first game in Premier league

were not carried out, as the present system of licensed gambling was introduced in January 2019. Thus, the corresponding period of time during 2019 also may not be fully representative, typically for gambling types which had previously been offered by overseas non-licensed companies and which were transferred to the legal gambling market in 2019.

RESULTS

Overall Gambling Market

The overall level of gambling taxation decreased from February to March by 17%, but recovered partly in April to a level at 5% below the February level. At the end of the study period, in June, the overall level remained at 5% below the February level.

In the comparison year of 2019, the overall market increased in March, April, and May by 10, 10, and 8%, respectively, compared to the February level, whereas it decreased again in June 2019 to a level 3% below the February level of that year.

Online Casino and Online/Land-Based Sports/Horse Betting

Commercial online casino/betting decreased by 8% from February to March, but within this category, the major horse betting operator decreased by 11% and the state-owned operator by 45%, whereas the remaining operators increased by 6%. Commercial online casino/betting thereafter increased in April to a level 5% below the February level; among these figures, the state-owned operator decreased further to a level 68% below the February level, whereas the major horse betting operator increased to a level 23% higher than the February level and the remaining operators decreased to a level 2% below the February levels.

In May and June, commercial online casino/betting stabilized on a level close to February levels (2% above in May and 2% below February levels in June). Through June, the state-owned operator recovered only partially, to a May level 53% below and a June level 47% below the February level. The major horse betting operator increased further in May, to a level 34% above the February level, but then decreased steeply in June, to nearly exactly the same level as in February. The remaining commercial online casino/betting operators remained in May on the same level as in April, i.e., 2% below the February level, but then increased in June, to a level 14% above the February levels.

In 2019, the overall market of commercial online casino/betting instead increased in March, April, and May, with 6, 7, and 4%, respectively, compared to the February level of that year, whereas it stabilized on a 1% decrease in June, compared to the February level. The major horse betting operator, in 2019, increased from February levels to 27, 21, 19, and 23%, respectively, in March through June. The state-owned operator, in 2019, saw a decrease compared to the February level of 3, 16, 15, and 35%, respectively, in March through June. Other remaining online casino/betting operators, in 2019, displayed figures fluctuating relatively little around the February level (a decrease of 3% in March, an increase of 6% in April, an increase of 1% in May, and a decrease of 3% in June).

Lottery and Land-Based Casino/Electronic Gaming Machine Gambling

State-owned lottery/electronic gaming machine (EGM) gambling decreased by 39% from February to March and was thereafter normalized back to a level 10% above the February level in April and further normalized in May and June, compared to February levels (5% lower in May and 2% higher in June than in February). In 2019, these gambling types displayed, compared to the month of February, an increase of 17–19% in March through May, but a decrease in June of 11% compared to the February level.

TABLE 2 | Revenue-based income taxes for Swedish licensed gambling operators, January–June, 2020 (approximated to thousands of Swedish krona, SEK).

	January	February	March	April	May	June
State-owned lottery/EGM (AB Svenska Spel, $n = 1$)	80,717	75,930	46,178	83,517	72,179	77,077
Commercial online casino + betting ($n = 77$)	237,123	219,734	201,266	209,702	223,921	216,213
- Principal horse betting operator AB Trav & Galopp ($n = 1$)	67,905	77,106	68,891	94,648	103,407	77,039
- State-owned Svenska Spel sports betting and online casino ($n = 1$)	40,744	37,877	20,862	12,138	17,708	19,908
- Other combined online casino/betting licenses ($n = 75$)	128,473	104,751	111,514	102,916	102,806	119,265
State-owned land-based casino (casino cosmopol, $n = 1$)	14,142	12,408	8,720	0	0	0
Land-based restaurant casino ($n = 29$)	3,397	3,501	2,510	1,888	2,074	1,910
Gambling for gifts (such as in funfairs and similar events, $n = 3$)	6,680	4,131	0	343	0	0
Total	335,388	311,583	258,681	295,113	298,180	295,199

Data not displayed: bingo, land-based (one company, no taxation during the study period), charity lotteries (seven companies, no taxation during the study period), and one private non-profit organization with a land-based card game license (and with a taxation fluctuating slightly during the study period, with a 5% decrease from February to May but missing data for June).

TABLE 3 | Revenue-based income taxes for Swedish licensed gambling operators, January–June, 2019 (approximated to thousands of Swedish krona, SEK).

	January	February	March	April	May	June
State-owned lottery/EGM (AB Svenska Spel, $n = 1$)	84,783	78,384	92,352	91,608	93,133	69,557
Commercial online casino + betting ($n = 77$)	195,748	202,408	213,792	216,443	209,594	201,090
- Principal horse betting operator AB Trav & Galopp ($n = 1$)	66,211	59,235	75,001	71,908	70,727	73,128
- State-owned Svenska Spel sports betting and online casino ($n = 1$)	33,904	35,438	34,494	29,853	30,273	23,037
- Other combined online casino/betting licenses ($n = 75$)	95,632	107,736	104,297	114,683	108,594	104,926
State-owned land-based casino (casino cosmopol, $n = 1$)	13,903	12,710	15,513	14,718	14,895	14,413
Land-based restaurant casino ($n = 29$)	2,353	2,677	3,524	3,330	2,996	3,101
Gambling for gifts (such as in funfairs and similar events, $n = 3$)	0	0	0	20,589	77,066	221,860
Total	296,787	296,179	325,180	326,119	320,700	288,383

Data not displayed: bingo, land-based (one company, no taxation during the study period), charity lotteries (seven companies, no taxation during the study period), and one private non-profit organization with a land-based card game license (and with a taxation fluctuating slightly during the study period, with a 5% decrease from February to May but missing data for June).

Land-based casino gambling decreased from February to March by 30%, whereas state-owned casinos decreased to zero due to their full closure on April 1st, which was maintained throughout the study period. In 2019, when this gambling activity was obviously opened throughout the period, the values increased with 22% from the month of February to the month of March (while the levels of April, May, and June were 16, 17, and 13% above the February levels).

From February to March, restaurant casino gambling decreased by 28%, and from March to April, restaurant casino decreased further to a level 46% below the February level, whereafter it stabilized on a low level in May (41% below the February levels) and June (45% below the February levels). For this type of gambling, the values in 2019 demonstrated increases during March through June with 22, 16, 17, and 13%, respectively, compared to the February level.

DISCUSSION

The present study, assessing revenue-based taxation of gambling operators and thereby indirectly reflecting changes in the gambling market during the COVID-19 pandemic, indicates some relatively pronounced changes in the gambling market in Sweden, primarily from February to March 2020, i.e., in the transition where the pandemic increased steeply in the country and where land-based establishments in the society were the most affected, including the nearly total lockdown of elite sports events. Overall, the gambling market decreased markedly during the first pandemic-affected month studied, but recovered to a large extent, whereas the changes onto different subsections of the market were very diverse.

Primarily, the state-owned operator with a large involvement in sports betting decreased its revenues steeply, with a slow recovery over the next months, whereas online-based horse race betting increased substantially. In addition, major land-based casinos were completely closed on April 1st, and the smaller market of limited-stake restaurant-based casinos also decreased substantially. In contrast, however, the larger overall market of combined online casino and sports betting operators showed only a modest decrease, despite the sports lockdown. When excluding the major horse race operator and the state-owned operator, this subsection of the market decreased only marginally or even demonstrated some increase from February to March, despite the dramatic impact of the pandemic on sports betting.

Thus, the overall gambling market decreased only marginally and recovered relatively soon during the study period. However, it is evident from the present data that subsections of the gambling market need to be assessed separately; despite the dramatic impact on sports betting, the large subsection with license for both commercial online casino gambling and commercial sports betting remained relatively unaffected. Thus, although the exact amount of gambling cannot be established, this overall category remained relatively unaffected despite the lockdown of sports. Thus, in light of the decrease in sports events, it could be argued that the Swedish online-based market of chance-based games appears to be relatively robust, as indicated also, for example, by its predominating role in Swedish televised gambling advertisements (13). Thus, it can be at least assumed that chance-based gambling, such as online casino gambling, maintained a strong position even during the early phases of COVID-19. This is in line with the previous self-reported survey data in two general population studies (7, 8), and online casino is known to play a predominating role in problem gambling in the present setting; a majority of treatment-seeking clinical patients (12) and helpline callers (17) report online gambling to be their problematic gambling type. Thus, it can be suspected that in a setting with a strong role of chance-based online gambling, even the physical lockdown during COVID-19 affected gambling to a limited extent.

Interestingly, the major operator in horse race betting demonstrated a large increase, but also close to a normalization, already in the month of June, the month when international (and Swedish) soccer reopened, allowing for relatively normalized sports betting opportunities. Thus, it can be suspected that horse race betting was a short-term replacement of sports betting in the most acute phases of the pandemic, as horse races remained active throughout this period (although without physical audience on site). The increase in horse race betting is in line with a recent study, where online survey data from online gamblers in May 2020 demonstrated that online horse betting was one of the gambling types less affected by the pandemic than other types, and possibly even more commonly reported during the pandemic than in previous research using the same methodology (8). In another general population survey from the same setting, carried out in late April and early May 2020, only a relatively limited minority reported increasing horse betting as a response to the limited sports betting opportunities. Also, sports betting, both land-based and online-based, represented the gambling types most clearly affected by the pandemic; the number of respondents reporting decreased gambling for sports betting was almost 10 times larger than the number reporting an increase. In the same study, it was shown that gambling types less affected by the pandemic, according to self-report data, were online horse betting, online lotteries, and online casino gambling. In particular, in that general population study and when excluding people reporting to be non-gamblers for that particular type, 6 and 14% reported having increased land-based or online horse betting during COVID-19, respectively (7). Thus, the increase seen in horse race betting in the present study may seem consistent with the self-reported data on a partial migration from other gambling types to an increased horse betting. Likewise, however, the steep decrease in horse betting shown in the month of June may represent a rapid movement back in the opposite direction, such that the onset of some types of particularly soccer leagues and other major sports events in June may have attracted some gamblers back.

Also, the present findings are consistent with those in an early Australian online survey carried out in early April 2020, where a significant minority of respondents reported increased online gambling, although for all subtypes of gambling, reporting a decrease was more common than reporting an increase. While some decrease in overseas sports betting was seen, descriptions of transitions between gambling types were somewhat mixed, and conclusions hard to be drawn (18). While some survey data have indicated some migration—although limited—from sports betting to other gambling (7, 10), one study demonstrated the opposite. Auer and coworkers reported from one specific (and anonymous) online gambling operator that sports betting at that particular operator decreased in March 2020 and that their online casino gambling also decreased, arguing that in this particular (but unknown) gambling operator, no migration from sports to online casino gambling could be seen (9).

The Swedish land-based casino market is limited, and therefore, conclusions are difficult to draw about migration from these particular gambling types to others. The state-owned casinos (in the three largest cities of the country and in one regional urban center in mid-Sweden) closed on April 1, but also represented a limited share of the gambling market before that, and the more limited so-called restaurant casinos are small in comparison to the other types of gambling in the country. However, the latter gambling modality decreased clearly during the pandemic. It remains to be seen whether this effect is related to characteristics of the gambling pattern as such, or whether it is more associated with a likely decrease in restaurant visits during COVID-19 regulations. Again, the relatively limited size of these gambling types confirm the picture of the present setting as being particularly prone to online gambling, and that crisis-related changes in the market are likely to occur within the large share of online-based gambling options.

Although the overall effect of COVID-19 on gambling behavior may be modest but largely negative, it cannot be excluded that when gambling is only modestly decreasing, such as in the present study, some individuals may increase their gambling and the health hazards occurring to them may be significant. In one of the online surveys carried out in the present setting, a minority reported that they increased online casino gambling in response to the decrease in sports betting, or that they increased other sports betting in contrast to sports seeing a decrease, and among them, rates of gambling problems were very large and even predominant (7). Thus, the public health effects from COVID-19-related changes in the gambling market may be highly diverse and could paradoxically deteriorate gambling behavior in some individuals and improve a problematic gambling behavior in others.

The sole period of time available for comparison to the present study period is the corresponding season during 2019, such that effects of seasonality (diverse sports events and climate- and weather-related differences) can be assessed only with that

comparison. However, this comparison must be judged difficult, as 2019 was the very first year in a novel license system, where previously overseas operators and markets had become legal and licensed in Sweden as late as in January 2019. However, when comparing, the overall gambling taxation for the whole license marked did not demonstrate a decrease from February to March in 2019, making it likely that this relatively pronounced decrease in March 2020 can be attributed to the effects of COVID-19. However, in 2020, the market recovered partly and ended on a June level which differed from that year's February level in a manner comparable to the 2019 change from February to June.

However, the commercial sports betting and online casino division of the state-owned operator, AB Svenska Spel, demonstrated a decrease from February through June 2019 of around 35%. Thus, based on the latter, it cannot be excluded that some part of the decrease during the present study's study period may derive from changes also occurring in the same season in 2019, but again, data are difficult to compare, as 2019 was the very 1st year with the present system and, therefore, may not provide a representative picture. However, the predominating horse betting operator, which in the present study demonstrated some decrease in March and a marked increase in April and May, demonstrated a 27% increase from February to March in 2019, whereafter the same level remained stable through June. Thus, the large fluctuations in horse race betting during COVID-19 are unlikely to be explained by any factor also occurring in 2019 and, therefore, may be more likely to be related to actual changes in the pandemic. The remaining commercial betting/online casino operators altogether demonstrated relatively stable figures from February through June in 2019, with a 3% decrease in June compared to February. Thus, although again 2019 is the sole and possibly limited opportunity for actual comparison, the stable but slightly increasing trend in these operators from February to June in 2020 is comparable to 2019, or even indicating a potential increase. Again, this comparison also does not clearly reveal other explanatory factors to the development seen during COVID-19.

For land-based restaurant casinos, the operators available did not demonstrate a decrease in 2019 similar to the one seen during the COVID-19 period; instead, all months from March through June in 2019 saw higher values then in February in this category, such that changes seen in the present study also may not be attributable to season-related changes but may be related to COVID-19-related factors. Thus, also for this category, changes in the present study cannot readily be explained by historic factors such as seasonality.

The present study may have implications for preventive work and for harm reduction programs in gambling, as well as for future research. Self-exclusion is one of the harm reduction options for individuals with a problematic gambling behavior (19, 20), and there is growing evidence in therapeutic interventions in gambling disorder (21, 22). Thus, in case of a growing gambling problem due to the COVID-19 pandemic or other similar crises, actions from stakeholders can involve efforts to increase early detection, self-exclusion from gambling, and structured gambling disorder treatment. Thus, beyond the macrolevel effects on gambling markets, they demonstrate a certain likelihood that subpopulations may present worsening symptoms during this crisis, calling for earlier intervention in those changing their gambling habits in response to this specific crisis.

The current study has limitations and strengths. It uses a novel source of information describing the activity in the gambling market, i.e., the level of taxation based on the financial revenue of gambling operators, thereby theoretically reflecting the true level of gambling within the country, rather than data reported in previous self-report surveys (7, 8). Likewise, limitations include the fact that the data used do not reflect actual gambling activity from the perspective of individual gamblers, but instead from the perspective of the gambling operator; while the level of profit of the company may change from month to month because of hazard-based outcome actual gambling events, these differences are likely to be limited. Also, the possibilities of further statistical analyses were limited, due to the fact that regarding potential seasonality of gambling activity, data could be compared only to the corresponding months in the previous year, as the current system of legal, licensed gambling was introduced as late as in January 2019. Also, it could be suspected that the first months of such a system may not be fully representable. For these reasons, a statistical analysis, such as a formal time series analysis involving both 2020 and months from 2019 which were comparable to a limited extent, was not carried out. In addition, taxations can theoretically be corrected up to 6 years later, although this is likely to be rare and to have a very limited impact on the monthly trends in taxation.

CONCLUSIONS

Based on revenue-based taxations of licensed gambling operators, in total and for subsections of the gambling market, the present study demonstrates that some substantial changes in gambling activity occurred during early COVID-19 in Sweden, although changes appeared to be normalized to a large extent already during the third full month of COVID-19-related restrictions in the country. In the present online-based gambling markets, commercial operators' revenues were little affected by the steep decrease in sports events, likely because of the parallel online casino involvement of these companies. Instead, theoretically decreased sports betting may instead transfer a substantial proportion of gambling to horse races while these were not canceled during the pandemic. The relative stability of the total gambling market activity in a highly online-based gambling market is noteworthy, given the nearly total cancelation of sports during the early COVID-19 phases. This calls for further research in order to understand possible transitions across gambling types in times of crisis.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: Data are publicly available

upon request to Swedish authorities, such that data of the present kind are typically presented as follow-up data by the Swedish Gambling Authority. Thus, the present data can be requested from that authority, or indirectly through the author.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Sleep or Play Online Poker?: Gambling Behaviors and Tilt Symptoms While Sleep Deprived

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Online poker has the convenience of being accessible 24/7 allowing a large proportion of players to gamble at night. Although some studies postulate a bi-directional relationship between excessive online poker playing and sleep disturbances, sleep has yet to be studied as a primary outcome variable in online poker studies. Sleep deprivation has been linked to alterations in emotional regulation, decision-making, and risk-taking behaviors. All of which are known to induce episodes of tilt. Conversely, online poker playing during regular sleep hours may interfere with sleep quality. The objectives of the present study are (a) to explore the effects of sleep deprivation on tilt symptoms and gambling behaviors and (b) to assess whether playing an online poker session shortly before bedtime (120 min) influences the player's sleep quality. Sleeping habits, tilt symptoms, and online poker behaviors of 23 regular online poker players (22 men, 1 woman) were monitored daily for 28 days using questionnaires and hand histories. Tilt and gambling behaviors during online poker sessions ($n = 588$) played while the player was sleep-deprived were compared to sessions played while not sleep-deprived. Different sleep variables were also compared for sessions ($n = 897$) played 2 h before bedtime to no sessions played before sleep. Sleep-deprived poker sessions revealed higher emotional and behavioral tilt, a higher number of hands played and unfavorable financial results than at-rest sessions. Also, emotional and behavioral tilt was higher when alcohol was consumed. Sessions played 2 h before bedtime revealed a shorter sleep onset latency than when no sessions were played before bedtime. *Post-hoc* mixed regression analyses revealed that emotional and behavioral tilt is associated with shorter total sleep time and shorter sleep onset latency, while cognitive tilt is associated with a decrease in sleep efficiency. This study is the first to specifically explore sleep variables with online poker players within an ecological study design. The findings shed light on the daily impacts of nighttime online gambling practices. Future studies are needed to further explore the interaction between subjective and objective sleep variables and online gambling habits as well as investigate players' motives for playing while sleep deprived.

Keywords: online gambling behavior, tilt, sleep deprivation, poker, sleep quality

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INTRODUCTION

Poker is a gambling card game that has seen a significant increase in popularity since the beginning of the 2000s (1, 2). Online poker (OP), being a billion-dollar industry (3), allows players to compete with others worldwide using the electronic device of their choice at a time that is convenient for them. The 24-h accessibility of OP is a greatly appreciated characteristic of the game (4). However, this accessibility has been shown to be associated with the loss of control over gambling behavior (5). Furthermore, playing OP during regular sleep hours appears to be common and may also lead to adverse consequences for gamblers. In a survey conducted by the *Observatoire des Jeux* in France (2012; $N = 4{,}042$), nearly three-quarters (72.5%) of OP players reported playing late in the evening or during the night, and nearly half (45.6%) reported that OP interfered with their sleeping time (6). Late-night gambling is also possible and popular in the province of Quebec (Canada) where tournaments are offered every night via the online government website EspaceJeux.com (7).

Sleep disturbances and difficulties may affect gambling behavior. Data from the National Comorbidity Survey suggests that individuals with reported gambling problems are more likely to experience one or more sleep-related difficulties in comparison to general population (8). These sleep disturbances and difficulties may, in turn, decrease a player's ability to maintain control over their gambling behaviors and impair their decision-making ability (9, 10). Despite the research highlighting the fact that a large proportion of OP players gamble late in the evening or during the night and that sleep difficulties are associated with worrisome gambling practices, no research has specifically examined the effects of night-time gambling behaviors on the loss of control. Also, no studies have been conducted exploring the consequences of late-night gambling on sleep quality. The objectives of the present study are (a) to explore the impacts of sleep deprivation on the loss of control in OP players and (b) to explore the impacts of OP on sleep quality the night following an OP session.

Poker is a gambling card game where several players (usually 2–10) compete to win the pot. Different variations of poker exist of which Texas Hold'Em is the most popular (11, 12). Texas Hold'Em can either be played in a cash game or a tournament.

OP players are predominantly men between the ages of 26 and 35 years old (13). The reasons for playing generally include skill development, pleasure, to make money, compete but also to escape problems (14–16). OP is a gambling game with structural characteristics that differ from other forms of games of chance, such as video lottery terminals, lotteries, or scratch tickets. Unlike these pure forms of games of chance, there is a skill component present in OP that allows some more experienced and skilled players to make long-term profits (17).

Decision-making capabilities and emotional regulation are two crucial elements in OP (18, 19). Decision-making is a complex cognitive process necessary for individuals to make optimal choices according to predetermined criteria (20). Emotional regulation refers to the processes responsible for observing, evaluating, and modulating emotions, which enable an individual to accomplish goals and function in a variety of contexts (21, 22). A player willing to have an advantage in OP must be able to determine the statistics and probabilities of winning a hand based on the cards on the table and his private cards. Using this knowledge, the player must make rational choices based on the level of risk associated with each decision if he wishes to optimize the probability of long-term gains (17, 23). To do this, many techniques are employed: developing experience by playing, reading books on poker strategy, discussing poker with other players, and using tools such as hand-tracking software (24, 25). Findings by Morgan show that experienced players use probability more effectively by adjusting their level of risk-taking according to the expected winnings of a hand in comparison to less experienced players. These findings also show a relationship between negative emotions and the propensity to take risks in less experienced players. Morgan's work highlights the importance of decision-making in OP and the effect that emotions and player experiences may have on the gambler's decision-making capabilities. However, these findings stem from laboratory experiments, limiting their ecological validity. This experimental design limits the observation as to what can cause emotions and decision-making to vary leading to a loss of control over gambling behavior or the onset of tilt episodes [e.g., (26, 27)]. In poker, tilt refers to a transient loss of control of gambling behaviors associated with emotional, cognitive, and behavioral manifestations (28).

Tilt in Online Poker

Tilt can occur because of events that may or may not be poker-related (28). For example, a tilt episode may occur following a bad hand, a loss of a large bet when the odds of winning were favorable, or as a result of intimidation by other players. Inattention, fatigue, lack of concentration, stress, drug or alcohol use may contribute to the occurrence of tilt episodes (26, 28). Emotional regulation strategies appear to be effective in preventing tilt episodes and are often used by more experienced players (26, 29). These strategies can include becoming aware of and accepting the emotions associated with the tilt episode or even momentarily leaving the game to cool down (26, 30). Tilt is known for its effects on game strategy. For example, amongst others, tilt episodes may provoke a gambler to play the game in a more aggressive manner than they would have initially (28). Tilt can lead to impaired decision-making, the illusion of control, increased risk-taking, increase the likelihood for impulsive behavior, and make it difficult for the player to stop gambling (26–29). The loss of control over gambling behaviors through tilt is associated with negative financial consequences.

Abbreviations: CPGI, Canadian Problem Gambling Index; CPGI – Consequences, CPGI-Adverse Consequences on Individuals, Families, and Communities; NOP-Evening, No online poker session played within 2 h before trying to sleep condition; NSDpr, Online poker session is played while not sleep-deprived condition; OP, Online poker; OP-Evening, Online poker session played within 2 h before trying to sleep condition; OPTS, Online Poker Tilt Scale; PE, Poker Experience; PGSI, Problem Gambling Severity Index; PGSI-OP, Problem Gambling Severity Index specific to online poker; SDpr, Online poker session is played while sleep-deprived condition.

Indeed, tilt is believed to result in player's being less responsible when it comes to bankroll management (28, 31).

Tilt can destabilize the player and require the gambler to employ emotional regulation strategies to prevent or limit its consequences (26). A multitude of factors can cause tilt including fatigue and a lack of concentration (28). This can impair the player's ability to make optimal decisions leading to poor game sequences (26, 28). However, tilt is not the only factor that may affect the gambler during an OP game. Numerous studies have linked sleep deprivation to impaired decision-making and a reduced ability to regulate emotions (9, 22, 32–34). Sleep deprivation can be defined as an extension of an individual's wakefulness period that adversely affects their physical and psychological abilities (35). Contrary to popular belief, it is not necessary to be awake for 24 h or more to experience the negative effects of sleep deprivation. In fact, Van Dongen and colleagues (36) observed a decrease in neurobehavioral abilities after 15.84 h of wakefulness ($SD = 0.73$), although this period varies from one individual to another.

Effects of Sleep Deprivation on Cognitive Abilities and Emotional Regulation

Sleep deprivation has been reported to be associated with impaired decision-making ability (9), increased impulsivity (37) and risk-taking when there is a chance of financial gain (32, 34). Research has shown that impaired cognitive ability increases with sleep deprivation (38). Emotional regulation has also been shown to be greatly affected by sleep deprivation. In fact, sleep deprivation has been found to have a greater effect on emotions and mood than on cognitive abilities (33). A meta-analysis exploring the effects of sleep deprivation found that participants experienced significant changes in self-reported emotions while sleep-deprived (33). Various levels of sleep deprivation are associated with a decrease in self-reported positive emotions and increase in self-reported negative emotions (39–41), as well as an alteration in the individual's ability to regulate emotions (40, 42). These emotional changes that are associated with sleep deprivation may be explained by a decrease in the threshold of emotional activation (39).

Even though research findings have shown adverse effects of sleep deprivation on critical functioning abilities (9, 32, 34, 37, 39–42), most of these effects are investigated in controlled laboratory studies providing very little ecological validity. Consequently, these results do not allow researchers to measure the impacts of sleep deprivation on participants' daily activities. Furthermore, the results highlighting the effect of sleep deprivation on risk-taking behaviors are derived from studies where the tasks are initially unknown to participants and from samples where the participants are not necessarily experienced in risk-taking activities such as poker. Considering these facts, it seems appropriate to explore how sleep deprivation affect gambling behaviors and daily functioning in OP players.

Effects of Online Poker on Sleep

Research exploring the link between a player's sleep patterns and their ability to regulate gambling behavior is promising, yet incomplete. Indeed, as reported by Parhami et al. (8), there appears to be a bi-directional association. Problem gamblers reported poorer sleep quality and more sleep problems such as difficulty falling asleep, staying asleep, and early morning awakenings. Personal and financial consequences frequently associated with gambling problems may contribute to the reported sleep difficulties (8). In fact, symptoms such as rumination can impair sleep quality and promote long-term sleep problems (43). Internet gambling, such as OP, can also interfere with normal sleep patterns (6). Furthermore, two systematic reviews including children and adolescents found that evening use of electronic devices is associated with less total sleep time and a later bedtime (44, 45). Similarly, Higuchi et al. (46) found that participants experienced an increase in emotional activation after playing video games, resulting in a greater sleep latency. Despite these findings, no studies appear to have investigated the relationship between playing OP at night and sleep. The present study aims to compare the quality of a night's sleep when it is preceded or not by a nightly OP session.

In summary, it is possible that playing OP sessions during regular sleep hours can have various consequences. Numerous studies have associated sleep deprivation with impaired decision-making ability, increased risk-taking (9, 32, 34), alterations in emotional reactions and impaired emotional regulation (39–42). Emotional regulation and decision-making abilities are important aspects of poker and OP players' quality of play (18, 19) and altering these may favor tilt symptoms (26, 28, 29). Moreover, gambling behaviors may negatively affect sleep (8). The present study will be comparing OP sessions played in sleep deprivation (SDpr) with OP sessions played not sleep-deprived (NSDpr) on tilt symptoms and gambling behaviors. It will also compare self-reported sleep quality following sessions played within 2 h before bedtime with the absence of sessions played during this period.

Objectives and Hypotheses

The main objective of this study is to determine whether SDpr produces a favorable context for tilt and worsen gambling behaviors among regular OP players within an ecological study design. It is expected that higher tilt scores (total score, emotional and behavioral factor and cognitive factor) and greater net losses will be observed for sessions played in SDpr compared to sessions played while NSDpr. The secondary objective is to test whether an OP session played 2 h before bedtime results in poorer sleep quality. It is expected that a later bedtime, a longer sleep-onset latency, a shorter total sleep time, a lower sleep efficiency, and a decreased feeling of rest the next day will be observed when a session is played 2 h before bedtime compared to when no session is played 2 h before bedtime.

MATERIALS AND METHODS

Participants

Players were recruited through advertisements on forums, websites, and Facebook pages dedicated to OP. An e-mail invitation to participate in the study was also sent to Université Laval employees' and students' as well as to a list of volunteers from our center. Participants were included if they: (a) played OP at least once a week while sleep deprived ($\geq$16 h between

awakening and the end of the gambling session), (b) played OP with money on average twice a week for at least 1 month, (c) primarily played on an OP platform that allows hands to be recorded, (d) were at least 18 years of age, (e) considered themself as primarily a poker or an OP player amongst other gambling activities, (f) primarily played on a computer, and (g) agreed to monitor their sleeping and gambling habits. Participants were excluded if they were working night or rotating shift work with regular night shifts and if they devoted more than half of their playing time to gambling activities other than OP.

Thirty-five players were interested in participating in the study. Among them, two did not follow up on attempts to contact them, seven did not meet the eligibility criteria and one was excluded because of working nightshift. Of the 25 gamblers who completed the socio-demographic questionnaire, two did not provide data that would allow the research objectives to be met. Descriptive analyses were conducted on the 23 players whose responses were complete. Our participants were primarily men (95.7%), between the ages on 20 and 52 ($M = 31.78$, $SD = 9.78$) from Canada (91.3%). Twelve gamblers lost money during the data collection period ($M = -284.70$ USD; $SD = 223.59$) [−761.23, −61.10] while seven gamblers gained money ($M = 224.18$ USD; $SD = 324.11$) [13.96; 768.30]. Of the 19 players who provided their hand histories, an average of 31.32 ($SD = 22.43$) [2; 102] OP sessions and 7,456 ($SD = 8{,}352.41$) [1.073; 31.991] hands were played during the data collection period. Socio-demographic information, information regarding problem gambling severity and the poker experience level of participants are presented in **Tables 1–3**.

Questionnaires

The questionnaires are presented in order of administration.

Eligibility questionnaire is a 10-item questionnaire addressing OP gambling habits, age, time dedicated to other gambling activities, and work schedule.

Socio-demographic questionnaire is 15 items collecting data on marital and civil status, occupation, level of education, annual income, etc.

Gambling Habits Questionnaire. Inspired by the questionnaire by Lévesque et al. (47), 13 self-report items assessed the participant's gambling habits by collecting data on expenses related to gambling, time spent gambling, frequency, and gains/losses associated with poker and OP.

Poker Experience (PE, 24), a French translation, measure the level of experience of OP players. The PE is a self-report questionnaire consisting of nine items on a 4-point Likert-type scale measuring player's perception of their level of experience with poker (years of experience, frequency of play, books read, etc.). The original EP has good internal consistency (Cronbach's $\alpha = 0.70$, 24).

Problem Gambling Severity Index (PGSI) is a subsection of the Canadian Problem Gambling Index (CPGI) and is used to measure the severity of problem gambling in the last 12 months. The scale consists of nine items rated on a 4-point Likert scale with answer options ranging from never to almost always. A score of 0 indicates non-problematic gambling, a score of 1–4 indicates low-risk gambling, a score of 5–7 refers to moderate-risk gambling, and a score of 8 or higher qualifies the gambling as problematic and possibly pathological (48). The PGSI items were asked twice, once for gambling in general (PGSI) and once for OP, producing a score specific for OP (PGSI-OP). The score of the PGSI-OP is interpreted in the same way as the score of the PGSI. This method has already been used (49).

CPGI-Adverse Consequences on Individuals, Families, and Communities (CPGI - Consequences) is a self-report 10-item questionnaire, measured on a 4-point Likert-type scale, that assesses the consequences of gambling in several areas of a person's life [interpersonal, marital, family, work, and community, (50)]. Items are modified to replace the terms "gambling" by online poker to solely address the consequences of this specific gambling activity.

Sleep Diary (51) is a daily nine item self-report questionnaire asking about: (a) the time at which the person attempts to fall asleep and the time at which the persons wakes-up, (b) time awake during the night, (c) perceived feelings of being rested (rated via a 5-point Likert scale), (d) the use of alcohol (yes or no), caffeinated beverages (yes or no) or drugs (stimulants, cannabis, hallucinogens or other) during the previous evening and (e) the partake in gambling activities other than OP during the previous day. The Sleep Diary used is a shortened and slightly modified version of Carney et al. (51). A question regarding drug use was added. The Sleep Diary also collected data such as sleep onset latency, total sleep time, and sleep efficiency. Sleep onset latency refers to the amount of time between turning off the lights with the intention to sleep and falling asleep. Total sleep time refers to the estimated time spent asleep, calculated from the time of attempted sleep to the time of awakening. Time spent awake during the night must also be deducted from the total sleep time. Sleep efficiency is defined as the proportion of time asleep out to the total time spent in bed.

Online poker session schedules questionnaire was created to survey participants about the start and end times of each OP session played the day before. This questionnaire ensured that the hours of each OP session were recorded even if hand histories were not provided by the participants.

Online Poker Tilt Scale (OPTS) is composed of 17 self-report items and is a validated measure to assess tilt episodes in OP players (27). This scale is scored on a 5-point Likert scale and is divided into two factors: (a) emotional and behavioral tilt (12 items) and (b) cognitive tilt (five items). The OPTS has good internal consistency (Cronbach's $\alpha > 0.80$ for the total score and each subscale) and the average inter-item correlation is 0.46. This questionnaire also has good convergent validity, as it is significantly correlated with the number of tilt episodes experienced (past 3 months; $r = 0.50$; $p < 0.001$) and with the sub-types of gamblers found in the PGSI (PGSI; $r = 0.77$; $p < 0.001$).

Software

Hold'Em Manager 2 is an OP hand tracking software, by Max Value Software (https://www.holdemmanager.com). Hold'Em Manager 2 transforms the text files of the hand histories into

TABLE 1 | Means, standard deviations, and demographic characteristics based on inclusion in the main analyses.

Variables	Players included in the analyses ($n = 23$) *M (SD)*	Dropouts ($n = 2$) *M (SD)*
Age	31.8 (9.7)	32.0 (8.5)
Frequency of OP in the last 30 days	26.8 (20.9)	25.0 (7.1)
Number of hours of OP played in the last 30 days	69.2 (43.3)	87.5 (17.7)
	Number of players (%)	**Number of players (%)**
Gender		
Male	22 (95.7)	2 (100)
Country of origin		
Canada (Qc)	21 (91.3)	1 (50.0)
Other	2 (8.7)	1 (50.0)
Marital status		
Single	6 (26.1)	1 (50.0)
Common-law partner/in a relationship	15 (65.2)	1 (50.0)
Married	1 (4.3)	0 (0)
Widowed	1 (4.3)	0 (0)
Education		
High school	2 (8.7)	1 (50.0)
Vocational education	4 (17.4)	0 (0)
College	8 (34.8)	0 (0)
University-undergraduate	8 (34.8)	0 (0)
University- graduate	1 (4.3)	1 (50.0)
Income		
14 999 $ or less	4 (17.4)	0 (0)
15 000$ to 24 999$	4 (17.4)	0 (0)
25 000$ to 34 999$	2 (8.7)	0 (0)
35 000$ to 49 999$	7 (30.4)	1 (50.0)
50 000$ to 74 999$	2 (8.7)	0 (0)
75 000$ to 99 999$	1 (4.3)	0 (0)
100 000$ and +	1 (4.3)	0 (0)
Socio-professional category		
Full time employee	16 (69.6)	1 (50.0)
Unemployed	2 (8.7)	0 (0)
Student	5 (21.7)	1 (50.0)

summarized and detailed data of the hands and the OP sessions played. Among the summarized statistics, the net gains/losses and the number of hands played per session were used for this study.

Procedure

Gamblers interested in participating in the study were contacted by the first author via telephone or Skype to verify their eligibility, to complete the verbal consent form and to complete

TABLE 2 | Distribution of players based on PGSI, PGSI-OP categories and responses to CPGI-consequences QUESTIONS.

Variables	Included ($n = 23$) Number of players (%)	Dropouts ($n = 2$) Number of players (%)
Problem gambling severity (PGSI)		
Non-problem gambler	2 (8.7)	0 (0)
Low risk gambler	12 (52.2)	1 (50.0)
Moderate risk gambler	6 (26.1)	0 (0)
Problem gambler	3 (13.0)	1 (50.0)
Problem gambling severity- Online poker (PGSI-OP)		
Non-problem gambler	2 (8.7)	0 (0)
Low risk gambler	14 (60.9)	2 (100)
Moderate risk gambler	4 (17.4)	0 (0)
Problem gambler	3 (13.0)	0 (0)
CPGI-Consequences 1_OP_Habits_Complicates life as a partner		
Never	16 (69.6)	2 (100)
Sometimes	6 (26.1)	0 (0)
Most of the time	1 (4.3)	0 (0)
Almost always	0 (0)	0 (0)
CPGI-Consequences 2_Spending less time with friends		
Never	17 (73.9)	1 (50)
Sometimes	5 (21.7)	0 (0)
Most of the time	0 (0)	1 (50)
Almost always	1 (4.3)	0 (0)
CPGI-Consequences 3_OP Habits Family difficulties		
Never	22 (95.7)	2 (100)
Sometimes	1 (4.3)	0 (0)
Most of the time	0 (0)	0 (0)
Almost always	0 (0)	0 (0)
CPGI-Consequences 4_Decreased productivity work/school		
Never	14 (60.9)	1 (50)
Sometimes	8 (34.8)	1 (50)
Most of the time	1 (4.3)	0 (0)
Almost always	0 (0)	0 (0)
CPGI-Consequences 5_OP Habits negative impact on neighbors		
Never	23 (100)	2 (0)
Sometimes	0 (0)	0 (0)
Most of the time	0 (0)	0 (0)
Almost always	0 (0)	0 (0)
CPGI-Consequences 6_Relationship problems		
Never	10 (43.5)	1 (50)
Sometimes	10 (43.5)	1 (50)
Most of the time	3 (13.0)	0 (0)
Almost always	0 (0)	0 (0)
CPGI-Consequences 7_Regular use of social services		
Never	22 (95.7)	2 (100)
Sometimes	1 (4.3)	0 (0)
Most of the time	0 (0)	0 (0)
Almost always	0 (0)	0 (0)
CPGI-Consequences 8_OP Habits Problems with friends		
Never	22 (95.7)	1 (50)
Sometimes	1 (4.3)	1 (50)
Most of the time	0 (0)	0 (0)

(Continued)

TABLE 2 | Continued

Variables	Included ($n = 23$) Number of players (%)	Dropouts ($n = 2$) Number of players (%)
Almost always	0 (0)	0 (0)
CPGI-Consequences 9_Frequent family disagreements		
Never	12 (52.2)	1 (50)
Sometimes	10 (43.5)	1 (50)
Most of the time	0 (0)	0 (0)
Almost always	1 (4.3)	0 (0)
CPGI-Consequences 10_OP Habits OP co-worker consequences		
Never	21 (91.3)	1 (50)
Sometimes	2 (8.7)	1 (50)
Most of the time	0 (0)	0 (0)
Almost always	0 (0)	0 (0)

the interview (socio-demographic questionnaire, gambling habits questionnaire, EP, PGSI, and CPGI-consequences). Players were then e-mailed information about completing the daily questionnaires as well as the procedure to activate the hand history tracking system. At the end of the interview, the researcher ensured that participants were able to activate the hand histories and, if necessary, assisted the participants. The completion of Sleep Diary, OPTS, and OP session schedules were carried out for 4 weeks on the secure web-based LimeSurvey platform. A daily e-mail was sent to the players as a reminder.

During the experimental period, participants completed the Sleep Diary at the beginning of each day. The OPTS and OP session schedule questionnaire were also completed if they had played OP the previous day. The player was asked to send their hand histories via e-mail after each week of data collection. Per each week of experimentation, the participants received $5 per day of participation in the form of a gift card (7 days x $5 = $35 gift card). The player was compensated if they completed the daily questionnaires, regardless of whether or not a session was played. The present study has a natural quasi-experimental design with control condition. The control condition is non-equivalent to the experimental condition and it was distinguished by session characteristics. This study has received ethical approval from the ethics committee of Université Laval, approval number 2017-338 A-3.

Statistical Analyses

Statistical analyses were performed using the 23rd version of the software Statistical Package for the Social Sciences (SPSS). Descriptive statistics were performed on responses to socio-demographic questions, gambling habits, PE, the PGSI and OPTS for the duration of the experiment.

Mixed-design analyses of variance (ANOVAs) were conducted to test the hypotheses of the study. When the basic statistical assumptions were not met, the data were transformed (logarithmic, square root, rank, or normalized rank).

To achieve the main objective of exploring the effects of sleep deprivation on tilt symptoms and gambling behaviors, a mixed-design analysis of variance (ANOVA) was conducted for each dependent variable: total OPTS, emotional & behavioral tilt, cognitive tilt, net gains, or losses (in US dollars) and number of hands played. When a statistically significant group effect was

TABLE 3 | Frequency of responses to questions in the Poker Experience (PE) questionnaire.

Variables	Included (23 players) Number of players (%)	Dropouts (2 players) Number of players (%)
PE 1_Years of experience		
<6 months	1 (4.3)	0 (0)
6 months to <1 year	0 (0)	0 (0)
1–5 years	4 (17.4)	0 (0)
More than 5 years	18 (78.3)	2 (100)
PE 2_Frequency		
Once a month or less	0 (0)	0 (0)
Every couple of weeks or so	1 (4.3)	0 (0)
Once or twice a week	9 (39.1)	0 (0)
Every day or almost everyday	13 (56.5)	2 (100)
PE 3_Frequency of discussing theory/strategy		
Never	2 (8.7)	0 (0)
Sometimes	8 (34.8)	1 (50)
Often	9 (39.1)	0 (0)
Almost everyday	4 (17.4)	1 (50)
PE 4_Number of poker theory/strategy books		
None	3 (13.0)	1 (50)
1–2	5 (21.7)	0 (0)
3–5	9 (39.1)	0 (0)
More than 5	6 (26.1)	1 (50)
PE 5_Frequency of reading theory/strategy articles		
Never	0 (0)	1 (50)
Sometimes	10 (43.5)	0 (0)
Often	10 (43.5)	1 (50)
Almost everyday	3 (13.0)	0 (0)
PE 6_Level of knowledge of poker stats/odds		
Poor	1 (4.3)	0 (0)
Average	5 (21.7)	0 (0)
Good	8 (34.8)	1 (50)
Excellent	9 (39.1)	1 (50)
PE 7_Difficulty to calculate poker stats/odds		
Very difficult	0 (0)	0 (0)
Somewhat difficult	2 (8.7)	1 (50)
Somewhat easy	11 (47.8)	0 (0)
Very easy	10 (43.5)	1 (50)
PE 8_Frequency poker with money		
Never	0 (0)	0 (0)
Sometimes	1 (4.3)	0 (0)
Often	4 (17.4)	1 (50)
Always	18 (78.3)	1 (50)
PE 9_Frequency of use of tracking software		
Never	9 (39.1)	1 (50)
Sometimes	1 (4.3)	0 (0)
Often	4 (17.4)	0 (0)
Always	9 (39.1)	1 (50)

observed, *post-hoc* ANOVAs were used to test for the presence of confounding variables related to alcohol, cannabis, stimulant, and hallucinogen use. Hand histories were not provided by four players in the sample. Another player provided only partial gambling session data, sometimes having played OP sessions for which it was not possible to obtain hand histories. As a result, self-reported session end times were used in the analyses on the self-reported dependent variables (OPTS and Sleep Diary variables) for these players. Players who did not provide hand histories were not included in the analyses of gambling behavior variables (net winnings and losses in US dollars and number of hands played). Hand history data was used to calculate sleep deprivation in the gambling behavior variable analyses for the player who provided only partial gambling information. To achieve the secondary objective of exploring the effect of evening OP sessions on sleep variables, a mixed-design ANOVA was conducted for each DV: time of attempted sleep, sleep onset latency, sleep efficiency, total sleep time, and feeling rested upon awakening in the morning. *Post-hoc* analyses were conducted using a mixed regression model to explore the association between tilt symptoms (emotional and behavioral tilt and cognitive tilt) and sleep dependent variables. For this purpose, the database was split according to whether an OP session was played the evening before or not (OP-Evening or NOP-Evening). The results for these analyses are presented this way.

Sample

For this study, the sample does not consist of individual gamblers, but rather of data from gambling sessions. To achieve the primary objective of the present study, a total sample size of 588 gambling sessions were collected. Two states of wakefulness were compared: (a) sleep deprivation (SDpr), which is categorized as a session having ended at least 16 h since the person woke up and (b) a non-sleep-deprived (NSDpr) condition consisting of all other gambling sessions. The Sleep Diary provided information regarding the participants' wake-up time and information regarding the hour of the end of the gambling session was provided by the hand history feature of the tracking software. During the data collection, which lasted between 10 and 35 days ($M = 27.19$; $SD = 6.39$), the average gambling session ended 11.06 h ($SD = 5.43$) after waking up in the morning [0.17; 22.57], 80.1% ($n = 479$) of sessions were played while NSDpr and 19.9% were played while in SDpr ($n = 119$).

To achieve the secondary objective, a total sample of 897 observations was collected. The independent variable was operationalized as the presence or absence of an OP session before falling asleep. Two conditions were compared: (a) the presence of an OP session between 1 and 120 min before trying to fall asleep (OP-Evening) and (b) the absence of an OP session between 1 and 120 min before trying to fall asleep (NOP-Evening). In the NOP-Evening condition, participants could either have played no OP sessions that day or sessions could have been played more than 120 min before trying to fall asleep. Twenty-one percent ($n = 190$) of sessions were grouped in the OP-Evening condition and 78.8% ($n = 707$) were grouped in the NOP-Evening condition.

RESULTS

Sleep Deprivation and Tilt Levels

As predicted, the mixed model ANOVA yielded a statistically significant difference on the OPTS Total with a higher score being observed in the SDpr condition in comparison with NSDpr condition (see **Table 4**). The final model also indicated that the OPTS Total score was significantly higher when the session was played while consuming alcohol [$F_{(1,488)} = 5.19$, $p = 0.0023$] ($M = 1.95$; $SD = 0.14$) vs. when no alcohol was consumed ($M = 1.75$; $SD = 0.13$) and when the session was categorized as SDpr [$F_{(1,485)} = 5.16$, $p = 0.024$] ($M = 1.95$; $SD = 0.14$) vs. when it was categorized as NSDpr ($M = 1.75$; $SD = 0.13$). There was no statistically significant difference in alcohol consumption between sessions in the SDpr condition (29.91%) and the NSDpr condition (32.21%).

As hypothesized, the mixed model ANOVA also showed a statistically significant group effect on OPTS emotional and behavioral score, being higher in the SDpr condition in comparison to the NSDpr condition (see **Table 4**). The final model suggested that the OPTS emotional and behavioral score was significantly higher when the player had consumed alcohol [$F_{(1,497)} = 5.89$; $p = 0.016$] ($M = 1.48$; $SD = 0.16$) in comparison to when no alcohol was consumed ($M = 1.26$; $SD = 0.15$) and when the session was categorized as SDpr [$F_{(1,490)} = 8.24$; $p = 0.004$] ($M = 1.49$; $SD = 0.16$) vs. when it was categorized as NSDpr ($M = 1.24$; $SD = 0.15$).

Contrary to our hypothesis, the mixed model ANOVA did not reveal a statistically significant difference in OPTS cognitive score between the two conditions.

Sleep Deprivation and Gambling Behaviors

As predicted, the mixed model ANOVA yielded a statistically significant group effect on the net gains/losses by the participants. Indeed, the mean net gains/losses amount was shown to be lower in the SDpr condition when compared to the NSDpr condition (see **Table 4**). *Post-hoc* analyses performed on alcohol, cannabis, stimulant, and hallucinogenic consumption did not reveal any statistically significant differences in the final model based on the conditions.

As hypothesized, the mixed model ANOVA also showed a statistically significant group effect on the number of hands played. The average total number of hands played was higher in the SDpr condition in comparison to the NSDpr condition (see **Table 4**). *Post-hoc* analyses performed on alcohol, cannabis, stimulant, and hallucinogenic consumption did not reveal any statistically significant differences in the final model based on the conditions.

Online Poker Sessions Before Bedtime and Sleep

The following results refer to comparisons between the OP-Evening condition and the NOP-Evening condition (see **Table 5**). Contrary to our hypothesis, the mixed model ANOVA did not reveal a statistically significant group effect between conditions regarding the hour of attempted sleep, total sleep time, sleep efficiency, or in feeling rested in the morning. For sleep

TABLE 4 | Degrees of freedom, means of NSDpr condition and SDpr condition, mixed model analysis of variance of symptoms of tilt according to total OPTS scores and OPTS subscales and gambling behaviors.

Variables	df numerator	df denominator	Mean SDpr	Standard error	df	Mean NSDpr	Standard error	df	*F*	*p*
OPTS_Total[a]	1	487	1.90	0.14	30.96	1.71	0.13	19.51	4.77	0.029
OPTS_Emotional & behavioral[a]	1	492	1.44	0.16	27.96	1.20	0.15	19.54	7.57	0.006
OPTS_Cognitive[a]	1	500	1.16	0.13	27.86	1.12	0.12	19.82	0.25	0.620
Net gains/losses (USD)[b]	1	528	−0.28	0.12	39.47	−0.18	0.09	12.53	5.91	0.015
Number of hands played[a]	1	559	5.08	0.25	23.65	4.73	0.23	16.48	6.64	0.010

[a]*Data transformation = logarithmic transformed scores, ln(Var +1).* [b]*Data transformation = standardized scores.*

TABLE 5 | Mixed model analysis of variance on OP-Evening and NOP-Evening groups for sleep quality variables.

Variables	df numerator	df denominator	Mean NOP-Evening	Standard error	df	Mean OP-Evening	Standard error	df	*F*	*p*
Hour of attempted sleep[c]	1	761	435.03	37.17	28	415.69	35.66	24	1.98	0.16
Sleep onset latency[d]	1	762	358.83	33.24	31	397.04	31.15	24	6.26	0.013
Total sleep time[d]	1	769	377.51	27.63	38	394.94	24.30	23	0.99	0.32
Sleep efficiency[d]	1	754	379.99	30.42	33	386.58	28.05	24	0.18	0.67
Feeling rested in the morning	1	759	3.26	0.15	35	3.32	0.13	23	0.43	0.51

[c]*Data transformation = ranked scores.* [d]*Data transformation = standardized ranked scores.*

onset latency, the mixed model ANOVA revealed a statistically significant group effect. Indeed, sleep onset latency was shown to be longer in the NOP-Evening group contrary to our hypothesis.

Tilt and Sleep

Five *post-hoc* analyses were conducted to better understand the effects of tilt on sleep quality measured by the hour at which the player attempted to go to sleep, sleep latency, total sleep time, sleep efficiency, and the reported feeling of being rested the following morning. These measures were compared based on the hour at which the last OP session was played (OP-Evening or NOP-Evening). As shown in **Table 6**, the first mixed regression analysis showed a significant positive association between time of attempted sleep and OPTS emotional and behavioral score for both OP-Evening and NOP-Evening sessions. The second mixed regression analysis yielded a significant negative association between sleep onset latency and OPTS emotional and behavioral score for OP-Evening sessions. Subsequently, a negative association between total sleep time and OPTS emotional and behavioral score was found in both conditions (OP-Evening and NOP-Evening. A negative association was also found between sleep efficiency and OPTS cognitive score for the NOP-Evening condition. Finally, the last analyses did not reveal any statistically significant association.

DISCUSSION

The purpose of this study was to explore the relationship between sleep and at-risk gambling behaviors. The first objective was to study tilt when OP was played in SDpr. As hypothesized, higher total tilt scores were observed when OP sessions were played in SDpr compared to those played while NSDpr. Total tilt scores were significantly higher when alcohol was consumed as well. When the two tilt factors are considered separately, higher emotional and behavioral tilt scores are observed if the sessions played are in SDpr, but no statistically significant difference was observed for cognitive tilt scores. Emotional and behavioral tilt is also higher when the player has consumed alcohol.

Emotional and behavioral tilt is characterized by negative emotions such as frustration, anger, a sense of loss of emotional control as well as by acting out during the OP sessions (e.g., "I play without thinking about the consequences") or in actions surrounding OP session (e.g., "I throw things around or I attack my mouse"). In this study, higher emotional and behavioral tilt scores were observed during sessions where the player was in SDpr and when alcohol was consumed before or during the gambling session. There are few empirical studies exploring tilt in different contexts, but the results concerning emotional and behavioral tilt are consistent with the results of studies on emotional reactions, emotional regulation and acting out behaviors in SDpr.

Sleep is thought to play a role in the expression of emotions. However, SDpr may contribute to alterations in this function (22, 39). Among the studies identified by Watling et al. (22), only Zohar et al.'s (41) study was conducted in a natural setting. Conducted among 78 physicians on duty during the first 2 years of their residency, this study examined the relationship between the emotions reported following various professional situations and sleep. In the context of SDpr (measured using a numerical ActiGraph[1]), residents reported more negative emotions when experiencing unexpected or disruptive events and fewer positive emotions following successful outcomes compared to the resting state. Although medical residents and OP players may differ in

[1]Instrument usually worn on the wrist that measures sleep/wake cycles via the participants' body movements.

TABLE 6 | *Post-hoc* Mixed regression analysis for sleep quality variables according to the time of the last online poker session between the two tilt factors.

Sleep quality	Moment of the last online poker session	Predictors	dl numerator	dl denominator	Estimation	*Standard error*	*F*	*p*
Time of attempted sleep[C]	OP-Evening	*OPTS_Emotional & Behavioral*	1	158	11.81	3.31	12.77	0.000
		OPTS_Cognitive	1	159	−2.09	6.02	0.12	0.730
	NOP-Evening	*OPTS_Emotional & Behavioral*	1	312	10.60	3.23	10.77	0.001
		OPTS_Cognitive	1	316	−5.29	6.03	0.77	0.380
Sleep latency[C]	OP-Evening	*OPTS_Emotional & Behavioral*	1	163	−8.86	4.31	4.23	0.041
		OPTS_Cognitive	1	164	8.14	7.80	1.09	0.300
	NOP-Evening	*OPTS_Emotional & Behavioral*	1	316	−2.62	3.72	0.49	0.480
		OPTS_Cognitive	1	319	−2.28	6.91	0.11	0.740
Total sleep time[C]	OP-Evening	*OPTS_Emotional & Behavioral*	1	168	−15.16	4.70	10.40	0.002
		OPTS_Cognitive	1	169	6.52	8.50	0.588	0.440
	NOP-Evening	*OPTS_Emotional & Behavioral*	1	318	−8.47	4.21	4.06	0.045
		OPTS_Cognitive	1	318	3.39	7.79	0.19	0.663
Sleep efficiency[C]	OP-Evening	*OPTS_Emotional & Behavioral*	1	168	2.81	4.62	0.369	0.540
		OPTS_Cognitive	1	168	−12.31	8.68	2.01	0.160
	NOP-Evening	*OPTS_Emotional & Behavioral*	1	317	6.81	4.15	2.69	0.100
		OPTS_Cognitive	1	309	−18.7	7.75	5.82	0.016
Feeling rested in the morning	OP-Evening	*OPTS_Emotional & Behavioral*	1	160	−0.006	0.025	0.057	0.810
		OPTS_Cognitive	1	159	0.028	0.046	0.374	0.540
	NOP-Evening	*OPTS_Emotional & Behavioral*	1	315	0.000	0.022	0.00	0.990
		OPTS_Cognitive	1	304	0.010	0.040	0.071	0.790

[C]*Data transformation = ranked scores.*

several ways, the study by Zohar et al. (41) illustrates that altered sleep patterns can have a negative impact on the emotional experience in an ecological context where participants have a level of experience and knowledge of the context in which the study takes place. The SDpr sessions in our study could thus be associated with an increase in frustration, anger or other emotions when an unexpected or disruptive event occurs, thereby promoting tilt symptoms. As reported by poker players (28), these events may occur during the OP session (e.g., bullying by another player, losing when the odds are in favor of winning, following a bad sequence of play) and be either internal (e.g., inattention) or external (e.g., conflict during the day) in nature.

Sleep is also thought to play a role in emotional regulation (22). However, as for the expression of emotions, SDpr may also impair a person's ability to regulate emotions (40, 42). Impaired emotional regulation is characterized by difficulty in observing, assessing, and modulating emotions to achieve goal-directed behaviors (22, 52). Based on the results of Mauss and Talbot's studies (40, 42), the higher level of emotional and behavioral tilt observed in our study during sleep-deprived OP sessions could be explained not only by a different rapport to emotions, but also by an impairment in the ability to regulate those emotions. Without being able to adequately mentalize their internal states, it would be more difficult for the sleep-deprived OP player to take a step back from the situation and adopt regulatory strategies to reduce the intensity of emotions. Therefore, a greater propensity to act out may be observed as measured by some OPTS items (e.g., "I click faster and hit my keyboard harder," "I shout and insult other people," "I play without thinking about the consequences"). These behaviors then correspond to the externalization of emotions that could not be adequately regulated.

While gambling sessions played while sleep-deprived may lead to more emotional and behavioral tilt, this effect is not observed for cognitive tilt (e.g., "I am less focused; I take more risks; my decisions are no longer rational; I don't feel like myself; it's like I have no control over the game"). This result contradicts the original hypothesis which was based on several research findings suggesting that SDpr has an effect on cognitive abilities, decision-making capacities. and risk-taking behaviors of participants in laboratory studies (9, 32, 34, 38). It is possible that sessions played in SDpr simply did not promote cognitive tilt episodes for our sample. That is, gamblers did not experience changes in their level of concentration, their risk-taking propensity, their decision-making abilities, their feelings of dissociation or loss of control over gambling when they were sleep-deprived. This interpretation could be supported by the level of experience of the players in our sample as well as using tracking software during the sessions. In fact, more than 75% of the participants in our study have been playing poker for more than 5 years and almost half of the participants' sample perceived they had an excellent knowledge of poker statistics and probability. More than 60% of the players in our sample used a tracking strategy during their sessions. In addition, all the players reported having already played OP while sleep-deprived in the past. Given their level of experience and the use of tracking strategies for the majority of the sessions, it is possible that these players were able, to some

extent, to maintain their gambling strategy and limit the loss of control even while in a state of SDpr and potentially in a episode of emotional and behavioral tilt. This would be consistent with the results of Morgan's (25) study where experienced gamblers did not experience an increase in risk-taking behaviors as a result of situations that induced negative emotions. Despite the lack of significant results between groups for cognitive tilt, gambling sessions played in SDpr did have unfavorable financial outcomes compared to sessions played at rest.

The hypothesis that greater net losses will be observed in sessions played while in SDpr compared to sessions played while NSDpr was confirmed. This result suggests that playing while sleep-deprived may lead to unfavorable financial outcomes. This finding is most likely explained by the adverse effects that SDpr has on decision-making ability, risk-taking (9, 32, 34, 38) and emotional regulation (40, 42). Concretely, this variation in net losses could be explained by a greater diversity in gambling styles (e.g., the aggressiveness of the player, risk-taking, etc.) leading to more losses when the player is sleep-deprived. This would be consistent with the results found by Womack et al. (34) and Demos et al. (37) who noted that SDpr promotes increased risk-taking and impulsivity. However, this interpretation is not supported in our study as no difference was detected between groups with respect to the item on risk-taking in the cognitive tilt factor. It is, however, important to note that cognitive tilt does not specifically measure risk-taking, as the OPTS is not necessarily sensitive enough to detect a variation in participant's risk-taking behaviors. An alternative interpretation can be found when considering the findings related to emotional and behavioral tilt. It is possible that results pertaining to financial outcomes revealed in this study may partially be explained by the higher level of emotional and behavioral tilt symptoms in the SDpr group. Indeed, tilt is associated with a loss of control over gambling behaviors and more monetary losses (28, 31). From this perspective, emotional and behavioral tilt would better explain financial outcomes then sleep deprivation state. It would be beneficial to test these two explanatory hypotheses in future studies.

It was also observed that more hands were played in SDpr sessions. For this result, it is difficult to offer an explanation based on a potential loss of control of gambling behaviors when sessions are played in SDpr as the data from this study was collected from sessions played in both cash games and tournaments. Thus, more hands do not indicate the same phenomenon for both conditions. A gambler who plays more cash games is more likely to lose because of the possibility to put more money back into the bankroll. However, more hands played in a tournament is an indication that the player is getting further in the competition: there is no possibility to add extra money into the bankroll, however there is a better chance of recovering expenses from the buy-in and even making a profit.

Ultimately, gambling sessions played in SDpr indicate that gambling while sleep-deprived is a risky practice for the players in our sample. In fact, players who often gamble while sleep-deprived may incur more losses and financial debt. Similarly, players who gamble a greater number of hands while sleep-deprived may experience negative impacts in regard to their daytime occupations, their relationships or work activities. In fact, almost a third of the gamblers in our sample reported that OP may have caused complications in their partner's life. However, these hypotheses should be tested in longitudinal studies.

Conversely, the tilt episode itself can adversely affect the players' sleep. In our sample, emotional and behavioral tilt was associated with participants having a later bedtime and less total sleep hours regardless of when the sessions were played. This finding implies that players experiencing tilt symptoms go to bed later, irrespective of the time the session was played, suggesting that the effects of tilt may extend over several hours. This result provides a nuance to findings observed in the qualitative study by Moreau et al. (28), in which players describe tilt as a transitory phenomenon that passes when the player leaves the gambling table. It is possible that more time is needed to relax before going to bed after a tilt episode is experienced. Following episodes of tilt, players report a tendency to ruminate and experience a range of emotions such as disappointment, anxiety (26), guilt, sadness and disgust (28). A great deal of emotional regulation may be required to prevent these emotions from impairing sleep quality (22). The association between the emotional and behavioral factor of tilt and total sleep time is consistent with these findings. Players in our sample experiencing emotional and behavioral tilt symptoms go to bed later and therefore sleep fewer hours. Further studies are necessary to better understand the effects of tilt on the time of attempted sleep and total sleep time.

Emotional and behavioral tilt is also associated with a shorter sleep onset latency when the session is played 2 h before bedtime. This result can be interpreted in terms of participant's later bedtime, a variable that is also influenced by tilt. Gamblers experiencing emotional and behavioral tilt episodes may be inclined to go to bed later, leading to greater feelings of exhaustion and therefore a shorter sleep onset latency. However, further research is needed to confirm this interpretation. Finally, our results show that cognitive tilt is associated with a decrease in sleep efficiency the night following an OP session when this session is played more than 2 h before bedtime. As highlighted in the results of Browne's (26) qualitative study as well as outlined by certain OPTS items, cognitive tilt may cause the player to ruminate about the consequences of poor decision making. Based on this interpretation of the results, a longer period between the end of the session and bedtime could lead to an exacerbation in the player's rumination. This can, in turn, have an effect of sleep quality as rumination is amongst the symptoms that impair sleep and contribute to long-term sleep problems (43). Curiously, cognitive tilt is only associated with reduced sleep efficiency and not with other sleep quality variables. Future studies exploring rumination in the context of a tilt episode and its effects on sleep could further contribute to our understanding.

The secondary objective of this study was to explore whether or not OP sessions played near bedtime has an effect on sleep quality. More specifically, it was hypothesized that OP sessions played in OP-Evening condition would result in a later bedtime, increased sleep latency, decreased sleep efficiency, shorter total sleep time, and feeling less rested the following morning compared to NOP-Evening condition. These hypotheses were all

refuted and, in fact, a shorter sleep onset latency was observed when sessions were played 2 h before bedtime. It was expected that gambling shortly before bedtime would have adverse effects on sleep, either by interfering with sleep (6), due to the emotional stimulation that playing may provide (46) or by increasing rumination before bedtime (43). However, it appears that an evening OP session does not yield any of these adverse effects to such an extent to affect sleep quality in participants.

Another surprising result was the observation of a shorter sleep onset latency when playing OP at night. This finding was unexpected and raises the question of whether OP can help players go to sleep. On one side, shorter sleep onset latency observed after an evening session could indicate that OP has a role in regulating players' emotions before bedtime, thus the shorter sleep latency after an evening OP session. This comprehension is supported by Wood et al. (15) results, in which problem gambling was predicted by playing to escape problems. In fact, almost two-thirds (60.9%) of our sample are low-risk gamblers and 30.4% are either moderate or possibly pathological gamblers (PGSI-OP). In this context, OP may be beneficial for players' sleep in the short term but may have adverse consequences if the player needs to play in order to have a good night's sleep. On the other hand, it is also possible that OP is part of an evening routine for the players in our sample. Referring to Morin's (53) recommendations for the treatment of insomnia, a consistent sleep routine is an integrative part of an overall sleep hygiene. It is possible that the players in our sample found OP to be a relaxing activity associated with pleasure which may explain the shorter sleep onset latency observed. However, our study did not explore the motivations to play or other aspects in the gambler's nighttime routine other than OP and therefore these interpretations of the results must be addressed by future studies.

Strengths and Limitations

The results of this study must be considered in light of certain strengths and limitations. Firstly, the research protocol used allowed us to collect objective OP data as well as subjective data on tilt episodes and daily sleep variables. The daily questionnaires allowed us to observe changes in the key study variables over 24-h periods, ultimately allowing us to gain a better understanding on how these variations may interact with each other. This close follow-up also made an ecological study design possible for the key variables. The use of mixed-analyses statistics permitted comparisons of gambling sessions based on the time of day they were played rather than separating gamblers into groups, ultimately providing statistical control for the intra-group variance. This ensures that sessions played by a subgroup of participants do not, in themselves, explain the observed differences in conditions. It also provided access to a large pool of gambling sessions providing good statistical power. However, due to our research protocol, data regarding key variables (OPTS and sleep quality) could be collected over a 24-h period. Yet, one or several OP sessions could be played in the same 24-h period by participants, making it impossible to discriminate data between groups (SDpr vs. NSDpr), which may have negatively affected the statistical power of our analysis. Moreover, as daily data collection required a great deal of engagement and discipline from the participants, many daily questionnaires were left incomplete or empty. As a result, some gambling sessions could not be associated with the dependent variables, resulting in a loss of data. A similar study with more objective data such as the use of a digital ActiGraph watch would make it possible to offset this limitation.

Furthermore, the eligibility criteria for this study solely included OP players who occasionally played while in SDpr, defined as playing 16 h since awakening. Eligibility criteria also favored regular and more experienced players; thus, our sample included a high rate of problem and probable pathological gamblers according to the PGSI. It was not possible to observe how gambling problems interacted with the variables under study. Thus, the results are not generalizable to all OP gamblers, but rather to regular OP gamblers who gamble frequently late at night or in the evening. Finally, our cross-sectional design does not allow causality to emerge, however our protocol allows us to observe a temporal link between our main variables.

Clinical Implications

The results of this study have clinical implications for public health and health professionals. Poker players should be informed that their sleeping habits have repercussions on tilt symptoms and loss of control while gambling, especially if they use alcohol. Playing poker while sleep deprived could have lingering effects on various spheres of their lives. Working on changing harmful sleep habits should be one of the goals of therapy for poker players who gamble at night.

CONCLUSION

In summary, the objective of this study was to explore the relationship between sleep problems and risky gambling behaviors of OP players' gambling sessions based on the time of day at which they were played. The results from our study suggest that higher levels of emotional and behavioral tilt are present for sessions played sleep-deprived (SDpr condition) compared to when the player was well-rested (NSDpr condition). Alcohol consumption was also shown to have an impact on the level of emotional and behavioral tilt. No cognitive tilt symptoms differences were observed between SDpr and NSDpr conditions. However, larger number of hands and more losses/sessions were observed in the SDpr condition. This relationship was not affected by alcohol or substance use. In addition, there was no significant relationship found between sessions played 2 h before bedtime and sleep quality. Nevertheless, participants reported a shorter sleep latency when sessions were played 2 h before bedtime. Although our results suggest that OP has little impact on sleep, sleep does seem to be affected when tilt symptoms are reported. Our findings show that emotional and behavioral tilt is associated with later bedtime, decreased total sleep time and shorter sleep latency. Also, cognitive tilt is associated with decreased sleep efficiency when gambling sessions have not taken place 2 h before bedtime. More studies are needed to better understand the association between gambling behaviors and sleep patterns. To shed further light on our findings, future studies could explore the motives for late night OP playing.

Future studies are also needed to explore what happens between a gambler's tilt episode and the time they go to sleep. Similarly, the inclusion of objective data on gambling and sleep patterns, via the use of a numerical ActiGraph for example, in future studies would provide further insight and enrich the interpretation of the results.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Comités d'éthique de la recherche avec des êtres humains de l'Université Laval (CERUL). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

This study is part of AH doctoral dissertation in psychology at Université Laval. He was co-supervised by IG and CB. AH led all parts of the study and the redaction process. IG had the original idea for the study. IG and CB supervised every step of the process, they revised every document, and provided their respective expertise in gambling and sleep research, they revised every document, and provided their respective expertise in gambling and sleep research. CJ research professional at the Center québécois d'excellence pour la prévention et le traitement du jeu also provided his expertise in gambling and helped a lot to increase the methodology quality. He also revised the article mostly toward the end of the process. AM provided her expertise regarding the online poker aspect of the article and the study. Her insights helped to reach online poker players. She also revised the document. All authors contributed to the article and approved the submitted version.

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Current Addiction in Youth: Online Sports Betting

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Background: Gambling landscape has changed in recent years with the emergence of online gambling (OG). Greater accessibility and availability of this betting modality can increase the risk of developing a gambling disorder (GD). Online sports betting (OSB) is currently the most common type of OG, but little is known about the clinical characteristics of OSB compared to slot-machine (SM) gamblers, the most common offline gambling disorder.

Methods: This was a prospective study conducted between October 2005 and September 2019, and included outpatients diagnosed with GD seen in a Pathological Gambling and Behavioral Addictions referral unit. Only patients with OSB and SM disorders were included. The main objective was to assess the clinical profile of OSB compared to SM gamblers, and to define clinical predictors for developing OSB gambling disorder. Logistic regression was performed to determine the effects of variables on the likelihood of this disorder.

Results: Among 1,186 patients attended in our Unit during the study period, 873 patients were included; 32 (3.7%) were OSB gamblers and 841 (96.3%) were SM gamblers. Overall, mean age was 45 ± 13 years and 94.3% were men. Compared to SM patients, OSB patients were younger (34.9 ± 9.5 vs. 45.3 ±13), more frequently single (43.8 vs. 20.6%) and had a university education level (43.8 vs. 4.5%); they were also more frequently non-smokers (18.7 vs. 66.7%) and had fewer psychiatric comorbidities (12.5 vs. 29.4%) than SM gamblers. GD duration before treatment initiation was shorter in OSB patients than in SM gamblers, most of them (81.3 vs. 42.4%) with ≤5 years of GD duration. OSB gamblers showed significant differences in weekly gambling expenditure, spending higher amounts than SM patients. Younger age (OR: 0.919; 95% CI: 0.874–0.966), university education level (OR: 10.658; 95% CI: 3.330–34.119), weekly expenditure >100€ (OR: 5.811; 95% CI:1.544–21.869), and being a non-smoker (OR:13.248; 95% CI:4.332–40.517) were associated with an increased likelihood of OSB gambling behavior.

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Conclusions: We identified different profiles for OSB and SM gamblers. Younger age, university education level, higher weekly expenditure, and non-smoking habit were associated with OSB compared to SM disorders. Prevention strategies should help young people become aware of the severe risks of OSB.

Keywords: gambling disorder, online gambling, sports betting, offline gambling, slot machine, predictors

INTRODUCTION

Gambling disorder (GD) is a gambler's inability to control their gambling behavior despite the negative consequences that this entails. The latest version of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), includes this disorder within the "Addictive and substance-related disorders," and describes it as "a maladaptive, persistent and recurrent behavior that disrupts personal, family and/or work" (1).

In a systematic review of 69 studies from different countries, adult gambling prevalence was between 0.7 and 6.5% (2). However, most of these epidemiological studies were based on offline gambling samples. Evidence on online gambling practices is scarce, but prevalence is estimated to range from 1 to 13% of the general population (3, 4). In a study conducted in Spain, Choliz et al. found a prevalence of 0.56% in adults, and 1.04% in young people (5).

Gambling was legalized in Spain in 1977. Slot-machines (SM) appeared in 1981, and rapidly became one of the most widely used forms of gambling, and the cause of most gambling problems (6).

The gambling market has changed in recent years due to the emergence of new technologies and online gambling (OG) (6, 7). The possibility of gambling from home and betting with "virtual money" has increased the accessibility, frequency, disinhibition, and lack of control of OG (8). All these features, as well as the diversification in different types of online games, can increase the risk of developing problems derived from OG (9). There are different types of OG, such as sports betting, poker, casino games, bingo, and gambling machines, but online sports betting (OSB) is currently the most common OG modality.

The advertising and marketing strategies used by the online gaming sector provide an unreal image of OSB as a lucrative leisure activity that can bring economic and social success to the gambler. It establishes a relationship between fun, sports, competition, friendship, and other values associated with adolescence and youth. All these characteristics have contributed to a better positive social perception of OSB (9, 10).

Some previous studies have compared general samples of online and offline gamblers (11–13). However, little is known about specific comparisons between OSB and land-based SM gamblers. In fact, these were the most common gambling modes in 2019 in Spain (31 and 21%, respectively) (14). Because of their high prevalence, particularly among young people, these forms of gambling are an important health problem that must be addressed and prevented (7). So we aimed to compare gambling behavior characteristics between OSB and SM gamblers, and to define clinical predictors for OSB.

MATERIALS AND METHODS

Study Design

This was a prospective study conducted from October 2005 to September 2019 among outpatients seen in a Pathological Gambling and Behavioral Addictions Unit from a referral population of 1.3 million. Most patients are referred from primary care physicians within the public healthcare system.

All patients were diagnosed with GD according to the DSM-IV-TR, or DSM-5 when appropriate (1, 15). For this study, only patients with OSB and SM disorders were included. All participants provided written or oral informed consent. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Consorci Sanitari de Terrassa (Barcelona, Spain). All patients were treated and followed-up by a team of psychologists, supervised by a senior clinical psychologist with more than 15 years' experience in the diagnosis and treatment of GD.

The therapeutic program has been described elsewhere and consists of individualized outpatient cognitive-behavioral therapy for PG, aimed at achieving abstinence from gambling. Treatment was protocolized, and the main techniques used were psychoeducation, motivational interviewing, stimulus control, cognitive restructuring and relapse prevention (16, 17).

The main objective was to assess the clinical profile of OSB gamblers compared with SM gamblers, and to define clinical predictors for developing OSB.

Variables

Gambling Variables

We recorded the type of game (OSB or SM), age of gambling behavior onset, duration of GD, frequency of gambling, and weekly gambling expenditure.

Sociodemographic and Clinical Variables

We recorded age, gender, marital status, education level, and employment status. Psychiatric comorbidities were assessed according to DSM-IV-TR or DMS-5 (affective disorder, psychotic disorder, anxiety disorder, adaptive disorder, attention deficit disorder, and substance use disorder).

Statistical Analysis

A descriptive statistical analysis was performed for all categorical and continuous variables and expressed as proportions or means with standard deviations (SD), respectively. We used chi-square or Fisher's exact tests to compare categorical data between groups. Continuous variables were compared using the Student *t*-test. We used two-tailed unpaired *t*-tests to compare

normally distributed continuous data between two groups, and the Mann-Whitney U test for non-normally distributed continuous data comparisons. To control the effect of age on the differences found between OSB and SM gamblers, we performed a *post-hoc* analysis including gamblers who started gambling at ≤25 years of age. *P*-values < 0.05 were considered statistically significant.

Logistic regression analyses were performed to identify associated risk factors for OSB gambling and presented as odds ratios (OR) with 95% confidence intervals (95% CI). For the manual backward stepwise multivariate logistic regression model, we assessed variables that had a significant p level <0.05 in univariate analyses. The Hosmer and Lemeshow test was applied;

TABLE 1 | Bivariate analysis comparing online sports betting and slot machine gamblers.

Variable	Online sports betting gamblers (*n* = 32)	Slot machine gamblers (*n* = 841)	*p*-value
Age, mean (SD)	34.9 ± 9.5	45.3 ± 13.0	**0.000**
Gender, *n* (%)			
Male	31 (96.9%)	792 (94.2%)	1.000
Female	1 (3.1)	49 (5.8%)	
Marital status, *n* (%)			
Single	14 (43.8%)	173 (20.6%)	**0.002**
With partner	18 (56.3%)	668 (79.4%)	
Stable partner	14 (43.8%)	462 (54.9%)	
Separated	2 (6.3%)	129 (15.3%)	
Divorced	2 (6.3%)	64 (7.6%)	
Widowed	0	13 (1.5%)	
Education level, *n* (%)			
University	14 (43.8%)	38 (4.5%)	**0.000**
Non-university	18 (56.3%)	776 (92.3%)	
Primary/Secondary	18(56.3%)	708 (84.2%)	
Illiterate	0	68 (8.1%)	
Employment status, *n* (%)			
Employed	22 (68.8%)	441 (52.4%)	0.077
Unemployed	10 (31.3%)	393 (46.7%)	
Student	5 (15.6%)	2 (0.2%)	
Age at gambling onset, mean (SD)	26.41 ± 9.5	26.52 ± 11	0.956
Duration of GD before treatment, *n* (%)			
≤5 years	26 (81.3%)	357 (42.4%)	**0.000**
>5 years	6 (18.8%)	477 (56.7%)	
6–10 years	5 (15.6%)	178 (21.2%)	
>10 years	1 (3.1%)	299 (35.6%)	
Daily frequency of gambling, *n* (%)	16 (50%)	344 (41%)	0.204
Gambling expenditure per week, *n* (%)			
≤100€/week	6 (18.8%)	377 (44.8%)	**0.003**
>100€/week	22 (68.8%)	372 (44.2%)	
>500€/week	8 (25%)	82 (9.8%)	
Psychiatric comorbidity, *n* (%)	4 (12.5%)	247 (29.4%)	**0.039**
Affective disorder	0 (0%)	44 (5.2%)	0.400
Psychotic disorder	0 (0%)	48 (5.7%)	0.251
Anxiety disorder	1 (3.1%)	24 (2.9%)	0.612
Adaptive disorder	1 (3.1%)	40 (4.8%)	1.000
Attention deficit disorder	1 (3.1%)	17 (2%)	0.493
Substance use disorder, *n* (%)			
Alcohol dependence	3 (9.4%)	186 (22.1%)	0.200
Tobacco dependence	6 (18.8%)	561 (66.7%)	**0.000**
Cannabis dependence	0	56 (6.7%)	0.400
Cocaine dependence	0	42 (5%)	0.629

The blod values means "statistically significant values".

TABLE 2 | Bivariate analysis comparing online sports betting and slot machine gamblers with gambling onset before 25 years of age.

Variable	Online sports betting gamblers (*n* = 18)	Slot machine gamblers (*n* = 438)	*p*-value
Age, mean (SD)	29.72 ± 7.6	40.07 ± 10.9	**0.000**
Gender, *n* (%)			
Male	17 (94.4%)	426 (97.2%)	0.412
Female	1 (5.5%)	12 (2.7%)	
Marital status, *n* (%)			
Single	13 (72.2%)	114 (26%)	**0.000**
With partner	5 (27.7%)	324 (74%)	
Stable partner	5 (27.7%)	218 (49.8%)	
Separated	0	88 (20.1%)	
Divorced	0	18 (4.1%)	
Widowed	0	0	
Education level, *n* (%)			
University	9 (50%)	21 (4.8%)	**0.000**
Non-university	9 (50%)	405 (92.5%)	
Primary/Secondary	9 (50%)	378 (86.3%)	
Illiterate	0	27 (6.2%)	
Employment status, *n* (%)			
Employed	11 (61.1%)	269 (61.4%)	0.950
Unemployed	7 (38.9%)	166 (37.9%)	
Student	5 (27.8%)	2 (0.5%)	
Age at gambling onset	19.72 ± 3.4	19.28 ± 3.1	0.559
Length of GD before treatment, *n* (%)			
≤5 years	16 (88.9%)	176 (41.2%)	**0.000**
>5 years	2 (11.1%)	261 (59.6%)	
6–10 years	1 (5.6%)	99 (22.6%)	
>10 years	1 (5.6%)	162 (37%)	
Daily frequency of gambling, *n* (%)	9 (50%)	180 (41.09%)	0.630
Gambling expenditure per week, *n* (%)			
≤100€/week	3 (16.7%)	190 (43.4%)	**0.013**
>100€/week	15 (83.3%)	204 (46.6%)	
>500€/week	5 (27.7%)	48 (11%)	
Psychiatric comorbidity, *n* (%)	2 (11.1%)	123 (28.1%)	0.175
Substance use disorder, *n* (%)			
Alcohol dependence	1 (5.6%)	113 (25.8%)	0.192
Tobacco dependence	4 (22.2%)	307 (70.1%)	**0.000**
Cannabis dependence	0	41 (9.4%)	0.625
Cocaine dependence	0	25(5.7%)	1

The blod values means "statistically significant values".

a *p*-value of 0.05 or higher indicated that the model fitted well with the data. The variance inflation factors (VIF) of each variable included in the final model were computed, and a VIF of >10 indicated that multicollinearity of the corresponding variable was high. Analyses were performed using SPSS, version 25 for PC (SPSS Inc., Chicago, IL, USA).

RESULTS

Among 1,186 patients attended in our Unit during the study period, 172 patients were excluded due to other behavioral addictions and 141 patients due to other types of gambling. Finally, 873 patients were included: 32 (3.7%) were OSB gamblers and 841 (96.3%) were SM gamblers. Overall, mean age was 45 ± 13 years and 94.3% were men. Most patients had a stable partner (54.5%), had completed primary or secondary education (83.2%), were employed (53%) and were smokers (65%). Mean age for gambling onset was 26.5 ± 10.9 years. Most patients (55.3%) had a gambling history of >5 years.

Compared to SM patients, OSB patients were younger (34.9 ± 9.5 vs. 45.3 ± 13), more frequently single (43.8 vs. 20.6%) and with university education level (43.8 vs. 4.5%); they were also more frequently non-smokers (18.8 vs. 66.7%) and had fewer psychiatric comorbidities (12.5 vs. 29.4%) than SM gamblers. Duration of the GD was shorter in OSB patients than in SM gamblers, most of them (81.3 vs. 42.4%) with ≤5 years of GD duration before treatment initiation. OSB gamblers showed significant differences in their weekly gambling expenditure, spending higher amounts than SM patients. Comparison between OSB and SM gamblers is shown in **Table 1**.

We aimed to assess the impact of OSB compared to SM among those who started gambling when young. We performed a *post-hoc* analysis in the subgroup of gamblers who started gambling at ≤25 years old. Compared to SM gamblers, OSB gamblers were more frequently single (72.2 vs. 26%) and with university education level (50 vs. 4.8%). In addition, OSB gamblers had higher weekly gambling expenditure and shorter length of GD before starting treatment compared to SM gamblers (88.9% of OSB vs. 41.2% of SM gamblers reported GD onset ≤5 years) (**Table 2**).

The regression model used to determine the effects of variables on the likelihood for OSB or SM gambling included four out of the 18 predictor variables (age, education level, weekly expenditure and tobacco use) with an accuracy of 97.5% and a Nagelkerke R2 of 55.6%. Younger age (OR: 0.919; 95% CI: 0.874–0.966), university education level (OR: 10.658; 95% CI: 3.330–34.119), weekly expenditure >100€ (OR: 5.811; 95% CI: 1.544–21.869) and being a non-smoker (OR: 13.248; 95% CI: 4.332–40.517) were associated with an increased likelihood of OSB gambling behavior (**Table 3**).

DISCUSSION

This is the first study comparing OSB with SM gamblers, in which we aimed to define clinical predictors for OSB. The results of our study reveal a different profile between OSB and SM gamblers. We also found that younger age, university education level, gambling expenditure of more than 100€ per week and being a non-smoker increases the likelihood of being an OSB gambler.

In accordance with previous studies, almost all OSB gamblers from our study were male, single and had a higher education level (9, 12). We also found lower tobacco use and fewer psychiatric comorbidities in OSB compared to SM gamblers. The smoking prevalence in our OSB sample is slightly lower than in previous studies among online gamblers (18–20). This could be because almost half of OSB gamblers from our study have reached a university education level that has shown a negative association with smoking prevalence (21). The presence of psychiatric comorbidities has a negative effect on offline gambling outcomes (16, 22). However, the influence of this variable on OSB gambling is controversial (23, 24). In fact, although OSB gamblers in our study exhibit severe gambling behavior (spending more money on gambling and developing GD faster than SM gamblers), they presented a lower prevalence of psychiatric comorbidity than SM gamblers (12.5 vs. 29.4% respectively). This could be related to the type of gambling, as OG was more addictive than offline gambling and could induce more deleterious behavior (5). More studies are needed in online gamblers to assess the effect of psychiatric comorbidity on the course of the disorder and on response to treatment.

In our study, being younger and university education level were predictors for OSB. These results are in line with previous studies (9). Sports betting associate new technologies with an unreal concept of sport, and is becoming a common activity amongst sports audiences, especially youth. Furthermore, because knowledge of sports is widespread amongst the general population, and young people are "tech-savvy," OSB gamblers may have a false perception of a higher probability of winning

TABLE 3 | Multivariate analysis predicting online sports betting and slot machine gamblers.

Variable	beta	SE	Wald	*P*	OR	95% CI	
						Lower	Upper
Age	−0.805	0.026	11.036	0.001	0.919	0.874	0.966
University education level	2.366	0.594	15.896	0.000	10.658	3.330	34.119
>100€ gambling expenditure per week	1.760	0.676	6.773	0.009	5.811	1.544	21.869
Non-smoker	2.584	0.570	20.525	0.000	13.248	4.332	40.517

OR, odds ratio; CI, confidence interval.

with a lower influence of chance than in other types of games. All these characteristics have contributed to change gambling as a common leisure activity among young people. Thus, OSB has been added to other inherent risk behaviors of young people, where there is a higher risk of developing addiction problems (25). Adolescence is a critical period for brain development, with an imbalance between emotional (reward motivation) and cognitive (executive control) processes, and this is why adolescents are sensitive to the effect of alcohol and other psychoactive substances (26). Furthermore, some studies have demonstrated that earlier onset of the disorder is predictive of gambling severity (27). These results underscore the need to early recognition and to design preventive interventions focused on young people, especially university groups, and also adolescents in order to raise awareness of the risks of OSB gambling, and to avoid an escalation of GD once they reach the legal age for betting (9)

In our study, although both groups began gambling at a similar age (26.4 years for OSB gamblers vs. 26.5 years for SM gamblers), most OSB gamblers develop GD within the first 5 years of gambling onset (81.3% for OSB gamblers vs. 42.4% for SM gamblers). Moreover, OSB gamblers spend more money than SM gamblers, and amounts of more than 100€ per week increase the likelihood of being an OSB gambler. This higher expenditure and rapid progression of GD also appeared when we selected those gamblers who had started gambling at ≤25 years. These findings corroborate the negative effect of the structural characteristics of OG. The availability 24/7 for gambling at home or remotely from an electronic device with "virtual money" increases accessibility and loss of control during gambling (8, 9, 25). Montes et al., in a laboratory environment study on poker, found that online gamblers play more hands and incur higher losses than non-online gamblers (28). These results support the finding that OG induces more deleterious behavior, and could explain why OSB gamblers seek treatment earlier than other types of gamblers, as we found.

Furthermore, current massive marketing of OG, mainly during sport events, is becoming aggressive and contributing to increasing OG problems (29). Advertising of gambling only highlighting an unrealistic ease of winning without the real possibilities of losing can contribute to perceiving gambling as a desirable activity among young people. Moreover, this deceptive image contributes to game incitement among those risky gamblers, especially among youth (30). The focus of OG marketing on young people has contributed to increasing the incidence of OSB gambling disorder in this group, as we found when comparing SM gamblers.

The impact of OSB advertising and marketing among young people deserves special attention. Although most countries have laws that ban minors from gambling, controlling their access to the game is not easy and requires further efforts (25). As the gambling landscape has changed, regulation of gambling also needs to change. Effective public health policies are needed to develop comprehensive regulatory frameworks that protect young people, including university students, from this excessive exposure to OG (31).

Our study has some limitations that should be mentioned. Firstly, because of its descriptive nature, our sample groups had an unbalanced sample size. This could be attributed to the long study period, which started in 2005, while OSB gambling disorder developed some years later. Secondly, the lack of a specific comparison between OSB and land-based sports bettors. However, the accessibility and availability of gambling on electronic devices make it hard to confirm which patients are exclusively land-based sports bettors, and to compare both groups. Thirdly, other variables such as personality traits were not included in the study. Finally, our study has an observational design, so our results must be confirmed and validated in further studies.

In conclusion, a different profile between OSB and SM gamblers has been described. Younger age, university education level, higher weekly expenditure, and non-smoking habit were associated with OSB compared to SM disorders. These variables should be included in prevention strategies designed to raise awareness among young people of the severe risks of OSB and help them avoid this behavior.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Consorci Sanitari de Terrassa (Barcelona, Spain). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors have participated in the preparation of the manuscript and have approved the final version of the manuscript.

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Impulsivity, Lack of Premeditation, and Debts in Online Gambling Disorder

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Background and Objectives: Gambling disorder (GD) is a recurrent and persistent problematic gambling behavior that impairs multiple areas of an individual's life. GD can persist through two modes: online or offline. This study aims to compare sociodemographic, clinical, and psychological characteristics between treatment-seeking online and offline gamblers and analyze the effect of the gambling mode (online or offline) on anxiety, depression, impulsivity, and debts.

Methods: Seventy-nine treatment-seeking gamblers (96.2% males), who were simultaneously receiving treatment at a specialized Pathological Gambling and Behavioral Addictions Unit, participated in this study. The sample was divided into two subsamples: online ($n = 29$, 100% males) and offline ($n = 50$, 94% males); the characteristics of these two groups were compared and analyzed using Chi-Square test (χ^2), *t*-Test or Mann–Whitney *U*-test ($p < 0.05$). Multiple linear regression analyses were performed to determine the effects of gambling mode on significant variables (lack of premeditation and debts).

Results: The online sample with a mean age of 29.4 years mainly chose to engage in sports betting (45%, $p < 0.05$) and showed a higher lack of premeditation levels (25.8 points, $p < 0.05$) than the offline sample. In addition, the online sample was younger with respect to their onset to gambling (20.2 years, $p < 0.05$) and the beginning of their gambling problems (25 years, $p < 0.05$) compared to the offline sample. Online gambling increased the levels of lack of premeditation by an average of 5.43 points compared to offline gambling ($p < 0.05$). Accumulated debts of the online sample were lower (€11,000) than those of the offline sample (€12,000). However, the interaction between age and gambling mode revealed that online gamblers increased their debt amounts with age at an average increase of €2,726.33 per year compared to offline gamblers ($p < 0.05$). No significant influence of gambling mode was found on GD severity, anxiety, and depression levels.

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Conclusions: Gambling mode has a significant relationship with lack of premeditation—a component of impulsivity—and accumulation of debts in treatment-seeking people with GD; however, no relationship was found with the rest of the variables analyzed. Future research with larger samples is needed to confirm these findings.

Keywords: gambling disorder (GD), online gambling, offline gambling, sports betting, impulsivity (IMP), lack of premeditation, debt, pathological gambling

INTRODUCTION

Gambling disorder (GD) has been defined as a recurrent and persistent gambling behavior that deteriorates multiple areas of an individual's life and generates significant emotional distress (1). Such maladaptive gambling behavior can occur in two modes: online (i.e., on the Internet) and offline (2). In Spain, the probability of adults developing gambling-related behaviors is 4.4%, 1% for problem gambling, and 0.9% for GD throughout their lifespan (3), whereas for Spanish adolescents, 8.2% could be considered at-risk gamblers, 5.6% problem gamblers and 1.84% pathological gamblers (4, 5).

Modern technology has led to the unprecedented development and expansion of gambling activities, primarily through online gambling. Recently, there has been an increase in the number of online gamblers in Spain. According to the Directorate General for the Regulation of Gambling (DGOJ), an organization that regulates gambling nationwide in Spain, 83.46% of those who gambled online ranged between 18 and 45 years in 2018 (6). Structural characteristics (ease of betting, immediacy of the prize, and high probability of winning) and immediate infrastructure and environment (privacy, comfort, availability, and accessibility) make online gambling more addictive than offline (5). Problem gambling is more common among online gamblers, especially among vulnerable individuals (7, 8). Gambling advertising and promotion contribute to increased demand for and indulgence in gambling (9). Most gambling advertisements on television are concerned with online gambling (10), which has a significant impact on the probability of developing GD (8). Currently, online gambling, mainly sports betting, acts as the main cause of GD among treatment-seeking patients (11). In Spain, online sports betting has grown rapidly in recent years, contributing largely to the gambling industry's profits. Since 2012, more than half of the online gamblers have indulged in sports betting (52.2%) (12); it has also become a frequent gambling activity among the younger population (13).

GD has often been associated with impulsive behavior and it is considered a risk factor in its etiology (14). Impulsive behaviors in childhood have predicted problem gambling in adulthood (15). A systematic meta-review conducted by Lee et al. (16), showed that impulsivity is a fundamental process underlying addictive behaviors, with and without substance, especially in alcohol abuse and GD. In line with these findings, high impulsivity has been pronounced in people with GD as opposed to healthy controls (17). There are many models that have tried to explain impulsivity and its complex nature (14, 18). The UPPS-P Impulsive Behavior Scale, developed by Whiteside and Lynam (19) and modified by Cyders et al. (20) measures five personality dimensions that contribute to impulsive behavior.

In addition to impulsive behavior, GD is often related to higher stress, anxiety, depression (21, 22), GD severity (23), and debt levels (10). In some instances, the psychological distress may even be mediated by financial debt (24). In addition to the personal economic cost, it has a high sanitary cost related to treatments. A German study estimated an added increase of €27.24 million per year in their health sector, fundamentally caused by increasing gambling problems among online gamblers (25).

To the best of our knowledge, there are few studies that have focused on sociodemographic, clinical, and psychopathological differences between samples of online and offline pathological gamblers. In recent years, there has been a growing interest in the study of GD, especially since the expansion of the online gambling industry and increase in the number of online gamblers.

Previous studies have shown significant differences in sociodemographic variables, such as age and education level, with respect to the gambling mode (26, 27). Studies conducted with samples of pathological gamblers have also found significant differences in GD severity, psychological distress, and personality traits, comparing strategic gambling which emphasize the importance of individual skills (poker, craps, or sports betting) and non-strategic gambling which emphasize chance as playing a bigger part (lotteries, bingo, or slots-machine) (28) or samples of online and offline sports betting gamblers with another sample of general offline gamblers (29).

With respect to impulsivity variables, strategic gamblers have shown a higher lack of perseverance levels than non-strategic gamblers (30). However, they showed similar scores on all impulsivity variables when online and offline gambling samples were compared (30). In addition, high negative urgency levels (31), online gambling, and high levels of debts were identified as predictors of dropout in a cohort of pathological gamblers seeking treatment (32).

Given the context of and increasing number people indulging in online gambling and its addictive component, the objective of the present study was to explore and compare sociodemographic, clinical, and psychopathological variables between two treatment-seeking samples of persons with GD and estimate the effect of gambling mode on GD severity,

Abbreviations: GD, Gambling Disorder; UPPS-P, Impulsive Behavior Scale; SOGS, South Oaks Gambling Screen; PG-YBOCS, Pathological Gambling Yale-Brown Obsessive Compulsive Scale; BDI-II, Beck Depression Inventory-Second Edition; STAI, State-Trait Anxiety Inventory.

anxiety, depression, impulsivity, and accumulated debts. We hypothesized higher GD severity, impulsivity, accumulated debts, anxiety, and depression levels in online gamblers compared to offline gamblers. Considering that online gambling is more harmful than offline gambling, we expected to be able to estimate the effect of gambling mode on the variables under study. Additionally, given that most online samples indulged in sports betting, we wanted to explore its effect on online gamblers.

MATERIALS AND METHODS

Participants

The participants were pathological gamblers, who were treated together in the Pathological Gambling and Behavioral Addictions Unit of the Ramon y Cajal University Hospital (Madrid, Spain), between January 2019 and March 2020. The inclusion criteria were a diagnosis of GD according to DSM-5 criteria and over 18 years of age. Comorbidity with intellectual disability; history of substance abuse/dependence; diagnosis of schizophrenia, or other psychotic disorders, major depression, or bipolar disorder, as well as severe organic and/or neurological pathology including history of traumatic brain injury, or epilepsy were set as exclusion criteria. The initial sample consisted of 102 patients, 23 of which were excluded because of comorbidities; thus, the final sample comprised of 79 patients. The total sample was divided into online (inclusion criteria: gambling predominantly or exclusively online) and offline (inclusion criteria: gambling predominantly or exclusively offline) gamblers. Finally in our sample all the players included in the offline sample played exclusively offline, none of them had any problems with the online game.

Measures

Diagnostic Questionnaire for Pathological Gambling According to the DSM-5 Criteria

This is a self-report questionnaire developed to identify the presence of GD according to DSM-5 (1). It has 19-item based on the DSM criteria. The total scores range from 0 to 10. The cutoff point was 4 or more (33). It is a reliable, valid, and accurate instrument for GD diagnosis (Cronbach's alpha for our sample, $\alpha = 0.85$).

South Oaks Gambling Screen (SOGS)

It is a screening instrument that is used in many studies as a measure of severity of gambling activity. It has 20-item, which a total scores range from 0 to 20. The cutoff point was 5 or more, indicating a probable pathological gambler (34, 35). This study used the Spanish version of the scale, which showed high internal consistency in our sample (Cronbach's alpha, $\alpha = 0.85$).

Yale-Brown Obsessive Compulsive Scale Adapted for Pathological Gambling (PG-YBOCS)

PG-YBOCS measures the severity and change in GD symptoms over a recent time interval (usually within the past 1 or 2 weeks). This is a 10-item scale, divided into two subscales (gambling thoughts or urges and gambling related behavior) and an overall symptom severity score. The total scores range from 0 to 40 (36). It is a reliable and valid instrument for GD severity, showing high internal consistency (Cronbach's alpha, $\alpha = 0.85$).

State-Trait Anxiety Inventory (STAI)

This questionnaire evaluates anxiety as a state (momentary, transitory) and as a trait (more stable condition). It comprises of 40 items divided into two subscales: trait and state, with Likert-type responses from 0 to 3. The total score for each subscale ranges from 0 to 60. There is no cut-off point (37). This study used the Spanish version of the scale, which showed high internal consistency in our sample (trait anxiety Cronbach's alpha, $\alpha = 0.85$, and state anxiety Cronbach's alpha, $\alpha = 0.85$).

Beck Depression Inventory-Second Edition (BDI-II)

This questionnaire measures the severity of depression in adults and adolescents aged 13 and older. It comprises of 21 items. The total score ranges from 0 to 63 points. The following cut-off points were established: 0–13, minimal depression; 14–19, mild depression; 20–28, moderate depression; and 29–63, severe depression (38, 39). This study used the Spanish version of the scale, which showed high internal consistency in our sample (Cronbach's alpha, $\alpha = 0.85$).

The UPPS-P Impulsive Behavior Scale

This scale measures five personality dimensions that contribute to impulsive behavior: negative urgency (tendency to lose control under negative emotions), positive urgency (tendency to lose control under positive emotions), sensation seeking (predisposition to try new and stimulating activities), lack of premeditation (tendency to make decisions without considering their consequences), and lack of perseverance (inability to maintain the level of effort needed during a demanding task). It has 59 items, which are scored using a Likert-type scale (19, 40). This study used the Spanish version of the scale, which showed high internal consistency in our sample (Cronbach's alpha negative urgency, $\alpha = 0.86$; positive urgency, $\alpha = 0.87$; sensation-seeking, $\alpha = 0.90$; lack of premeditation, $\alpha = 0.88$; lack of perseverance, $\alpha = 0.86$).

Other Variables

Data about sociodemographic variables such as age, gender, marital status, educational level, and employment were collected. Furthermore, gambling mode and type, onset of gambling activity, onset of GD, GD progression, and accumulated debts were registered using a standardized *ad hoc* questionnaire. All variables were systematically collected from the participants.

Procedure

This study was approved by the Ethics Committee of the Ramon y Cajal University Hospital and was in accordance with the principles of the Declaration of Helsinki. All patients provided written informed consent for their participation in the study. There was no monetary compensation for their participation.

All the assessment procedures were conducted in a single session where patients completed the self-report questionnaires (for determining GD severity, impulsivity, anxiety, and depression levels), participated in a structured face-to-face clinical interview, and answered a standardized

ad hoc questionnaire (for reporting sociodemographic and clinical variables).

Statistical Analyses

The total sample was divided into two groups for the initial analysis: online gambling sample ($n = 29$) and offline gambling sample ($n = 50$). Sociodemographic, clinical, and gambling characteristics (age, sex, marital status, educational level, employment, family gambling history, gambling activity, debts, and impulsivity levels) were explored. Qualitative variables were assessed by absolute and relative frequency and differences between samples were assessed using the chi-square test (χ^2). Continuous variables were assessed using mean and standard deviation (SD) in variables with normal distribution, or median and interquartile range (IQR) in non-normal distribution variables; differences between samples were explored using a *t*-test or Mann–Whitney *U*-test, respectively. All contrasts were bilateral, with a significance level of $p < 0.05$.

Multiple linear regression analyses were performed to determine the effects of gambling mode and gambling type on the variables that showed significant differences between the groups (lack of premeditation and accumulated debts). Due to significant differences between participants' age in the online and offline groups, all models were adjusted for age. The method to introduce variables in models was stepwise and was completed from the beginning. As both age and gambling mode had significant effects on accumulated debt, the interaction effect was studied to assess the effect of gambling mode on different ages. Statistical analyses were carried out using SPSS (Version 26) and STATA (Version 16.1 for Windows).

RESULTS

Sample Characteristics

Table 1 includes a description of sociodemographic, gambling type, debts and impulsivity variables, and differences found between samples. The online sample comprised of only males, while the offline sample was predominantly males (94%). The demographics showed that online sample had higher levels of unmarried (52%), educated (41%, secondary; 31%, university) and employed (62%) individuals than the offline gambling sample; however, the offline sample had a higher level of family gambling history (22%), than the online sample. The primary significant difference was seen in the age ($p < 0.05$) between the online (M = 29.4 years, SD = 7.6) and offline (M = 46.8 years, SD = 15.8) sample. In addition, the results reported a significant difference ($p < 0.05$) in the gambling type between the online (45%, sports betting; 34% sports betting in combination with other gambling types) and offline (54% slot machines, 12% other combinations of offline gambling activity) gambling samples. Lastly, significant differences were detected in one of the impulsivity components, namely, lack of premeditation levels as per the scores of the UPPS-P subscales (online = 25.8, offline = 22, $p < 0.05$). No other significant differences were found in any variables.

Activity Onset, GD Onset, GD Progression and Clinical Profile

Table 2 contains a description of the onset of gambling activity, onset of GD, GD progression, and other clinical variables (GD severity, anxiety, and depression levels). Significant differences were found between samples in terms of gambling activity onset ($p < 0.05$), where online gamblers were on average 7.43 years younger than offline gamblers at the onset of gambling activity. At the onset of GD ($p < 0.05$), online gamblers were on average 8.89 years younger compared to the offline gamblers.

No statistically significant differences between the groups were found for GD progression ($p = 0.604$), DSM-5 total criteria ($p = 0.959$), SOGS total ($p = 0.417$), PG-YBOCS total ($p = 0.653$), BDI-II ($p = 0.756$), STAI-state ($p = 0.632$), and STAI-trait ($p = 0.631$).

Effect Estimation Models

Estimation results of linear regression models are showed in **Table 3**.

Model 1 contains the effect of gambling mode on the lack of premeditation. Online gambling, as the main effect on lack of premeditation, was an explanatory variable ($p < 0.05$). Online gambling increased the levels of lack of premeditation by an average of 5.43 points compared to offline gambling.

Model 2 shows the effect of lack of premeditation in online gambling, controlling for sports betting and age. Only online gambling had a significant effect on lack of premeditation which increased on average 4.48 points compared to offline gambling ($p < 0.05$).

Model 3 displays the effect of online gambling and sports betting on accumulated debts (only in patients with debts), and the interaction effect between gambling mode and age. Gambling mode had a significant main effect on accumulated debts ($p < 0.05$). The interaction effect between age and gambling mode showed that online gamblers' amount of debt increases with age, with an average increase of €2,726.33 per year compared to offline gamblers.

DISCUSSION

This study examined and compared sociodemographic, clinical, and psychopathological variables between two patient samples (online and offline gamblers) seeking treatment for GD. The main hypothesis was that online and offline gambler profiles would be different and that online gamblers would present higher GD severity, impulsivity, anxiety and depression levels, and accumulated debts than offline gamblers.

Sociodemographic Variables

The results of this study showed that there are significant age differences between the online sample, (M = 29.4 years) compared to the offline sample (M = 46.8 years). This can be attributed to the legalization of online gambling, which has led to an increase in the number of pathological gamblers, especially among young adults. Of the online gamblers in Spain, 34.41% are between 26 and 35 years (6). In this study, the onset of gambling activity in the online sample was at a younger age

TABLE 1 | Online and offline gambler characteristics.

		Online gamblers ($n = 29$)	Offline gamblers ($n = 50$)	*P*-value
Age (years), mean (SD)		29.4 (7.6)	46.8 (15.8)	0.000*
Gender				
	Men	29 (100%)	47 (94%)	***
	Women	0 (0%)	3 (6%)	
Marital status				
	Single	15 (52%)	14 (28%)	0.072
	Married-couple	9 (31%)	28 (56%)	
	Divorced-separated	3 (10%)	5 (10%)	
	Lost values	2 (7%)	3 (6%)	
Education level				
	Primary	6 (21%)	16 (42%)	0.225
	Secondary	12 (41%)	14 (37%)	
	University	9 (31%)	8 (21%)	
	Lost values	2 (7%)	0 (0%)	
Employment				
	Employed	18 (62%)	28 (56%)	0.837
	Unemployed	10 (35%)	14 (28%)	
	Lost values	1 (3%)	8 (16%)	
Family gambling history				
	No family gambling history	25 (86%)	39 (78%)	0.613
	First degree family	2 (7%)	6 (12%)	
	Second degree family	2 (7%)	5 (10%)	
Gambling type				
	Slot machine	0 (0%)	27 (54%)	0.000*
	Sport betting	13 (45%)	7 (14%)	
	Roulette	4 (14%)	6 (12%)	
	Other (e.g., bingo, lottery, poker)	2 (7%)	4 (8%)	
	Two or more types	10 (34%)	6 (12%)	
Debts				
	Yes	24 (83%)	33 (66%)	0.109
	No	5 (17%)	17 (34%)	
Accumulated debts (€) median (IQR)**		11000 (5000; 35000)	12000 (3500; 21000)	0.059
UPPS-P impulsive behavior scale				
	Negative urgency, mean (SD)	30.2 (6.7)	33.3 (9.0)	0.236
	Positive urgency, mean (SD)	27.5 (7.8)	34.4 (13.5)	0.062
	Sensation-seeking, mean (SD)	31.8 (8.7)	27.2 (9.7)	0.129
	Lack of premeditation, mean (SD)	25.8 (4.7)	22.0 (6.3)	0.040*
	Lack of perseverance, mean (SD)	22.5 (3.8)	20.8 (6.0)	0.325

*SD, standard deviation; IQR, interquartile range; UPPS-P, Impulsive Behavior Scale. *p < 0.05; **Median and range have been calculated only in patients with debts.*
****The distribution by gender is shown for the purposes of sample description. Statistical analysis cannot be performed because of the small sample size in women, who are only represented in the offline sample.*

(about 20 years) than in the offline sample (about 27 years). Similarly, the age at onset of GD in online gambling was lower than that in the offline sample. Although online gamblers are not a homogeneous group, since different types of behavior can be considered in the online gambling sphere (41), there is evidence that increased participation in online gambling increases the likelihood of developing GD (8).

Relative to the type of game, the differences between the samples are also notable. Sports betting is the most practiced type of gambling among online sample. Previous literature provides evidence of different phenotypes of online sports betting gamblers (42). In contrast, among offline gamblers, slot machines are the most common gambling activity. Until the advent of online gambling, slot machines were largely responsible for GD behaviors due to their high addictive levels (43).

The finding that online gamblers were younger than offline gamblers could be partly explained by the fact that the advertising and promotion of online gambling, mostly related to sports

TABLE 2 | Activity onset, GD onset, GD progression, and clinical profile.

	Online gamblers ($n = 29$)	Offline gamblers ($n = 50$)	Coefficient (CI 95%)	*P*-value
Gambling activity onset (age, years), mean (SD)	20.2 (4.2)	27.6 (13.7)	7.43 (1.99; 12.86)	0.008*
GD onset (age, years), mean (SD)	25.0 (7.1)	33.6 (14.1)	8.89 (2.96; 14.83)	0.004*
GD progression (age, years), mean (SD)	4.8 (6.5)	6.0 (10.1)	1.16 (−3.28; 5.61)	0.604
DSM-5 total criteria	7.3 (2.0)	7.4 (2.0)	0.02 (−0.95; 1.00)	0.959
SOGS total	11.6 (3.1)	11.06 (2.7)	−0.56 (−1.95; 0.82)	0.417
PG-YBOCS total	17.8 (10.0)	16.8 (9.4)	−1.06 (−5.77; 3.64)	0.653
BDI-II	20.4 (17.7)	18.9 (13.7)	−1.48 (−11.06; 8.10)	0.756
STAI-state	26.6 (18.0)	24.2 (14.1)	−2.37 (−12.28; 7.54)	0.632
STAI-trait	28.2 (15.8)	26.0 (13.2)	−2.18 (−11.29; 6.93)	0.631

*SD, standard deviation; CI, confidence interval; GD, Gambling disorder; SOGS, South Oaks Gambling Screen; PG-YBOCS, Pathological Gambling Yale-Brown Obsessive Compulsive Scale; BDI-II, Beck Depression Inventory-Second Edition; STAI, State-Trait Anxiety Inventory. *p < 0.05.*

TABLE 3 | Estimation results of linear regression models.

	Coefficient	*P*-value	95% CI
Model 1: Lack of premeditation (UPPS-P)			
Gambling mode (online)	5.43	0.021*	−10.00; −0.86
Age (years)	0.089	0.250	−0.07; 0.24
Model 2: Lack of premeditation (UPPS-P)			
Gambling mode (online)	4.84	0.039*	0.27; 9.41
Gambling type (sports betting)	2.96	0.136	−0.98; 6.91
Age (years)	0.07	0.329	−0.08; 0.23
Model 3: Accumulated Debts (€)			
Gambling mode (online)	−63345.59	0.036*	−122313.5; −4377.68
Gambling type (sports betting)	5711.50	0.530	−12332.2; 23755.92
Age (years)	240.78	0.416	−346.77; 828.32
Online gambling, age (years)	2726.33	0.003*	984.27; 4468.39

*CI, confidence interval; UPPS-P, Impulsive Behavior Scale. *p < 0.05.*

betting, targets young adults. There are studies that link the type of gambling to the emergence of gambling advertising. For example, in a sample of Swedish online gamblers, casino games were the most advertised and practiced compared to other types of gambling (10). Sports betting advertisements seek to normalize betting activity (43), by highlighting positive aspects (44). Young adults are beginning to bet on well-known soccer, tennis, or basketball competitions (13). Based on the small number of women in our sample, we were unable to assess gender differences. Previous literature has showed that women are less represented than men in clinical samples (45).

GD Severity

The results reported no statistically significant differences GD severity between online and offline samples. In line with our results, a study also compared sociodemographic and clinical characteristics of treatment-seeking GD patients; no differences were found in DSM-5 and SOGS severity levels between offline gamblers, sports online and non-sports online gambling groups (29). In another study, which compared strategic and non-strategic treatment-seeking GD, no differences between groups were found either. However, age and age of GD onset were found to be predictive of the severity of the disorder in another (28).

Impulsivity (Lack of Premeditation)

According to the UPPS-P model, lack of premeditation is the tendency to make decisions without considering their consequences (19). It is known that in people with GD, lack of premeditation is related to unfavorable decision-making (46), such as an inability to identify the possible negative financial problems due to gambling (18). This could be a potential explanation for the lower premeditation scores obtained in online gamblers than offline gamblers in the current sample. Similar results were obtained in another study, where a higher lack of premeditation was found among strategic gamblers, such as sports betting gamblers, compared to non-strategic gamblers (30). This is because sports betting may be considered less harmful or problematic by gamblers than other gambling types. A survey of Canadian teenagers reported that they understood betting (sports betting) and gambling differently, where betting was not considered as gambling (47). Lack of premeditation has also been associated with drinking behavior in daily life (48), and it is considered a risk predictor of problem alcohol use (49). Furthermore, it could increase the likelihood of being a smoker as an adult (50). Nevertheless, according to the results of this study, online gambling would significantly increase the lack of premeditation level than offline gambling. Therefore, the structural characteristics and environmental conditions in which the online gambling takes place (5) could encourage online gamblers to take less premeditated actions, regardless of the gambling type.

Accumulated Debts

In this study, the accumulated debts between the samples were also compared. Although the difference was not statistically significant, the findings revealed that debts are more common among online than offline gamblers. However, the average

amount of debt accumulated in offline gamblers is higher than that in online gamblers. These findings are inconsistent with a previous study carried out in a treatment-seeking gamblers, which found that the highest mean debt for online gamblers was $20,000, compared to $500 for offline gamblers (51). Some online gamblers are in debt or over-indebted (10). The current results are consistent variables such as age are considered, for instance, since online gamblers are younger than offline gamblers, they have lesser time to accumulate more debt. In addition, it could be explained by the fact that among online gamblers, the percentage of unemployment is higher than in the offline sample, thus, one possibility is that online gamblers have less money to spend in gambling. Lastly, the annual debt increase of €2,726.33 of online gamblers as their age increases may indicate greater involvement and expenditure in gambling.

Anxiety and Depression

Several studies have reported high levels of anxiety and depression in GD (24, 52). Depression severity has even been predicted by gamblers involved in multiple online activities (53). The results are in line with these findings with high scores on the STAI and BDI-II. However, no differences in anxiety and depression levels were found between online and offline samples, which counters the initial hypothesis that online gamblers would have higher levels for both. STAI and BDI-II scores were high in both samples, which indicates high psychological stress related to GD behaviors.

Strengths and Limitations

The results of this study are preliminary, and its major strengths are the use of standardized instruments and the study of patients in a treatment program. However, this study also has some limitations that should be considered. The main limitation is the sample size, which is a limiting factor in the power of the statistical analyses and effect size. Due to the limitations of the sample size, the analyses were focused on the significant results obtained in variables of clinical interest by comparing the samples (anxiety, depression, lack of premeditation, and debt). Therefore, no correction methods were employed for the multiple comparisons to avoid losing the statistical power and increasing the type II error. Another limitation of this study is the underrepresentation of women; thus, gender differences could not be explored. Exploring impulsivity and lack of premeditation through a single measure is also a limitation; therefore, future research should include a more comprehensive assessment, which also includes a non-gambling control sample. In addition, this study was not specifically designed to explore the interaction between the mode and type of gambling; thus, its analysis can only be considered preliminary.

CONCLUSION AND IMPLICATIONS

In conclusion, the results obtained in our study suggest that the gambling mode (online or offline) could be related to impulsivity and accumulated debts in treatment-seeking people with GD. Thus, online gambling was associated with higher levels of lack of premeditation and lower accumulated debts. However, the amount of debt of online gamblers increases with age increases as compared to offline gamblers.

No influence of gambling mode was found on GD severity, anxiety and depression levels, or other components of impulsivity, such as negative and positive urgency, sensation-seeking, or lack of perseverance.

Future researchers should increase the sample size, including subsamples of online, offline, and mixed gamblers (gambling both online and offline), who might show differentiated clinical and psychological characteristics, and with adequate gender representation. The design of future studies should also include a greater representation of the different types of gambling within each gambling mode (online vs. offline) to specifically explore the interaction between these two variables in GD. Finally, future research might be able to help design psychotherapeutic treatment programs that are more adjusted to patients' needs. It would be interesting to devise treatment programs that place special emphasis on the lack of premeditation to achieve greater control over one's own behavior as well as a reduction in the harmful effects caused by gambling, such as the amount of accumulated debts among people with GD.

DATA AVAILABILITY STATEMENT

The datasets generated for this article are not readily available because they belong to the hospital database and are not available for public access in order to protect patient confidentiality and in accordance with the informed consent signed by the patients. Requests to access the datasets should be directed to Angela Ibáñez, angela.ibanez@uah.es.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of the Ramon and Cajal University Hospital. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AI outlined the conceptualization. IL-T, LL-Q, and AI were responsible for organizing the fieldwork and took part in the data analyses and contributed to the interpretation of the results. IL-T and LL-Q were responsible for the preparation and checks of the data. IL-T drafted the initial version of the manuscript. All authors revised the manuscript for important intellectual content and approved the final manuscript.

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The Effects of Responsible Gambling Pop-Up Messages on Gambling Behaviors and Cognitions: A Systematic Review and Meta-Analysis

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Pop-up messages utilized by gambling operators are normally presented to gamblers during gambling sessions in order to prevent excessive gambling and/or to help in the appraisal of maladaptive gambling cognitions. However, the effect of such messages on gambling behavior and gambling cognitions has not previously been synthesized quantitatively. Consequently, a meta-analysis estimating the efficacy of pop-up messages on gambling behavior and cognitions was conducted. A systematic literature search with no time constraints was performed on Web of Science, PsychInfo, Medline, PsychNET, and the Cochrane Library. Search terms included "gambling," "pop-up," "reminder," "warning message," and "dynamic message." Studies based on randomized controlled trials, quasi-experimental designs and pre-post studies reporting both pre- and post-pop-up data were included. Two authors independently extracted data using pre-defined fields including quality assessment. A total of 18 studies were included and data were synthesized using a random effects model estimating Hedges' g. The effects of pop-ups were $g = 0.413$ for cognitive measures (95% CI = 0.115–0.707) and $g = 0.505$ for behavioral measures (95% CI = 0.256–0.746). For both outcomes there was significant between-study heterogeneity which could not be explained by setting (laboratory vs. naturalistic) or sample (gambler vs. non-gamblers). It is concluded that pop-up messages provide moderate effects on gambling behavior and cognitions in the short-term and that such messages play an important role in the gambling operators' portfolio of responsible gambling tools.

Keywords: gambling, responsible gambling, gambling behavior, gambling cognition, pop-up message, warning message, meta-analysis, dynamic warning message

INTRODUCTION

Gambling can be defined as wagering money or other objects of value on an event of an uncertain outcome that is partly or completely determined by chance (1), and has become increasingly available to individuals due to such factors as increased accessibility via the internet and liberalization of gambling regulation. For most individuals, gambling represents a recreational activity. However, it is estimated that between 0.1 and 3.4% of the population in Europe and 0.1–5.8% of the population worldwide engage in problematic gambling behavior (2). Problem gambling is, according to Blaszczynski et al. [(3), p. 305], "a lay term that refers to a broader category of individuals exhibiting patterns of excessive gambling behavior that is associated with harmful effects" (p. 305). The terms "pathological gambling" and "gambling disorder" refer to a more specific pattern of problematic gambling, and has been classified as a mental disorder (3). Blaszczynski et al. [(3), p. 305] suggest that "problem gamblers may or may not suffer impaired control" and "conceptually, all pathological gamblers are problem gamblers, but not all problem gamblers are pathological gamblers."

Gambling disorder (formerly pathological gambling) was the first non-chemical (i.e., behavioral) addiction to be recognized in formal diagnostic systems (4). According to the fifth edition of *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), gambling disorder is defined by nine criteria similar to those of substance abuse, such as lack of control, tolerance, withdrawal, and the maintaining of harmful behavior despite negative consequences (5). In the eleventh revision of the *International Statistical Classification of Diseases* (ICD-11), the World Health Organization (6) defines gambling disorder as "a pattern of persistent or recurrent gambling behavior, which may be online (i.e., over the internet) or offline." The gambling behavior of individuals suffering from gambling disorder can significantly affect an individual's personal, family and social life, as well as their educational and/or occupational functioning (7–9).

Treatment of gambling disorder is associated with involvement of health services (e.g., counseling administered by specialists employed in public health programs). An important feature of treatment is the emphasis on gamblers who are already suffering from severe gambling problems (3). Different treatment approaches have been developed, including cognitive behavioral therapy incorporating motivational interviewing (10), mindfulness (11), and pharmacological treatment (12, 13). Overall, results show positive effect of these treatments. However, limitations across studies points to a lack of evidence of successful long-term effects and attrition (10–14). Furthermore, the treatment of problem gambling is usually costly and few of those affected seeks out treatment on their own (15, 16). For these reasons, the development and implementation of effective and cost efficient tools to reduce gambling-related problems seems warranted.

The past two decades' efforts to create, shape, and implement responsible gambling (RG) strategies and programs regarding the management of gambling-related activities, have been characterized by two main frameworks [(17), p. 1]: The Public Health Model and the Reno Model, with the latter historically and geographically being the more influential of the two (18). While it is true that they share some objectives (e.g., reliance on strong empirical data and collaborative efforts between stakeholders), they differ in the areas of focus and approaches (17, 19–21).

One of the central tenets of the Reno model, is informed choice—the making of a decision based on as much information as possible—"the ultimate decision to gamble or not lies with the gambler" [(17), p. 9]. Furthermore, the Reno Model states that measures to prevent problem gambling should be as non-intrusive as possible, so as to let recreational gamblers engage in "healthy gambling" (i.e., gambling without negative/adverse consequences). It also stresses the point that efforts from the medical community (i.e., treatments and prevention) ought to specifically target at-risk groups, without being intrusive toward the larger population (22). The Reno Model's emphasis on individual responsibility, informed choice, personal control, and prioritization of the recreational benefits of gambling, has been critiqued by Hancock and Smith (20), Delfabbro and King (19), and Young and Markham (21) for being ideological at its core with libertarianism as its central tenet. Hancock and Smith (18) further criticize the Reno Model for its minimal regard to effective RG safeguards following the last two decades' rapid increase of gambling.

The Public Health Model, casting a wider net, seeks the widespread use of epidemiological studies to map the impact of gambling-related harm (23). Public health officials should, in line with this perspective, view gambling as a population-based phenomenon and seek to identify the cultural, social, and economic factors that mediate gambling (17). Public policy should be guided in such a way so as to increase health in the population and to prevent gambling-related harm (23). The Public Health Model suggests implementing guidelines that promote healthy gambling, including large-scale public informational campaigns, similar to informational campaigns regarding alcohol and tobacco, about the possible adverse effects of gambling (23). The Public Health Model further urges for public policy and governmental legislation to regulate gamblers' behavior in such a way so as to reduce the likelihood of gambling-related harm (e.g., mandatory loss-limits, mandatory breaks in play, and reduced accessibility during specific hours) (23). Hancock and Smith (20), and Young and Markham (21) have called for a broad implementation of the Public Health Model on account of what they argue is the failure of the Reno Model to properly implement measures to reduce gambling-related harm.

"Responsible gambling" can be defined as the "policies and practices designed to prevent and reduce potential harms associated with gambling" and is emphasized by both frameworks [(3), p. 308]. More explicitly, RG refers to guidelines, strategies, or programs that attempt to avert possible harmful health outcomes, in contrast to the principles of treatment (3). RG may also imply "means to prevent gambling problems or to reduce the negative consequences of existing problems" [(24), p. 1,376]. "Means" may refer to "self-exclusion programs; behavioral tracking of play patterns; loss and deposit limit setting (both player and corporate); player pre-commitment to deposits, losses, wins, or gambling time; and warning messages" [(25), p. 225].

Most of these measures require registration and collection of player account gambling data, which are enabled by gambling via online gambling accounts or via loyalty card/player cards (26). An example of RG measures put into practice, is New Zealand's policy regarding EGMs in gambling venues, which are required by law to display pop-up messages to interrupt play at "irregular intervals not exceeding 30 min of continuous play" [(27), p. 1,116].

Hence, RG is about the necessity to sustain a safe environment for gamblers, and because the main objective of RG programs is to prevent gambling related harm, "[RG] programs should provide information that consumers use to make decisions" [(28), p. 570], which represents a perspective on RG tools congruent with the Reno Model. The use of pre-commitment to limit expenditure is an example of this. Such a measure permits gamblers to regulate how much money and/or time they can spend gambling, and allows gamblers to temporarily (or permanently) exclude themselves from gambling (24). Personal feedback interventions (PFIs) are another approach, where information about an individual's gambling behavior is compared to another individual's gambling behavior, and then presented to the gambler (29).

Pop-ups or dynamic messages, as understood in an RG context, comprise informative messages appearing on screen during gambling, halting play, with the overall aim of preventing and/or reducing gambling-related harm (30). The message subsequently either disappears after a set duration of time or requires some kind of action to be taken (e.g., pressing *"OK"* or *"Press/click here to continue"*) on the part of the gambler [(31), p. 933]. It can be used to present factually descriptive or normative information, such as information about time and/or monetary expenditure, either regarding the individual player solely, or in comparison with other gamblers (30). It can also be used to correct irrational or distorted beliefs about gambling (e.g., *"Winning is not due to luck. It's random"* or *"The next spin has nothing to do with your previous spin"*) (31), or as a reminder of progress toward a previously set limit (i.e., progression toward a monetary limit set before initiating a gambling session) (30). Furthermore, messages can be worded to encourage self-appraisal, so as to increase gamblers' awareness of their own gambling behavior (e.g., *"Pause and think … Are you in control of your risk taking?"*) (32, 33). Pop-up messages can vary in time of appearance, and usually appear after a set duration of time or a set monetary expenditure (34). In short, pop-up messages serve as a tool to deliver RG information to gamblers during play.

Several researchers have investigated both the efficacy of information delivery and the effect of various types of content on expenditure and time spent playing (35–38). Furthermore, Monaghan and Blaszczynski (39) conducted a study on recollection of message content, where the participants recalled dynamic messages (pop-up messages) more easily than static messages, and another study where pop-up messages where recalled more effectively than static messages, both immediately and at a 2-weeks follow-up (33). Studies on pop-up messages and limit setting—that is, a monetary limit set by the gambler before initiating a gambling session—suggest that individuals exposed to monetary limit reminders via pop-up messages, are more likely to adhere to the pre-set limits (40, 41).

As previously mentioned, gambling is more accessible to the public than ever before, which in turn may increase problem gambling. This, combined with the fact that there is support to suggest that pop-up messages can be an effective RG tool, and that (to date) no meta-analysis have been conducted on the effects of pop-up messaging (as far as the authors of the present meta-analysis are aware of), the goal of the present meta-analysis is to explore the effect of pop-up messages on gambling-related behaviors and cognitions.

METHOD

The present meta-analysis was conducted in accordance with the guidelines of the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) (42, 43). For complete checklist, see **Table 1**.

Eligibility Criteria: Participants, Interventions, Comparators

The meta-analysis included (i) randomized controlled trials, quasi-experimental studies as well as pre-post studies investigating the effect of (ii) RG pop-up messages on (iii) gambling behaviors and/or gambling cognitions in (iv) gamblers and non-gamblers of (v) all ages equal to or above the legal gambling age, and (vi) published in peer reviewed journals or as conference presentations.

A study was deemed to include a comparator/control group if the intervention group was compared to a group of any of the following kind: (i) no pop-up message control (including cases with other forms of warnings or pauses before, during, or after play), (ii) passive pop-up message controls (e.g., "click ok to continue"), (iii) irrelevant pop-up message intervention (e.g., *"The roulette game was invented in 1720"*), or (iv) active pop-up messages assumed to have significantly less of an effect than the experiment intervention (e.g., *"You have now played 1,000 slot games. Do you want to continue? (YES/NO)"* vs. *"We would like to inform you, that you have just played 1,000 slot games. Only a few people play more than 1,000 slot games. The chance of winning does not increase with the duration of the session. Taking a break often helps, and you can choose the duration of the break"*) [(36), p. 3]. In studies containing two or more control conditions, the control group selected for effect size calculations was chosen in line with the aforementioned order [e.g., (44)].

Studies with a quasi-experimental design (e.g., studies without randomization of participants to conditions) were included as this is often the only method of getting real life data from gambling providers. Furthermore, studies lacking comparison/control conditions were included if both pre- and post-intervention data were reported or obtained from the author(s).

RG pop-up messages were operationalized as dynamic messages intended to reduce gambling harm in some form or another, by interrupting play and that provided either (i) information regarding gambling behavior (e.g., time spent, trials

TABLE 1 | PRISMA checklist.

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3–5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6-–7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	7
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	7
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	7
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	8
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	8
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	9
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	8
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	10
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	25
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	**Figures 2**, **4**
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	11
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	10–11
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	11
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	12–14
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	12-13
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	14

played, money spent, progression toward a pre-set limit), (ii) general information about the nature of gambling machines (e.g., *"You cannot predict anything in a game of chance"*), or (iii) messages containing encouraging self-appraisal (e.g., *"Stop and think… Are you in control of your risk-taking?"*). Furthermore, RG pop-up messages had to appear on a gambling device containing a screen [e.g., electronic gaming machine [EGM] or personal computer]. This implied that studies where pop-ups either appeared prior to gambling or after gambling had ended, were administered via other forms of communications (e.g., email or SMS), or randomly over a longer period (i.e., weeks or months), were excluded [e.g., (45)]. In addition, this also meant that studies with encouraging messages (e.g., *"You are a skillful player!"*) were excluded, as were studies where RG pop-ups were not the primary independent variable (e.g., the message *"The game is now paused,"* followed by a forced pause in the game). Outcome measures of interest were pooled into two main categories: (i) behavioral (e.g., total number of bets, total amount spent, limit adherence), and (ii) cognitive (e.g., recall, arousal, dissociation).

The population in all included studies were classified as either gamblers or non-gamblers. This categorization was made by the authors of the individual included studies. Trials contained participants of both sexes and all ages, as long as they were equal to or over the legal age to gamble (this was 18 years in most cases, but could be 20 or 21, depending on area of jurisdiction). The trials took place in one of the following locations: (i) gambling venue, (ii) laboratory, and (iii) online. Studies were excluded if they (i) failed to meet the aforementioned inclusion criteria, (ii) were duplicates, (iii) written in a language other than Norwegian, Swedish, Danish, English, or Italian, (iv) did not contain sufficient information to calculate effect size, or (v) had self-report data on behavioral measures (e.g., time spent, amount spent, number of spins).

Search Strategy

Studies were identified by searching electronic databases, reference lists of relevant papers, and through contacting study authors, in cases where supplementary information was needed. No limits were set on language or time periods. The search was conducted on Web of Science (1945-Present), APA PsychINFO (Ovid) (1806-Present), Medline (Ovid) (1946-present), PubMed (1993-present), APA PsychNET (unable to retrieve information on time period), Cochrane Library on Wiley Online Library [including Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects (DARE)] and the Cochrane Central Register of Controlled Trials (CENTRAL) (1995-present). The last search was conducted by the first author on May 21, 2020.

The following search terms were used in all databases and trial registers searched: "gambling"; "pop up"; "pop ups"; "pop-up"*; "reminder"; "warning message"; and "dynamic message." The final search strategy was developed through identification and discussion of relevant keywords. Preliminary searches were conducted to identify further relevant keywords. The final search strategy was agreed upon through consensus. For detailed overview of search terms and search strategy, see **Table 2**.

Data Extraction

All studies were screened independently by two authors. Most studies were excluded based on screening of title and abstract (e.g., when it was apparent that the study did not report on the effects of pop-ups). Inclusion to the next review stage was determined by consensus, and by consultation with a third author. Full texts were subsequently screened by two authors independently, with disagreements being resolved through discussion and consultation with the third author. The reference lists of all included studies in the meta-analyses were also screened.

A data extraction sheet, based on the Cochrane Consumers and Communication Review Group's data extraction template, was developed by two authors and pilot-tested on eight randomly selected studies. The extraction sheet was then refined to code further aspects of studies included. Data were extracted from the included studies by the three first authors and the extracted data then checked by two authors independently. Disagreements regarding extracted data were resolved through discussion.

In cases without sufficient data to calculate effect sizes, authors listed with contact information were contacted via email. Means, standard deviations, and sample sizes on all measures were obtained from four sets of authors (46–49) as data had only been presented graphically or was not included in the original publication. Furthermore, four authors (50–53) responded, but were for various reasons unable to provide data. Additionally, three authors did not respond.

Data were extracted from each trial on: (i) characteristics of participants (age, gender, and categorization into gamblers or non-gamblers); (ii) study design (including between-participants design, pre-post measurement design, and repeated measures design); (iii) exclusion and inclusion criteria; (iv) type of intervention, including the type of pop-up intervention and the type of control condition (i.e., no intervention, passive intervention, or intervention assumed less effective than experiment intervention); (v) type of outcome measure (behavioral and/or cognitive), and (vi) follow-up interventions. Behavioral outcome measures were defined as any type of gambling action measured, while cognitive measures comprised any type of gambling cognition assessed.

Assessment of Risk of Bias

Risk of bias in individual studies was assessed using the Evidence Project Risk of Bias Tool developed by Kennedy et al. (54). Using this tool, two individual authors assessed the following areas of bias: (a) cohort, (b) control or comparison group, (c) pre-post intervention data, (d) random assignment of participants to the intervention, (e) random selection of participants for assessment, (f) follow-up rate of 80% or more, (g) comparison groups equivalent on socio-demographics, and (h) comparison groups equivalent on outcome measures at baseline. Items *a, b, c,* and *e* are dichotomous and have the response options "yes" and "no," *d* is categorical and has "yes," "no," and "NA" (not applicable) as response options, whereas *f, g,* and *h* are categorical and have the response options "yes", "no", "NA" and "NR" (not reported) as response options. In cases of disagreement, a third author was consulted and disagreements resolved through

TABLE 2 | Search terms and strategy.

Searches and databases
Abbreviations: "ti": title; "ab": abstract; "kw": keyword; "mp" in the APA PsycINFO database includes: title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh; "any field" in the APA PsycINFO and Medline databases includes: author, journal title, book title, keywords, first page, title, abstract, affiliation, author of review item, conference, correction date, correspondence, DOI number, geographic location, grant/sponsorship, index terms, ISBN, ISSN, language, MeSH: medical subject heading, publication date, publisher, PubMed ID, release date, tests & measures, title of review item, unique identifier, year of review item; "all fields" in the PubMed database includes: affiliation, author, author – corporate, author – first, author – identifier, author—last, book, conflict of interest statements, date—completion, date—create, date—entry, date—mesh, date—modification, date—publication, EC/RN number, editor, filter, grant number, ISBN, investigator, issue, journal, language, location ID, mesh major topic, mesh subheading, mesh terms, other term, pagination, pharmacological action, publication type, publisher, secondary source ID, subject—personal name, supplementary concept, text word, title, title/abstract, transliterated title, volume; "all" in the Web of Science database includes: topic, title, author, author identifiers, group author, editor, publication name, DOI, year published, address, organization-enhanced, organization, suborganization, abstract, author keywords, keyword plus, street address, city, province/state, country/region, zip/postal code, funding agency, grant number, funding text, research area, web of science category, ISSN/ISBN, accession number, PubMed ID.
APA PsycINFO (Ovid)
gambling AND ("pop up" OR "pop ups" OR pop-up* OR reminder OR "Warning message*" OR "Dynamic message*"): mp
APA PsycNet
gambling AND ("pop up" OR "pop ups" OR pop-up* OR reminder OR "Warning message*" OR "Dynamic message*"): any field
Cochrane Library
gambling AND ("pop up" OR "pop ups" OR pop-up* OR reminder OR "Warning message*" OR "Dynamic message*"): ti,ab,kw (Word variations have been searched)
MEDLINE (Ovid)
gambling AND ("pop up" OR "pop ups" OR pop-up* OR reminder OR "Warning message*" OR "Dynamic message*"): mp
PubMed
gambling AND ("pop up" OR "pop ups" OR pop-up* OR reminder OR "Warning message*" OR "Dynamic message*"): all fields
Web of science
gambling AND ("pop up" OR "pop ups" OR pop-up* OR reminder OR "Warning message*" OR "Dynamic message*"): all

discussion. Risk of bias was assessed at both the study and outcome level and Cohen's kappa was calculated to assess inter-rater reliability. No risk of bias scores were calculated, based on the recommendations of Kennedy et al. (54).

Meta-Analyses

Two meta-analyses were conducted: one investigating cognitive measures, and the other investigating behavioral measures. Cognitive measures comprised different non-behavioral outcomes such as player experience, keeping track of play, estimation of time and money spent, erroneous beliefs, dissociation, and recall of pop-up messages, whereas the behavioral outcomes typically consisted of measures such as amount of money spent, speed of gambling, number of games played, etc. For each study, Hedges' g was computed. The primary outcome measure of the meta-analyses was Hedges' g and Cochrane's Q. I^2 were calculated to assess heterogeneity, as it reflects the proportion of variation in observed effects that is due to variation in true effects (55). I^2 values of 0.25, 0.50, and 0.75 are regarded as small, medium, and large, respectively (56). Initially, additional meta-analyses were planned to assess the effect at follow-up. However, in the sample of studies, only two included follow-up data (33, 53), which rendered meta-analyses for follow-up data less meaningful. Therefore, no additional meta-analyses were conducted. Furthermore, in cases where studies had more than one pop-up condition not conceptually different from each other, the groups were collapsed, and standard error—and consequently the 95% confidence intervals—were adjusted accordingly, in order not to repeat the control group data, as per the recommendations of Giang et al. (57).

In cases with more than one pop-up condition conceptually different from the other, the control group was split into corresponding numbers of groups, as recommended in the *Cochrane Handbook for Systematic Reviews of Interventions* (58).

Two moderators were decided upon in case of significant heterogeneity: (i) laboratory setting vs. naturalistic setting, and (ii) gamblers vs. non-gamblers (a sample was deemed to consist of non-gamblers in cases where they accounted for 50% or more of the total sample). Many studies included multiple measures within the same category (category referring to either behavioral or cognitive). In these instances, the mean effect size and variance was calculated for the study as a whole. When combining results from more than one outcome within the same outcome category from the same study, setting the correlation coefficient between outcomes to the default ($r = 1.00$) used in most meta-analytic software overestimates the standard error (59). To correct for this, the correlation coefficient between the outcomes was set to 0.70.

In cases of significant heterogeneity, subgroup analyses were conducted with a focus on the two aforementioned *a priori* determined moderators. The moderator analyses comprised mixed effects models (random across subgroups pooling tau across studies, but combining subgroups using fixed effect models), as recommended by Borenstein et al. (59). The planned moderator analyses were conducted when there were four or more studies within each category, in line with the suggested minimum criteria for number of studies (60).

Publication Bias

Publication bias was examined by creating and inspecting funnel plots, and by using Duval and Tweedie's (61) "trim and fill" procedure, calculating a new and adjusted effect size which takes into account potential publication bias. In addition to this, Orwin's fail safe *N* was calculated, measuring the number of studies with zero effect needed to bring the observed effect size (Hedge's *g*) down to a pre-set trivial effect size (62), set to $g = 0.20$, which equals a small effect (63).

RESULTS

Selection and Inclusion of Studies

A total of 18 papers involving 19 studies [(33) included two individual studies] were deemed eligible and were included in the present meta-analyses. The systematic searches conducted in Web of Science, PsychInfo, Medline, PubMed and Cochrane Library yielded a total of 436 hits. A total of 306 papers remained after the removal of duplicates. All of the remaining papers were systematically reviewed by the authors. Of the 306 papers, 263 were excluded based on title and abstract. This left 43 papers to be assessed for eligibility, of which 25 were excluded for the following reasons: seven did not provide sufficient data for calculation of effect size, six lacked a pop-up message condition altogether, three included measures deemed unreliable (e.g., self-report measures for spins per minute), three were review articles, two lacked a pop-up message condition during play, one had experiment and control condition deemed too similar, one contained a non RG-pop-up message (i.e., the message content was encouraging play), one was excluded due to language restrictions, and one was an abstract with no full text paper available. One unpublished study was identified through the database searches and found eligible. The screening process can be found in the PRISMA flow chart (see **Figure 1**).

Characteristics of the Included Studies

In total 14 studies were conducted in laboratory settings, three were *in situ* (naturalistic) studies, and one study was conducted in a laboratory setting and subsequently replicated in a naturalistic setting. All studies were published in English. Furthermore, all studies were conducted within the past 15 years (from 2006 to 2019). Participants in seven out of the 18 studies were university students whereas participants in 12 out of the 18 studies consisted of non-university gamblers of all types. Nine of the included studies did not display pop-ups in their control condition, seven displayed some variation of a pop-up message in the control condition and two used pre-pop-up measures as the control condition. Only two studies included follow-up assessments, at 1 and 2 weeks, respectively. Eight studies contained outcome measures for behavior only and two for cognition only, whereas eight included outcomes for both behavior and cognition. The total number of participants included in the studies could not be assessed exactly because two studies listed approximate sample sizes of 50,000 [i.e., (35)] and 70,000 [i.e., (36)]. Studies lacking information on the socio-demographics of their samples were assumed to contain both genders and different ages, as the sheer size would have made gender and age homogeneity highly unlikely. **Tables 3–5** provide a complete overview of the studies' key properties and characteristics.

Risk of Bias

Risk of bias of the included studies was assessed using the Evidence Project Risk of Bias Tool (54). This instrument was used by two authors independently, rating each of the 18 studies. Disagreements were resolved by consulting the third author. Of the 18 studies included, one met the criteria of cohort. Seventeen studies had a control or a comparison group, whereas one was based on a pre-post measurement design. In total, six studies reported data both pre- and post-pop-up intervention. All except two studies scored "yes" on "random assignment of participants to the intervention"; the two that did not were rated "not applicable" as their datasets were anonymous and provided by a real-world online gambling site. Two studies had random selection of participants of assessment, whereas the other 16 consisted of gamblers. Of the two studies containing follow up intervention, one met the criteria of retaining at least 80% of the participants.

All but two studies had comparison groups equivalent on socio-demographics (both rated "not applicable"). Lastly, two studies reported comparison groups equivalent on outcome measures at baseline, whereas the others were categorized as "not reported." A calculation of inter-rater reliability of risk of bias yielded a Cohen's Kappa of 0.96 which according to Landis and Koch (68) is regarded as a perfect agreement. The risk of bias in the included studies is shown in **Table 6**.

Synthesized Findings

Cognitive Measures

Results for cognitive measures after pop-up intervention during gambling showed an overall effect size of $g = 0.413$ (95% CI = 0.155–0.707), $p < 0.01$ (see **Figure 2**). Cochrane's *Q* was 48.63 (df = 13), $p < 0.01$) and the I^2 was 73.27. No subgroup analysis was performed due to lack of studies including non-gamblers ($k = 2$) and *in situ* trials ($k = 1$). In order to investigate whether the present findings were influenced by publication bias, a funnel plot was drawn. The funnel plot was not entirely symmetrical (see **Figure 3**), suggesting a lack of potential studies to the right of the distribution. The Duval and Tweedie s "trim and fill" procedure provided an adjusted effect size g = 0.578 (95% CI = 0.325–0.830, $p < 0.01$). Orwin's fail-safe N showed that 22 studies with zero effect would be needed to bring the overall effect size down to a trivial level (g = 0.20).

Behavioral Measures

The overall effect size for behavioral measures was $g = 0.507$ (95% CI = 0.267–0.747, $p < 0.01$; see forest plot, **Figure 4**). Cochrane's *Q* was 109.84 (df = 20), $p < 0.5$, and $I^2 = 81.97$, suggesting significant heterogeneity. Four studies ($k = 4$) were done in a naturalistic setting and 17 were performed in a laboratory setting, and thus, a subgroup analysis was performed. The effect size difference turned out not significant ($Q_{bet} = 0.010$, df = 1, $p = 0.919$). No subgroup analysis was performed

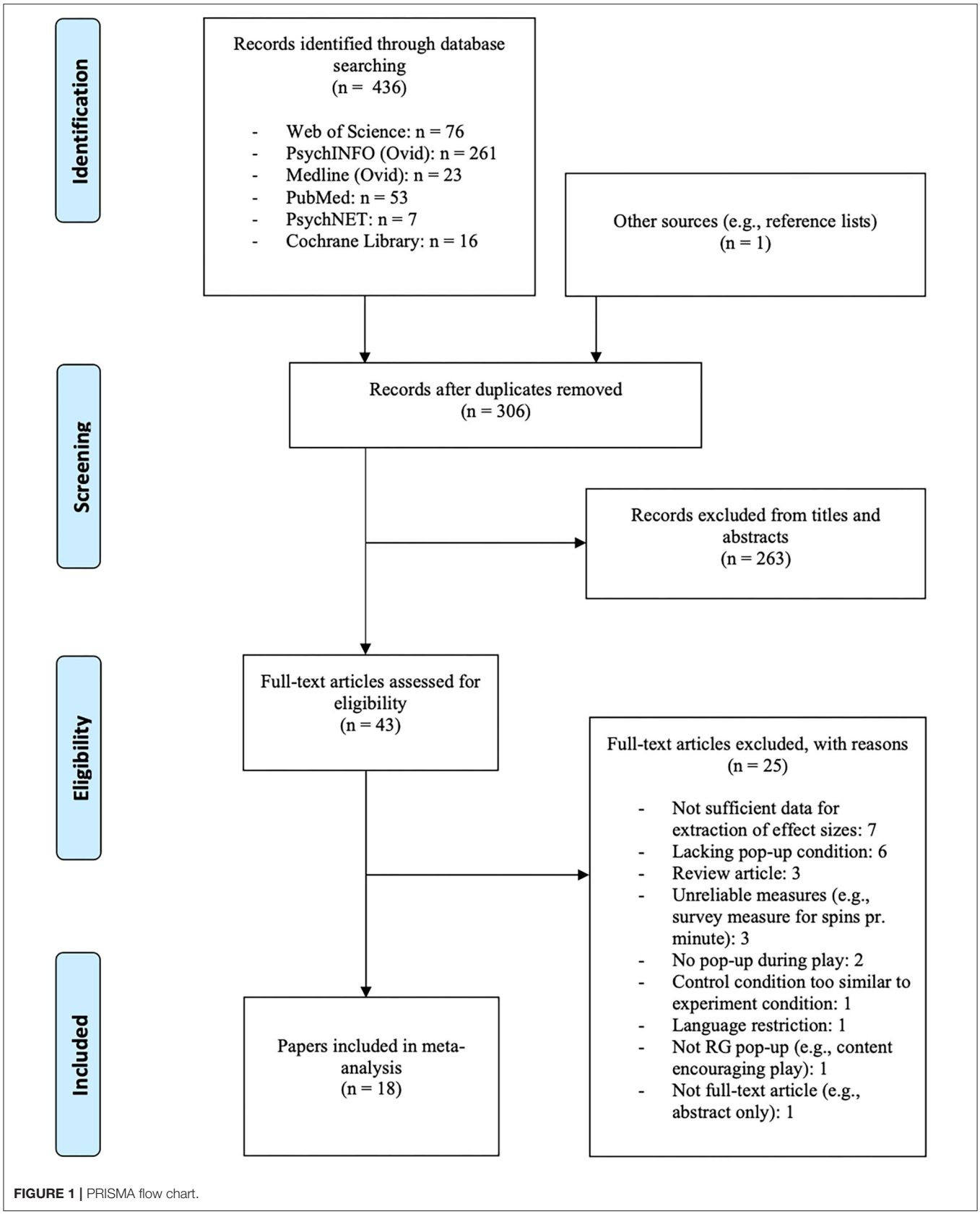

FIGURE 1 | PRISMA flow chart.

TABLE 3 | Study characteristics, studies A-H.

References	Study design	Participants (N at start of trial in parenthesis)	Mean age	Sex	Inclusion criteria	Type of intervention in experimental condition	Type of intervention in control condition	Outcome	Measures	Follow-up
Auer and Griffiths (36)	Naturalistic	Approximately 70.000 online slot machine gamblers	NR	NR	Gamblers on gambling site	Enhanced (normative and self-appraisal feedback) pop-ups	Non-enhanced pop-up	Behavior	Termination of session	None
Auer et al. (35)	Naturalistic	Approximately 200.000 gamblers	NR	NR	Gamblers on gambling site	Slot machine pop-up	Pre pop-up intervention	Behavior	Termination of session	None
Byrne et al. (46)	Lab/RCT	213	38.83	108 males; 104 females; 1 other	Gamblers of all EGM experience levels	Present pop-up message	No pop-up	Behavior and Cognition	Behavior: Gambling persistence, keeping track of play usage; Cognition: Estimation accuracy; player experience	None
Cloutier et al. (64)	Lab/RCT	40	22.20 (control group); 23.40 (message group)	50% males (control); 55% males (message group)	University students	A correcting message (targeting the illusion of control), every 15th game played	Pop-up with the word "Pause"	Behavior and Cognition	Behavior: Number of games played; Cognition: Erroneous beliefs	None
Ginley et al. (53)	Lab/RCT	154	22.7	Approximately 60% females	University students	Periodic warning messages	"Press ok to continue"	Behavior	Total number of spins	1 week follow-up
Harris and Parke (32)	Lab/RCT	26 (30)	23.08/30	18 males; 12 females	Gamblers playing on EGMs within 6 months prior to participation	Self-appraisal message	Pre pop-up intervention	Behavior	Betting speed, average stake size and betting intensity	None

NR, not reported; Lab, laboratory study; RCT, randomized controlled trial; RG, responsible gambling; EGM, Electronic Gaming Machine.
Explanations of measures: Keeping track of play usage=amount spent, time played, spins played; Estimation accuracy=amount spent, time played, spins played; Player experience=dissociation, enjoyment, annoyance/frustration.

TABLE 4 | Study characteristics, studies H-M.

References	Study design	Participants (N at start of trial in parenthesis)	Mean age	Sex	Inclusion criteria	Type of intervention in experimental condition	Type of intervention in control condition	Outcome	Measures	Follow-up
Harris et al. (65)	Lab/RCT	65 (70)	31.14	53/70 males	Regular gamblers	Emotive vs. informative pop-ups	No pop-up	Behavior and Cognition	Behavior: Reaction time, response inhibition; Cognition: Arousal, valence and dissociation; IST choice latency, IST balls sampled, IST p-correct and MCQ k-value	None
Hollingshead et al. (47)	Lab/RCT	98	50.25	42 males	Gamblers at their respective casinos to play slots but had not yet gambled	RG educational information provided in advance of a RG-related decision	RG information not tied to RG decision making	Cognition	Desire to gamble, self-reported dissociation during play, future limit setting intentions	None
Jardin and Wulfert (44)	Lab/RCT	80	44	60 males; 20 females	High-frequency gamblers	Accurate vs. inaccurate vs. neutral pop-up	No pop-up	Behavior	Total bet amount, number of trials played	None
McGivern et al. (37)	Lab/RCT	45	NR	19 males; 24 females; 2 undisclosed	Casual gamblers	Expenditure-specific warning messages	"Press ok to continue"	Behavior	Amount wagered during "open bets"	None
Mizerski et al. (66)	Naturalistic/RCT	831	NR	NR	University students	Strong vs. weak message	No pop-up	Behavior	Number of bets, bet amount, length of gambling session	None
Monaghan and Blaszczynski (39)	Lab/RCT	92	19.3	75% females	University students	Dynamic standard message	Static message	Cognition	Free recall, cued recall, recall accuracy, recollection confidence	None
Monaghan and Blaszczynski (33)[a]	Lab/RCT	127	20.3	76.4% males	University students	Dynamic: Informative vs. self-appraisal	Static pop-up without content	Behavior and Cognition	Behavior: Impact on real EGM-play, influence on session length, within-session behavior; Cognition: Awareness of time, disruption, recall, within-session thoughts	2 weeks follow-up

IST, Information Sampling Task; MCQ, Monetary Choice Questionaire.
Explanation of variables.
[a]*Study 1/2.*

TABLE 5 | Study characteristics, studies M-W.

References	Study design	Participants (N at start of trial in parenthesis)	Mean age	Sex	Inclusion criteria	Type of intervention in experimental condition	Type of intervention in control condition	Outcome	Measures	Follow-up
Monaghan and Blaszczynski (33)[a]	Naturalistic/RCT	124	44.1	71.8% males	Regular gamblers	Dynamic: Informative vs. self-appraisal	Static pop-up without content	Behavior and Cognition	Behavior: Impact on real EGM-play, influence on session length, likelihood of taking a break, likelihood of cashing out prize, likelihood of leaving, within-session behavior; Cognition: Influence awareness, recall, within-session thoughts, disruption	2 weeks follow-up
Rockloff et al. (48)	Lab/RCT	107	NR	45 males; 62 females	Casual gamblers	Relevant pop-up messag	No pop-up	Behavior and Cognition	Behavior: Average bets, bets pr. minute, total trials, losses, skin conductance (SC); Cognition: Enjoyment	None
Stewart and Wohl (40)	Lab/RCT	59	20.76	43 males; 16 females	University students	Monetary limit pop-up	No pop-up	Behavior and Cognition	Behavior: Adherence to self-proclaimed monetary limits; Cognition: Dissociation, craving to continue	None
Tabri et al. (38)	Lab/RCT	88	55.13	54.5% females	Community gamblers	Monetary limit pop-ups: approaching limit vs. 90% of limit vs. 70% of limit	No pop-up	Behavior	Percentage of players who stopped gambling before reaching monetary limit	None
Wohl et al. (41)[b)]	Lab/RCT	72	19.69	70.8% females	University students	Monetary limit pop-up	No pop-up	Behavior and Cognition	Behavior: Adherence to pre-set monetary limit; Cognition: Erroneous cognition, limit detection	None
Wohl et al. (67)[c]	Lab/RCT	56	20.38	19 males; 37 females	Casual gamblers	HCI and PSD inspired pop-up(s)	Standard monetary limit pop-up	Behavior and Cognition	Behavior: Adherence to pre-set monetary limit, engagement with pop-up tool; Cognition: Dissociation	None

HCI, Human Computer Interaction; PSD, Persuasive Systems Design.
Explanations of measures: Influence awareness=money spent, time, estimation of prize, understanding play, estimation of win/loss.
[a]*Study 2/2.*
[b]*Study 1/2.*
[c]*Study 2/2.*

TABLE 6 | Evaluation of risk of bias in the individual studies.

Study	Cohort	Control or comparison group	Pre-post intervention data	Random assignment of participants to the intervention	Random selection of participants for assessment	Follow-up rate of 80% or more	Comparison groups equivalent on socio-demographics	Comparison groups equivalent on outcome measures at baseline
Auer et al.	No	Yes	Yes	NA	No	NA	NA	NR
Auer and Griffiths	No	Yes	Yes	NA	No	NA	NA	NR
Byrne and Russell	No	Yes	Yes	Yes	Yes	NA	Yes	Yes
Cloutier et al.	No	Yes	Yes	Yes	No	NA	Yes	NR
Ginley et al.	Yes	Yes	No	Yes	No	No	Yes	NR
Harris and Parke	No	No	Yes	Yes	No	NA	Yes	NR
Harris et al.	No	Yes	No	Yes	No	NA	Yes	NR
Hollingshead et al.	No	Yes	No	Yes	No	NA	Yes	NR
Jardin and Wulfert	No	Yes	No	Yes	No	NA	Yes	NR
McGivern et al.	No	Yes	No	Yes	No	NA	Yes	NR
Mizerski et al.	No	Yes	No	Yes	No	NA	Yes	NR
Monaghan and Blaszczynski[a]	No	Yes	No	Yes	No	NA	Yes	NR
Monaghan and Blaszczynski[b]	No	Yes	Yes	Yes	No	Yes[c]	Yes	Yes
Rockloff et al.	No	Yes	No	Yes	Yes	NA	Yes	NR
Stewart and Wohl	No	Yes	No	Yes	No	NA	Yes	NR
Tabri et al.	No	Yes	No	Yes	No	NA	Yes	NR
Wohl et al.[d]	No	Yes	No	Yes	No	NA	Yes	NR
Wohl et al.[e]	No	Yes	No	Yes	No	NA	Yes	NR
Auer et al.	No	Yes	Yes	NA	No	NA	NA	NR

NR, not reported; NA, not applicable.
[a]*Monaghan and Blaszczynski (39).*
[b]*Monaghan and Blaszczynski (33).*
[c]*Only study 1 fulfilled this criteria.*
[d]*Wohl et al. (41).*
[e]*Wohl et al. (67).*

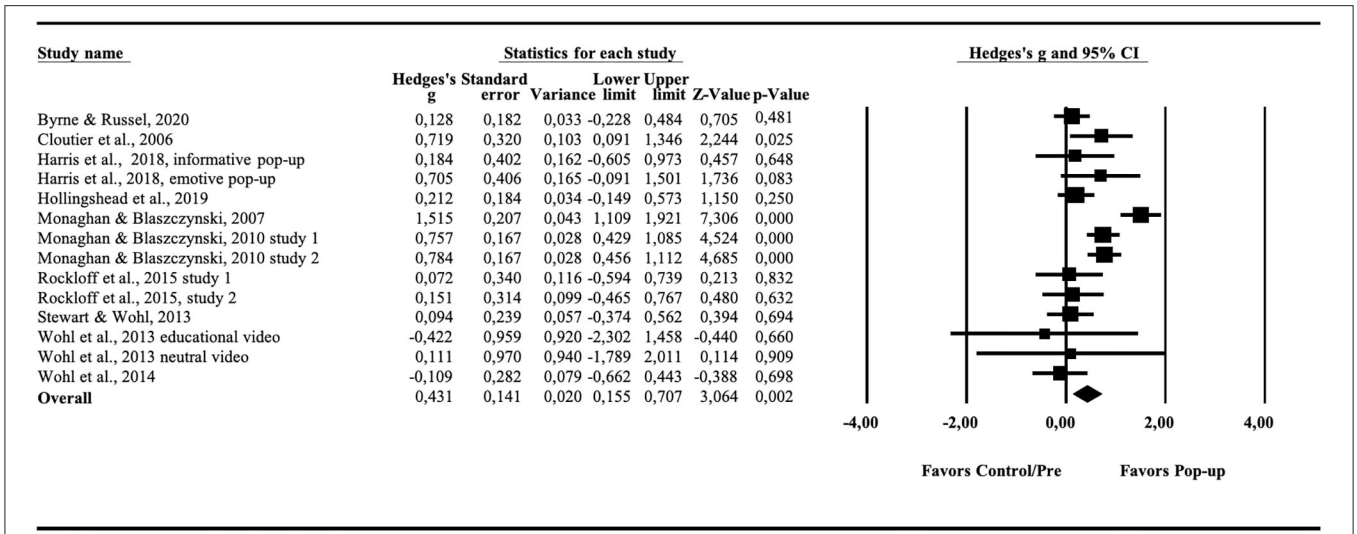

FIGURE 2 | Forest plot showing the effect (Hedges' g) of pop-up messages on cognitive measures.

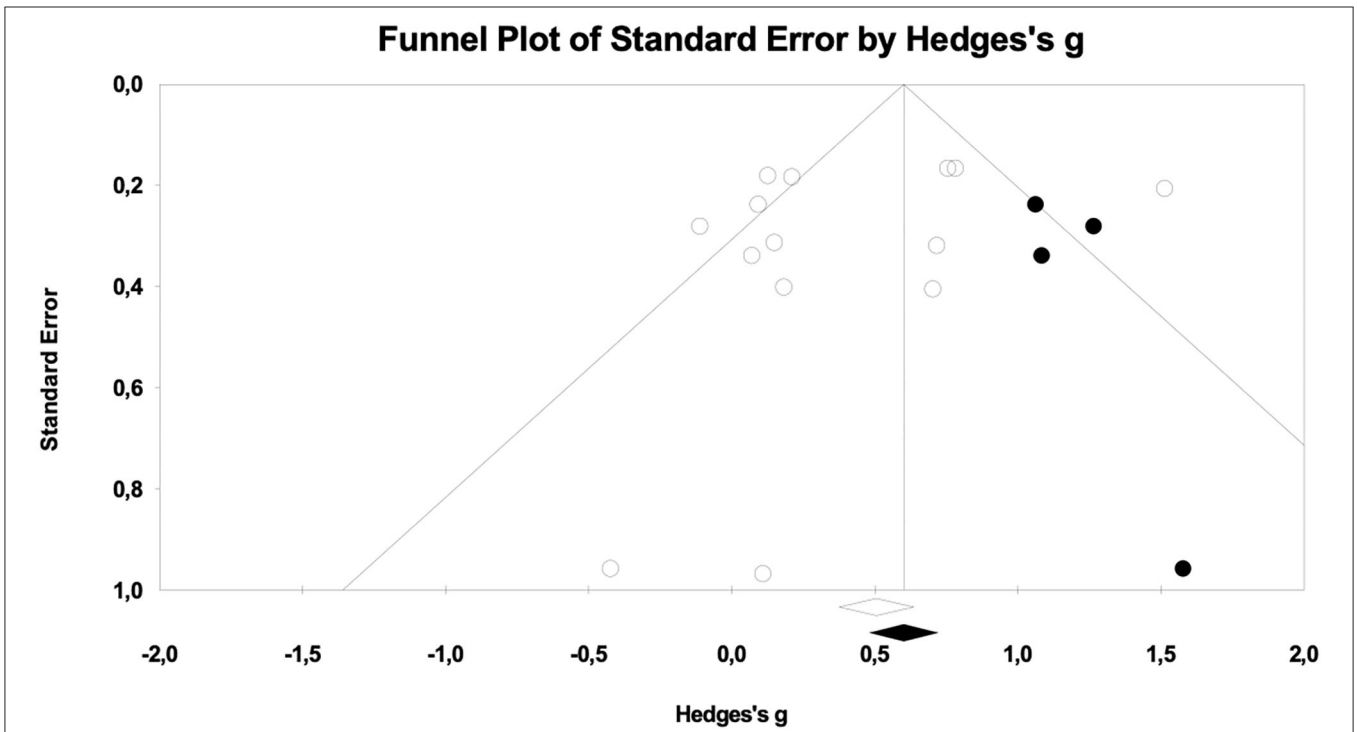

FIGURE 3 | Funnel plot from the meta-analysis of cognitive measures, adjusted using Duval and Tweedie's trim and fill.

due to the lack of studies containing non-gamblers ($k = 1$). To detect potential publication bias, a funnel plot was drawn. The plot was not symmetrical (see **Figure 5**), and indicated lack of potential studies to the right of the distribution. Hence, Duwal and Tweedie's "trim and fill" procedure was conducted, providing an adjusted effect size of 0.616 (95% CI = 0.359–0.872, $p <$ 0.01). Orwin's fail-safe N showed that the number of missing studies with zero effect needed to bring Hedges' g below 0.20, was 12.

DISCUSSION

The aim of the present meta-analysis was to investigate the effect of gambling pop-up message interventions on behavioral

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Auer & Griffiths, 2015	0,254	0,080	0,006	0,098	0,410	3,197	0,001
Auer et al., 2014	1,219	0,260	0,068	0,709	1,728	4,684	0,000
Byrne & Russell, 2020	-0,044	0,173	0,030	-0,383	0,295	-0,254	0,799
Cloutier et al., 2006	0,030	0,310	0,096	-0,578	0,637	0,096	0,924
Ginley et al., 2016	0,070	0,686	0,470	-1,274	1,414	0,102	0,919
Harris & Parke, 2015, study 1	-0,520	0,259	0,067	-1,027	-0,013	-2,009	0,045
Harris & Parke, 2015, study 2	-0,165	0,266	0,071	-0,687	0,357	-0,619	0,536
Harris et al., 2018, emotive pop-up	0,062	0,415	0,172	-0,751	0,875	0,149	0,881
Harris et al., 2018, informative pop-up	-0,034	0,435	0,189	-0,886	0,818	-0,078	0,938
Jardin & Wulfert, 2012	0,897	0,302	0,091	0,306	1,488	2,974	0,003
McGivern et al, 2019	1,234	0,337	0,113	0,574	1,894	3,664	0,000
Mizerski et al., 2012	0,055	0,078	0,006	-0,097	0,207	0,708	0,479
Monaghan & Blaszczynski, 2010 study 1	0,583	0,167	0,028	0,255	0,911	3,484	0,000
Monaghan & Blaszczynski, 2010 study 2	0,758	0,167	0,028	0,430	1,086	4,530	0,000
Rockloff et al., 2015, study 1	0,625	0,310	0,096	0,018	1,232	2,017	0,044
Rockloff et al., 2015, study 2	0,317	0,872	0,760	-1,392	2,026	0,364	0,716
Stewart & Wohl, 2013	1,321	0,388	0,150	0,561	2,080	3,408	0,001
Tabri et al., 2019	1,430	0,364	0,132	0,718	2,143	3,935	0,000
Wohl et al., 2014	2,210	0,359	0,129	1,506	2,914	6,153	0,000
Wohl et al., 2013, educational video	0,093	0,785	0,615	-1,445	1,630	0,118	0,906
Wohl et al., 2013, neutral video	-0,093	0,785	0,615	-1,630	1,445	-0,118	0,906
Overall	0,507	0,123	0,015	0,267	0,747	4,135	0,000

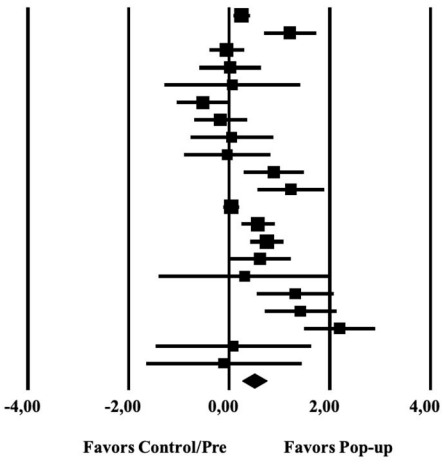

FIGURE 4 | Forest plot showing the effect (Hedges' g) of pop-up messages on behavioral measures.

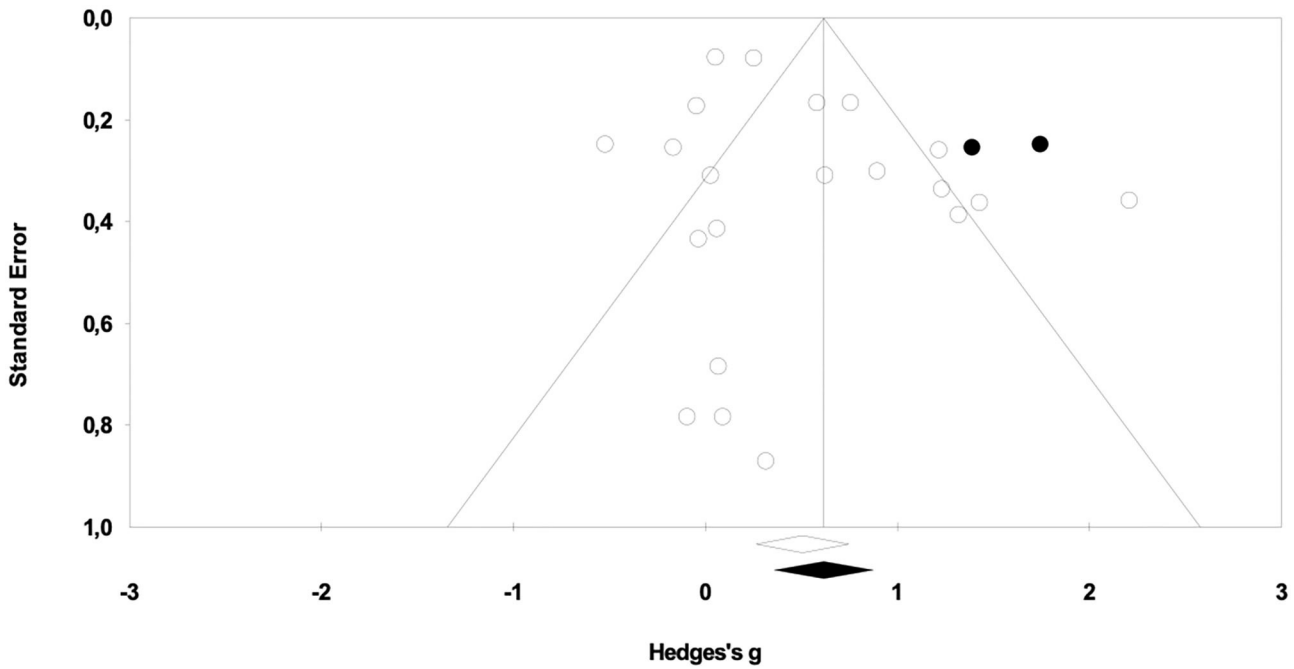

FIGURE 5 | Funnel plot from the meta-analysis of behavioral measures, adjusted using Duval and Tweedie's trim and fill.

and cognitive outcomes at first exposure and at follow-up, as well as to investigate the potential moderating effect of study setting and sample characteristics. The meta-analysis of behavioral measures demonstrated a significant effect amounting to a medium effect size in accordance with Cohen (63), indicating that RG pop-up message interventions have a substantial impact on participants' gambling behavior. The heterogeneity was significant, reflecting true differences in effect size across studies (59). Consequently, a subgroup analysis was conducted. However, no significant difference between effects

from laboratory settings and naturalistic settings was found. Orwin's fail-safe *N* demonstrated that the total number of studies needed to bring the effect size down to a trivial level ($g = 0.20$), was 12, which suggest some stability of the findings.

A total of five studies provided effect sizes above 1.00 (35, 37, 38, 38, 40, 67). When looking at the pop-ups from these studies, they all appeared to be personalized in terms of gambling behavior [e.g., *"You have reached your preset limit"*; (40)], whereas pop-ups of studies with no effect appeared to be more generic [e.g., *"No matter how you play, you cannot influence the outcome of the game"*; (64)]. Regarding effects in the three real world studies, the first study showed that when being informed of having played 1,000 slot games, 45 of 4,205 sessions ended compared to 5 of 4,220 sessions before the pop-up had been introduced by the gaming operator (35). The second study found that 169 of 11,878 sessions ended following an enhanced pop-up message compared to 75 of 11,232 sessions with a simple pop-up message (36). The third study reported a mean number of spins and amount wagered of 15.8 and $17.70 in the strong pop-up message condition, respectively, whereas the corresponding values in the control condition were 18.1 and $24.90 (66).

A significant and positive effect was also found for the cognitive measures, reflecting a medium effect size. Also here, the heterogeneity was significant. No subgroup analysis was conducted, as there were too few studies in the smallest of the subgroups. Orwin's fail-safe *N* demonstrated that the total number of studies with zero effect needed to bring the overall effect size down to a trivial level ($g = 0.20$) was 22, indicating that the findings are stable.

The gamblers vs. non-gambler moderator, was chosen as previous studies have shown that gamblers diverge from non-gamblers on some gambling-related behaviors and cognitions compared to non-gamblers (69). For instance, it has been found that gamblers discount probabilistic rewards less steeply than non-gamblers (70), that laboratory trials with student populations yield larger effects than with non-student populations (71), and that gamblers take larger monetary risks during roulette play than non-gamblers (72). The second moderator (laboratory vs. real gambling settings) was emphasized as there might be ecological challenges associated with laboratory studies such as the laboratory cubicle-casino ambiance variance and the absence of direct or personal monetary risk or loss (71, 73). The fact that this moderator turned out non-significant may be due to the relatively small amount of studies included in naturalistic settings. It may also reflect that other potential moderators, not identified by the authors, could explain significant proportions of the heterogeneity. The present analyses of heterogeneity could therefore have benefited from either different or simply more moderators.

Implications for RG Practices

The results of the present meta-analysis show that pop-up messaging appear to be an effective RG tool, as it seemed to reduce possible harmful gambling behaviors and cognitions. As previous studies have indicated, the intervention of a pop-up message reduces, amongst other things, the total amount wagered, spins per minute, and irrational beliefs. Within the framework of responsible gambling in both the Reno Model and the Public Health Model, these results are encouraging, as it complies with some of the models' central tenets: the emphasis on a scientific approach in the development of measures to promote responsible gambling and at the same time, reducing gambling-related harm. Furthermore, the non-intrusive and non-restrictive nature of pop-up messages coincides with three central Reno Model principles: (i) the opportunity to gamble without intrusion, (ii) the maintenance of personal control (as opposed to, for example, reduced casino opening hours), and (iii) the opportunity to gamble in an unrestricted, but informed manner. In addition to this, the result of the present meta-analyses provides further evidence of the suggestion that gamblers gamble more responsibly (e.g., fewer spins, less money wagered, less time spent playing, increased limit-adherence) when informed about the nature of the game they are playing (41, 44, 74). Finally, the relative non-intrusive nature of a pop-up message could help facilitate increased collaboration between different stakeholders involved in gambling, as emphasized in the Reno Model (17). This is further attested to, because major online gambling sites already have implemented pop-up messages as an RG feature (35, 36).

Although there is some support suggesting that RG pop-up messages influence behavior of a small number of people playing for a long time (1,000 or more spins on a virtual roulette game) (35), the failure to identify a sufficient number of studies containing problem gamblers, makes it difficult to assess the effect of pop-up messages on gamblers who already suffer from gambling-related problems, and therefore fails to shed any new light on its effectiveness in mitigating problematic gambling among problem gamblers. However, the effect it has on gambling behavior of casual/regular gamblers, contributes (at least short-term) to a reduction of gambling harm, which in turn promotes a public health perspective of safe gambling (17). As gambling becomes increasingly digitalized, pop-up messaging appears to represent an accessible and cost-effective way to attenuate excessive gambling behavior and to modify gambling-related cognitions.

Limitations and Future Directions

The present meta-analysis has several limitations that should be noted. One limitation concerns the risk of bias of the included studies, with several studies failing to pass some of the criteria of the assessment tool used (54). Most of the studies lacked one or more of the following: (i) a cohort (pre and post data on the same subjects), (ii) random selection of participants for assessment, (iii) follow-up assessments, and (iv) did not report whether there was equivalency on outcome measures at baseline for comparison groups. Only two studies (33, 53) included follow-up data. The lack of follow-up data in the included studies makes it difficult to draw conclusions about the long-term effects of pop-up interventions on gambling behavior and cognition. Furthermore, the absence

of random sampling and equivalency on outcome measures at baseline for comparison groups, should be considered a limitation, as it can limit the generalizability of the results (59).

Only two of the included studies (35, 36) evaluated gamblers in their real-life gambling environments (i.e., actual gambling with players spending their own money). It is therefore important to be cognizant of the ecological validity of the findings from the majority of studies included in the present meta-analysis. Even though it has been shown that certain types of rewards (i.e., the possibility to win via raffle or lottery tickets) can be as effective as immediate monetary rewards (75–77), there is still reason to question the true ecological validity and generalizability of such trials, as, for example, the absence of risking one's own money in a gambling situation, has been shown to increase spending in gamblers (78). Other limitations related to studying gambling behavior in laboratory settings are that such settings often lack aspects present in real-life gambling such as variety of gambling motives, ability to choose between different games, playing games in different ways, and the distinct milieu of gambling venues (79). Therefore, more studies on the effects of pop-ups should be conducted in real world gambling contexts with real gamblers in real time [like those of Auer et al. (35) and Auer and Griffiths (36)]. Another limitation of the present meta-analysis is that outcomes subsumed as cognitive outcomes varied significantly. However, the limited number of studies prevented meta-analyses of more narrow outcomes and constructs.

One area for future research concerns the long-term effects of pop-ups. It can be argued that the main aim of pop-ups is to change behaviors and cognitions in the specific context of a gambling session. Consequently, it would be of interest to investigate whether repeated exposure to pop-ups during gambling can cause long-lasting and robust changes in gambling behaviors and cognitions or not. This should be addressed in future research. In addition to this, the authors of the present review echo other researchers' call for further investigation into the possible habituation of warning messages (31, 52). The effect of pop-ups in specific vulnerable populations (e.g., problem gamblers) should also be addressed in future studies.

The comparison condition of the included studies differed across studies. Some comprised a non-pop-up intervention, whereas other comprised a pause or neutral or irrelevant pop-up messages. This makes it difficult to conclude whether some of the effects are attributable to the presence of a pop-up in itself, or whether the effects were contingent on the specific form, placement, duration, or content of the pop-up. Given that the experimental interventions differed in message content (e.g., limit reminders, self-appraisal feedback, personalized feedback), future studies and meta-analyses are advised also to further investigate the effects of differences in message content. The present meta-analysis did not investigate the effects of pauses *per se* during gambling, and pure pauses comprised the control condition in several studies. Therefore, the present meta-analysis does not provide information about the effect of pauses on gambling cognitions and behavior. We thus recommend that future studies and reviews systematically investigate the effects of pauses, preferably by experimental designs in real-world settings.

CONCLUSIONS

The present meta-analysis examined the efficacy of RG pop-up messages on gambling behaviors and cognitions. The results showed that RG pop-up messages had a moderate effect on gambling behaviors and cognitions, using interventions which should be considered as highly cost-effective. The present meta-analysis is of importance, as it is the first meta-analyses on the efficacy of pop-up messages on gambling behaviors and cognitions [although narrative literature reviews have been previously conducted (34, 80, 81)]. As such, the meta-analysis contributes to the literature by filling an important gap in knowledge of the efficacy of pop-up messages as a tool to promote responsible gambling. The findings imply that there are benefits to using pop-up messages to promote responsible gambling, although caution should be exercised in terms of generalizability to real-world gambling settings, hence more studies in such contexts should be conducted.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

As only secondary data were analyzed the study was exempted from approval by Regional Committees for Medical and Health Research Ethics.

AUTHOR CONTRIBUTIONS

SP assisted by BB, JS, and AB: conceptualization. BB, JS, and AB: literature search and study coding. BB, JS, and AB assisted by SP: data analysis. BB, JS, AB, and SP: drafting the manuscript. EE, TL, and MG: critically revising the original manuscript and the revised version. All authors contributed to finalizing the paper and approved the submitted version.

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*References marked with an asterisk indicate studies included in the meta-analysis.

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A Perspective on Age Restrictions and Other Harm Reduction Approaches Targeting Youth Online Gambling, Considering Convergences of Gambling and Videogaming

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Internet gambling has become a popular activity among some youth. Vulnerable youth may be particularly at risk due to limited harm reduction and enforcement measures. This article explores age restrictions and other harm reduction measures relating to youth and young adult online gambling. A systematic rapid review was conducted by searching eight databases. Additional articles on online gambling (e.g., from references) were later included. To place this perspective into context, articles on adult gambling, land-based gambling, and substance use and other problematic behaviors were also considered. Several studies show promising findings for legally restricting youth from gambling in that such restrictions may reduce the amount of youth gambling and gambling-related harms. However, simply labeling an activity as "age-restricted" may not deter youth from gambling; in some instances, it may generate increased appeal for gambling. Therefore, advertising and warning labels should be examined in conjunction with age restrictions. Recommendations for age enforcement strategies, advertising, education, and warning labels are made to help multiple stakeholders including policymakers and public health officials internationally. Age restrictions in online gambling should consider multiple populations including youth and young adults. Prevention and harm reduction in gambling should examine how age-restriction strategies may affect problem gambling and how they may be best enforced across gambling platforms. More research is needed to protect youth with respect to online gambling.

Keywords: gambling, harm reduction, gaming, video games, addictive behavior, child, adolescent, Internet

INTRODUCTION

People with gambling problems typically meet criteria for hazardous gambling, betting or gambling disorder in the International Classification of Diseases, 11th edition (1, 2). Global estimates of 10- to 24-year-olds suggest 0.2–12% of youth and young adults experience gambling problems (3, 4), with an additional 8–14% at risk for developing gambling problems (5). Online gambling prevalence in 13- to 24-year-olds range between 4 and 24% (6). It is estimated that 2.5% of youth, or 18.1% of those who gambled online, experiences problematic gambling (7).

Gambling-related harms may be experienced by those who gamble, associated individuals, and communities through social systems and/or health systems costs (8, 9). The Conceptual Framework of Harmful Gambling proposed that the definition of harmful gambling is, "any type of repetitive gambling that a person engages in that leads to (or aggravates) recurring negative consequences, such as significant financial problems, addiction, or physical and mental health issues." p. 4 (9). Such harms may include financial and interpersonal problems (10, 11), nongambling psychiatric disorders (12, 13), and they could increase strain on welfare systems and generate economic harms in the community (8). Youth and young adults may be particularly susceptible to problem-gambling-related harms, especially to online gambling since it is often fast-paced and easily accessible (6, 14, 15). As new forms of online gambling emerge, the issue of problem gambling in youth may become more prevalent and differ significantly from land-based gambling (e.g., at in-person venues like casinos).

Enforcement of harm reduction measures related to online gambling varies. Youth may gamble online by clicking to indicate they are "over 18 years old." Furthermore, a convergence of gambling and videogaming has implications for youth gambling. Limited or no age restrictions for online games such as free-to-play slot machines may allow youth early opportunities to engage in gambling-like activities that may lead to gambling problems (16). Social casino games (SCGs) that involve virtual currency may lead to monetary gambling (17, 18). Other videogaming-related features such as loot boxes[1] (19) and skins betting[2] (20) offer non-monetary rewards with in-game value that may also have monetary value. A convergence between gambling and videogaming platforms may facilitate behavioral involvement across networks and consoles, providing robust access to gambling-like activities (21). It is therefore important to understand how best to use age restrictions and other harm-reduction measures for online gambling and videogaming in preventing or minimizing online-gambling-related harms.

METHODS

A rapid review was conducted for age restrictions and warning labels in youth gambling by searching Cochrane, PsychInfo, Embase, Medline, Child Development and Adolescent Studies, PAIS, Web of Science, and Social Care Online between February 2–18, 2020. In order to put this perspective narrative into context, additional articles on online gambling were included between March to November 2020 through database and internet searches. Articles on adult gambling, land-based gambling, and other potentially risky behaviors were considered. Here, "youth" refers to people under the legal gambling age; however, young adults are also considered since some youth studies included people up to age 25. Further rationale for including young adults is described below.

YOUTH AND YOUNG ADULT ONLINE GAMBLING

Youth are often exposed to gambling at early ages, and many gamble online (22). The idea that gambling is potentially harmful for youth is longstanding. In 1978, Cornish (23) stated that it is dangerous to introduce gambling to youth because their lives are not yet structured by the constraints, obligations, and rewards that adults have which act to prevent excessive involvement with gambling. An early age of gambling onset is associated with developing gambling problems, particularly for males (24–26), and more severe gambling problems later in life (27). Early gambling also is associated with serious negative psychological, social, financial, and substance use problems (28–30).

Adolescents are more inclined to participate in, and underestimate the risk of risk-taking behaviors such as substance use and online gambling (3, 31). Failure to address youth concerns may lead to negative impacts (15, 32). However, young adults (ages 18–24) may also be at elevated risk given neurodevelopmental processes underlying risk-taking and addictive behaviors. Emotional regulation, logic and other processes are not fully developed by young adulthood (33). Therefore, poor decision-making may lead young adults to take more risks and act more impulsively when gambling (33). For example, individuals aged 18–20 years are particularly likely to chase losses and bet more than they can afford (33). This may present a problem because young adults up to 25 years old may be overlooked by gambling legislation in several countries that have legal age restrictions for those under 18- to 21-year-olds.

Youth and young adult online gambling is a growing concern as studies suggest that this demographic is shifting away from land-based gambling to online gambling (34–36). Youth are also moving from social gambling with friends to solo gambling online that is available across time and locations (14). This is particularly concerning since, for youth, online gambling has been associated more with problem gambling than land-based

[1]Loot boxes are videogame features (often in the shape of a box) available in many game genres that one can find or purchase. They often contain a seemingly random mix of items, ranging from common to rare items. The rarer the item, the more valuable it typically is in the game. In some cases, a loot box may be found in-game but requires a key to open it—this key may be purchased or earned. A distinction from gambling is that loot boxes can create monetary losses but typically no monetary gains.

[2]Skins in videogames change the appearance of an item or character. For example, a skin may give your gun camouflage coloring, or give it the appearance of flames. Skins can be obtained through loot boxes, earned during gameplay, purchased with virtual currency and/or purchased with real money. For some videogames, skins become a valuable commodity that can be sold or used to place bets with on third-party websites.

gambling. International studies found higher proportions of problem gambling among youth who gambling online vs. non-online (34, 36–38). Jurisdictions should enact and enforce strict measures to stop early gambling in order to prevent the onset of gambling problems later in life.

CONVERGENCE OF GAMBLING AND VIDEOGAMING

Videogames that include gambling-like features or free-to-play gambling-related games, like SCGs, vary with respect to age restrictions and their enforcement (39–41). Gambling-related games without monetary wagering typically do not fulfill legal criteria for gambling (39, 40). Access to land-based or online video, amusement, and slot machines may have ambiguous age restrictions, and children under 16 years old sometimes have legal access (41). A Canadian sample of youth in grades 9–12 found 12.4% had played SCGs in the past 3 months. These youth were more prevalently classified as experiencing problem gambling (18). A similar study in the United States found that ∼10% of adolescent gamblers reported gambling at a casino, with estimates of 40% among those with gambling problems (42). In a Hong Kong school-based survey, 71.4% of individuals who gambled online reported earlier participation in games on free-to-play websites. These individuals were likely to view gambling as safe and healthy entertainment (36). However, free-to-play gambling-related games have been linked to gambling for money and problem gambling in youth (14, 16, 22, 43). Furthermore, microtransactions in simulated gambling-related games have been associated with subsequent gambling (35, 42). However, more longitudinal research is needed.

Forms of gambling may be incorporated into videogames and vice versa, blurring boundaries (20, 43). For example, some governmental and regulatory bodies consider loot boxes as gambling elements in videogames (44). Individuals who play videogames problematically have reported using online videogames and digital platforms to gamble (45). For example, some in-game items (even non-game-enhancing, cosmetic ones) may be exchanged for significant real-world money (46). Loot boxes, skins, and other random-chance features are considered to have similarities to gambling. These are found in games deemed suitable for youth as young as 8-years-old (47). Among the top 100 grossing videogames, loot boxes were prevalent, especially on mobile platforms, with these videogames often available to children 12 years or older (48).

Videogaming features such as loot boxes (19, 48–51) and skins betting (20) may be gateways to gambling and gambling problems in youth. Youth participating in skins betting and gambling may be at elevated risk for gambling-related harms (20, 48). A qualitative analysis of 16- to 18-year-olds who purchased loot boxes suggested that reasons for purchases were similar to reasons for engaging in gambling (51). These included wanting to advance in videogames more quickly, raising money, excitement, and escaping from stress (19, 51). Such findings indicate that age restrictions and harm-reduction measures should be considered for videogames that contain gambling/gambling-like elements. Healthcare professionals should understand the natures of videogames played in relation to their clients'/patients' lives (44). Contexualizing youth videogaming and gambling may be critical in preventing online gambling problems (14).

The role of virtual communities for gambling and videogaming should be considered during prevention and treatment of gambling/videogaming problems, especially for women (52). Identification within virtual communities may considerably influence in-game spending behaviors (52). Additional input is needed from game developers and rating boards (50). Online videogaming and gambling providers could take proactive roles in identifiying and excluding gambling youth. Similar approaches may be applicable to identifying, intervening and limiting at-risk gambling/videogaming (31). Providers could also include links to online counseling, peer-support chats, educational materials, and virtual communities that may serve as protection against excessive use (31, 52). Policymakers could consider placing limits on chance-items and use other controls that are traditionally used in gambling settings to limit youth spending and prevent youth engagement (49, 50, 53, 54). Additional harm-reduction measures are discussed below.

Effectiveness of Age Restrictions as a Harm-Reduction Measure

Limited research exists on the effectiveness of age restrictions on youth gambling, despite theoretical support (55). While age restrictions may prevent problem gambling or related harms (56–58), their effectiveness have largely been untested. Effectiveness of legal age limits appears largely inferred based on worldwide implementation (58). However, a global solution may be unfeasible. Customers typically prefer easy access, gambling and videogaming corporations are often profit-driven, and many governments take some revenue either directly or indirectly through taxation from gambling (58). Therefore, harm reduction or prevention of problem gambling by limiting the number of customers and the profits from these customers may not be the first solution considered.

Effectiveness of age restrictions on gambling may be influenced by public awareness and enforcement. A Finnish study found that teacher awareness for the minimum legal age of gambling was not as accurate as for purchasing alcohol, purchasing cigarettes, or driving a car (59). Similarly, in Canada, youth gambling was viewed as requiring less attention than other risk behaviors by teachers (60) and parents (61). With social acceptance of gambling, few caregivers may be aware of potential risks of early gambling onset (61). Underaged youth often participate in illegal gambling despite age restrictions (36, 41, 62, 63). Infringements against or disregard for age restrictions appear more common among males (64).

As with tobacco and alcohol, age restrictions are only effective when rigorously enforced (55, 65). There currently appears to be inadequate enforcement of age restriction regulations across multiple gambling activities (24, 41, 66). Enforcing age restrictions for online gambling may be particularly difficult. Underaged individuals who gamble may be committing credit

TABLE 1 | Age restrictions enforcement strategies.

Recommendation	Description
Use Age Verification	Compliance with age limits is poor (65). Age verification with personal identifications systems, by having users log on using a national identification number, can prevent underage gambling (14). Verifying age verbally *and* requesting identification in-person for land-based venues appear important. Simply asking the age of an individual is largely ineffective in enforcing underaged gambling. Compliance rates were the following for asking for: age only (0%); identification only (67%); age and identification (75%) (58).
Use Fines	Introduce fines for non-compliance may increase effectiveness. In the Netherlands, underaged individuals who gamble may be fined (19). Fines may also be introduced to vendors of gambling products.
Restrict visibility	Relaxation of gambling controls in the U.K. allowed retail outlets (e.g. newsagents, convenience stores, petrol stations, etc.) to have online terminals to sell lottery tickets including instant (scratch) lottery tickets. This gives vulnerable populations exposure and increased opportunity to participate in gambling (41).
Restrict convenient access	More access to gambling was noted in off-site locations such as gambling stores like the ones mentioned above (0% compliance rate) compared to on-site locations such as casinos (14% compliance rate) (58). Access to public gambling machines presents a potential threat for gambling disorder in minors as entry into casinos is limited to individuals 18 years or older in many jurisdictions (67).
Restrict availability	In theory, legal age limits should act to limit availability of gambling products. Enforcement of laws has been easier when limiting availability of slot machines within dedicated gambling areas (24, 68). However, setting limits may potentially increase gambling problems for some people; stakeholders should examine directly the consequences of placing limits if and when they do (69).
Use warning labels and messages	Warning labels are effective at modifying gambling behavior (70). Messages are informative to consumers, and if applied appropriately, they have the potential to reduce harm (70). In a laboratory setting with undergraduate students, those who received warning messages on common irrational gambling beliefs demonstrated significantly fewer irrational beliefs and less risky gambling behavior than those in the control condition who received messages on the history of roulette (71).

card fraud or are being supported by older friends and relatives to gamble online (31, 36). There are currently few safeguards to protect underaged individuals from gambling, and there have been calls for strict verification systems to be implemented (15, 36). Strategies used to enforce age restriction for in-person gambling may work for online gambling, although challenges exist in applicability (**Table 1**).

Raising Age Minimums

Research examining effectiveness of raising legal ages for gambling is limited; however, a review suggests that raising minimal ages may reduce gambling-related harms (72). Finnish studies examined effects of raising the legal minimum age to gamble from 15 to 18 years with an interest in protecting youth from gambling-related harms (55, 68, 73, 74). Unsurprisingly, 18-year-olds who were not targeted by the age increase showed no significant changes in gambling activity (74). The intervention was successful in reducing lottery and slot-machine gambling for the 15- to 17-year-old age group and, interestingly, also the 18- to 19-year-old age group 3 years post-legislation (73). Nonetheless, underaged gambling was still occurring in about 13% of youth (55). Online gambling for all age groups, except for underaged 15- to 17-year-olds, increased. Online gambling was rare in the 15–17 age group [4%] (68), perhaps related to difficulties in obtaining credit cards to gamble.

In sum, the Lotteries Act enacted in Finland on October 1, 2010 that raised the minimum age limit for gambling from 15 to 18 years of age helped decrease adolescent gambling and problem gambling between 2011 and 2015 (59). Teens who were still gambling experienced significantly less gambling-related harms 6 years after raising the age minimum (73). Therefore, negative consequences experienced by youth from gambling may be less prevalent after raising the age minimum (74). Follow-up is required to examine longer-term effects, especially on online gambling.

Warning Labels

Warning labels and advertising may reduce youth online gambling (75). However, few studies have examined intervention effectiveness in real-world gambling settings (76). Consumers do not appear "desensitized" to multiple warning messages (77, 78). Increased exposure to warnings may be beneficial in preventing youth online gambling. Also, providing only knowledge about gambling on warning labels does not necessarily impact gambling behavior. When gambling odds were on warning messages to alter irrational beliefs about winning, gambling behavior did not change significantly (79). A study with students (ages 14–17 years) found age-related warning labels with highly caffeinated food and drinks were similarly ineffective (80). In some cases, warning labels increased appeal of products (56% for videogames) (81). Gambling products were not part of this study, and therefore, it is uncertain whether such warnings on gambling products would increase gambling appeal to youth. Warning-label features that may be applicable to online youth gambling are discussed in **Table 2**.

Advertising and Education

Advertising and promotion of educational interventions warrant further study (14, 15). Interventions targeting youth gambling may fail without public awareness. When Finland raised age restrictions on gambling, mass media campaigns increased awareness and supported changes (55). Campaigns may use gambling websites, radio, physical posters in public spaces, online news, and social media platforms (31, 55). Conscientious marketing may help prevent under-aged involvement in online poker (16), especially when visibility of gambling advertisements contributes to people experiencing increased gambling accessibility (14). A UK study found harm-reduction messages were less visible than advertising (107). Recommendations for gambling advertising include:

TABLE 2 | Summary of recommendations for warning labels.

Recommendation	Description
Feature a trustworthy source	Although a U.S. study on youth and cigar warnings found no differences between sources of warning labels (82), a gambling study found that a trustworthy source for the warning label is important for its believability. Medical sources were found to be more effective than governmental sources (83). Moreover, a source related to the gambling provider had almost the same effect as no source (83).
Place warnings on each gambling machine, table, scratch ticket, and gambling website	An online survey at a U.S. college on waterpipe use showed that the location of the placement of the warning was important (84). In relation to gambling, this may mean that harm-based messages should be placed in noticeable locations where potential consumers can see them easily and frequently. For online gambling, placement on the website and how warnings are incorporated into experiences on the website are likely important considerations. Making labels conspicuous rather than discrete appears important (85).
Use pop-up style messages rather than static messages	Pop-up messages may have significantly more impact on thoughts and behaviors than static messages (86, 87). In one study, pop-up messages were recalled more immediately after gambling sessions and at a 2-week follow-up (86). Pop-up-style messages may be optimal when displayed in the center of screens, when they interrupt gambling, and when they require participant action to remove them (70).
Use honest warnings regarding negative consequences	Greater understanding of negative consequences may create more fear in people who gamble, which may then prompt them (at least in the short term) to consider risks that they are facing (83). However, long-term effects are less well known. For people with gambling problems, adults who had lower experiential avoidance were more responsive to fear-inducing warnings than were those with higher experiential avoidance (88).
Use simple descriptive messages rather than longer and more complex warnings	Longer patient-information warnings about gambling behaviors may be overwhelming (70) and, therefore, ineffective (89).
Use messages that discuss money spent	Messages that discuss money spent may have the greatest impact on gambling behavior (90).
Create tailored labels/messages	In a U.S. anti-substance-use study, youth were asked to design their own messages. The more time that youth had, the more persuasive their messages were in deterring youth substance use (91). In a focus group study with First Nations and Metis youth, messages tailored to cultural backgrounds and gender were found to be more effective (92). In a gambling study with young adults, people who gambled responded better to messages about their own gambling and expertise, with people engaging in "skill-based" gambling responding to messages on odds of winning and outcomes over time (93). Tailored message could also encourage self-appraisal rather than provide informative messages. Although both messages that encouraged self-appraisal and messages that were informative reduced gambling through behavior change (90), messages that ask people who gamble to self-appraise had significantly greater impact on thoughts and behaviors (86).
Use pictorial rather than text warning labels	Graphic warning labels (GWLs) were more effective than text-only warnings or personal testimonials (76, 94–96). Youth, especially those of younger age, tended to pay more attention to images than to text (97, 98). Images that created greater reactance or negative emotions (85, 99–102), were in full color (103), and used larger warnings with pictures (104) were found often to be more effective. Other studies found only comparable levels of negative emotions elicited by GWLs (103) and that they were generally more effective for those who already gambled. Similar studies were supported in the smoking literature where the effects of GWLs were lower for non-smoking than smoking individuals (95, 102). GWLs may not be an effective deterrent for youth who are not yet gambling. More research is needed to determine appropriate GWLs for youth videogaming and gambling.
Present two-sided messages	Framing warning messages as a "loss" or in a negative way, rather than what can be "gained" by not participating in the risky behavior, may be effective as a prevention method for adolescents (105). However, this may be different in the nutrition industry. Across three studies, dieting individuals who saw a negative message on unhealthy foods had an increased desire for consumption of those foods. Non-dieting individuals ignored the messages. In some cases, two-sided messages rather than just a negative message, may be a better option (106). An example used by the food industry is, "All dessert tastes good, but is bad for your health" p. 175 (106). Gambling products were not a part of these studies; however, framing two-sided messages may be a cautious way to proceed. A two-side message for gambling may be, "You can win money, but you can also lose *everything*."

1. Restricting advertising of online gambling (68, 108);
2. Including warning messages on all advertising and promotional materials (36);
3. Prohibiting marketing that targets underaged or vulnerable populations (73). This last point involves not depicting youth or people who look underaged participating in gambling activities (109, 110) and not implicitly or explicitly directing advertising at them (110). Increased education regarding risks should also be included in a comprehensive policy approach and harm-reduction guidelines (111).

While it may be nearly impossible to regulate all forms of online gambling, harm reduction in the form of educational awareness may help. Mass media campaigns and educational material that can inform youth of negative health effects could be implemented (31, 75, 108). Education to promote awareness of gambling risks could be implemented in schools and colleges, and incorporated into school curricula to prevent youth gambling and future gambling problems (31, 72, 112). Informational websites with links to treatment services and warnings to family/friends against providing funds to support youth gambling should also be considered (14, 36).

LIMITATIONS

This perspective paper provides a narrative overview of literature related to online youth and young adult gambling and age restrictions. Online gambling may change as videogaming and gambling converge and new technologies are developed (113). Although this paper began as rapid review on age restrictions and warning labels for youth, additional literature was cited to contextualize youth online gambling. This paper should not be considered a comprehensive critical description of the entire literature.

CONCLUSIONS

From the reviewed studies, there appears to be widespread adoption of legal age restrictions on gambling; however, studies of effectiveness pertaining specifically to online gambling appear limited. This may reflect indirect effects of harm-reduction regulations that primarily aim to denormalize and prevent youth from learning of financial and social rewards through gambling (114, 115). Enforcement of age restrictions, however, is another challenge. Future work surrounding prevention and harm reduction in online gambling should longitudinally examine optimal age restrictions and how they may be best enforced across the internet, considering adolescent/youth development. Current age restrictions should be consistently enforced to understand better their effects. In addition, further research is needed to reduce harms related to youth online gambling and gambling-related features in videogames. Early adoption of harm reduction measures including higher age restrictions for online gambling and for videogames with gambling-related features may be beneficial.

Evidence from research in gambling and related fields suggests that warning labels that simply state "age restricted" may not deter youth or may even increase appeal. Effective warning labels should consider tailored, strong, and colorful graphics that depict negative consequences of gambling. Messages that are simple and concise from a reliable source such as a medical organization may be effective with some youth. Balanced messages that tell two sides of the story (both positive and negative aspects of online gambling), are honest about negative consequences, discuss money spent, or encourage-self appraisal may also deter youth online gambling. Finally, youth may not become desensitized to warning labels and may require reminders as refreshments. Placing pop-up warning labels in noticeable areas where youth and other vulnerable populations may gamble online could be effective. However, direct examination of the effectiveness of each of these approaches for youth online gambling is needed.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

JS wrote the first draft of the paper and worked with the other co-authors on subsequent drafts. All authors contributed to the editorial process and have approved the final submitted version of the manuscript.

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Studying Gambling Behaviors and Responsible Gambling Tools in a Simulated Online Casino Integrated With Amazon Mechanical Turk: Development and Initial Validation of Survey Data and Platform Mechanics of the Frescati Online Research Casino

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Introduction: Online gambling, popular among both problem and recreational gamblers, simultaneously entails both heightened addiction risks as well as unique opportunities for prevention and intervention. There is a need to bridge the growing literature on learning and extinction mechanisms of gambling behavior, with account tracking studies using real-life gambling data. In this study, we describe the development and validation of the Frescati Online Research Casino (FORC): a simulated online casino where games, visual themes, outcome sizes, probabilities, and other variables of interest can be experimentally manipulated to conduct behavioral analytic studies and evaluate the efficacy of responsible gambling tools.

Methods: FORC features an initial survey for self-reporting of gambling and gambling problems, along with several games resembling regular real-life casino games, designed to allow Pavlovian and instrumental learning. FORC was developed with maximum flexibility in mind, allowing detailed experiment specification by setting parameters using an online interface, including the display of messages. To allow convenient and rapid data collection from diverse samples, FORC is independently hosted yet integrated with the popular crowdsourcing platform Amazon Mechanical Turk through a reimbursement key mechanism. To validate the survey data quality and game mechanics of FORC, $n = 101$ participants were recruited, who answered an questionnaire on gambling habits and problems, then played both slot machine and card-draw type games. Questionnaire and trial-by-trial behavioral data were analyzed using standard psychometric tests, and outcome distribution modeling.

Results: The expected associations among variables in the introductory questionnaire were found along with good psychometric properties, suggestive of good quality data. Only 6% of participants provided seemingly poor behavioral data. Game mechanics worked as intended: gambling outcomes showed the expected pattern of random sampling with replacement and were normally distributed around the set percentages, while balances developed according to the set return to player rate.

Conclusions: FORC appears to be a valid paradigm for simulating online gambling and for collecting survey and behavioral data, offering a valuable compromise between stringent experimental paradigms with lower external validity, and real-world gambling account tracking data with lower internal validity.

Keywords: online gambling behavior, software, Amazon mechanical turk, casino gambling, Pavlovian (classical) conditioning, instrumental (operant) behavior

INTRODUCTION

Gambling refers to any activity involving wagering of money (or something of value), on an outcome that is fully or partially dependent on chance, with the possibility of winning money (or something of value). As evident by its long historical roots and popularity around the world, gambling is a popular recreational activity, often without any serious negative consequences (1). A subset of gamblers, however, develop problematic gambling behaviors such as loss-chasing, stake habituation, difficulty stopping, and gambling to escape negative emotions, and experience negative economic, psychosocial, and mental health consequences because of this (2). Gambling is now recognized as an addictive behavior in psychiatric diagnostics (3), yet unlike alcohol and substance addictions, problem gambling does not involve consuming psychoactive chemical agents. From a clinical perspective, this makes it even more important to study the specific learning and extinction mechanisms involved in gambling in order to inform gambling-specific treatment strategies, both for clinical settings and to inform so called Responsible Gambling Tools (RGT) (4).

Since the dawn of behavioral analysis, gambling has been considered a prototypical case of the effectiveness of intermittent reinforcement, wherein a behavior is rewarded some, but not all the time (5). Later behavioral analytic research has examined a broader set of learning and extinction phenomena of presumed importance to gambling (6), including other types of reinforcement schedules (7), reward discounting (8), the near-miss phenomenon (9), establishing operations (10), and verbal rules (11). Behavioral analytic research has challenged some popular preconceptions about what promotes problem gambling, e.g., revealing mixed or even contradictory evidence for the "Early Big Win" hypothesis (12–14). Recently, attempts have been made to translate these findings into clinical practice (15).

However, overall, there are surpassingly few published behavioral analytic studies of gambling behaviors given the population prevalence of both gambling and gambling problems, and its overt similarities with learning experiments (16). While the relatively small and student samples typically used in past research need not present an issue if the expected effects are large and presumed common to all humans, there is still arguably a translational need to bridge these findings with that of account tracking studies from real-life gambling, where legal requirements make it impossible to e.g., randomize participants to definitively demonstrate causality (17). Access to larger samples may also create opportunities to study even minor effects that would nonetheless have a significant public health impact. Additionally, there are surprisingly few experimental studies on specific RGT features and responsible gambling practices, given the clear policy implications and ubiquitous implementation (18).

Further, experimental studies that attempt to simulate live casino environments and games played therein, are likely to not fully capture the contextual factors that play a role in learning and extinction (19). With the advent and increasing popularity of online gambling, which is now the most prevalent type of gambling among both problem and recreational gamblers in many countries (1, 20), it is now possible to develop research paradigms that are unaffected by contextual confounders, while still accurately simulating real-life gambling. Studying learning and extinction of problem gambling behaviors in a naturalistic setting is arguably of even greater importance if the goal is to study new potential features of RGTs and responsible gambling policies in online gambling environments (21).

In the current study, we describe the development and an initial validation of the Frescati Online Research Casino (FORC): a simulated online casino where games, visual themes, outcome sizes, probabilities, and other variables can be experimentally manipulated to conduct a variety of behavioral analytic and experimental RGT research with great flexibility and convenience. Such an experimental platform would be valuable in bridging classic behavioral research and account-tracking studies on real-life gambling data, offering an attractive, translational compromise in terms of internal and external validity. Validation data was collected using an experimental setup that would allow detailed examination of the game mechanics; validity of questionnaire data was also examined using traditional psychometric techniques.

MATERIALS AND METHODS

Amazon Mechanical Turk

Amazon Mechanical Turk (AMT) is a crowdsourcing platform that allows so called *Requesters* to publish *Human Intelligence Task* for *Workers* to complete for a pre-set monetary reimbursement. AMT has been a popular platform for collecting scientific data and running psychological experiments for many years (22–24) and has been shown to provide data of equivalent quality to traditional data collection methods (25, 26), including valid and reliable gambling data specifically (27, 28). Connecting FORC to AMT, or in principle any other crowdsourcing platform with similar features, provides access to a large, global, diverse participant pool and is thus particularly suitable to conduct behavioral analytic research that study phenomena that are common to all people.

Development and Features

Back- and front-end development of the casino and AMT integration was outsourced to a professional web development firm. The application relies on C#, ASP.net, Jquery and Bootstrap CSS frameworks, and an SQL database, and features a responsive design suitable for both smartphones, tablets, and computers. Randomness (both stimuli presentation, outcomes, and arm allocation) is implemented through a trial-by-trial random number generator, ensuring random draws with replacement, as in real-life gambling. The validation analyses described below include examining the randomness generation mechanism, since this is crucial to mimicking real-life gambling (4).

Data from multiple experimental arms can be collected at the same time, with random allocation to arms according to a percentage specified in a design matrix. FORC features three types of games, which can be included in any sequence and with varying number of trials: a roulette wheel with a choice of betting on red or black color (potential instrumental learning task, **Figure 1C**), a three-reel slot machine with no choice (potential Pavlovian learning task, **Figure 1D**), and a simple card-choice game with a choice of two decks placed side-by-side either vertically or horizontally (potential instrumental learning task, **Figure 1B**). While the two former paradigms perfectly mimic real-life gambling, a deliberate design decision was made to not model existing casino card games in order to avoid evoking already learned play strategies that could interfere with the designed contingencies. All games feature realistic sound effects, both on interaction (button pressing) and win outcomes (**Figure 1D**). Continuous background music was not included due to technical reasons. Balance is by standard displayed in the lower right corner, as in real-life online casinos, but can be hidden by specifying this in the design matrix. Four distinct visual themes—different color schemes, all with graphical casino connotations (one with four variants with only minor differences in element composition)—are available for both the card game and slot machine, which can be randomly allocated per trial. A basic theme option is also available. For each arm, number of trials per sequence, starting balance, visual theme, bet size(s) and win amount(s) and win probabilities, per choice option (if any), can be conveniently set in the design matrix using an online administrator view. See **Figure 1A**. Short, customizable messages can be displayed in-between games (sequences) to e.g., mimic the sort of messaging used in RGTs (e.g., "Remember that there is no guarantee that you will win back lost credits") (21).

AMT and Casino Procedure

Experiments are published on lists of available tasks on AMT; the platform offers the possibility to offer the task only to users with curtained registered characteristics (e.g., country of residence). Task listing includes a short description and reimbursement offered. Interested participants are referred to an AMT landing page featuring a full, customizable description of the experiment, along with participant and informed consent information (see below). Participants consent by clicking on a link that refers to FORC, housed on a separate server. The FORC landing page includes some final instructions, including an emphasis on playing the games as if it were a real working casino. Participants then answer questions on sex, age, last-year gambling frequency (in five steps, from not at all to once a per day or more often, coded 0–4) and types (12 different ones including ones prevalent in non-Western countries, plus a none-option), and the Problem Gambling Severity Index, PGSI (29), a validated screener for gambling problems. Participants then proceed to the games, as dictated by the design matrix. At the end of the games, participants view a customizable message and are shown a custom key, and are then prompted to return to the AMT platform and the key there, which is then used on the AMT side to validate the work performed and approve reimbursement.

Data Structure

Experimental data are saved and structured trial-by-trial, in long format, and includes anonymous study ID (independent of AMT worker ID), timestamps (temporal resolution was set at seconds at time of collecting validation data, later changed to milliseconds), allocated study arm, game type, trial number, balance in, presented theme, chosen behavior (response), the outcome, and balance out. Survey data can be linked to experimental data through the anonymous study ID generated upon submitting survey data and proceeding to the games. Data can be exported at any time from the administrator view.

Validation Data

During a roughly 3-h period, $n = 102$ final participants (see below) were recruited from AMT with an offered reimbursement of 2 USD for a session lasting no longer than 30 min. This reimbursement is relatively high compared to the estimated AMT average (30), and would thus likely have made it an attractive opportunity and likely to have promoted high-quality data. The published task description advertised it as a scientific experiment about online gambling. After completing the survey, the experimental setup had participants complete 40 trials of the card-draw game, then 40 trials of the slot machine game, and finally 16 non-reinforced trials of the card-draw game (not used in analyses). While the recruitment aim was $n = 100$ participants, the AMT integration procedure by necessity makes it possible for participants to complete the experimental part without completing the AMT part and being registered as having done

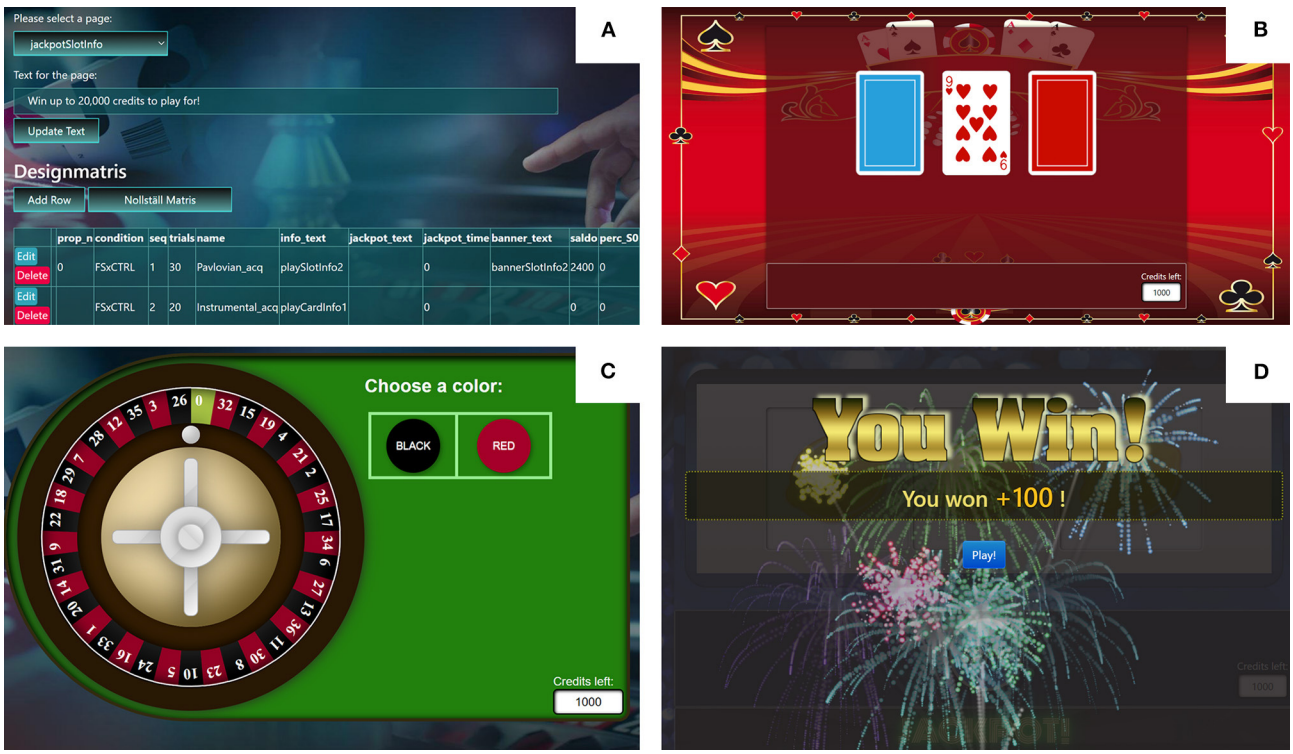

FIGURE 1 | Screenshots of the Frescati Online Research Casino (FORC). **(A)** Administrator view. **(B)** Card-draw game with one visual theme. **(C)** Roulette game with standard visual theme. **(D)** Slotmachine game with another visual theme.

this, explaining why the final sample size exceeded the intended. One participant was excluded for not completing all trials. A total of k = 9,696 trials from $n = 101$ participants were thus available for analysis. See **Table 1** for participant characteristics.

Analyses

All analyses were conducted in the R (3.6.3) statistical environment. FORC was validated as an experimental platform by considering three aspects: apparent data quality, randomness mechanics and resulting change in average credit balance over time, and psychometric properties of the survey data. Convergent validity of gambling behaviors observed on FORC was not examined since the experimental setup used was not designed specifically to evoke spontaneous gambling behaviors; however, demonstrating validity of the three aspects independently would suggest that an experimental setup designed to do so can be expected to show also convergent validity.

Quality of data was assessed by calculating percentage of participants who in the card-draw part showed no or limited response variation (outside a 10–90% response variation range), indicative of poor data quality due to indiscriminate, repetitive responding; or no such pattern, indicative of satisfactory data quality.

Second, three game mechanics aspects of FORC were empirically evaluated. First, the observed random appearances of gambling outcomes (wins) during the slot machine phase (with different win percentages dependent on random stimulus shown) were compared to those programmed in the design matrix (50% for theme S1A and 20% for theme S2), both on a trial-by-trial basis and overall. Second, to ensure that random draws (outcomes) were made with replacement (i.e. independent of previous ones), we calculated percentage of win outcomes during the instrumental acquisition phase (same 45% win probability in all trials) as a function of outcome of the preceding trial. Third, change in credit balance over time during the slot machine phase (same 20 credit possible win outcome in all trials) was compared to the expected credit balance change based on programmed probability. Since win probability differed between 20 and 50% depending on what stimulus was randomly presented for each trial, a perfect distribution of stimuli across trials and participants would give a 35% win probability. Since each bet cost 10 credits (at time of validation data collection not refunded in case of win; changed after collecting data for the current study, altering only the return to player rate but no game mechanics), and the win outcome was 20 credits regardless of theme, the return to player rate was 0.7 credits, meaning that with perfect distribution of themes between trials, a player's balance should decrease with on average 3 credits per trial.

Third, we performed psychometric analyses on the questionnaire data to estimate quality and validity of the different included measures. Cronbach's alpha (internal consistency) was calculated for the PGSI and factor structure

TABLE 1 | Participant characteristics (full sample).

Variable	Mean (SD) or n (of $n = 101$)
Age	34.89 (10.32)
Male	$n = 66$ (65%)
Any last-year gambling*	$n = 91$
Lottery	$n = 63$
Sports betting	$n = 22$
Race betting	$n = 6$
Cards	$n = 0$
Casino slots	$n = 41$
Festival	$n = 3$
Dice	$n = 13$
Online lottery	$n = 19$
Online betting	$n = 15$
Online cards	$n = 23$
Online slots	$n = 12$
Other	$n = 2$
Last year gambling frequency	
Not at all	$n = 10$
A few times	$n = 43$
Once a month	$n = 23$
Once per week	$n = 22$
Once per day or more	$n = 3$
PGSI score	4.26 (5.46)
PGSI score > 0	$n = 63$

**Participants could select multiple gambling forms. PGSI, Problem Gambling Severity Index.*

estimated using parallel analysis (31). Associations between PGSI score, gambling frequency and gambling types were also examined using regression models.

Ethics

The Regional Ethical Review Board in Stockholm has approved the use of FORC for a set of behavioral analytic research studies on gambling behaviors (2018/1968-32 and 2020-01863). Participant information is provided on the AMT platform, after which users can consent by actively choosing to be directed to FORC. In the participant information, it is recommended that potential participants with a history of or current problematic online gambling habits refrain from participation; As of current, it is however not technically possible to exclude participants with high scores on the included PGSI measure completed prior to beginning the experiment. After completing all trials, the end-message is configured to include a statement about the study aims and structure, that any gambling strategies learned in the experiment will not translate into real-life gambling, that the house always wins in real-life gambling, and that participants worried about their gambling habits should seek help locally. For ethical reasons, participant reimbursement is not made contingent on behavior during the experiment (due to e.g., allocation to different win probabilities).

RESULTS

Data Quality and Feasibility

During the 40 trials of the card-draw game, no participant showed zero response variation and only $n = 6$ had a response variation outside the 10–90% range, indicative of poor data quality. The remaining $n = 95$ showed greater response variation, with a sample average variation score of 52.4% (SD = 17.7%), i.e., equal response frequencies. Mean completion time was 10.05 min (SD = 3.68), with minimum of 6.35 and maximum of 29.28 min. Examining the duration distributions revealed that only a small minority of participants had durations in excess of 15 min ($n = 8$) and even fewer ($n = 3$) in excess of 20 min. Importantly, a longer duration need not in itself present an issue since the experiment was divided into phases, and participants could have loaded the game and delayed the start. In lieu of any obvious thresholds for determining quality at this level of detail, duration was not considered a quality indicator and hence not used for further exclusion.

Game Mechanic Validation

Observed win outcome percentages across slot-machine trials were normally distributed at a sample-level around 49.9 and 20.8%, respectively, against set win percentages of 50 and 20%. Observed percentage wins across card-draw trials was 44.5% when preceding trial had a loss outcome, and 45.2% when preceding trial had a winning outcome, revealing that the random mechanism (random sampling with replacement) worked as intended (set win percentage 45%). See **Figures 2A1–A3**.

Themes were randomly sampled during the slot-machine trials (set probabilities 50–50%), resulting in a 51.5% occurrence of theme S1. This, in combination with the set difference in win percentages between themes (50 vs. 20%), resulted in a total observed win percentage of 35.45% (with perfect 50–50% distribution of themes, the total win percentage would have been 35%, i.e., halfway between 50 and 20%), and in turn an expected credit loss at each turn of −2.911 (which would have been −3 with perfect 50–50% distribution of themes) against a bet of 10 and the equivalent of a return to player rate of 0.71. Observed balance decrease closely followed the expected decrease and was in general normally distributed around it. However, due to a random fluctuation of increased winnings around trial 5–15, and balance being an accumulated measure, the average total momentary expected-observed discrepancy was positively skewed to a mean of M = 1.12 (95% CI: 0.48–1.83). Average balance change from the preceding trial was however a perfect−2.909 (95% CI: −3.22 to −2.60) and normally distributed, revealing that the game mechanics worked as intended when considering that presentations and outcomes were random by design see **Figures 2B1–B3**.

Quality and Validity of Survey Data

Quality and validity of survey data was examined among the $n = 95$ who provided quality data in the card-draw game. As expected from a general population sample with an established overrepresentation of problem gamblers (27), PGSI scores were

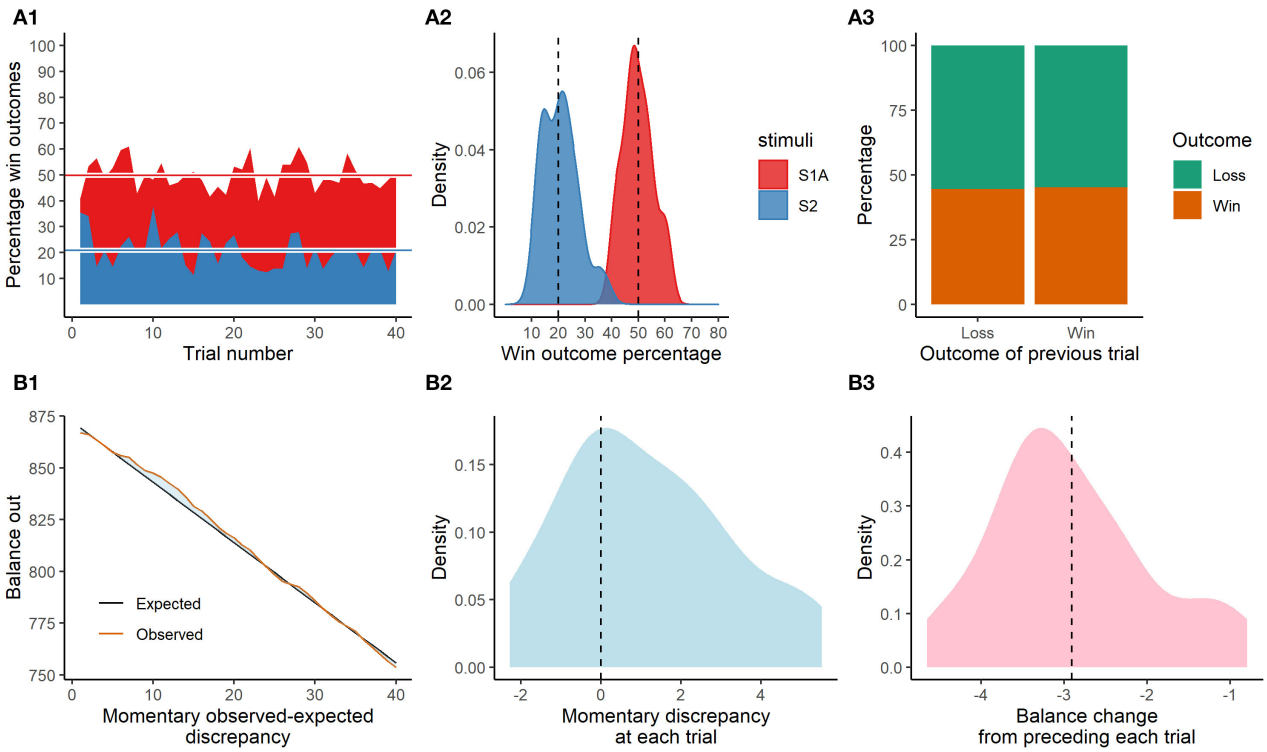

FIGURE 2 | Game mechanics validation results. **(A1)** Percentage win outcomes and distribution thereof **(A2)** across trials depending on randomly displayed theme (stimulus). **(A3)** Win outcomes as function of preceeding trial outcome. **(B1)** Observed balance out across trials compared to expected based on programmed return to player rate. **(B2)** Distribution of observed-expected discrepancies (vertical reference line of zero). **(B3)** Change in balance out as compared to the preceeding trial (vertical reference line corresponds to programmed return to player rate).

Poisson distributed with excess zeros yet with a long tail. See **Figure 3A**. Participants who reported no past-year gambling had significantly lower PGSI scores (B = −4.53, SE = 1.88, p = 0.0183), and both number of gambling types (B = 0.82, SE = 0.37, $p = 0.0278$) and gambling frequency (B = 2.60, SE = 0.49, $p < 0.001$) were associated with PGSI scores in the expected direction. In a Poisson regression model, gambling frequency significantly predicted number of gambling types (B = 0.34, SE = 0.067, $p < 0.001$).

Cronbach's alpha for the PGSI was calculated to $\alpha = 0.95$ (95% CI: 0.93–0.96). Even when omitting participants with a PGSI score of zero to avoid artificial inflations of internal consistency due to floor effects (32), α was 0.92 (95% CI: 0.89–0.95). Parallel analysis of PGSI items showed a convincing one-component solution; see **Figure 3B**.

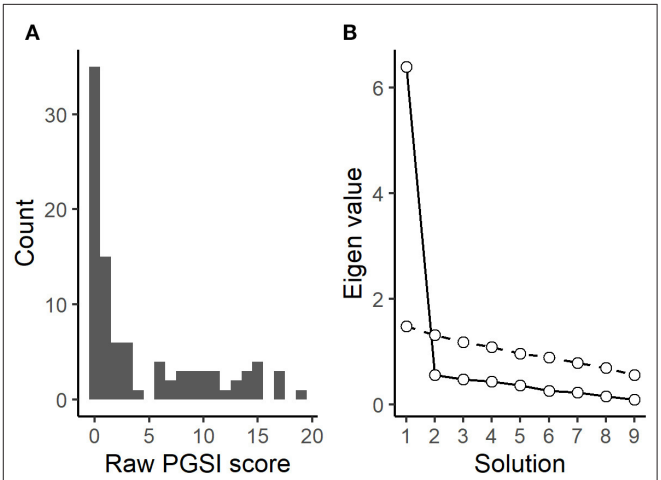

FIGURE 3 | Questionnaire findings. **(A)** Distribution of PGSI scores. **(B)** Parallel analysis screen plot of PGSI items: solid line shows observed values, dashed resampled (comparison).

DISCUSSION

The Frescati Online Research Casino (FORC) was designed to offer a valuable middle-ground between internal and external validity, providing full and flexible experimental control of a realistic, simulated online casino, in order to study the learning and extinction mechanisms of gambling behavior and evaluate responsible gambling tools and policies in a convenient way. This first validation study showed that data collection through integration with the Amazon Mechanical Turk crowdsourcing platform was feasible, provided a high percentage of high-quality behavioral and survey data, and that the game mechanics worked

as intended. This suggests that FORC is ready to be used for experimental studies on gambling behavior and effects of RGTs.

Online gambling is now the most prevalent type amongst problem gamblers (1, 20) (at least in countries where this gambling form is widespread), and can be simulated for research purposes more easily than a traditional casino games since contextual confounders do not apply: participants engage with FORC in the same environment (on their computer or smartphone) that they would with real online gambling. Online gambling as a modality provides better opportunities for behavioral tracking and collecting other data, as well as providing micro-interventions like automated feedback that can all be packaged as part of RGTs (32), making it easier to simulate for research purposes with retained face validity. While there are empirical studies on RGTs (21), most of these have either prioritize internal validity over external validity (e.g., small samples and a laboratory setting), or vice versa (e.g., lack of randomization, allowing no causal conclusions). Deploying experiments via FORC provides a valuable, translational middle-ground that could help to establish an evidence base for RGTs on par with the scientific standards of psychological and medical interventions.

Of note, by both design and current functionality, FORC is limited in some respects as to what types of gambling that can be simulated (see Limitations below). Prominently, we opted to design a new card game—with familiar symbols and general mechanics—to allow the study of instrumental learning, rather than use existing ones, in order to avoid confounding effects of prior learning (i.e., playing styles). The other two FORC games however are very similar to their real-life equivalents, albeit somewhat simpler in gambling options. Of importance to learning experiments, a deliberate design was made to require user input for every trial of the slot-machine, since we considered this to be a key feature of real-life gambling. Although requiring user action to initiate a learning trial deviates somewhat from traditional Pavlovian paradigms, users were presented with only a single option (to continue, i.e., no option to either quit, change bet etc.). According to the so called functional-cognitive framework wherein learning is seen as an ontogenetic adaptation (33), learning in absence of choice can only be Pavlovian and not instrumental.

For ethical reasons, participants with a history of gambling problems are explicitly discouraged from participating. However, it is currently not technically feasible to automatically exclude users with high PGSI scores from participating, for example, or to use this information for arm allocation (although a conditional statement with reference to the PGSI variable would have been easy to add to gate progression from the questionnaire section to games, it would not have hindered participants from simply reloading the page and reporting differently). Not unexpectedly, a large percentage of participants did report at least some gambling problems—even higher than in previous studies using AMT (27), although the international recruitment base make these numbers hard to compare. This observation makes deployment of FORC an ethical issue, rather than theoretically imposing a limitation on generalizability of findings (since little or no selection bias is apparent). As with any research on this topic and/or using similar methods, planned experiments should be vetted by an independent review board. Of importance, FORC includes several features that address this issue directly, including post-experiment debriefing, a reminder that the house always wins, that gambling strategies applied in FORC will not work elsewhere, and encouragements to seek help. Further, considering the ubiquity of online advertisements for gambling opportunities, it could also be argued that presenting AMT users with possibility of participating in a gambling experiments does not in any practical sense increase their exposure to gambling opportunities.

A stated aim of FORC was to offer a wide variety of possible outcome measures, the choice of which must be considered for each particular experiment. Delay in specific responses may be of interest in some experiments (34), yet setting up distinct behavioral choices in the card-draw game, e.g., a high vs. low risk option, may have better convergent validity as a proxy measure of problem gambling and has seen use in past research (35, 36). Whether such measure shows convergent validity will however ultimately depend on the exact experimental setup and must thus be examined in each study carried out using FORC. Of note, another commonly used proxy measures of problematic gambling, gambling persistence (13), is not possible to examine with FORC since AMT participants have no incentive to continue playing beyond the required trials and reimbursement is fixed for both technical and ethical reasons.

The detailed logging procedure featured in FORC also allows for a variety of quality assurance measures. Although AMT experiments do tend to produce high-quality data (26), this does not apply to 100% of participants. In the current study, we examined both within-questionnaire convergent validity and psychometric properties, as well as response variation—the latter on the grounds that fully repetitive gambling would be in violation of experiment instructions and the easiest way to play through the experiment and gain reimbursement as quickly as possible. Response variation is likely to be a sensitive proxy measure of quality, yet possibly at the price of some specificity, and the exact threshold should thus be carefully considered. Since collecting validation data, a new quality assurance feature has been added to FORC in the form of a pop-up question on contingency knowledge acquisition, used in previous research (37). These questions, along with response variation patterns and timing of responses, should be sufficient to make an accurate assessment of data quality in any experimental setup.

Since collecting validation data for the current study, some additional changes have been made to FORC. Win outcomes now always return the bet—this decision was informed by parallel beta testing by other researchers and students (unfortunately, not systematically collected or analyzed), who expressed an expectation from real-life gambling experiences that this was expected. Return of bets upon winning is now explicitly explained in the pre-game instructions, and we can thus see no reason why it would change the game mechanics beyond calculation of the return to player rate, which with one exception (see Limitations below) can easily be adapted. Another change is that bet size, which could previously only be observed through change in the credit balance, is now displayed visually immediately upon pressing a button or selecting a deck, then fading rapidly.

Temporal resolution of logged behaviors has been updated to milliseconds to enable computational modeling experiment (34). Additional features added include the possibility to display different messages to different experiment arms at the beginning of each game as per the design matrix, as well as the possibility to add a banner-type advertisement to the background. Both these features were included to be able to study the effects of RGTs like pop-up messaging (21) as well as rule-governed behavior (4).

Limitations

Both this validation study, and the FORC platform itself, have some limitations that need to be acknowledged. First, the experimental setup was designed to allow a detailed evaluation of the game mechanics, rather than to evoke spontaneous gambling behaviors perfectly reflective of real-life gambling. For example, the return to player rate of the slot machine game was 0.7, which is lower than in typical real-life gambling; although the degree to which participants could discriminate this is unknown (38). For this reason, we refrained from examining associations between observed gambling behavior and collected measures of gambling habits and gambling problems. Instead, we emphasize that each study in which FORC is used should examine convergent validity in relation to what can be reasonably expected given the particular experimental setup used. If, for example, a study aims to immediately promote Pavlovian or instrumental learning in order to avoid possible confounding, the resulting gambling behaviors may be shaped more by the newly learned contingencies than regular gambling strategies, decreasing power to detect convergent associations with survey-reported gambling. Second, the current study did not collect any additional data to examine data quality (e.g., participant ratings or free-text evaluations), opting instead to examine data quality using the same metrics that would be available to subsequent experiments run using the same platform. Importantly, data quality assessment should be carried out in every study that uses FORC, adapted to the specific experimental setup and preferably using pre-registered thresholds. Third, this validation study was not designed to evaluate the optimal description used for recruiting AMT workers to complete the experiment.

While the FORC platform was designed to offer great flexibility in terms of experimental setup, some limitations nonetheless apply. First, although the aesthetic of FORC was designed to mimic that of modern online casinos, graphical quality is not fully comparable, at least to those prevalent in Western countries. To some extent, this was a deliberate design decision: too complex graphical presentations may have distracted participants and presented technical issues for users running the experiment on smartphones and cellular internet connections. Also for technical reasons, including background sound was not possible, although FORC does feature realistic casino sound effects. The impact of lack of background music on external validity remains unknown; although background music during e.g., slot-machine playing may drive immersion and put the gambler in a so called "Dark Flow" (39), gambler may be equally likely to turn down repetitive background music of this kind if they find it disturbing or distracting. A second FORC feature limitation is that only one win probability and amount can be set for each trial sequence, unlike in real-life gambling where there are often several win outcomes available, with probabilities decreasing with increasing amounts. However, jackpot-type setups can still be simulated by setting up several consecutive trial sequences of the same game, with randomized allocation to different number of trials and specific jackpot outcomes if need be. Third, custom gambling options are not available and cannot be simulated at present, meaning that research questions on this particular topic cannot at present be investigated using FORC. Fourth, our subsequent choice to modify the game mechanic to always return the bet on a winning outcome, entails that FORC cannot at current be used to study the losses-disguised-as-wins phenomenon (40). Returning this parameter setting would however require only a minor change to the underlying source code. Finally, it should be acknowledged that as with real-life gambling outcomes, appropriate statistical methods may be necessary to properly analyze some outcomes, e.g., if a particular experimental setup generates an of excess zeroes (41).

CONCLUSIONS

The Frescati Online Research Casino offers a convenient way of performing large-scale experiments on gambling behavior and responsible gambling tools, with an experience resembling real-life online casino gambling. In this first validation study, we show that behavioral and survey data quality appears adequate, and that the game mechanics work as intended.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. The authors will consider requests for FORC source code.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Swedish Ethical Review Authority. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

PL, JR, and PC designed FORC. EI made significant contributions to design and beta-testing. PL oversaw development, analyzed data, and drafted manuscript. JR, EI, and PC substantial contribution to the interpretation of data and revision of the manuscript for important intellectual content. All authors contributed to the article and approved the submitted version.

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Gambling Marketing Strategies and the Internet: What Do We Know? A Systematic Review

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Background: The gambling industry has developed many types of gambling on Internet in recent years. Gambling is a social activity for a majority of the world population, but problem gambling (PG) can emerge. The trajectories of gamblers from initiation to PG development are influenced by many variables, including individual and environmental variables and also variables linked to the gambling characteristics. Marketing has been reported to influence gamblers' perceptions and behaviors, but this is not as clear for digital marketing. Digital gambling marketing is broad, ranging from the marketing of gambling websites to communication and advertising on the social media and networks. The objective of this article was to fill this gap by conducting a systematic literature review in order to answer the following questions: (1) What are the strategies of digital gambling marketing? (2) What is the effect of this exposure on gambling representations, intentions and practices?

Method: A systematic review was conducted following the PRISMA guidelines on Pubmed database (Medline) from February 2020 to March 2020 and Scopus. Existing papers published between January 2000 and February 2020 were identified by searching with this algorithm: ((("internet"[MeSH Major Topic] OR (communications[All Fields] AND media[All Fields])) OR ("social media"[MeSH Terms] OR ("social"[All Fields] AND "media"[All Fields]) OR "social media"[All Fields])) AND "gambling"[MeSH Major Topic]) AND ("marketing"[MeSH Terms] OR "marketing"[All Fields]), in title, keywords or abstract.

Results: Ninety-one candidate studies were selected, 21 studies were selected for the systematic review. Sport appeared as a specific target of online gambling marketing. A growing range of platforms for online sport betting and the development of strategies on the social media were identified. Regarding content, a systematic association between sport and gambling was highlighted. Vulnerable populations, such as young people, appeared to be at high risk of exposure to gambling marketing.

Conclusion: Little data is available on the strategies of digital gambling marketing or on exposure to it. Sport could be the first target for future research to understand how the industry is targeting specific populations, and what influence these strategies could have on PG development.

Keywords: gambling, marketing, online, betting, advertising

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INTRODUCTION

Internet has become a part of our lives and is both a medium for providing a wealth of information and an important tool for connecting with others around the globe (1). In recent years, the gambling industry has developed many types of gambling on different media, especially on the Internet. This expansion of legalized gambling has been identified as a public health concern (2–4). Gambling is a widespread social activity worldwide and nearly all national surveys conclude that there are more gamblers than non-gamblers (5). For example, 74% of the French population reported having gambled in their lifetime (6). In a majority of cases, gambling remains social gambling, but problem gambling (PG) can emerge (5). PG is defined as a persistent, maladaptive pattern of gambling resulting in clinically significant impairment or distress (7). Around the world, lifetime prevalence of PG ranges from 0.7 to 6.5% (5), and damage is severe: professional and financial (8), psychological, with an increased suicide risk (9), familial (5) etc. The trajectories of gamblers from initiation to PG development are influenced by many variables, including individual and environmental variables and also variables linked to the gambling characteristics (10, 11). Participation in gambling is increasing with the growing availability of gambling, advertising, marketing, and gambling deregulation (12, 13).

The gambling industry is one of the pioneers in internet technology development. It has designed gambling experiences to stimulate the human senses, by creatively integrating audio-visual technology, such as touch screens, surround sound, augmented reality, haptic actuators etc. (14). This strategy, based on experiential marketing, is very effective in influencing consumers' behavior, satisfaction, and loyalty (15). Through the creative use of touch, hearing and sight, the digital world has innovated in many ways of controlling and capturing human emotions (16). These evolutions in gambling types and the media used with the development of digital tools has enabled the gambling industry to expand its customer base (17). The legal status of online sports betting has been progressively changed and legalized in Europe since the mid-2000s, leading to a normalization of the practice. Consequently, the number of betting platforms legally available to consumers has increased. This has led to competition between companies to position themselves and attract customers to a relatively new market (18). Strategies developed by gambling operators on the internet can be included in the larger concept of the strategies of gambling marketing, defined as a management process from concept to customer.

Several studies have highlighted the links between the availability and proximity of gambling opportunities and excessive gambling practices (19–23). The causal mechanisms of the influence of advertising on gambling behavior are unknown despite a growing body of scientific evidence (24). Binde in 2014 in a critical review concluded that despite the lack of evidence, it was likely that gambling advertising had impact on gambling behaviors (25). Moreover in correlational studies, problem gamblers typically reported greater exposure to gambling advertising (26). Problem gamblers are a specific target for the gambling industry, in 2007, in Canada, 17.1% of online gamblers were considered as problem gamblers, and the money they spent amounted to 41% of the money spent online in the country (27). Gambling advertisements have been reported to have a greater impact on problem gamblers (25, 28, 29). Russel et al. found that in a large population of gamblers, 20% of those who reported a negative influence of repeated gambling advertisements were at risk or problem gamblers (30).

The recent prolific development in online gambling has been accompanied by growing concern for its potential harm (31). Regular and problem gamblers could be particularly concerned by the impact of digital gambling marketing. Online gamblers are defined as more at risk for problem gambling. Some studies have reported that online poker gamblers were two or three times more at risk of being problem gamblers than those gambling offline (27). In another study, Internet gamblers were significantly more likely to increase their gambling in response to online gambling promotions than non-interactive gamblers (26).

However, if advertising and traditional marketing have been reported to influence gamblers perceptions and behaviors, things are not as clear for digital marketing. Digital gambling marketing is broad, ranging from the marketing of online gambling websites to communication and advertising on the social media and networks. Social networks are considered to amount to a set of applications with various operating modes and uses: general networking (Facebook, MySpace), micro-blogging (Twitter), photo sharing, or exchange of ephemeral content (Instagram, Snapchat, etc.). These companies broadcast messages directly by insertion of classic advertisements into Internet users' news feeds, into stories, in the animation of official pages via community managers (Facebook, Instagram), and in the creation of cultural, sporting or festive events associated with the brand.

Analyzing the impact of the digital gambling marketing is important because 51% of people worldwide are connected to Internet (2019), especially young people: more than 90% of the 12 to 24-year-olds connect to the Internet every day, and respectively 80 and 94% of 12–17 and 18 to 24-year-olds used the social networks in 2019 (32). It can be supposed that the digital development of gambling and gambling marketing strategies on the Internet could influence gambling behaviors Very few studies in the literature have focused on this topic. The objective of this article was to fill this gap by conducting a systematic literature review in order to answer the following questions: (1) What strategies can be identified in digital gambling marketing? (2) What is the effect of this exposure on gambling representations, intentions and practices?

MATERIALS AND METHODS

Protocol, Registration, and Eligibility Criteria

The PRISMA statement for reporting systematic reviews was adopted. Inclusion criteria were coded by both authors (MGL, KGM), reaching an agreement regarding the coding process and were as follows: (a) inclusion of studies concerning gambling marketing strategies on the Internet, (b) inclusion of articles

containing quantitative and/or qualitative data, (c) inclusion of articles published in a peer-reviewed journal and following IMRAD, (d) inclusion of articles available as a full text in English or French.

Information Sources and Search Strategy

From February 2020 to March 2020 existing papers published between January 2000and February 2020 were identified by searching the academic databases Pubmed (medline), and Scopus. The two authors drew up a list of agreed English keywords for the systematic search: ((("internet"[MeSH Major Topic] OR (communications[All Fields] AND media[All Fields])) OR ("social media"[MeSH Terms] OR ("social"[All Fields] AND "media"[All Fields]) OR "social media"[All Fields])) AND "gambling"[MeSH Major Topic]) AND ("marketing"[MeSH Terms] OR "marketing"[All Fields]), in title, keywords or abstract.

The inclusion and exclusion criteria are presented in **Table 1**.

Study Selection and Data Collection Process

The reviewers were the first two authors (MGL-KGM); they were researchers with previous experience in conducting literature reviews, and one of them had specific expertise in gambling disorders (MGL). The reviewers independently reviewed titles and abstracts, to ensure the reliability of the screening process. They then met to exchange their individual decisions and discussed their rationale for these decisions. Consensus was reached when the two reviewers agreed on article inclusion or exclusion. Full text articles for each included article were then collected, and screened by the two reviewers against the inclusion/exclusion criteria. The reviewers discussed any articles where a reviewer was unsure. Information extracted from the articles included: author names, year, and study location; journal, objective of the study, key results, key points of the discussion. Quality ratings were undertaken for all included peer-reviewed articles. We determined that all peer-reviewed research following IMRAD format was generally well-conducted and met the rating criteria. No studies were excluded for poor quality.

Ninety-one candidate studies were selected. After elimination of the duplicates ($n = 7$), and after reading the title and summary, 50 papers were retained after elimination of 34 studies(not concerning gambling marketing: 29, not concerning digital marketing: 4, not following IMRAD: 1).

After perusal of the full texts, 21 studies were selected for the systematic review, after elimination of 29 studies (not concerning gambling marketing: 13, not concerning digital marketing: 11, not following IMRAD: 5).

The selection and inclusion processes are presented in a flow chart (**Figure 1**).

RESULTS

All 21 studies that met the inclusion criteria were analyzed. Of the 21 studies included, two were conducted in Europe (Spain, UK and UK) and one in Canada, one in USA/Australia and 17 in Australia or New Zealand. Quantitative methods were used in seven studies, mixed methods in five studies, qualitative methods in four studies, and content analyses in four studies. A majority focused on sport betting marketing strategies online (12 studies), only one study focused on poker, one on online bingo, and six studies concerned all types of digital gambling marketing strategies. One study concerned the marketing of social casino gaming. We included this study, because although casino games are free games, they are similar to gambling games. Users play with free virtual credits and cannot win monetary prizes, so that to some extent social casino games and gambling industry products converge (33).

Three main themes were identified in the selected articles. The first is that sport is a huge target for digital gambling marketing. A multiplicity of online platforms for gambling marketing diffusion have been identified and a wide range of digital gambling marketing strategies on the social media concerning sport betting have been observed. In addition, another recurrent subtheme was the systematic association of sport and gambling, fostering a normalization of betting and of gambling. The second theme was that digital gambling marketing strategies are gendered. A majority targeted young men, more particularly for betting and poker, and bingo websites were defined as targeting women. The third theme identified was that digital gambling marketing strategies focused on vulnerable populations, including young people and problem gamblers or at risk gamblers. The main results of the selected studies are presented in **Tables 2A–D** (2a: Articles concerning gambling marketing and sports; 2b: Articles concerning specific profiles (according to gambling characteristics: type of game, number of accounts); 2c: Articles concerning the use of social media or websites tools; 2d: Articles concerning harm reduction or responsible gambling and online gambling marketing).

DISCUSSION

This review included only 21 articles on the topic of the digital marketing of gambling. They were for a large majority conducted in Australia or New Zealand. This lack of data, more particularly for North America or Europe, is surprising, given the development of online gambling and online internet gambling marketing in the last 10 years. As an example, the total market value of the global mobile phone gambling industry increased 10-fold between 2006 and 2011 ($23 billion compared to $2 billion) (54) These developments, and the structural characteristics of Internet, combining easy and cost-effective access, has prompted the gambling industry to widely invest in emerging technological tools. The high level of exposure to positive gambling cues in society has led to the perception of gambling as an acceptable, credible and harmless leisure activity (55).

Sport: A Huge Target for Digital Gambling Marketing

In the literature on Internet marketing of gambling, the main emerging area concerned sports betting. The majority of selected articles (12) concerned gambling marketing in relation to sports.

TABLE 1 | Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Population	
Gambling	Not concerning gambling
Internet or digital communications (phone, e-mails or text messages)	Not concerning Internet Concerning only "traditional media": television, radio, newspapers or magazines.
All ages	
All types of digital marketing or advertising strategies (online gambling activities offered through interactive media, advertising on social media, pop-up ads, supported by the gambling industry or relayed by individuals)	
Study design	
Published in peer-reviewed journals, qualitative or quantitative studies or systematic reviews Following IMRAD format	Non peer-reviewed documents (e.g., websites, blogs, anecdotal evidence, case reports, guidelines)
Countries, date, language	
January 2000 - February 2020 Studies reported in English or French	In other languages

A Multiplicity of Platforms and the Development of Strategies on the Social Media

The multiplicity of online platforms has enabled both the development and the repetition of positive messages promoting gambling practices and brand-names.

Gambling advertising has entered everyday life, and people can be exposed without having sought tony information on gambling. Gambling advertising and promotions can be found outside the traditional commercial-break advertising (43). Deans et al. showed that gambling marketing products had entered everyday community and media spaces. In their sample of young men, 50% reported having seen online betting marketing (pop-up banners) and 36% had seen it on the social media (36). In a qualitative study, Pitt et al. showed that parents and adolescents were conscious of the increasing development of marketing, more particularly for sports betting. Parents thought their adolescents were at risk because of the link between gambling marketing and accessibility via mobile technologies and websites (43). Browne et al. using an Ecological Momentary Assessment found that more than 8% of bettors remembered exposure to gambling advertisements on unrelated apps or websites. More than 11% reported social media posts concerning gambling and more than 10% reported direct messages. This last strategy is a specific concern: direct messaging via e-mails, texts, and phone calls from gambling operators is a problem. The majority of these direct messages promote specific gambling inducements, and bettors report that this type of marketing is intense and particularly influential on their betting, encouraging them to bet and to spend more on betting (44). Browne et al. also found that this type of advertising was associated with greater intention to bet, more betting, and betting more than intended for regular horse-race bettors (34).

The digital media have helped to broaden the scope of advertising messages, especially in sports betting. Gainsbury et al. showed that in a large sample of online gamblers, online gambling advertising influenced gamblers in their initial decision to choose an operator. They also reported that those more involved, with multiple online accounts, were more active bettors and were influenced by promotions (47). Browne et al. showed that exposure to gambling marketing increased the likelihood of betting, and increased spending on bets. They concluded in their study that gambling marketing negatively affected substantial numbers of bettors already at risk for, or currently experiencing, gambling problems (34). The promotion of gambling inducements increased impulsive in-play betting among problem gamblers and involved gamblers at higher risk of problem gambling. They were however less aware of online gambling promotions, compared to less involved gamblers (38).

Regarding the social media, the prevalence of users of the social media in the world is high, particularly in higher-income countries such as North America, where 56% of the population are active social network users, or in Western Europe, where 43% are concerned (50). The social media enable gambling operators to promote products and brand-names with fewer constraints than in traditional forms of media. Many social marketing campaigns aim to generate the equivalent of "word-of-mouth" (56). Social media marketing strategies have the potential to create a particular personal relationship between users and brand-names (57). Research on brand engagement on the social media has found that relationships between consumers and the brand-name, the product and companies all positively influenced trust and brand loyalty (58). An Australian study has shown that reputation is the most important factor in choosing an online gambling site (47). Even a limited use of social media by gambling operators could have a large impact in terms of promoting gambling products and causing harm. Through the social media, gambling marketing reinforces social norms and over-represents attitudes among fans, followers and their peers (50). The social media are used to portray a "brand personality," and to foster enthusiasm in their communities (49, 59). Interviews of gambling operators have suggested that the social media are perceived as useful tools to increase website traffic, to raise interest and awareness and ultimately to increase gambling sales (60). Gambling operators are established on the social networks, Facebook and Twitter, collecting an average of 62,084 likes and 30,594 followers across the UK's top 10 betting sites (61). A survey of Australian gamblers found 40% had seen gambling marketing on Facebook (28).

A Systematic Association of Sport and Gambling Fostering a Normalization

The extent of gambling advertising and penetration through the digital media and Internet is a contributory factor in strengthening the mental association between sport and gambling (62, 63). The content of gambling advertising reinforces links between gamblers and sport: betting is rooted deep in the relationship between sport and fans (39). For example, the love metaphor is used in gambling advertising online, calling on both romantic love and friendship, and appealing to bettor

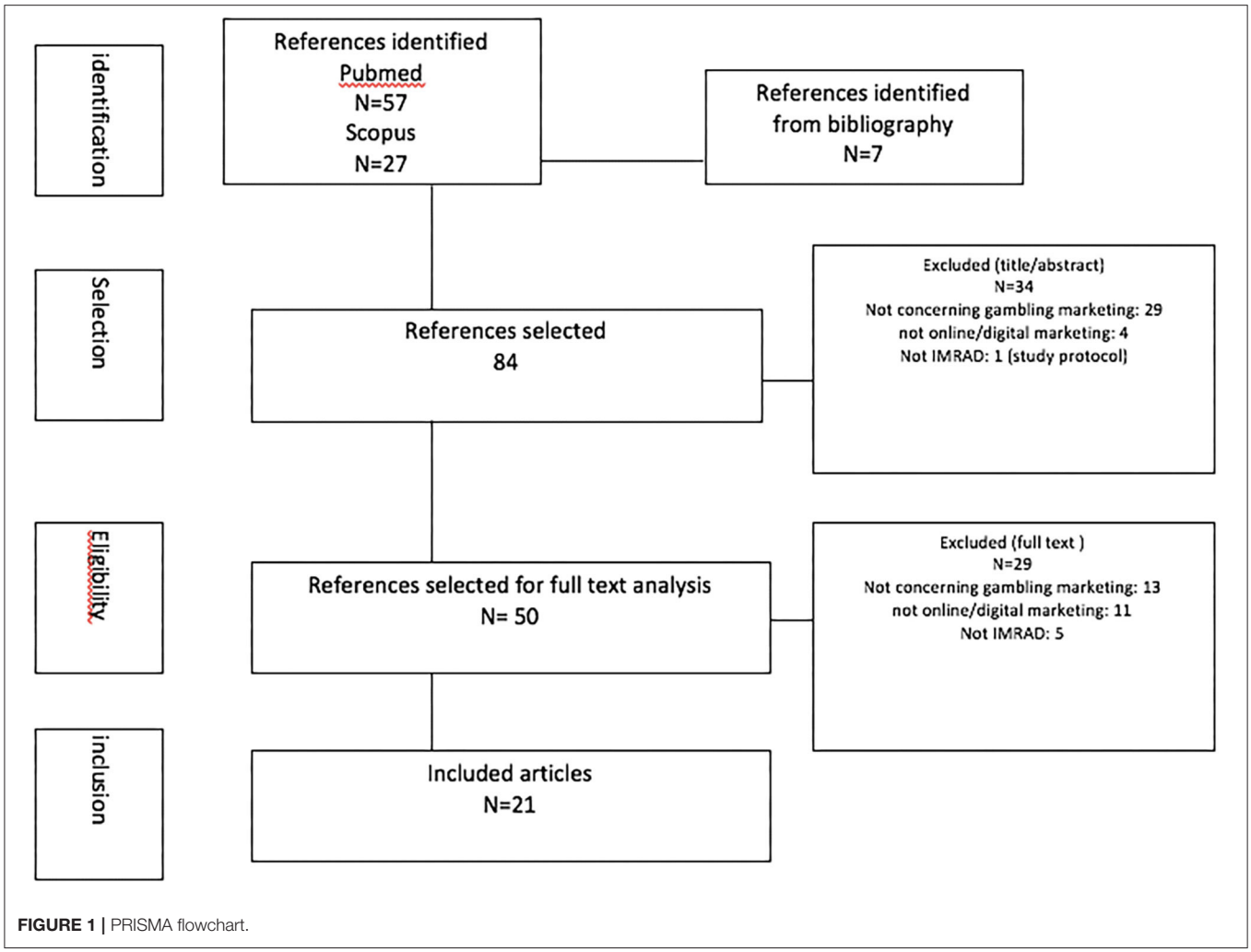

FIGURE 1 | PRISMA flowchart.

loyalty. Gambling is depicted as a truly positive activity. On the social media, some posts portray gambling as glamorous, exciting and fun, others emphasize gambling winnings, and community benefits are also highlighted (35, 50). The message conveyed through these positive contents is that gambling provides easy money, fun, enjoyment and an entertaining, easy, effort-free lifestyle (64). The sports betting industry uses numerous symbolic strategies to promote the social acceptance of sports betting, similar those to used in the promotion of other unhealthy products, such as alcohol or tobacco (35).

Gambling marketing influences gambling perceptions and interpretations of gambling and minimizes the risks. One of the main and longer-lasting effects of gambling advertising is the normalization of gambling (65, 66). Normalization is a long-term process, including sub-processes of cultural and legal legitimization. Gambling marketing cues introduced into the community and daily life (36) normalize potentially risky products by portraying their use in different everyday situations. Gambling marketing attempts to elicit emotive responses, or to trigger memories (50). Some author have referred to "the sportification of gambling and the gamblification of sport" (67). This phenomenon is identified in different articles: Gainsbury et al. found that the aligning of gambling with sport was a frequent content, and Lopez-Gonzalez showed that engagement and loyalty is also used to enhance involvement in gambling (39, 50). The risk underlined by authors regarding this association between betting and sport is that sport is represented as systematically associated with gambling, while gambling is represented as a sport (35, 36, 39). Online sport advertising uses the metaphor of betting as a sport, and the gambling companies are thus associated with the healthy attributes of sport (39). Moreover, if gambling is a sport, skills and training could help gamblers to improve their results, and these messages could reinforce cognitive distortions among gamblers, which is one well-known risk factor for problem gambling (68, 69).

Sport is a very attractive venue for companies to reach people and promote products and brand-names (40). Sponsorship of peak sporting events by unhealthy food, beverage, alcohol, and gambling product companies is prevalent in Australia according to the results of Mc Niven et al. who reported that 14.6% of unhealthy sponsorships concerned gambling (40). Sport sponsorship is a marketing tool, more acceptable by

TABLE 2A | Articles concerning gambling marketing and sport.

Country	Author	Year	Journal	Objectives of the study	Type of study	Main results	Discussion
Australia	Browne et al. (34)	2019	Journal of Behavioral Addictions	To determine whether exposure to betting advertisements and inducements influenced intended betting expenditure, or spending more than intended – and whether or not this differed by PGSI group	Quantitative study After completing a baseline survey, participants who were bettors (horse-racing or other sports) completed up to 15 short Ecological Momentary Assessment surveys: 5 per week over 3 non-consecutive weeks. The following were collected: participants' exposure to different types of betting advertisements, inducements, intended and actual betting behavior.	597 bettors completed at least one follow-up EMA survey *Exposure:* Horse-racing/sport bettors reported being often exposed to: -Gambling advertisements on betting app/websites: 14.0%/14.6% -Gambling advertisements not on app/websites not linked to gambling: 8.5%/8.3% -Direct messages: 11.1%/10.2% - Advertisements on social media posts: 11.1%/12.3% *Influence of exposure* Horse-racing bettors Exposure to company advertising, websites, and in-game commentary were independently associated with a greater likelihood of betting. Brand names and commentary were associated with increased spending, and with excessive spending. Inducements offered via direct messaging increased the likelihood of intending to bet, actual betting, and betting when not having intended to do so. Stake-back offers increased the likelihood of betting and the amount spent. Sports bettors Exposure to advertising on websites/apps and brand names, as well as to multibet inducements were associated with a higher likelihood of betting. Exposure to television advertisements was related to greater spending. Exposure to gambling websites/apps predicted an increased likelihood of betting when it was not originally intended.	The authors suggested that a reduction in betting advertising would be a positive consumer protection measure across the board. It would be likely to reduce betting expenditure and spending more than intended, including people at higher risk of experiencing gambling-related harm. Multibets and stake-back offers were the inducements that had the most influence on betting expenditure Direct messaging was a problematic form of gambling marketing: it was associated with a greater intention to bet, more betting, and betting more than intended for regular race bettors

(Continued)

TABLE 2A | Continued

Country	Author	Year	Journal	Objectives of the study	Type of study	Main results	Discussion
Australia	Deans et al. (35)	2016	BMC Public Health	To provide a theoretical and empirical understanding of the use of symbolic appeal strategies in sports gambling advertising in Australia	Mixed method Analysis of the content of 85 sports betting advertisements issued by 11 Australian and multinational betting companies.	Ten main strategies appeared in the coding framework: Sports Fan Rituals and Behaviors/Mateship/Gender Stereotypes/Winning Social Status/Adventure, Thrill and Risk /Happiness/Sexualized Imagery/Power and Control/Patriotism Gendered messages were used in betting advertisements	The sports betting industry may be using multiple symbolic consumption strategies to influence social acceptance of sports betting, as used in the promotion of other unhealthy products The most overt strategy was the use of creative strategies to embed sports bets directly in sport rituals and practices, or to align gambling with peer-based social activities Sports betting advertising during sporting events or aligned with them was an exceptionally influential form of promotion The authors recommended new research on how processes of "symbolic consumption" are occurring and how marketing contributes to a new set of individual and peer group identities related to gambling on sport
Australia	Deans et al. (36)	2017	Harm Reduct J	To explore how marketing strategies can influence the gambling attitudes and consumer intentions of young men	Qualitative study, in-depth qualitative research with young male sports gamblers (20–37 years; *N* = 50)	Four main themes emerged: - Changing the marketing environment for sports betting products induces normalization: marketing reported in environments not designed for gambling (TV (100%), online (pop-up banners) (50%), and on social media websites (36%) and in gambling environments: on mobile sports betting apps 16%). - Participants described the role of sponsorship deals between the industry and sporting codes as creating a symbolic alignment between gambling and sports - The majority of participants believed that young men were the key target market for gambling companies and that marketing played an important role in shaping the gambling identities of young men - Many ($n = 34$) participants considered that the incentives offered by the betting industry were amongst the most effective marketing strategies in leading themselves and others to bet on sports.	Marketing for sports betting products is no longer confined to specific gambling environments. It has entered everyday community and media spaces. The "gamblification" of sports, has created a new cultural representation that betting is essential to the sporting experience. The authors recommended the development of sustained and adequately funded public education programmes, or mass media campaigns, developed independently from the gambling industry, to complement the legislative approaches already suggested for policy makers.

(Continued)

TABLE 2A | Continued

Country	Author	Year	Journal	Objectives of the study	Type of study	Main results	Discussion
Australia	Hing et al. (37)	2017	Journal of Gambling Behavior	To examine whether responses to gambling promotions in televised sport vary with problem gambling severity amongst Internet sports bettors	Quantitative study Online survey of 639 sports bettors from Queensland, Australia	Male and younger online sports bettors had higher overall problem gambling severity than their female counterparts Significant predictors of higher PGSI scores were: being male, younger, more favorable sponsorship response, higher approval of gambling promotional techniques, and a higher subjective influence of gambling promotions on sports betting behavior	Internet sports bettors with higher problem gambling severity responded more positively to gambling promotions during televised sport. This study provided more detailed insights into how attitudes to particular aspects of sports betting advertising vary with problem gambling severity. Online sports bettors with more PG symptoms had a more positive response to gambling sponsors: increased awareness of, attention to, and recall of the sponsor's name and their promotions (interest), a more favorable disposition toward the sponsor (favorability), and a greater likelihood of using the sponsor's products (use). Attitudes that sports-embedded messages engender are more salient than frequency of exposure in predicting gambling problems amongst online sports bettors.
Australia	Hing et al. (38)	2018	Journal of Behavioral Addictions	To examine whether uptake of betting inducements predicts impulse betting on sport	Quantitative study Online survey on a panel of 1,813 gamblers (sports bettors)	More frequent uptake of all types of betting inducements predicted a more instantaneous, unplanned and unreflective approach to betting through the placement of in-play bets.	The authors concluded that more frequent users of sports betting inducements tended to bet more impulsively, but only in relation to impulse bets placed during the match. In-play betting *per se* was especially attractive to problem gamblers: it offers frequent, repetitive, gambling opportunities within a short timeframe. The promotion of betting inducements could increase in-play betting among problem gamblers by incentivizing and stimulating impulse urges to bet. The authors concluded that structural characteristics of betting products could lead to gambling problems. Respondents who reported lower incidence of seeing or hearing advertisements and promotions for sports betting when exposed to the media had a greater tendency to bet impulsively during play. The authors supposed that higher-risk gamblers were less consciously aware of this type of promotion when it occurred. The authors underlined that marketing targeted young male sports bettors, more impulsive and vulnerable to advertising.
Europe (Spain and UK)	Lopez-Gonzales et al. (39)	2018	J Gambl Stud	To examine the structural metaphors underpinning online sports betting (OSB) advertising and the consequences for bettors of this characterization	Content analysis of the structural metaphors underpinning OSB advertising in 135 advertisements extracted from YouTube channels of 29 betting brands	4 common reiterative metaphorical constructions were selected (out of 20 initially identified), betting was represented as: (1) an act of love: compared to love or friendly relationships, betting as an equivalent of showing your love to your team, the emotion of betting and winning a bet as compared to sex (2) a market: gambling is predictable, rational, and regulated and concerning professionals and experts; changes in betting amounts compared to stock price fluctuations (3) a natural environment: competition is akin to survival, bettor seen as a predator, intuition or superstition in betting seen as a natural instinct	The most cross-sectional and enduring metaphor was "betting is a sport." The notion of sport attached health attributes to brand names: success through work and skill, with possibilities of control over sports events, body consciousness, fat and sugar-free diet and exercise, team building, cooperation, joyfulness and amusement. This metaphor led to 2 interpretations: betting is understood as a sport and sport is understood in terms of betting. Advertising for OSB can use the emotional connections of bettors with their teams, athletes or organizations. The love metaphor appeals to gamblers' loyalty. The market metaphor reinforces the image of bettors as business people, controlling their risks, which is not the case, as bettors behave like fans, and betting marketing is increasingly advertising more complex bets with higher expected losses. The natural metaphor completes the market metaphor, this conflates the understanding of betting as an inevitable process that escapes individual volition, and is underpinned by the competitive backdrop in which bettors need to compete in order to win/ survive.

(Continued)

TABLE 2A | Continued

Country	Author	Year	Journal	Objectives of the study	Type of study	Main results	Discussion
						of animals, fast decision-making in gambling seen as ferocity (4) a sport: bettor compared to a manager, studying betting as training, in-play betting seen as playing, bet selection seen as a strategy, a winning bettor as a champion Absence of traditional gambling narratives: no dream metaphor. The multiplicity of forms that OSB advertising adopts accentuates the need for a neutral approach platform that analyses how betting activity is constructed in different settings	
Australia	Macniven et al. (40)	2015	Health Promot J Austr.	To determine the extent of unhealthy food and beverage, alcohol and gambling sponsorship in Australia	Data collected from websites of the 53 national sport organizations (Australia) and 360 territorial sporting organizations; Structured survey tool assessing sponsoring content, classified as healthy or unhealthy, analyzed over 1 year (2012-2013)	1975 website sponsors identified. 26.9% of websites had only healthy sponsorships. 14.6% of sponsorship concerned gambling companies: - Australian football had the highest number of gambling sponsors. - Lottery West was the most common gambling sponsor.	Unhealthy sports website sponsorship is not consistent with the health-promoting goals of sport. The widespread unhealthy sponsorships pose ethical issues, such as the exposure of children. The statutory requirement for gambling companies to cede 5% of profits to the Western Department of Sport and Recreation, probably influences the presence of Lottery West on Western Australian websites, which is concomitant with branding presence. The authors concluded that sport was a very attractive venue for companies to reach people and promote products and brand names, but associations of unhealthy products with sport normalizes unhealthy products and undermines the health benefits of sports.
New Zealand	Maher et al. (41)	2006	BMC Public Health	To examine the extent and nature of both "healthy" and "unhealthy" sport sponsorship for popular sports in New Zealand	Quantitative study concerning sponsorship and type of sponsorship (healthy products vs. unhealthy products) of 107 sport organizations (belonging to the top eight sports for those aged 5–17 years)	73.8% ($n = 79$) of websites contained information about sponsorship Sponsorship of popular sports for 5 to 17-year-olds was dominated by sponsorship associated with unhealthy products, and by gambling in first place. Gambling was the most common specific sponsorship category: 18.8% of total sport sponsorship.	Sponsorship on popular sport websites in New Zealand was common. "Unhealthy" sponsorship was more than twice as prominent as "Healthy" sponsorship The authors concluded that governments may need to consider regulations that limit "unhealthy" sponsorship and/or adopt alternative funding mechanisms for sponsoring popular sports.

(Continued)

TABLE 2A | Continued

Country	Author	Year	Journal	Objectives of the study	Type of study	Main results	Discussion
Australia	Pitt et al. (42)	2016	Aust NZ J Public Health	To investigate how children and adults recall the content and promotional channels of sports betting marketing	Mixed method study of 152 parent/child dyads (children 8 to 16-years old) conducted on Australian football League, national Rugby League, and soccer sporting sites in Australia	304 participants were included. 91.4% of the children and 98.0% of the adults recalled having at some time seen a promotion for sports betting. The top four environments for children were: TV (97.1%), stadiums (75.5%), radio (49.6%), and websites (46.0%) The top four environments for adults were: TV (96.6%), stadiums (61.7%), websites (45.6%), and newspapers (44.3%). 75% of the children and 90% of the adults perceived that sports betting was becoming a normal part of sport.	Children were widely exposed to sports betting marketing, for 46% on websites. Children were exposed to a range of industry tactics and reported that they regularly saw gambling marketing embedded in sporting programs, and they recalled gambling brand names. Children were more attuned to the content of gambling promotions than adults. Children specifically recalled promotions that fostered a perception of low risk or an increased chances of financial gain.
Australia	Pitt et al. (43)	2016	BMC Public Health	To explore adolescents' and parents' attitudes toward the marketing of gambling products in sport	Qualitative study conducted with 59 family groups (at least 1 parent and 1 adolescent 14 to 18-years-old) in Australia	Three main themes emerged *Initiation - the use of sport as a platform for the promotion of gambling* -Peak of gambling marketing during sports matches - Alignment of gambling with sports fan loyalty - Promotion of betting by sporting stars and commentators. *Influence - key promotional messages in sports-based gambling promotions* - An easy way to win money - Linking gambling to the emotion of the game - Linking technology to accessible gambling: parents perceived adolescents as being at risk because of the link between marketing and accessibility through mobile technologies and websites. Adolescent boys recalled they had seen marketing that talked about the ease of online gambling, provided incentives to open online accounts, and informed viewers how to access websites. They felt "encouraged to bet," more particularly on the phone. - Intertwining gambling with the game *Impact - engaging in sport through a gambling lens* - An "everyday" part of sport - Discussing sport via gambling discourse	Parents and adolescents were aware of the increasing alignment of gambling and sport. Parents were increasingly concerned about the excessive promotion of gambling, in particular betting advertising in sport. They felt unable to counter the persuasiveness and volume of promotions of gambling. The authors concluded that policy makers should consider how they can expand regulatory frameworks to encompass a wider range of promotions that can occur outside traditional commercial-break advertising. Adolescents were aware of promotions outside traditional commercial-break advertising, they perceived that the use of current or ex athletes was an influential tactic in aligning gambling with sport.

(Continued)

TABLE 2A | Continued

Country	Author	Year	Journal	Objectives of the study	Type of study	Main results	Discussion
Australia	Russel et al. (44)	2018	Journal of Behavioral Addictions	To determine whether betting expenditure is related to receiving direct gambling messages (text and e-mails), and the specific inducements they promote	Quantitative study Online survey in a population of bettors using a daily ecological momentary assessment The following were collected: numbers of emails, texts the participants received from betting operators; expenditure over the previous 24 h and intended over the next 24 h. Messages and emails were forwarded to the research team and analyzed.	98 sports bettors were included. They received an average of 3.7 emails and 2.3 texts over the course of 7 days. 104 horse-racing bettors were included. They received an average of 6.5 emails and 4.3 texts over the course of 7 days. Those who received more direct messages were more likely to intend to bet in the next 24 h, and for sport bettors to bet more money. The number of emails received was positively associated with both a higher intention to bet and intention to bet larger amounts, and likelihood of actually betting and the amount anticipated.	The authors concluded to a clear relationship between direct messaging from betting operators and both intention to bet, and actual betting behavior, including the amount bet. The channel used had an impact: emails were associated with intentions, and texts with actual expenditure. Direct messages, containing inducements or not, served as cue to bet. The authors suggested placing conservative limits on how frequently operators can message individual consumers, or requiring operators to only contact consumers with an account, and who have opted in, or to establish a "Do not" direct message.
Australia	Thomas et al. (45)	2018	Harm Reduct. J.	To enhance understanding of young people's exposure to and awareness of gambling advertising restrictions in Australia.	Mixed method Influence of online gambling advertising on young people (11 to 16-years-old) who were basket-ball fans	111 participants were included (mean age = 12.9 y.) *Engagement in sport* 97.3% played basketball for a domestic or representative team. 92.8% had watched professional basketball in the last 6 months: free to air and subscription TV (70.2%), via YouTube (23.4%), or other websites (15.3%) The 13 to 16-year-olds used social media to follow basketball players or teams via Instagram (52.3%), YouTube (21.6%), and Snapchat (21.6%). *Recall of placements and gambling advertising* Over 90% of young people reported seeing gambling advertising on television 55% of young people recalled seeing gambling advertising on social media platforms They saw gambling advertising at all times of the day, but particularly in the early evening before 8:30 p.m. 79.3% stated that there were too many gambling advertisements in sport and said there should be fewer or none.	Young people were exposed to gambling advertising across a range of different media platforms: TV and social media. The authors underlined that regulations focused on traditional media, like TV, but the social media are an influential marketing space for companies. The authors concluded that in Australia sport continues to be a large contributor to young people's exposure to gambling advertising. Most young people thought that sporting regulations should do more to protect them from exposure to gambling advertisements.

TABLE 2B | Articles concerning specific profiles (according gambling characteristics: type of game, numbers of accounts).

Country	Author	Year	Journal	Objectives of the study	Type of study	Main results	Discussion
USA/Australia	Abarbanel et al. (46)	2017	Policy Internet	To provide an empirical understanding of social casino gaming advertisements seen by young adults	Analysis of content of a sample of 115 social casino gaming advertisements captured by young adults during their regular Internet use	Imagery featured likely to appeal to young adults, with references to positive images (sport, cartoons, popular culture etc.) Messages included glamorization of gambling, winning, normalization of gambling, playing for free, and general encouragement to play 90% did not contain reference to problem gambling or responsible gambling	The authors recommended that: - Gaming companies recognize the potential harm of advertisements - Companies embrace corporate social responsibility standards: adding warning messages to advertisements and ensuring that marketing messages do not encourage excessive gambling.
Australia	Gainsbury et al. (47)	2015	Eur J Public Health	To compare online gamblers with a single Internet gambling account to those with multiple accounts	Quantitative study Online survey on a sample of online gamblers recruited through advertisements on various websites The following were collected: Internet gambling participation, and gambling-related problems	3,182 participants were included 45.2% had only one account *Gamblers with multiple accounts:* Participated in a significantly greater number of different forms of gambling Were more likely to do most or all their gambling online Were more likely to engage in sports betting, to classify themselves as professional, and as being moderate risk or problem gamblers Two-thirds were influenced by prices and gambling promotions in selecting gambling operators *Choice of website was based on:* For gamblers with multiple accounts: number of betting options, games available, fast payout rates, better interface For gamblers with a single account: advertising/marketing, jurisdiction where the site is regulated, whether the site is licensed, customer protection and responsible gambling tools.	Gamblers with multiple accounts were more involved (frequency, engagement in multiple activities). Advertising influenced those with a single account, but those with multiple accounts were more influenced by promotions: advertising was more influential in gamblers' initial decision to choose an operator. The authors supposed that gamblers with multiple accounts were willing to "shop around" to get their preferred experience.
UK	Stead et al. (48)	2016	PLoS ONE	To identify and analyse the characteristics of online bingo and explain the potential appeal of online bingo in the UK to bingo players	Qualitative study using 2 distinct data sources: content analysis of websites / in-depth interviews of 12 bingo players	*Websites* The bingo websites offered a wide variety of games and promotions, including big prize money, new member promotions and free games. All sites had information about self-exclusion. *Interviews: 3 themes identified* Drawing in the first-time user: sites presented as an exciting, likable and easily accessible experience. Bingo presented as normal, popular and ubiquitous. Gendered design of sites: color, hearts, cocktails, fashion glitter balls, offers for beauty products and references to "mums" Creating belonging: references to social interaction, inclusive language, community and chats on websites, development of feelings of belonging and cementing of relationships between the user and the game Stepping up involvement: users encouraged to include bingo in their daily routine, facilities offered to pre-purchase tickets for future games, use of metaphors such as metaphors of achievement, reward linked to engagement	Websites deployed a number of structural, textual and design features to draw in first-time users: easy to access, minimum age verification, possible to play and win "for free" before entering credit card details. The design, color, imagery of websites were designed to meet marketing objectives: the bingo websites had the effect of positioning online bingo as a benign, homely, women-friendly, social activity. Belonging was a major theme on the bingo websites, mascots and offers were used to convey a brand "personality" and to build a relationship between brand and users. There was congruence between the strategies used by websites and the motivations of bingo players: the bingo websites replicate and updated the sociability of traditional bingo halls. Online bingo differs from traditional bingo in its ability to be played anywhere, at any time, its capacity to offer a deeply immersive experience, and it is considered as presenting a higher risk of harm. The authors concluded that gambling marketing strategies influenced both new and existing players. Strategies used by websites performed 3 functions: drawing in new users, consolidating users' relationship with the websites by creating feelings of belonging, and encouraging existing users to step up their involvement.

TABLE 2C | Articles concerning the use of social media or websites tools.

Country	Author	Year	Journal	Objectives of the study	Type of study	Main results	Discussion
Australia	Gainsbury et al. (49)	2015	International Gambling Studies	To explore how gambling operators are using the social media to engage with users and promote products and services	Qualitative method Thematic analyses of 12 semi-structured interviews with 19 individuals representing different sectors of the gambling industry	*Use of the social media* The social media are integrated into a global strategic business and communication plan, with the aim of increasing brand-name awareness and customer commitment Facebook, Twitter, YouTube, Instagram and Pinterest were used by operators. Community narratives are an important part of the social media content. *Target audience* Operators targeted young men. The social media were considered useful to engage with new consumers by enhancing brand-name salience, building customer relationships, and encouraging visits to their website *Impact of the social media* Risks of negative feedback for brand names were cited: companies have no control over how consumers engage with the company. Risks of reputational damage were noted *Inclusion of responsible gambling* Most operators stated that they included responsible gambling messaging in the content posted.	The social media involvement appeared to be crucial for gambling operators and is increasingly embraced The social media were used to engage with existing customers, and potentially reach users already interested in gambling products. Successful use of the social media was measured from brand involvement. The goal of increasing sales was not reported by operators. The social media were defined as a way to recruit customers by different means: running competitions, asking questions, posting relevant articles, links and stories, or responding to customers' comments, queries or complaints All operators appeared to be mindful and cautious about ensuring that the social media were not used to promote excessive gambling and did not target vulnerable populations (consistent with Australian advertising rules of conduct). But little control of the sharing of contents with minors. Several operators included responsible gambling messages on their social media profiles, but most of the time, they were not accessible. Operators found that the social media were not an appropriate channel for discussion on responsible gambling and that users would not like these messages.
Australia	Gainsbury et al. (50)	2016	J Gambl Stud	To examine the use of the social media for marketing purposes by gambling companies	Audit of 101 sites over 4 weeks: Mixed method, quantitative variables collected and thematic analysis of social media utilization by gambling operators in Australia	*Quantitative data* 87% of operators had a Facebook page, 52% a Twitter page 11.9% of operators had information about responsible gambling or PG services on their social media profiles *Qualitative data* Latent message promotional content: raising awareness/glamorizing gambling/emphasizing ease of use/Encouraging new use/emphasizing winning/encouraging venue patronage/encouraging betting/aligning gambling with sport/brand engagement/promoting community benefits of gambling/limited warning messages	The majority of gambling operators had social media presence, betting agencies more particularly The most popular social media platform was Facebook Gambling was depicted in an overwhelmingly positive light: glamorous, exciting, fun Gambling promoted as having a natural alignment with sport to convey gendered messages: gambling a way to show masculinity, team loyalty, skills etc. The practices of gambling operators encourage potential sharing of social media posts, facilitate exposure of vulnerable populations to gambling marketing (underage individuals) A lack of responsible gambling content on social network pages and content posted by Australian gambling operators The authors recommended research to monitor the impact of gambling marketing via the social media on young people
Australia	Gainsbury et al. (29)	2016	Psychol Addict Behav	To investigate recall of exposure to, and reported impact on gamblers of gambling promotions on the social media, with a focus on current problem gamblers	Online quantitative study on a sample of 964 participants (self-reported use of social media and gambling within the previous 12 months)	*Exposure* Moderate-risk gamblers significantly more likely to report having seen gambling promotions on the social media than non-problem gamblers (66.2 vs. 39.8%), and to report having seen all types of gambling promotions, and having interacted with gambling operators on social media. *Impact of exposure* 29.3% of moderate-risk gamblers reported that social media promotions had increased their problems. A minority of low-risk and non-problem gamblers reported that their gambling had changed under the influence of	The authors distinguished a subset of vulnerable gamblers for whom social media marketing could influence their gambling problems: better recall of promotions, and reported influence on gambling practices. The authors suggested that operators were not as vigilant at detecting users with gambling problems as claimed, or that it is difficult to detect gambling problems on the basis of social media interactions. The authors concluded that moderate-risk gamblers were an appropriate target audience for responsible gambling messages, and were more receptive to the use of social media platforms.

(Continued)

TABLE 2C | Continued

Country	Author	Year	Journal	Objectives of the study	Type of study	Main results	Discussion
						promotions. *Responsible gambling messages* The majority did not recall seeing responsible gambling messages on social media. Moderate/risk-prone gamblers were significantly more likely to recall responsible gambling messages on social media websites than non-problem gamblers.	
Canada	McMullan et Kervin (51)	2012	Int J Ment health and Addiction	To examine the web design and engineering of advertising and marketing, and pedagogical features present in a random sample of 71 international poker websites obtained from the Casino City directory in the summer of 2009	Qualitative study Content analysis of 71 poker websites	22 variables were coded, related to access, appeal, player protection, customer services, on-site security, use of images, text, language, interactive and immersive materials, promotional products and programs, sponsorships, celebrities, tutelage resources, responsible gambling programs	The poker websites were defined as an instrument of friendship. 92% of the websites defined poker as a natural consumer activity. Poker websites were instruments of promotion: attractiveness, bright-color, design, 97% used promotional sales practices, 81% featured reward programs and 76% affiliate programs. Marketing targeted young people: 28% of the individuals portrayed in images appeared to be 25 years old or under Gendered marketing strategies were identified: 11% promoted overtly sexualized images to send the message that poker was seductive

TABLE 2D | Articles concerning harm reduction or responsible gambling and online gambling marketing.

Country	Author	Year	Journal	Objectives of the study	Type of study	Main Results	Discussion
Australia	Howe et al. (52)	2019	Plos One	To determine the relative importance of selected predictors (including the degree to which individuals see advertisements and receive promotional material) in determining both gambling frequency and PG	Quantitative study using an online survey panel	3,361 participants were included *Factors associated with gambling frequency* The degree to which peers or family were perceived as gamblers, self-reported approval of gambling, participation in offline discussions on gambling, PGSI scores *Factors associated with PGSI scores* Exposure to advertisements and receiving promotional material were correlated, but 91% of the explainable variance could be explained by 5 predictors: positive urgency, playing on poker machines at pubs, hotels, or sports clubs, gambling on the Internet, online discussions on gaming tables at casinos, overestimating chances of winning.	The degree to which others being perceived as gamblers was one of the strongest predictors of gambling frequency. Individuals overestimated how much others gambled and overestimated how far they approved of gambling. The authors suggested that interventions designed to reduce PG should concentrate on identified factors: reduction of access to poker machines, interventions to reduce people's overestimation of their chances of winning. A campaign of this type could aim to educate people to avoid common gambling fallacies.
Australia	Thomas et al. (53)	2017	Harm Reduct J	To explore how Victorian adolescents and adults attribute harm to different types of gambling activities To examine the extent to which Victorian adolescents and adults support the introduction of strategies aimed at reducing the harm associated with gambling	Mixed quantitative and qualitative method study Online panel survey to explore the attitudes of 500 Australian residents (16 to 88-years-old)	500 participants were included *Gambling practice* 40.2% of participants were at risk of experiencing some level of harm from gambling (PGSI $\geq$ 1) 16.6% recorded scores that indicated problem gambling (PGSI $\geq$ 8) *Perception of harm* The mean level of perception of harm was higher for casinos and EGM than for horse-racing or sports betting. Participants defined characteristics entailing risks of harm according the type of gambling: Casinos: seductive nature of the venue, no concept of time, environment encouraging gambling. EGMs: perception of EGMs as deceptive or exploitative, perception that EGMs were not risky, accessibility and availability Horse-racing and sport betting: multiple markets offered by online betting providers, constant availability of opportunities to gamble, easy to lose financial control when betting on apps, and role of marketing in the normalization of sports betting. *Agreement and disagreement with gambling harm reduction strategies* More than 90% of participants agreed or strongly agreed with a ban on gambling advertising during children's viewing hours (n = 457, 91.4%) 86.2% of participants agreed or strongly agreed that sporting organizations should take more responsibility for how gambling is promoted. There was strong agreement with proposals for increased public education about the harm associated with gambling.	EGMs and casinos were identified as the most at risk, participants aware of EGM risks Perceptions of harm do not necessarily translate into behavioral choices. Overwhelming community support for: - Campaigns that focus on educating the community about the harm associated with gambling - Stricter boundaries placed around gambling products and the marketing of these products Government approaches in Australia are out of line with community attitudes and public expectations for mechanisms to protect communities from potentially harmful products. The authors sound a caution, in case of significant efforts of regulation of products, and negative community attitudes, industries could develop counter-measures to appear as "good corporate citizens" to avoid or minimize the impact of restrictions or regulations.

the public because it is indirect and it builds public goodwill toward the company (70). It associates sponsored products with a healthy positive image, which is particularly important for products that can involve risks for health (70). A study conducted in 2006 by Maher showed that gambling was the first sponsorship product in the most popular sports for 5 to 17-year-olds in New Zealand (41). In 2015 Macniven showed that only 26.9% of national sport organization websites had solely healthy sponsorships, and that 14.6% of sponsorships of websites concerned gambling companies.

These strategies concerning sport and online gambling have been implicated in the general development of gambling. One study showed that gambling advertising was associated with the development of sports betting among people who did not previously gamble (71). In a recent study, Newall et al. in the UK analyzed "Live-odds" gambling adverts, during World Cup matches on TV. They showed that advertisements were skewed toward complex events, more difficult to predict, and that the content of advertisements made bets appear more urgent than necessary (72). With this development and potentially greater diversity in gambler populations, there is likely to be an extension to new population groups experiencing problem gambling, and greater concern for vulnerable populations.

A Gendered Marketing Strategy

Young men are defined as targets for betting and poker websites. Australian gambling operators interviewed by Gainsbury et al. reported that, on the social media, they targeted the population of young adult men (49). In an exploratory study of gambling operator contents, the same authors showed that gambling was naturally aligned with sport, to convey messages that gambling is a way to demonstrate team loyalty and masculinity (50). Deans et al. showed that young gamblers believed that young men were especially vulnerable to gambling harm, and that marketing amplified the risks associated with sports betting and played an important role in shaping the gambling identities of young men (36). In another study analyzing the content of sports betting advertisements, Deans et al. (35) showed that there was clear gender stereotyping in sports betting advertising. Men were mostly represented as central actors, women were sexually objectified, with advertisements portraying male dominance or power over women. Two key stereotypes of men in Australian gambling advertisements were noted: the first is the average "Australian male," for whom sports gambling could represent an escape from the ordinary to become more attractive to women, to gain power and authority or to be able to afford a glamorous lifestyle. The second stereotype concerns bookmakers, portrayed as powerful players (35).

Regarding the online sports betting marketing, metaphors are used, and among four metaphors identified by Lopez-Gonzalez et al. the metaphor of "gambling as a market" and "gambling as natural" could also be compared to a gendered approach. These metaphors represent betting as an inevitable, innate behavior, akin to instincts or sexual relationships. Betting is defined as an inevitable process, escaping individual volition, as a survival process or as a struggle to survive (39). These gendered digital marketing strategies are particularly concerning, as young adult males are the socio-demographic group the most at risk for gambling problems (11). Hing et al. showed that impulse betting both before and after match commencement was more frequent among young men, who were clearly the target for sports betting advertising, including promotions for incentivized bets during play (38). Concerning poker websites, marketing strategies were also shown to be focused on men: Mc Mullan and Kervin analyzed online poker websites and found that adult-oriented imagery, such as young women in bikinis or adults depicted in sophisticated clothing and settings, were frequently used (51).

In contrast, one study conducted in the UK on bingo websites, showed that marketing strategies on these websites were congruent with the expectations of women who play bingo. The authors reported that bingo websites seemed to be designed largely to appeal to women, through the use of the colors pink and purple, images of hearts, cocktails, fashion, and glitter balls, offers for beauty products, and references to "mums." The bingo sites had the effect of positioning gambling as a benign, child-like, homely, women-friendly, social activity (48).

Online Gambling Marketing and Vulnerable Targets

In a public health approach to prevention of gambling and in order to determine the potential impact of gambling marketing on vulnerable populations, a comparison can be made with alcohol. Babor et al. established that young people and heavy drinkers are vulnerable populations for exposure to alcohol marketing strategies (73). The same vulnerabilities can be presumed concerning gambling behaviors and gambling marketing methods. An early age of initiation is a high risk factor for the development of problem gambling later in life, and it is associated with greater severity of problem gambling (74–76). Despite the fact that regulations prohibit gambling by minors in many countries, for instance France or Spain, evidence exists that these populations gamble (11, 77). Gambling advertisements and specific promotions also have a greater impact in encouraging gambling amongst problem gamblers than among non-problematic gamblers (78).

Younger Targets

The familiarity of minors with the Internet increases their likelihood of playing. For instance, 72% of adolescents use the Internet more than once a day in Australia (79). Pitt et al. showed that 8 to 16-year-olds were widely exposed to sports gambling marketing, for 46% through websites (42). In addition, online gambling is private and feasible anywhere, and online gambling websites offer prizes and a wide range of temporary promotions. Online gamblers report a positive playing experience and greater physical comfort than offline gamblers (80). In another study adolescents felt "encouraged to bet," more particularly on mobile phone (43).

Major social media and online gaming companies have started making inroads into the gambling business. This "digital convergence" has created opportunities for the gambling industry to expand its customer base, particularly among young people (81). The evolution of technical aspects of betting, such as opening accounts and betting via mobile phones, are also

perfectly modeled for young people (82). The proliferation of simulated forms of gambling not involving money on the social media is a gateway to encourage adolescents to progress to online gambling. Social gambling can also lead to a diversification of gambling offers for young people, with an easier, more attractive access to casinos. Abarbanel et al., using a content analysis of a sample of 115 social casino gaming advertisements, clearly showed that the images and messages were designed to target young populations, by including references to popular culture, cartoons, and sport, and deploying a glamorization and encouragement for gambling, including free play (46).

Despite this observation that young people are particularly prominent consumers on digital media platforms, very few studies have focused on this topic (45, 83). There is still very limited information about the promotion of gambling on these media and on how it influences the exposure of young people to gambling advertising (45, 83). Deans et al. interviewed a sample of young male gamblers, and the majority believed that young men were the key target for gambling companies (36).

However, digital communications are liable to enhance exposure to favorable presentations of online gambling. An analysis of poker websites showed that 28% of the images portrayed concerned people aged 25 or under, in attractive environments (51). Gambling marketing clearly influences gambling intentions. Derevensky et al. noted that 40% of the young people in their study stated that they had wanted to try gambling after seeing gambling advertisements (77). Thomas et al. found that 75% of a sample of 8 to 16-year-olds could recall the brand name of at least one sports betting company (84).

Many European countries have identified a large increase in gambling participation among underage young people. For example in the United Kingdom, 38% of the 16 to 24-year-olds gambled in 2016 compared to 5% the previous year (85). In other reports, ∼60–80% of young people engaged in formal or informal gambling before the legal age (11, 86, 87). This population is at higher risk of losing control compared to older adults, and the prevalence of problem gambling is higher. In Finland a survey identified 4.9% of 12 to 15-year-olds as risk-prone gamblers (88); in Sweden one study found that the incidence of PG among 16 to 24-year-olds was more than double the proportion for adults aged 25–44 years (89). Links between the development of marketing strategies, more particularly online, and these gambling behaviors among young people need to be explored further. Gainsbury et al. for their part failed to show that content on social media directly appealed to young people. However, given the few restrictions on social media use, the inherent difficulties in monitoring and the widespread use of social media among young people, continuing research is needed to monitor the impact of gambling marketing via the social media on young people (50).

Problem Gamblers

Hing et al. in an online survey on a sample of 639 online sport bettors in Australia, showed that attitudes to particular aspects of sports betting advertising vary with PG severity. Online sports bettors with more severe PG symptoms had a more positive response to gambling sponsors: increased awareness of, attention to, and recall of the sponsor's name and their promotions (interest), a more favorable disposition toward the sponsor (favorability), and a greater likelihood of using the sponsor's products (use) (37). The frequency of gambling on the Internet and participation in online discussions on gaming tables at casinos were predictors of gambling severity in a study by Howe et al. (52). Moderate-risk gamblers were significantly more likely to report seeing gambling promotions on the social media, and nearly 30% of moderate-risk gamblers reported that social media promotions had increased their problems (29). Gambling advertising compromises gambling prevention campaigns aimed at reducing gambling and encouraging help-seeking. The positive messages on gambling conveyed through the social media are not counterbalanced by warning messages, as observed by Gainsbury et al.: only 11.2% of the operators had information on responsible gambling or problem gambling on the social media (50). Moderate and risk-prone gamblers are more attentive to responsible gambling messages (50). Thus, given the impact of social media marketing on vulnerable gamblers, the inclusion of responsible gambling messages on these platforms seems effective (50). In addition, social media marketing influences both infrequent and frequent gamblers, who may be unable to resist urges to gamble elicited by external cues found in advertising (90). Gainsbury et al., in a study including 2,799 gamblers, found that problem gamblers were significantly more likely than non-problem gamblers to be influenced by promotions and incentives, such as credits or bonuses provided by online gambling sites (78). However, many difficulties exist in the development of responsible gambling messages. Aspects that are critical to the effectiveness of these messages concern the type of content used, the way it is framed, whether it engages consumers in self-referential processing, the level of specificity and applicability for use in real-world settings, and the social norms deployed. Messages should be personalized to target specific population subgroups. Adequate understanding of the characteristics of these subgroups is important and could enhance the presentation of health information (91).

Implications: A Need for Regulations?

Over the last 2 decades there has been a significant shift toward more liberal gambling regulatory frameworks in many countries around the world. The availability and accessibility of gambling has risen in community settings. The Internet has evolved rapidly, leaving policy makers and regulators far behind the innovative commercial products and offers (92). More recently, the liberalization of gambling has led to a legalization of more pervasive forms of gambling, alongside the development of new technologies and higher-intensity products leading to a larger penetration of gambling products in the community (53).

Governments have been largely unwilling to enact a comprehensive public health approach to gambling as applied in other areas such as tobacco. Governmental regulation efforts remain focused on individual responsibility frameworks to minimize the harm associated with "problem gambling," which place few constraints on commercial activities and enable continued increases in revenue for both industry and government. There is growing ethical tension for governments between the revenue obtained from gambling products, and the

need to be responsible and design rules that are acceptable for the community and public health (93).

It is important that regulations should keep pace with the advances in technology to ensure that social media platforms fall under the same regulatory frameworks as traditional advertising channels (45). Indeed, existing regulations do not apply to gambling advertising on social media platforms. This includes promoted content on YouTube, Instagram or Snapchat, which are the three most widely used social media by young people (45). To protect consumers better, any restrictions should cover digital as well as traditional advertising, to prevent the migration of advertising to less restricted, online, social media, and mobile platforms, as has occurred with the introduction of earlier advertising restrictions (34, 49). As online gambling companies should be responsible for the harm related to their activities, Yani-De-Soriano suggested that corporate social responsibility policies should be fully implemented, monitored and clearly reported; all forms of advertising should be reduced substantially, and unfair or misleading promotional techniques should be banned (94). Gainsbury et al. found that gambling operators reported being cautious toward the risk of problem gambling, but that social media operators thought they were not suited to discussing responsible gambling (49) and most operators do not incorporate responsible gambling into the content posted (50). In many countries and particularly in Australia, as identified in this literature review, regulations have predominantly focused on traditional media such as television, and there are no regulations to restrict gambling advertising on social media platforms. In the UK, there have been some attempts to enforce restrictions on gambling advertisements online, with the banishment from websites of gambling advertisements directed toward young people (95).

It has been shown in Australia that there were discrepancies between government regulations and public expectations. Government approaches were not in line with community attitudes and public expectations for mechanisms for protecting communities from potentially harmful products (53), even for young people (45). Abarbanel et al. in a sample of social casino gaming advertisements targeting young gamblers, showed that 90% did not refer to responsible gambling or the risk of problem gambling (46). Thomas et al. reported that young people thought that sport regulations should protect them better from exposure to gambling advertisements. Young people reported a need to remove gambling advertising from sport (45). Targeted problem gambling prevention could be developed, and Gainsbury et al. hypothesized that moderate-risk gamblers were an appropriate target audience for responsible gambling messages and were more receptive to the use of social media platforms (29). Community support for advertising restrictions is much stronger than for other harmful products (such as alcohol or tobacco) (53). In another study, more than 90% of the participants agreed or strongly agreed with a proposed ban on gambling advertising in Australia (53).

However, caution is necessary regarding regulations. First, statutory requirements for gambling companies could in fact enhance gambling sponsorship, as in Australia, where 5% of the profits of West Lottery are due to the Western Department of Sport and Recreation. This probably influences the presence of Lottery West on Western Australian websites, ensuring brand-name presence (40). Thus, in the case of regulations limiting "unhealthy" sponsorships, governments would also need to adopt alternative funding mechanisms for sponsoring popular sports (41).

Petticrew et al. showed that the gambling industry, like the tobacco, alcohol, or food industries, frequently uses the concept of complexity, in response to policy announcements and to new scientific evidence. "Complexity" is apparently used to distract the audience from the industry's contribution to the problem and to promote inaction or ineffective solutions (96). When there is significant support for the regulation of products and negative attitudes in the community toward industries such as gambling or alcohol and tobacco, those industries could develop new strategies or countermeasures. For instance they might frame themselves as "good corporate citizens" to avoid or minimize the impact of restrictions or regulations (53). Some governments and government agencies periodically attempt to counter pro-gambling messages, for instance the Victorian Responsible Gambling Foundation which promoted a social media campaign named "Love the game, not the odds." However, it is hard for these transient social media campaigns to counteract the overwhelming pro-gambling messages (97). Media campaigns that emphasize the damage associated with gambling reduce gambling intentions, but pro-gambling media campaigns are much more effective in enhancing intentions to gamble (98, 99).

It will be important for public health advocates and coalitions to consider and recognize these strategies and to develop adapted online gambling regulations (100).

Future Research Development

Gaps in the literature were identified here and could fuel future research. Beyond the evaluation of influence and content analysis, there is no data on the exposure to digital gambling marketing stimuli, in terms of modalities, frequency, time, or potential influence. Secondly in the case of digital alcohol marketing, participatory forms generated by users but driven by the industry's marketing have been described (101). These strategies mobilize intermediaries (influencers) who disseminate messages in favor of the industries within the framework of remunerated partnerships. In addition, industries also encourage Internet users themselves to interact with the official pages of their brands (follow, like, comment, identify a friend, share, re-tweet, etc.) via the humorous content of quizzes and riddles, or contests. There is little data on the influence of these strategies in the context of gambling. There is also little research on the impact of gambling advertising online, on inducements or on loyalty programs (102).

Finally, regarding social interactions and the diffusion of gambling behaviors, the social media afford new opportunities for intervention, such as online counseling or pop-ups that remind users of the time and money spent on gambling. Embedded messages in sports contents are more salient than frequency of exposure in predicting gambling problems amongst online sports bettors (37). This implies a need for social marketing and public education to counter promotional

messages. They should aim to moderate positive sentiments toward gambling, brands and their promotion, since this is what that leads to excessive gambling. Social marketing is still a largely unexplored avenue for the prevention of gambling, and more particularly among young gamblers (103).

Strengths and Limitations

This study focused on gambling, a growing public health concern, for which a preventive, therapeutic approach is needed. Twenty articles were selected following PRISMA guidelines among 64 identified initially. The analysis of these articles enabled identification of themes and characteristics of digital gambling marketing. One limitation is the focus on only two databases (Pubmed and SCOPUS), which could limit the results. In addition, the results of this review are subject to two biases limiting the generalizability of the data. There is firstly a cultural bias, in that a majority of studies concerned Australia or New Zealand. There is also a selection bias since a majority of the studies selected focused on digital strategies in sports betting. We did not include studies concerning gambling marketing on traditional media (television, radio, press).

CONCLUSION

The literature is currently sparse regarding digital gambling marketing, despite its huge development in recent years. The main available data concerns the development of digital marketing and sports betting, and their vulnerable targets, especially young people. We have shown in this review that sport is a major target for marketing, and operators have developed gendered marketing strategies to reach and influence gamblers' behaviors. The multiplicity of forms that online gambling marketing and advertising adopt accentuates the need for research on content and exposure on digital platforms. This fast-evolving area of gambling has brought new challenges to communities, problem gambling treatment providers, and researchers in the field of addictive disorders. It also remains an issue for regulators and policy makers.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

MG-L and KG-M conducted the literature review and wrote the article. DLev, DLe, and J-YL contributed to the method and the drafting, and reviewed the article. All authors contributed to the article and approved the submitted version.

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Association Between Adolescent Internet Gaming and Adult Problematic Web-Based Board Gaming

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Introduction: The results of studies comparing the characteristics of Internet gaming with those of Internet gambling have been controversial. We hypothesized that problematic web-based board gaming behaviors are associated with psychological and social interaction factors. We also hypothesized that non-problematic adolescent Internet gaming is a protective factor against problematic web-based board gaming and that problematic Internet gaming is a predictive factor for problematic web-based board gaming.

Methods: We recruited 104 adults who reported engaging in web-based gaming. All participants were asked to complete the Problematic Web Board Gameplay Scale, Center for Epidemiologic Studies Depression Scale (CESD), State-Trait Anxiety Inventory (STAI), Adult Attention Deficit/Hyperactivity Disorder Self-Report Scale (K-AADHD), Family Environmental Scale (FES), Social Avoidance and Distress Scale (SADS), and questionnaires on their web-based board gaming patterns and Internet gaming history.

Results: Problematic web-based board gamers showed a lower history of adolescent Internet gaming but a greater rate of problematic Internet gaming compared with healthy web-based board gamers. Moreover, problematic web-based board gamers showed an increase in CES-D, STAI, K-AADHD, and SADS scores but decreased FES scores compared with healthy web-based board gamers. Joblessness; less experience as an Internet gamer; a history of problematic Internet gaming; higher CES-D, STAI, and K-AADHD scores; and lower FES scores were significant predictors of problematic web-based board gaming.

Discussion: Psychological, social, and environmental factors can positively influence problematic Web-based board gaming. Healthy Internet gaming during adolescence may play a preventive role in adult problematic web-based board gaming. However, because adolescent problematic Internet gaming tends to lead to problematic web-based board gaming, measures should be taken to prevent it.

Keywords: internet gameplay, problematic web board gameplay scale, psychological scales, interaction scales, adolescent

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INTRODUCTION

Internet gaming is a popular leisure activity worldwide (1). In Korea, 65.7% of the population enjoys Internet gaming, and 90.8% of teenagers play games on the Internet (2). However, concerns about internet gaming are increasing as it becomes more globally popular. Studies have found that gaming can lead to addiction (3–5). The American Psychiatric Association included Internet gaming disorder (IGD) in the Diagnostic and Statistical Manual of Mental Disorders under a provisional status (6), and the World Health Assembly added gaming disorder in the International Classification of Diseases in May 2019 (7).

Several factors have been linked to problematic Internet gaming (8–17). For example, IGD in adolescence is thought to be related to psychological factors, such as mood, anxiety, attention, and impulse control (8–11). Environmental and family factors such as parental monitoring, family conflicts, and family relationships are also considered risk factors for IGD (12, 13).

Web-based board games are real-time board games played through online web browsers (18), such as chess, monopoly, backgammon, gomoku, poker, and flower card games (i.e., Korean-style card games). Web-based card games are played with virtual money that can be purchased on the website hosting the game after adult authentication. Players whose daily lives are negatively impacted by these games are referred to as "problematic web-based board gamers" (19, 20). These online casino players show a tendency to chase losses that is greater than that of real-time casino gamblers (21). Internet gambling is illegal in Korea, but some individuals use illegal gambling betting sites employing actual currency, usually through credit cards (22). The terms and conditions of the game prohibit items and accounts from being traded in cash, but some users trade their in-game property for real goods (23).

Problematic web-based board gaming has not been officially designated a formal disorder. Problematic web-based board gaming is thought to have aspects of both Internet gaming disorder and internet-related gambling disorder (20, 24). Moreover, the characteristics of web-based board gaming can be applied to internet-based gambling and illegal online gambling (22). Problematic web-based board game players and individuals with Internet Gaming Disorder (IGD) both tend toward depression, anxiety, and impulsivity (20). In addition, the environmental factors that affect internet-related gambling disorder and internet gaming disorder are both associated with satisfaction with life, well-being, and social adaptation (24). Both Internet gaming and Internet gambling are associated with engagement in reward-seeking behavior without the accomplishment of long-term goals, can cause harm with excessive use, are performed through Internet-enabled devices, and are considered addictive (25–27). However, studies have reported differences between their biological and psychological domains (28–30). Internet gaming can have positive effects on cognitive enhancement and education (28, 29). Individuals with IGD showed increased brain activity within their cognitive network compared with those with Internet-based gambling disorder (30). Despite the ambiguous nosological implications of problematic web-based board gaming, studies of the correlation between IGD in adolescents and problematic web-based board gaming in adults suggest the potential for healthy web-board game play.

Several studies have reported common risk characteristics and transits from problematic Internet gaming to pathologic gambling (31, 32). Problematic Internet use—including in Internet gaming, social media use, web-streaming, pornography viewing, Internet gambling, and buying—has been linked to emotional dysregulation and negative affect (31). The transition from problematic Internet gaming to pathologic gambling has been associated with old age, low self-directedness, and preference for non-strategic gambling (32).

We hypothesized that problematic web-based board gaming behaviors are associated with psychological and social interaction factors. We also hypothesized that problematic adolescent Internet gaming is associated with problematic web-based board gaming in adults.

MATERIALS AND METHODS

Participants

We recruited participants with a special history of web-based board game play by advertising our study online via an online research company as well as offline, including at Chung Ang University and Chung Ang University Hospital from March 2019 to February 2020. People who wanted to participate in the study were invited to visit the IT & Human Research Center at Chung Ang University for screening.

Embrain®, a Seoul-based online research company, sent an e-mail to all registered members aged 20 to 60 years. Of these 150,000 members, 4,735 opened the e-mail, and 1,274 completed the screening questions. Of these, 139 satisfied the inclusion criteria and were invited to participate in our study. Of these, 64 accepted the invitation and visited the IT & Human Research Center to participate in the study. Of these 64 people, three were excluded: one due to bipolar disorder, one due to major depressive disorder, and one due to alcohol use disorder. Through banner ads, posters, and flyers at Chung Ang University and Chung Ang University Hospital, 44 people visited the IT & Human Research Center at Chung Ang University. Of the 44 participants, one dropped out due to severe major depressive disorder. Finally, data from 104 participants [61 + 43] were used for the analyses. The inclusion criteria were as follows: (1) age from 20 to 60 years; (2) engagement in web-based board gaming (i.e., flower cards, poker, or Texas holdem) more often than 1 day a week, for a period of more than 1 year, on a legal online site; (3) an official report of web-based board gaming activity, supplied by the web-based board game company at the customer's request; and (4) no history of psychiatric disorders, including substance abuse. The study protocol was approved by the institutional review board of Chung Ang University. Informed consent was obtained from all participants and was confirmed by the board.

Assessment

Demographic Characteristics

The demographic data collected by the study included age, gender, education year, job status, economic status, web-based board game pattern, and history of Internet game play.

Pattern of Internet Gaming

The pattern of Internet gaming was assessed using two questionnaires: internet game play time (hour/day) and genre of Internet game. The first question, regarding the participant's Internet game play history, asked, "When you were an adolescent, did you engage in internet gaming at least once a week for 1 year?" The one-week frequency and one-year duration mentioned in the question were based on the IGD research (33) and diagnostic criteria in the DSM-5 (6). The second question, on problematic Internet game play history, asked, "When you were an adolescent, did anyone, important, or close to you consider your gaming to be a problem?" This question has also been used in the IGD research (33).

Scales of Psychological Status

We estimated depressive symptoms using the Center for Epidemiologic Studies Depression Scale (CESD). The CESD is a 20-item, four-point self-report instrument (34). The total CESD score ranges from 0 (best) to 60 (worst; 34). A score of 16 is the cut-off point representing "depression" (34). We estimated the presence and severity of symptoms of anxiety, including the propensity to be anxious, using the State-Trait Anxiety Inventory (STAI). The STAI is a 40-item, four-point self-report instrument (35). The total STAI score ranges from 0 (best) to 60 (worst). A score of 30 is the cut-off point representing "anxiety disorder" (35). Attention problems were estimated using the Adult Attention Deficit/Hyperactivity Disorder Self-Report Scale (K-AADHD). The K-AADHD is an 18-item, five-point self-report instrument. The total K-AADHD score ranges from 0 (best) to 72 (worst; 34). The questions in the K-AADHD are split into two parts: a (six questions) and B (12 questions). Four or more positive answers in Part A may indicate ADHD (36, 37).

Interaction Scales

Family cohesion was estimated using the Family Environmental Scale (FES). Higher FES scores indicate better family cohesion. The internal consistency of the scale was 0.86 (38, 39). We estimated participants' social intimacy levels using the Social Avoidance and Distress Scale (SADS). The scale consists of 28 questionnaires measuring social anxiety and social avoidance using a five-point Likert scale. The internal consistency of the scale was 0.68 (40, 41).

Definition of a Problematic Web-Based Board Gamer

We used the Problematic Web Board Gameplay Scale (20) to define problematic web-based board gamers. Those with Problematic Web Board Gameplay Scale scores above 22 (20) and a history of illegal Internet gambling, illegal online money trading with game money within the past month, or purchasing or selling web board identifiers were considered problematic web-based board game players.

Statistical Analysis

Differences in demographic data between problematic web-based board gamers and healthy web-based board gamers were analyzed using an independent *t*-test or $\chi 2$ test. Web-based board gaming patterns and Internet gaming histories were analyzed using independent *t*-tests and the $\chi 2$ test. Scores on the psychological and interaction scales were analyzed using independent *t*-tests.

We used hierarchical logistic regression analysis to confirm whether the study's variables could predict statistically significant variance in the dependent variable, for which problematic web-based board gaming was coded as 1, and healthy web-board gaming was coded as 0. Regarding the independent variables, the following discrete set of hierarchical variables was added: demographic factors (age, gender, school year, job, and social economic status) for model 1, model 1 + history of Internet gaming (history of Internet game play and problematic Internet game play) for model 2, model 2 + psychological status (depressed mood, anxiety, attention) for model 3, and model 3 + interaction factors (family environment and social avoidance and distress) for model 4.

The overall fit of each step of the logistic regression model was evaluated with $\chi 2$-values (model $\chi 2$ and step $\chi 2$), while the goodness-of-fit was evaluated with -2 log likelihood. The $\chi 2$ values showed the improvement observed in the model, with the predictors relative to the constant-only model or the model preceding the current model. We also evaluated the practical usefulness of each model using tables of classification accuracy to determine the relative success of each model in predicting the correlations with improved golfers. In addition, Nagelkerke's R2 was assessed as an approximate estimate of the amount of variance in the dependent variable accounted for by the model. Wald statistics were used to test whether each individual factor had a significant relationship with improved golfers. When a significant relationship was detected by the Wald test, the interpretation of the coefficient was followed by a determination of the odds ratio—that is, the ratio of the probability that the event (problematic web-based board gaming) would occur to the probability that it would not.

RESULTS

Demographic and Web-Based Board Gaming Characteristics

Problematic web-based board gaming was associated with older age (problematic web-based board gamers: 32.9 ± 9.9 vs. healthy web-based board gamers: 27.7 ± 6.4) and joblessness (job/jobless, 26/10 vs. 61/7) compared with healthy web-based board gamers. There were no significant differences in gender, years of education, or socioeconomic status between the two groups (see **Table 1**).

Problematic web-based board gamers showed higher Problematic Web Board Gameplay Scale scores (26.6 ± 3.9 vs. 17.9 ± 4.3), number of logins (2.2 ± 1.8 vs. 1.3 ± 1.5), and play time (1.6 ± 0.8 vs. 1.3 ± 0.6 hours/day) compared with healthy web-based board gamers. There was no significant difference in the game-winning rate between the two groups (see **Table 1**).

Problematic web-based board gamers showed a shorter history of adolescent Internet gaming (yes/no, 14/22 vs. 41/27) but a higher rate of problematic Internet gaming (yes/no, 12/24

TABLE 1 | Demographic and gaming characteristics of web-based board gamers.

	Healthy gamers ($n = 68$)	Problematic gamers ($n = 36$)	Statistics
Demographic data			
Age (years)	27.7 ± 6.4	32.9 ± 9.9	$t = -3.27$, $p < 0.01$*
Gender (man/woman)	38/30	18/18	$\chi^2 = 0.33$, $p = 0.68$
Education (year)	14.5 ± 1.6	15.0 ± 1.8	$t = -1.41$, $p = 0.16$
Job status (yes/no)	61/7	26/10	$\chi^2 = 5.26$, $p = 0.03$*
Socioeconomic status ($/year)			
< $20,000	10	10	$\chi^2 = 3.19$, $p = 0.20$
$20,000–40,000	50	24	
> $40,000	8	2	
Web-based board gaming pattern			
Problematic web board game play scale	17.9 ± 4.3	26.6 ± 3.9	$t = -10.1$, $p < 0.01$*
Number of logins per day	1.3 ± 1.5	2.2 ± 1.8	$t = -2.51$, $p = 0.01$*
Play time (hour/day)	1.3 ± 0.6	1.6 ± 0.8	$t = -2.06$, $p = 0.04$*
Winning rate (%)	40.4 ± 11.4	42.7 ± 9.5	$t = -1.04$, $p = 0.30$
Internet game play history			
History of Internet game play (yes/no)	41/27	14/22	$\chi^2 = 4.33$, $p = 0.04$*
Problematic Internet game play (yes/no)	4/64	12/24	$\chi^2 = 13.63$, $p < 0.01$*
Play time (hour/day)	1.5 ± 0.6	3.8 ± 1.9	$t = -6.98$, $p < 0.01$*
Genre of internet game			
MMORPG	16	6	$\chi^2 = 0.43$, $p = 0.93$
RTS	15	4	
FPS	6	2	
Others	4	2	

**Statistically significant.*

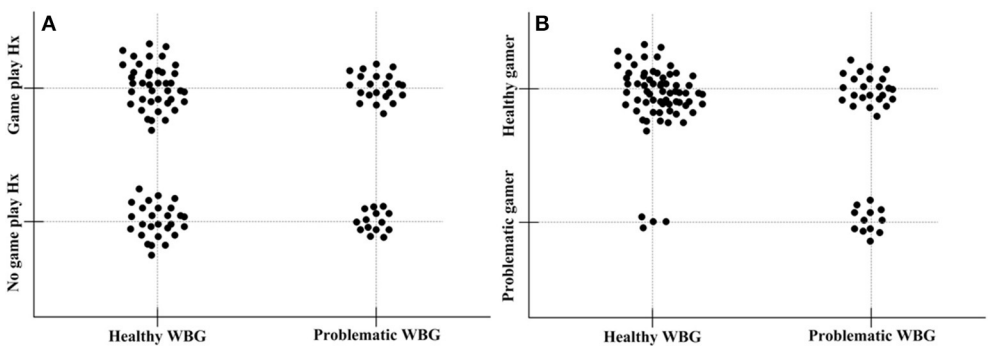

FIGURE 1 | The correlation between internet gaming and web-based board gaming. **(A)** The correlation between history of internet game play (Game play Hx) and problematic web-based board game play (Problematic WBG). **(B)** The correlation between history of problematic internet game play (Problematic gamer) and problematic web-based board game play (Problematic WBG).

vs. 4/64) compared with healthy web-based board gamers (see **Table 1** and **Figure 1**). In addition, problematic web-based board gamers showed longer Internet game play time compared to healthy web-based board gamers. There was no significant difference in game genre between the two groups.

Psychological and Social Interaction Scale

Problematic web-based board gamers showed higher scores on the CES-D (problematic web-based board gamers: 15.3 ± 11.1 vs. healthy web-based board gamers: 6.4 ± 6.3), STAI (85.9 ± 19.9 vs. 76.5 ± 16.5), and K-AADHD (15.6 ± 7.5 vs. 6.6 ± 5.1) scores compared with healthy web-based board gamers (see **Table 2**). Problematic web-based board gamers showed lower scores on the FES (27.1 ± 5.4 vs. 34.9 ± 4.7) but higher SADS (80.3 ± 20.1 vs. 72.3 ± 16.9) scores compared with healthy web-based board gamers (**Table 2**).

Hierarchical Logistic Regression Analysis

A Durbin–Watson test indicated that there was no autocorrelation in the data. Of the four models employed,

TABLE 2 | Comparison of scores on the psychological and social interaction scales.

	Healthy gamers ($n = 68$)	Problematic gamers ($n = 36$)	Statistics
Psychological scale			
CES-D	6.4 ± 6.3	15.3 ± 11.1	$t = -5.24$, $p < 0.01$*
STAI	76.5 ± 16.5	85.9 ± 19.9	$t = -2.55$, $p = 0.01$*
K-AADHD	6.6 ± 5.1	15.6 ± 7.5	$t = -7.21$, $p < 0.01$*
Interaction scale			
FES	34.9 ± 4.7	27.1 ± 5.4	$t = 7.62$, $p < 0.01$*
SADS	72.3 ± 16.9	80.3 ± 20.1	$t = -2.14$, $p = 0.04$*

CES-D, Center for Epidemiologic Studies Depression Scale; STAI, state-trait anxiety inventory; K-AADHD, adult attention deficit/hyperactivity disorder scale; FES, family environment scale; SADS, social avoidance and distress scale.

all were significantly associated with problematic web-based board gaming. Considering its highest step $\chi 2$ value and the improved classification accuracy, adolescent Internet gaming history was the strongest factor for problematic web-based board gaming among all the domains. Considering its highest model $\chi 2$ value and the improved classification accuracy, Model 4, which included all domains, predicted problematic web-based board gaming most strongly among the models.

In Model 1, the $\chi 2$ (21.9, $p < 0.01$) and Nagelkerke's R2 (0.262, 26.2% variance in the dependent variable of problematic web-based board gaming) indicated that the model was good enough to predict problematic web-based board gaming. When we examined the practical usefulness of the model based on classification accuracy, five variables in Model 1 enhanced the prediction accuracy of the group membership of the dependent variable to 73.1%. The step $\chi 2$ value (step $\chi 2 = 21.9$, $p < 0.01$) showed that demographic factors were the main predictive factors for problematic web-based board gaming. In Model 2, the $\chi 2$ (56.4, $p < 0.01$) and Nagelkerke's R2 (0.578, 57.8% variance in the dependent variable of problematic web-based board gaming) indicated that the model was good enough to predict problematic web-based board gaming. The seven variables in Model 2 enhanced the prediction accuracy of the group membership of the dependent variable by 84.8%. The step $\chi 2$ value (step $\chi 2 = 34.5$, $p < 0.01$) showed that the factors of pattern of internet game play were the main predictive factors for problematic web-based board gaming. In Model 3, the $\chi 2$ (77.0, $p < 0.01$) and Nagelkerke's R2 (0.722, 72.2% variance in the dependent variable of problematic web-based board gaming) indicated that the model was good enough to predict problematic web-based board gaming. Ten variables in Model 3 enhanced the prediction accuracy of the group membership of the dependent variable to 89.4%. The step $\chi 2$ value (step $\chi 2 = 20.7$, $p < 0.01$) showed that the factors of psychological status were the main predictive factors for problematic web-based board gaming. In Model 4, the $\chi 2$ (94.1, $p < 0.01$) and Nagelkerke's R2 (0.821, 82.1% variance in the dependent variable of problematic web-based board gaming) indicated that the model was good enough to predict problematic web-based board gaming. The 12 variables in Model 4 enhanced the prediction accuracy of the group membership of the dependent variable to 94.14%. The step $\chi 2$ value (step $\chi 2 = 16.9$, $p < 0.01$) showed that the interaction factors were the main predictive factors for problematic web-based board gaming (see **Table 3**).

The results of the Wald's statistics for all independent variables indicated that joblessness; less experience of Internet gaming; problematic Internet gaming history; higher scores on the CES-D, STAI, and K-AADHD; and lower scores on the FES were significant predictors of problematic web-based board gaming (see **Table 3**).

DISCUSSION

Problematic web-based board gaming was associated with a shorter history of adolescent Internet gaming but a greater rate of problematic Internet gaming compared with healthy web-based board gamers. Problematic web-based board gaming was associated with higher CES-D, STAI, K-AADHD, and SADS scores but lower FES scores than healthy web-based board gaming. Overall, joblessness; less experience with Internet gaming; a history of problematic Internet gaming; higher scores on the CES-D, STAI, and K-AADHD; and lower FES scores were significant predictors of problematic web-based board gaming.

Considering the step χ^2 values, this study found that demographic factors could be significant predictive factors for problematic web-based board game play. Of the demographic domains, such as IGD (35, 36), problematic web-based board gaming was associated with joblessness. Young asserted that problematic Internet use could aggravate occupational impairment (42). Kim et al. reported that adults with IGD are more likely to be unemployed than healthy individuals (43).

Of the four domains, Internet gaming pattern was found to be the most crucial for problematic web-based board gaming. Considering the negative beta value of Internet game play history, experience of adolescent Internet gaming would be negatively correlated with adult problematic web-based board gaming. Considering its positive beta value, history of problematic adolescent Internet gaming was associated with adult problematic web-based board gaming. The beta value of the regression analysis was reflected in the slope of the regression line (44). Taken together, the two results concerning the Internet gaming pattern domain suggest that individuals with a history of Internet gaming but no history of problematic Internet gaming do not have a higher probability of problematic web-based board gaming.

TABLE 3 | Results of the hierarchical logistic regression analysis.

Independent variable		Model 1			Model 2			Model 3			Model 4		
		Beta	**Wald**	**OR**	**Beta**	**Wald**	**OR**	**Beta**	**Wald**	**OR**	**Beta**	**Wald**	**OR**
Demographic	Age	0.084	7.524	1.088**	0.159	11.637	1.172*	0.141	7.695	1.151**	0.111	3.328	1.118
factors	Gender	0.068	0.018	1.070	0.138	0.048	1.148	0.269	0.092	1.309	2.099	2.294	8.158
	School	0.051	0.103	1.052	−0.315	2.363	0.730	−0.520	3.341	0.594	−0.801	2.967	0.449
	Job	−1.598	6.101	0.202*	−1.719	4.539	0.179*	−1.779	2.968	0.169	−2.917	3.900	0.054*
	SES		7.374			5.003			0.919			0.154	
	SES (1)	2.704	5.134	14.944	2.738	4.937	15.463	0.453	0.070	1.574	−0.459	0.051	0.632
	SES (2)	1.336	1.441	3.804	2.332	3.767	10.296	1.252	0.678	3.498	−0.769	0.150	0.463
Pattern of	Hx Game				−5.572	17.042	0.004**	−5.944	10.618	0.003**	−3.681	2.255	0.025*
Internet game play	P Game				3.703	11.564	40.583	4.258	7.372	70.659	6.296	5.921	542.627**
Psychological	CES-D							0.134	3.538	1.143	0.237	4.514	1.268*
status	STAI							−0.070	3.631	0.933	−0.130	5.359	0.878*
	K-AADHD							0.236	8.747	1.266**	0.177	4.561	1.194*
Interaction	FES										−0.553	6.174	0.575*
factors	SADS										0.073	3.372	1.075

Indices	**Model 0**	**Model 1**	**Model 2**	**Model 3**	**Model 4**
−2LL	134.14	112.22	77.76	57.11	40.11
Step χ^2/p	N/A	21.9/<0.01	34.5/<0.01	20.7/<0.01	16.9/<0.01
Model χ^2/p	N/A	21.9/<0.01	56.4/<0.01	77.0/<0.01	94.1/<0.01
Nag 2	N/A	0.262	0.578	0.722	0.821
Class Accur	65.4	73.1	84.8	89.4	94.1

*$p < 0.05$, **$p < 0.01$; −2LL, −2 log likelihood; Nag R2, Nagelkerke's R2; class accur, classification accuracy; dependent factor, problematic web-based board game play; SES, social economic status; Hx game, history of internet game play; P game, problematic internet game play; CES-D, Center for Epidemiologic Studies Depression Scale; STAI, State-Trait Anxiety Inventory; K-AADHD, adult attention deficit/hyperactivity disorder scale; FES, family environment scale; SADS, social avoidance and distress scale.*

These results offer new insights into the prevention of problematic web-based board gaming. In contrast to our results, several previous studies have demonstrated the risks of early exposure to Internet gaming or gambling (42–46). The results of retrospective studies by Shaffer et al. (47) and Abbott et al. (48) indicated that adults who are problematic gamblers are likely to have gambled in their adolescence and that the younger they are when exposed to gambling, the more likely they are to experience subsequent problems related to it (49). Similarly, Ni et al. (50) reported that the age at first exposure to Internet gaming was associated with Internet addiction. However, our results reported that the experience of adolescent Internet gaming did not lead to problematic web-based board gaming in adults, but served as a protective factor. Caretakers' care for and interest in their child's Internet gaming pattern and Internet use are thought to be important factors for Internet gaming disorder (12, 13). Kwak et al. (51) compared the changes in behavioral patterns and brain activities between problematic gaming students and student pro-gamers for 1 year. Despite their heavy exposure to Internet gaming, student pro-gamers, who had planned gaming schedules and gaming discipline, showed fewer problematic behaviors than problematic gaming students did. Jones et al. found that a moderate level of gaming may positively influence well-being by improving mood, regulating emotions, and reducing stress (52). The authors also suggested that relationships with peers and socializing with other players promoted positive social functioning. Hence, support from parents and teachers can prevent problematic online gaming (12, 46). The protective effect found in our study might be associated with adaptation to the online environment, which may protect against problematic web-based board gaming.

Several studies have shown that, for complicated reasons, a problematic Internet gaming history could be a higher risk for problematic Internet gaming or gambling than exposure to Internet gaming or gambling itself (43, 45). Karlsson et al. (53) reported that problem gaming and problematic Internet use are associated with problem gambling. Problematic Internet gaming and problematic gambling share similar risk factors, including male gender, social isolation, feelings of loneliness, and underlying psychiatric diseases such as attention deficit hyperactivity disorder and major depressive disorder (43, 45, 54, 55).

We have already shown that problematic web-based board gaming may be linked to users' psychological and social problems (24). Similarly, in this study, problematic web-based board gamers showed more depression, anxiety, and attention deficiency as measured with psychological scales, along with less family cohesion and social intimacy as measured with interaction scales. Multiple studies have suggested that psychological and environmental factors are strongly correlated with IGD (12–17).

Specifically, parental care (12) and teacher support can enhance social engagement, which can help prevent IGD (46).

LIMITATIONS

This study has several limitations. First, the sample size was relatively small and had a cross-sectional design; therefore, the results may have limited generalizability. Future studies should consider a longitudinal design with a larger population. Second, we did not examine adolescent web-based board gaming history or adult Internet gaming history. There may be correlations between these two factors; however, this study recruited only web-based board gamers and collected data on their Internet gaming. Thus, further studies are required to classify the characteristics of each group. Finally, the study did not assess tobacco information details. Tobacco habits are known to be associated with gambling disorder. Future studies should assess the relationship between tobacco habits and web-based board gameplay.

CONCLUSION

The results of this study showed that psychological, social, and environmental factors can positively influence problematic web-based board gaming. Healthy Internet gaming during adolescence may play a preventive role against problematic web-based board gaming during adulthood. However, measures should be taken to prevent problematic adolescent Internet gaming because it tends to lead to problematic web-based board gaming.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board of the Chung Ang University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SB and DH contributed to the conception of the study. DH and KM contributed to the study methodology. SK contributed to the formal analysis of the study. HR contributed to the investigation of this study, preparation of the original draft, review, and editing of the manuscript. DH supervised the study. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Changes Over Time and Predictors of Online Gambling in Three Norwegian Population Studies 2013–2019

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Objectives: To investigate changes over time and identify predictors of online gambling among gamblers by using three Norwegian representative samples covering a 6-year (2013–2019) period. We also aimed to identify different characteristics (including video game participation and video gaming problems) of online compared to offline gamblers.

Methods: Data from gamblers (N = 15,096) participating in three cross-sectional surveys (2013, 2015, and 2019) based on random sampling from the Norwegian Population Registry were analyzed. Participants were asked how frequently they engaged in online gambling on different platforms (e.g., mobile phone). Data on sociodemographics, games gambled, gambling problems, gaming, and problem gaming were collected and analyzed by logistic regression analyses.

Results: Overall, an increase in online gambling from 2013 to 2015 was found (a larger percentage of gamblers reported having gambled online at least once during the last year), and an increase in online gambling from 2015 to 2019 was found (more gamblers reported having gambled online at least once last year and at least once per week). The increase was largest for gambling on mobile phone. Consistent predictors of online gambling (at least once last year and at least once per week) were male gender, high income, being unemployed, being on disability pension, having work assessment allowance, being a homemaker or retiree, number of games gambled, and gambling problems.

Conclusions: Online gambling, especially on mobile phones, has increased significantly during the last 6 years in Norway. Hence, gambling availability seems to have grown, which may pose a risk for development of gambling problems. Compared to offline gamblers, online gamblers were more likely to be men, young, not working or studying, gambling on several games, and having gambling problems. Responsible gambling efforts aiming at preventing or minimizing harm related to online gambling should thus target these groups.

Keywords: online gambling, trend data, representative sample, predictors, mode of internet access, changes

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INTRODUCTION

During recent decades, we have witnessed a sharp rise in Internet use. The partial substitution of many offline activities, including gambling, with online analogs is probably both a cause and a consequence of this increase. Online gambling is however assumed to be more addictive than offline gambling, as the former entails greater availability (both in terms of time and location), anonymity, ease of betting, and enabling of games with high gambling speed (1–4). Online gambling is also cheaper to operate, often leading to higher payout ratios, which may also intensify gambling behavior. In line with this, a German study estimated that replacing 10% of offline gambling with online gambling would increase an individual's likelihood of being a problematic gambler by 8.8–12.6% (5).

So far, few studies (6, 7) have investigated which mode of access online gamblers use. However, one study of treatment-seeking gamblers showed that mobile phones were the most commonly used platform for gambling online (7). Whether the prevalence rates of online gambling through mobile phones have changed over time in line with the development of smart phone technology has previously not been investigated, hence this should be elucidated empirically.

The vast majority of studies to date show that online gamblers report more gambling problems than offline gamblers (8–14). However, one study found an inverse relationship between online gambling and gambling problems when controlling for the number of gambling activities (15). Consequently, it is recommended that controlling for the latter is important when investigating whether online gambling actually is associated with gambling problems (16–18). Another consistent finding, in addition to a higher prevalence of gambling problems among online compared to offline gamblers, is that online gambling is associated with the male gender and young subjects (9, 13, 19). The following factors have also been associated with online (as opposed to offline) gambling in at least one study: being single, consuming more alcohol, well-educated and in managerial/professional occupations, tobacco use, fewer gambling fallacies, being employed, more positive attitudes toward gambling, higher gambling expenditure, not being Asian, illicit drug use, higher household income, being engaged in a higher number of gambling activities, and being more likely to bet on sports (9, 19, 20). Still, the number of studies identifying predictors of online gambling is rather limited, and few such studies have been conducted using national representative samples of gamblers. Hence, more studies identifying characteristics of online gamblers are warranted.

Another pertinent topic in terms of online gambling concerns the relationship with video game playing. Although one study showed that consumers perceive clear market boundaries between online gambling and gaming products (21), it has nevertheless been suggested that video games with perceived gambling elements may initiate the process of normalizing and increasing the interest in gambling (22). Studies have attested to this notion, showing a positive relationship between online gambling and Internet gaming disorder (23), and a longitudinal study showed problematic video gaming to be a predictor of later problematic gambling (24). A link between problematic gambling and purchase of loot boxes in video games has also been documented (25).

Against this backdrop, the aim of the present study was to investigate changes over time and identify predictors of online gambling among gamblers by using three Norwegian representative samples covering a 6-year (2013–2019) period. We also aimed to identify different characteristics (including video game participation and video gaming problems) of online compared to offline gamblers. The following research questions were formulated: (1) Is there an overall difference in the proportion of Internet gamblers (gambling online either at least once last year and at least weekly) between 2013, 2015, and 2019? (2) Is there a difference in the proportion of gamblers using stationary computers, laptops, tablets, and mobile phones for gambling purposes (either at least once last year and at least weekly) between 2013, 2015, and 2019? (3) Across all time points, which factors (gender, age, marital status, children in household, educational level, income, occupational status, country of birth, gambling problem category, number of games gambled, video game participation, and video game problems category) can predict online gambling (either at least once last year and at least weekly)? These questions are important, as answering them can inform gambling operators, regulatory authorities, and treatment agencies about the development of online gambling and identify characteristics of gamblers engaged in online gambling. The potential added valued of the present study to the research field pertains in particular to the use of national representative samples of gamblers, cross-sectional data covering a 6-year period, and the ability to characterize online gamblers on central sociodemographic and gambling characteristics.

MATERIALS AND METHODS

Procedures

The data were collected as part of three national surveys about gaming and gambling problems in Norway. The first survey was conducted during autumn 2013. Here, 24,000 persons aged 16–74 years were randomly selected from the Norwegian Population Registry. They were sent a questionnaire with a prepaid return envelope and an information letter explaining the purpose of the study. Up to two reminders with a new questionnaire were sent to those who did not respond. The respondents could also answer on the Internet. A total of 10,081 answered, of whom 6,034 had gambled during the last year. Another national survey using a similar approach (albeit only based on paper-based questionnaires) was conducted during autumn 2015, entailing a gross sample of 14,000. A total of 5,485 took part in the survey, of whom 3,232 had gambled during the last year. A third survey was conducted in 2019, also using a similar procedure, except that the questions initially could only be answered online. However, both reminders in the 2019 survey included a paper-based questionnaire together with a prepaid return envelope. In the 2019 survey, the gross sample size was 30,000.

A total of 9,248 participated, of whom 5,830 had gambled during the last year. When adjusting for those not able to answer (wrong addresses, dead, abroad, sick, or not able to understand Norwegian), the response rates of the three surveys were 43.6, 40.8, and 32.7%, respectively. In terms of inclusion criteria in the surveys, no other requirement than having an address in Norway and being between 16 and 74 years was enforced. For participating in the present study, the only additional inclusion criterion was that the participant needed to have participated in gambling at least once last year. In order to keep the response rate as high as possible, recommended approaches such as keeping the questionnaire relatively short, printing it in color with a unique ID number, arranging a lottery with gift cards (worth 500 NOK $\approx$ 50 €) for those who replied, showing researchers' university affiliation, and highlighting confidentiality were emphasized in all three surveys (26). The first two surveys were approved by the Regional Committee for Medical and Health Research Ethics (REK vest 2013/120), whereas the third survey was approved by the Norwegian Center for Research Data (No. 528056).

Instruments

The same or similar items were used in all three surveys.

Sociodemographics

In 2013 and 2015, participants were asked to provide information about *gender* and *age* (in 2019, both were provided by the Norwegian Population Registry). Furthermore, all three surveys included questions about *marital status* ("married/common-law partner" vs. "single/separated/divorced/widow/widower"), *number of cohabitating children* participants had caretaker responsibility for, *highest completed educational level* ("not completed mandatory school," "mandatory school," "high school," "vocational school," "university/college bachelor's degree," "university/college master's degree," or "university/college PhD"), *income before tax* (single item with 11 response alternatives ranging from 0–99,999 NOK to 1,000,000 NOK or more, where each step represented an increase of 100,000 NOK), *occupational status* ("full-time employed," "part-time employed," "unemployed," "student," "homemaker," "disability pension/benefit," "work assessment allowance," or "retiree"), and *country of birth* ("Norway," "Nordic country outside Norway," "Europe outside Nordic country," "Africa," "Asia," "North America," "South and Central America," or "Oceania").

Gambling Participation

Participants were asked to report their gambling participation on an item defining gambling ("staking money on the outcome of an event or draw where one can win money") and asked if they had participated in gambling (in any form) during the last 12 months ("no"/"yes").

Online Gambling

Respondents were asked how often they gambled online using: (a) stationary PC, (b) laptop, (c) tablet, and (d) mobile phone. Each of these four items could be answered: "never," "less often than once per month," "about once per month," "about once per week," and "about once per day." Hence, online gambling was in the present paper defined as any type of gambling (e.g., from placing odds online to gamble online interactive games) involving the use of the Internet.

Problem Gambling Severity Index

The Problem Gambling Severity Index (PGSI) assesses gambling problems and comprises nine items, each consisting of a description of a problem gambling behavior or a consequence which the participants are asked to rate according to occurrence frequency, ranging from "never" (0) to "always" (3). Based upon the composite score across the nine items, each participant is assigned to one of four gambling categories: Non-problem gambling (sum score of 0), low-risk gambling (sum score of 1 or 2), moderate-risk gambling (sum score of 3–7), and problem gambling (sum score of 8–27) (27). Cronbach's alpha across the nine items was 0.90, 0.88, and 0.91 for the 2013, 2015, and 2019 survey, respectively.

Gambling on Specific Types of Games

A list of different types of gambling was provided, and the participants were asked to select the specific types of games they had participated in during the last 12 months. The number and types of games listed changed somewhat across the three surveys due to changes in the gambling marked. In order to compare gambling from survey to survey, only the types of gambling presented in all surveys were included in the present study. These amounted to 17 different games: "paper-based scratch card," "online-based scratch card," "bingo in bingo premises," "data bingo," "Belago (slot machine in bingo premises)," "online bingo in bingo premises," "Multix (slot machine)," "gambling on ferries," "online poker," "online casino gambling offshore," "horse racing," "sport betting, odds games offshore," "sport betting, odds games state monopolist," "pool betting," "number games," "private gambling," and "other games."

Participation in Video Gaming

One item defined video gaming (electronic games played on PC/Mac, tablets, mobile phone, or different game consoles like Playstation, Xbox, PS Vita, Nintendo 3DS, and the like), and the respondents were asked if they had participated in video gaming during the last 6 months ("yes"/"no").

Game Addiction Scale for Adolescents

The Game Addiction Scale for Adolescents (GASA) has seven items reflecting the six core addiction (salience, mood modification, tolerance, withdrawal symptoms, conflict, and relapse) components (28) as well as one item related to problems generated by gaming. The response alternatives range from "never" (1) to "very often" (5). According to the instructions, the responses should reflect experiences and behavior during the last 6 months (29). A common approach to identify problem gamers based on GASA is to categorize those scoring 3 or more (i.e., "sometimes" or more often) on 3–6 items as problem video gamers and those scoring 3 or more on all seven items as addicted to video games. In the present study, Cronbach's alpha for the GASA was 0.85, 0.86, and 0.87 for the survey conducted in 2013, 2015, and 2019, respectively.

Sample

Table 1 presents an overview of the distributions or mean scores and standard deviations for the study variables collected in the three surveys for those who had gambled at least once last year (weighted according to the distribution of age, gender, and county of the general population). Somewhat more men than women were present among the gamblers. Most were married or had a common-law partner, and most lived in households with no children they had caretaker responsibilities for. Bachelor's degree and 400,000–599,999 NOK were the most frequently reported educational and income level, respectively. The majority of the respondents were full-time employed and born in Norway. Among the online gamblers, the largest proportion accessed the Internet *via* a laptop in 2013 (15.4 vs. 12.4% for mobile phone), while the vast majority of online gamblers used a mobile phone (48.7 vs. 16.2% for laptop) for this purpose in 2019. About four in five of the gamblers were non-problem gamblers. Less than half of the gamblers had participated in video gaming during the last 6 months, and more than 90% were categorized as non-gamer/normal gamer.

Statistical Analysis

Data were analyzed with IBM SPSS Statistics, version 25. In all analyses, data were weighed in terms of age, gender, and resident county to adjust for any discrepancies between the full sample and the Norwegian population in the age range of 16–74 years. Adjusted logistic regression analyses (adjusting for gender, age group, and problem gambling category) were conducted in order to investigate whether online gambling of any of the following: stationary PC, laptop, tablet, mobile phone, or any of these platforms, had changed in the period 2013–2015. Year 2015 was used as a reference category. One analysis was performed for having gambled online at least once during the last 12 months (ever), and one analysis was performed for frequent (at least weekly) online gambling. Furthermore, adjusted logistic regression analyses were conducted to investigate characteristics associated with online gambling. Gambled online at least once last year across all modes of Internet access (ever gambled online) and gambled online at least once per week across all modes of Internet access (frequent online gambling) comprised the dependent variables. In both logistic regression models, the independent variables were gender, age group, marital status, children in household, educational level, income, occupational status, country of birth, problem gambling category, number of games gambled, gaming participation, and problem gaming category.

RESULTS

The first research question concerned the proportion of gamblers gambling over the Internet (either at least once last year or at least weekly) in 2013, 2015, and 2019. For any mode of access, the probability of gambling online at least once during the last year was lower in 2013 than in 2015 and higher in 2019 than in 2015 (**Figure 1** and **Table 2**). For any mode of access, the probability of gambling online at least weekly was higher in 2019 compared to 2015 (**Figure 2** and **Table 2**).

The second research question concerned the proportion of gamblers gambling over the Internet broken down by mode of access. For gambling at least once last year, no changes by year were found for either stationary PC or laptop. The probability of gambling online on a tablet was, however, significantly higher in 2019 than in 2015. For mobile phone, the probability of frequently gambling online was significantly higher in 2019 than 2015 (**Figure 1** and **Table 2**). For online gambling at least weekly the probability of gambling on a laptop was lower in 2015 than in 2013, wheres the probability of at least weekly online gambling using a mobile phone was higher in 2019 than in 2015 (**Figure 2** and **Table 2**). The third and last research question addressed differences between online and non-online gamblers. **Table 3** presents the finding for the results of the logistic regression analysis predicting online gambling at least once during the last year. The model was significant ($\chi^2 = 2669.6$, $df = 30$, $p < 0.001$), and the predictors explained between 17.9% (Cox and Snell R^2) and 24.2% (Nagelkerke R^2) of the variance. The model with the intercept only correctly classified 60.1% of the respondents, whereas the model including all predictors correctly classified 70.6% of the respondents. Significant predictors of online gambling at least once last year were male gender and young age. Those with three or more children in the household had a lower probability of online gambling at least once during the last year than those with no children in the household. Those with high school or bachelor's degree had a higher probability of online gambling at least once during the last year than those not having completed mandatory school or with mandatory school only. Those with higher income than the lowest class (0–199,999 NOK) had a higher probability of online gambling at least once during the last year. Compared to respondents with a full-time position, those working part-time, being unemployed/on disability pension/on work assessment allowance, and homemakers/retirees had a higher probability of online gambling at least once during the last year. Country of birth was unrelated to online gambling at least once during the last year. Those categorized as a low-risk gambler, moderate-risk gambler, and problem gambler all had a higher probability of online gambling at least once during the last year compared to those in the non-problem gambler category. Number of games gambled was positively associated with online gambling at least once during the last year. Participating in video gaming (as opposed to not participating) during the last 6 months was associated with an increased probability of online gambling at least once during the last year, whereas the category of video game problems was unrelated to online gambling at least once during the last year.

Table 3 also presents the findings for the results of the logistic regression analysis predicting frequent (at least once per week) online gambling. The model was significant ($\chi^2 = 1039.2$, $df = 30$, $p < 0.001$), and the predictors explained between 7.4% (Cox and Snell R^2) and 15.8% (Nagelkerke R^2) of the variance. The model with the intercept only correctly classified 90.5% of the respondents. Classification was not improved by the model including all predictors. Men gambled more frequently

TABLE 1 | Descriptive statistics of study variables in the three (2013, 2015, and 2019) surveys among gamblers.

	2013	2015	2019
Variable	**% or mean (SD)**	**% or mean (SD)**	**% or mean (SD)**
N	6,034	3,232	5,830
Gender men/women	54.0/46.0%	54.6/45.4%	51.5/48.5%
Age groups			
16–25 years	11.9%	12.0%	14.7%
26–35 years	18.4%	18.7%	19.7%
36–45 years	21.0%	19.4%	18.6%
46–55 years	19.8%	19.8%	18.9%
56–65 years	17.9%	17.9%	16.1%
66–74 years	11.0%	12.3%	12.0%
Marital status			
Married/common-law partner	71.5%	72.0%	68.6%
Single/separated/divorced/widow (er)	28.5%	28.0%	31.4%
Children in household			
None	60.7%	62.4%	64.0%
1–2	32.6%	31.2%	29.7%
3 or more	6.7%	6.3%	6.3%
Highest completed education			
Not completed mandatory school or mandatory school	8.7%	8.8%	7.5%
High school	24.0%	23.9%	24.1%
Vocational school	23.8%	23.8%	19.3%
Bachelor's degree	29.4%	28.4%	30.9%
Master's degree/PhD	14.1%	15.1%	18.0%
Income before tax			
0–199,999 NOK	16.6%	15.9%	17.2%
200,000–399,999 NOK	33.5%	28.3%	22.7%
400,000–599,999 NOK	33.3%	34.5%	33.2%
600,000–799,999 NOK	10.3%	12.8%	15.5%
800,000–999,999 NOK	3.5%	4.5%	6.3%
1,000,000 or more	2.8%	4.0%	5.1%
Occupational status			
Full-time employed	59.4%	58.5%	57.9%
Part-time employed	9.3%	10.6%	10.0%
Student	12.0%	7.8%	9.8%
Unemployed/disability pension/work assessment allowance	8.1%	10.7%	10.0%
Homemaker/retiree	11.2%	12.4%	12.3%
Country of birth			
Norway	92.1%	92.0%	89.1%
Europe outside Norway/North-America/Oceania	5.5%	5.5%	7.5%
Africa, Asia, South-, and Central-America	2.4%	2.5%	3.4%
Internet gambling (at least once)			
Stationary PC	9.1%	9.1%	9.9%
Lap-top	15.4%	14.3%	16.2%
Tablet	6.7%	7.8%	9.8%
Mobile phone	12.4%	17.0%	48.7%
Gambling category			
Non-problem gambler	82.1%	81.2%	79.0%
Low-risk gambler	12.9%	13.2%	13.9%
Moderate risk gambler	3.9%	4.0%	4.9%
Problem gambler	1.1%	1.6%	2.1%
Number of games gambled	2.4 (1.7)	2.1 (1.7)	2.1 (1.7)
Gaming participation (yes/no)	36.2%	36.9%	46.1%
Gaming category			
Non-gamer/normal gamer	94.5%	93.8%	90.6%
Problem gamer/game addict	5.5%	6.2%	9.5%

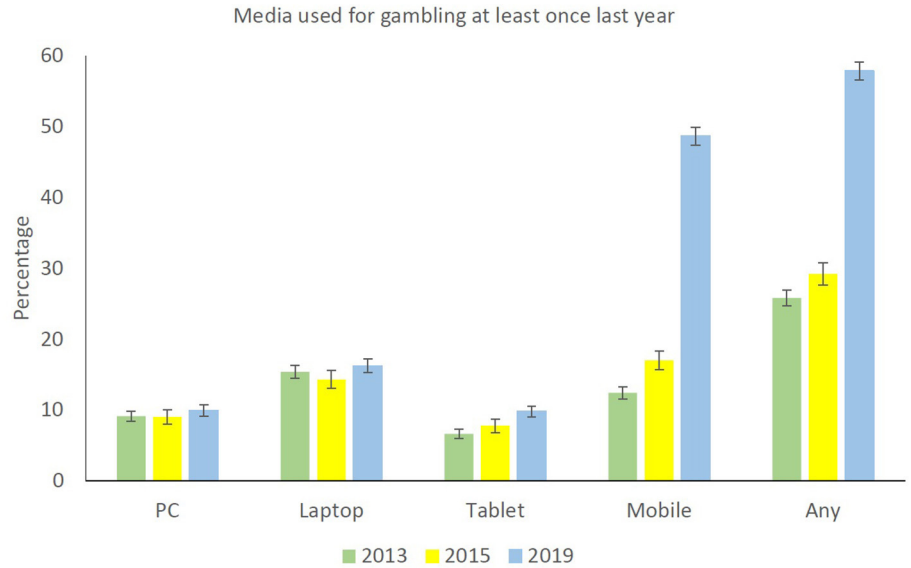

FIGURE 1 | Online gambling at least once last year among gamblers, broken down by year and mode of Internet access for gambling.

TABLE 2 | Odds ratios for online gambling at least once during the last year and at least weekly by mode of Internet access among gamblers.

		Online gambling at least once during the least year		Online gambling at least weekly	
Mode of access	**Year[a]**	**OR[b]**	**95% CI**	**OR[b]**	**95% CI**
Stationary PC	2013	1.03	0.88–1.21	1.05	0.76–1.45
	2019	1.10	0.94–1.28	0.88	0.63–1.23
Laptop	2013	1.12	0.99–1.28	**1.45**	**1.08–1.94**
	2019	1.13	0.99–1.28	0.87	0.64–1.19
Tablet	2013	0.85	0.72–1.01	1.12	0.75–1.67
	2019	**1.28**	**1.09–1.51**	1.08	0.72–1.60
Mobile phone	2013	**0.67**	**0.59–0.76**	1.03	0.80–1.32
	2019	**5.48**	**4.89–6.14**	**4.00**	**3.21–4.99**
Any	2013	**0.82**	**0.74–0.91**	1.10	0.92–1.32
	2019	**4.01**	**3.62–4.44**	**2.44**	**2.06–2.89**

[a] *Year 2015 is the reference.*
[b] *Adjusted for gender, age group, and problem gambling category.*
Significant findings are shown in bold.

online than women. The respondents in the age range of 46–55 years had a higher probability of frequent online gambling compared to ones in the age range of 66–74 years. Marital status and children in the household were unrelated to frequent online gambling. Those with a master's degree/PhD had a lower probability of frequent online gambling than those who had not completed or only completed mandatory school. People earning 200,000–999,999 NOK had a higher probability of frequent online gambling than those with the lowest (0–199,999 NOK) income. Those being unemployed/on disability pension/on work assessment allowance as well as homemakers/retirees had a higher probability of frequent online gambling compared to the reference group (full-time employed). Country of birth was not related to frequent online gambling. Low-risk gamblers, moderate-risk gamblers, and problem gamblers all had a higher probability of frequent online gambling compared to non-problem gamblers. Number of games gambled increased the probability of frequent online gambling. Neither involvement with video games nor gaming problems were associated with frequent online gambling.

Taken together, online gambling, especially on mobile phones, has increased significantly from 2013 to 2019. Consistent predictors of online gambling (both ever and frequent) were male gender, young age, earning high income, not working or studying, having gambling problems, and number of games gambled.

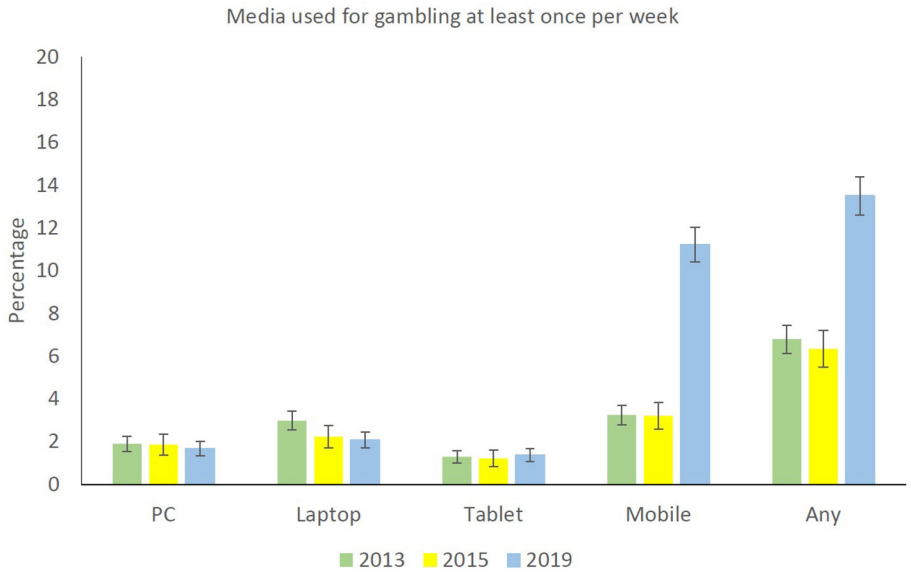

FIGURE 2 | Online gambling at least once per week among gamblers, broken down by year and mode of Internet access for gambling.

In the 2013 survey, 6.3% responded *via* Internet and 93.7% responded *via* a paper questionnaire. Of these, 50.4 and 25.2% ($\chi^2 = 111.9$, $df = 1$, $p < 0.001$, continuity correction) had gambled online, respectively. The data collection of the 2015 survey was exclusively conducted *via* paper-based questionnaires. In the 2019 survey, 65.6% responded *via* Internet and 34.4% responded *via* a paper questionnaire. Of these, 62.9 and 48.1% ($\chi^2 = 118.1$, $df = 1$, $p < 0.001$, continuity correction) had gambled online, respectively.

DISCUSSION

Overall, online gambling among gamblers had increased during the last 6 years in Norway, both in terms of ever (at least once during the last 12 months) and frequent (at least once per week) online gambling. This increase is attributable to increased online gambling on mobile phones, which now, by far, seems to be the most used mode of Internet access by gamblers. Another study showed however that online gambling *via* computers was the most frequent online gambling mode (20), whereas a more recent study of help-seeking gamblers attested to mobile phones as the preferred mode of Internet access for gambling purposes (7). Taking publication year into consideration, these findings overall suggest that mobile phone seems to have become the prevailing mode of accessing the Internet for gambling purposes. This development may be worrisome as, in line with the accessibility hypothesis, those gambling online on mobile phones report more often gambling problems than those who gamble on a computer (30).

Online gambling (ever and frequent) was more common among men than women. This is in line with several other studies (9, 13, 19, 20, 31) and most likely reflects that men generally are more involved in gambling than women (32). Young subjects had a higher probability of gambling online compared to older ones (especially at least once during the last 12 months). This also run tandem with previous findings (9, 19, 20, 31) and suggests that younger people in general are more familiar with Internet use than older people (33) and may also be more attracted to the games available there. For frequent online gambling, the only significant finding related to age was that the age group 46–55 years had a higher probability of such gambling than those 66–74 years old. Unlike other studies, marital status was unrelated to online gambling. One explanation to this is that the present study controlled for several sociodemographic variables simultaneously. Those with three or more children in the household had a lower probability of ever gambled online during the last year compared to those with no children in the household. This may imply that high childcare responsibility load, probably due to time constraints, prevents online gambling. Those with a high school education and a bachelor's degree had a higher probability of online gambling (at least once during the last year) than those not having completed any education beyond mandatory school. Similarly, those with a master's degree exhibited a lower probability for engaging in frequent online gambling. These findings are in accordance with a study from Sweden showing that a higher proportion of those with medium (as opposed to low and high) level of education gambled online (31). One explanation to this finding is that those with low education are more Internet-illiterate than those with a higher education (34). Those with the highest education were less inclined to frequent online gambling compared to those not having completed any education beyond mandatory school. This may reflect that the former group is less interested in online gambling due to being less influenced by cognitive biases (35) and may thus perceive

TABLE 3 | Results of logistic regression analysis predicting gambled online at least once last year and gambled online at least once per week among gamblers.

	Gambled online at least once last year		Gambled online at least once per week	
Independent variable	**OR**	**95% CI**	**OR**	**95% CI**
Gender				
Woman[a]	1.00		1.00	
Man	**1.62**	**1.48–1.76**	**1.97**	**1.70–2.29**
Age				
16–25 years	**2.92**	**2.31–3.69**	0.74	0.50–1.09
26–35 years	**2.64**	**2.15–3.24**	1.09	0.79–1.51
36–45 years	**2.09**	**1.70–2.58**	1.37	0.99–1.90
46–55 years	**1.76**	**1.44–2.14**	**1.57**	**1.15–2.14**
56–65 years	**1.31**	**1.09–1.58**	1.22	0.91–1.64
66–74 years[a]	1.00		1.00	
Marital status				
Married/common-law partner[a]	1.00		1.00	
Single/separated/divorced/widow (er)	1.03	0.93–1.13	1.08	0.93–1.26
Children in household				
None[a]	1.00		1.00	
1–2 children	0.95	0.86–1.05	0.97	0.83–1.14
3 or more children	**0.77**	**0.65–0.92**	0.87	0.66–1.15
Education				
Not completed mandatory/mandatory school[a]	1.00		1.00	
High school	**1.36**	**1.15–1.60**	1.13	0.89–1.44
Vocational school	1.10	0.93–1.31	0.84	0.66–1.08
Bachelor's degree	**1.37**	**1.16–1.62**	0.90	0.71–1.16
Master's degree/PhD	0.92	0.77–1.11	**0.67**	**0.50–0.90**
Income				
0–199,999 NOK[a]	1.00		1.00	
200,000–399,999 NOK	**1.44**	**1.23–1.69**	**1.48**	**1.15–1.92**
400,000–599,999 NOK	**2.18**	**1.82–2.60**	**2.00**	**1.50–2.67**
600,000–799,999 NOK	**3.07**	**2.50–3.77**	**2.11**	**1.52–2.92**
800,000–999,999 NOK	**3.28**	**2.57–4.19**	**2.68**	**1.84–3.90**
1,000,000 or more	**3.29**	**2.54–4.27**	1.49	0.96–2.30
Occupational status				
Full-time employed[a]	1.00		1.00	
Part-time employed	**1.16**	**1.00–1.35**	1.02	0.79–1.32
Student	1.01	0.84–1.21	0.91	0.66–1.24
Unemployed/disability pension/work assessment allowance	**1.51**	**1.29–1.77**	**1.42**	**1.14–1.86**
Homemaker/retiree	**1.21**	**1.02–1.44**	**1.37**	**1.06–1.78**
Country of birth				
Norway[a]	1.00		1.00	
Europe outside Norway/North America/Oceania	0.93	0.79–1.10	0.80	0.61–1.04
Africa, Asia, South America, and Central America	1.08	0.85–1.39	1.25	0.90–1.74
Gambling category				
Non-problem gambler[a]	1.00		1.00	
Low-risk gambler	**2.15**	**1.92–2.41**	**2.36**	**2.02–2.76**
Moderate-risk gambler	**3.47**	**2.79–4.31**	**3.74**	**2.99–4.70**
Problem gambler	**3.04**	**2.09–4.41**	**5.37**	**3.81–7.71**
Number of games gambled	**1.34**	**1.31–1.38**	**1.22**	**1.18–1.26**
Played video games last 6 months				
No[a]	1.00		1.00	
Yes	**1.52**	**1.41–1.69**	1.08	0.93–1.25
Gaming problems				
Non-gamer/normal gamer[a]	1.00		1.00	
Problem gamer/game addict	1.04	0.88–1.22	0.98	0.78–1.23

[a]*Comprise the reference category.*
Significant findings are shown in bold.

gambling in a more realistic way. Those in the lowest income class had a lower probability of Internet gambling (both ever and frequent) than those with higher incomes. This runs counter with two other studies showing no relationship between income and online gambling (9, 36). The present finding most likely reflects that people with a low income have limited amounts of money to spend gambling. Regarding occupational status, the results showed that unemployed, people on disability pension, work assessment allowance, homemakers, and retirees were overrepresented among online gamblers (both ever and frequent) compared to full-time employees. The reason for this is not clear, but it may reflect that those in the former groups have more free or available time to gamble than those employed full-time (19). Country of birth was unrelated to online gambling. Overall, the most consistent predictor of online gambling was gambling category, showing that both low-risk gamblers, moderate-risk gamblers, and problem gamblers had a higher probability of online gambling (both ever and frequent) than non-problem gamblers (while controlling for all other variables including number of games gambled). This is in contrast to a former study showing that gambling problems were inversely related to online gambling when controlling for the number of games gambled (15). The discrepancy between the current finding and the findings of Philander and MacKay (15) may relate to the year of the surveys, as the data of Philander and MacKay's (15) were collected in 2010, while the current study's data were collected in 2013, 2015, and 2019. It is conceivable that online gambling was more uncommon and less advanced in 2010 and that the association between problem gambling and online gambling in 2010 could be explained by problem gamblers seeking out a larger number of different games (online as well as offline). By 2013 and later, however, online gambling has become more common including more advance games containing "addictive features." Thus, the association between problem gambling and online gambling can no longer be explained solely by the number of games played and may instead perhaps be explained by features of online gambling facilitating the development of problem gambling. The finding showing that those with gambling problems were more involved (both ever and frequent) with online gambling than non-problem gamblers is further in line with the majority of studies on this topic (8–14). Having played video games during the last 6 months was associated with an increased probability of having gambled online at least once during the last year but was unrelated to frequent online gambling. This may suggest that a common denominator between gaming and online gambling is the use of relevant technology. The fact that gaming problems were not related to the probability of online gambling, neither ever nor frequent, supports this notion and does not support previous findings showing a positive relationship between online gambling and Internet gaming disorder (23).

It may appear contradictory that both high income and unemployment of some sort (e.g., disability pension) were associated with online gambling. However, each association was adjusted for all of the other included variables, thus it makes sense that individuals who are not at work may engage in more online gambling (and gambling in general) when income level is held constant and *vice versa*—that higher income may be associated with more gambling when employment status is held constant. Both in the 2013 and in the 2019 survey, a correspondence between answering format (*via* paper or Web) and participation in online gambling (no vs. yes) was found. This seems reasonable and suggests that people's general online usage is associated with online gambling. Still, as the sample was drawn from the National Population Registry, the mode of answering should not influence the overall representativeness of the sample as a whole.

Limitations and Strengths

A limitation of the present study is the mediocre response rates, which may limit the generalizability of the findings, although it could be argued that the response rates are reasonable, taking the general falling response rate to surveys worldwide into account (37). The cross-sectional design of the study, although based on three surveys conducted over a 6-year span, prevents conclusions about directionality and causality. Regarding the numbers of games controlled for, it should be noted that some categories were broad and contained more than one game (e.g., number games), whereas other games were represented by more than one category (sports betting offshore or with state monopolist). Another limitation is that the present study did not differentiate between online gambling in terms of just placing bets (e.g., sports betting and number games) and online gambling (e.g., online casino games) where the games themselves unfold on the Internet. Still, in both cases, it is arguable that online gambling increases availability, hence the current operationalization is justifiable from such point of view. The second regression model explained less variance than the first. This most likely reflects differences in base rate (in this case, proportion of those who have gambled online) between the two models (0.391 and 0.093), as the outcome in cases where the base rate is close to 0 or 1 is already much determined in contrast to outcomes in which the base rate is close to 0.5 (38). Strengths of the present study are the high number of respondents, the representative samples of gamblers drawn from the National Population Registry, and the use of validated instruments to assess gambling (27), as well as gaming problems (29). The fact that the relationship with online gambling and relevant correlates was analyzed using a multivariable approach, controlling for several confounders is also an asset of the present study. As far as we know, the present study is the first elucidating change over time in terms of online gambling in representative samples.

Conclusions

Among gamblers, online gambling, especially on mobile phones, has increased significantly from 2013 to 2019. Since the consistent predictors of online gambling (both ever and frequent) were found to be male gender, young age, earning high income, not working or studying, having gambling problems, and number of games gambled, responsible gambling initiatives aimed at preventing or minimizing harm related to online gambling (e.g., responsible gambling tools) should thus target those in these groups. In terms of policy implications, the results showing a significant increase in online gambling suggest that gambling

operators should use this as an opportunity to increase their focus on mandatory registered gambling and responsible gambling initiatives, as both are more feasible to implement in online compared to offline gambling settings (39).

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Regional Committee for Medical and Health Research Ethics (REK vest 2013/120). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

SP, RM, AM, and EE designed the study and collected the data. SP drafted the first version of the manuscript and conducted the analyses. RM, AM, JE, PK, and EE critically revised the manuscript. All authors approved the final version of the manuscript submitted for publication.

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Internet Use and Problematic Use in Seniors: A Comparative Study in Switzerland and Poland

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Background: Seniors have been only little considered in studies examining problematic internet use and associated health issues, although they may present risk factors that make them particularly vulnerable for the development of problematic internet use.

Objectives: (1) To compare Internet use and problematic use among seniors in Switzerland and Poland; (2) To examine the relationships between problematic internet use, impulsivity traits and well-being as previous studies showed that internet can be used to cope with negative emotions or life dissatisfaction.

Methods: A cross-sectional survey conducted between June 2016 and April 2017 with 264 older internet users aged above 60 years old recruited in Switzerland (88) and Poland (176) assessing sociodemographic variables, online activities, problematic internet use, impulsivity traits and well-being.

Results: The two groups differed in their reported online activities in that Polish participants reported more searching for information and buying, whereas Swiss participants reported significantly greater problematic internet use than Polish participants. Finally, a multiple linear regression analysis performed on the whole sample indicated that lower well-being and being a Swiss participant were both significantly associated with greater problematic internet use, after age, gender, level of education, impulsivity traits have been controlled for.

Discussion: Swiss seniors showed a more problematic internet use than Polish participants who focused more in their online activities on utility use of internet. The relationships between problematic internet use and well-being suggest that older adults use internet mainly to cope with negative emotion or life dissatisfaction. Socio-cultural differences that could account for these group differences as well as difference with young adults are discussed.

Keywords: problematic internet use, seniors, well-being, impulsivity, cultural differences

INTRODUCTION

The development and spread of the internet worldwide have been contributing to growing concerns among researchers and health professionals about problematic Internet use (PIU), prompting the World Health Organization (WHO) to examine since 2014, its public health implications (1). PIU is an umbrella construct, encompassing distress and functional impairment related to the uncontrolled use of one or more online activities in order to fulfill some specific need such as emotional coping, increased sense of belonging, improved self-esteem (2, 3). This repetitive pattern of use continues over time to an extent in which the subject experiences significant psychosocial (e.g., depression, anxiety, social isolation, academic or professional failures) and physical (e.g., sleep disorders, sedentary life-style, musculoskeletal issues) harms (1). The magnitude of the phenomenon is complex to draw due to the lack of gold standard to measure PIU and to the numerous sampling biases (e.g., youth being the main studied population and schools and universities being the most inclusion sources) (4). These issues have led to uninformative prevalence rates, to heterogeneous screeners used, to the lack of comparativeness between studies and countries and to the lack of data on additional vulnerable subgroups such as seniors (4).

PIU has been considered to result from the interplay of various psychological factors including poor self-regulation capacities, mood regulation and preference for online social interaction, with addictive properties of some online activities (e.g., gambling, gaming) and with a socio-cultural environment (2). Better understanding of PIU requires unveiling underlying psychosocial mechanisms and associated vulnerability factors, as well as examining the singularity of each of the potentially problematic online activities (i.e., gambling, gaming, social networking, porn) and specific environmental contributors (1). This is in line with the recent inclusion of Gambling and Gaming disorders among addictive behaviors category of ICD-11 (5) and with WHO ongoing efforts to develop a gold standard for each of these disorders, considering the vector Internet a facilitating factor only.

Although older adults constitute a part of the population with the lowest level of Internet use ("the digital divide"), Internet access and use among older adults is progressively increasing in Europe and worldwide. For instance, in Switzerland, 10% of older adults aged 60–69 and 1% above 70 were using the internet in 2000 growing to respectively 73 and 45% in 2017 (6). In the US, internet use among adults over 65 years old went from 12% in 2000 to 67% in 2016 (7). In Poland, the percentage of older adults using the internet increased to 77.5% (1.6% more than the previous year) in 2018 (8). A continuous increase of the internet use worldwide can be expected not only because of marketing coverage but also because of the current young adults using the internet will constitute the older users in the future (9).

While the proportion of older adults over 60 continuously increases worldwide, the question arises about the use and potential misuse of the internet in the seniors. The consequences of the internet use in seniors remain a controversial issue though (10). Indeed, on the one hand, some studies underlined the benefits of the internet use in the seniors inasmuch as internet can increase the number of contacts with family and friends, promote the development of new relationships, reduce social isolation and loneliness (11), provide entertainment, maintain social involvement, empowerment and experience of control which in turn increases mental health, life satisfaction and the quality of life (12). The use of internet for telemedicine might also be beneficial for the seniors (13). Finally, internet use in midlife has been significantly associated with a lower dementia incidence in a longitudinal study (14). On the other hand, some researchers stressed that Internet use was significantly associated with decreased time spent with friends and local social networking, which in turn increased loneliness, promotes isolation and marginalization as well as decreased quality of life (15–17). It seems thus likely that a subgroup of seniors presents PIU and associated negative consequences. In comparison to youths and young adults however, seniors have been only little considered in studies examining PIU and associated health issues (1), although they may present risk factors such as a sedentary life style, social isolation/loneliness, psychiatric and neurological disorders (e.g., depression, cognitive impairments) (9). Moreover, economic problems due to the reduction of the income can make them particularly vulnerable for the development of PIU, particularly online gambling disorder (9). Another unresolved question regards the cultural differences for Internet use and misuse and the need for more comparative research on PIU in older adults from Europe and other parts of the world (18, 19).

The first aim of the current study was thus to compare online behaviors among seniors in Switzerland and Poland. The two European countries have a comparable rate of Internet use among seniors (6, 8), and they represent different parts of the continent, which have been shaped by different socio-cultural environment (e.g., religious, economic, political and social systems). A second objective was to examine the association between PIU, impulsivity traits and emotional well-being in seniors from both countries. As frequently stressed in youth and young adults, lack of self-regulation and maladaptive emotional coping seem to play a role in the development of PIU, as internet can be used to cope with difficulties and negatives emotions or life dissatisfaction (20).

MATERIALS AND METHODS

Sample

Subjects consisted of French or Polish-speaking adults internet users aged 60 years or older recruited from June 2016 to April 2017. A total of 374 subjects began the survey (237 Polish and 137 Swiss) of whom 264 (176 Polish and 88 Swiss) were retained for the analyses after removing participants with too many missing data and/or participants reporting no internet use. Subjects' age ranged from 60 to 91 years ($M = 67.0$, $SD = 5.9$) in the Swiss sample (33% women), and from 60 to 84 ($M = 65.9$, $SD = 5.9$) in the Polish sample (57% of women). Regarding, the level of education, 59% of Swiss subjects report having completed higher studies (university level) compared to 22% in the Polish sample.

Questionnaires and Procedure

The Swiss sample was recruited through advertisement in seniors' university or clubs and researchers' private networking (e.g., acquaintances, neighborhood) and were invited to take part to an online survey. The Polish sample was recruited through researchers' private networking (e.g., acquaintances, neighborhood), by applying a snowball sampling procedure (e.g., study participants recruited further participants from among their acquaintances) and participants were administered the survey face-to-face in a paper-and pencil format.

Participants answered items assessing sociodemographic variables (age, gender, level of education), questions on type of online activities (yes/no format) following by three questionnaires assessing compulsive internet use, impulsivity traits and psychological well-being, respectively.

Compulsive Internet Use Scale

The CIUS (21) consisted of the 14 items scored on a 5-point Likert scale from 0 (never) to 4 (very often). The items of the CIUS assess several features of addiction such as loss of control (e.g., "Do you find it difficult to stop using the Internet when you are online?"), preoccupation regarding Internet use (e.g., "Do you think about the Internet, even when not online?"), withdrawal symptoms (e.g., "Do you feel restless, frustrated, or irritated when you cannot use the Internet?"), coping or mood modification (e.g., "Do you go on the Internet when you are feeling down?") and conflict, including inter- and intrapersonal conflict (e.g., "Do others say you should use the Internet less?"). This questionnaire showed fair psychometric properties in various languages, including French and Polish (22). The higher the score, the greater the compulsive use of the internet. In the current study, the internal consistency (Cronbach's alpha) of the scale is 0.92.

Short Urgency-Premeditation-Perseverance-Sensation Seeking-Positive Urgency Impulsivity Behavior Scale

The S-UPPS-P scale (23) is a 20-item self-report measure that assesses five dimensions of impulsivity: positive urgency (e.g., "When I'm happy, I often can't stop myself from going overboard"), negative urgency (e.g., "When I feel rejected, I often say things that I later regret"), (lack of) perseverance (e.g., "I am a person who always gets the job done"), (lack of) premeditation (e.g., "I usually make up my mind through careful reasoning"), and sensation-seeking (e.g., "I welcome new and exciting experiences, even if they are a little frightening or unconventional"). Items are rated on a 4-point scale ranging from 1 (I agree strongly) to 4 (I disagree strongly), with higher scores indicating greater impulsivity. This scale has good internal consistency, test–retest stability, predictive validity and has been validated in various languages (23). Higher score reflects greater impulsivity. In the current study, the internal consistency (Cronbach's alpha) of the subscales range from 0.63 to 0.86.

Short Happiness and Depression Scale

The SDHS (24) consists of six items assessing happiness (e.g., "I feel happy") or depression (e.g., "I feel dissatisfied with my life"). Scale items are scored from 1 (never) to 4 (often). We reversed depression items so that higher scores reflected positive mood. This reverse scoring has been used in the original version of the scale as well as in its shorter form and was shown to be valid (24). The scale thus provides a single continuous measure of the depression–happiness continuum. The SDHS has shown good internal consistency, test–retest reliability, and convergent and discriminant validity in various languages. In the current study, we used a French and, respectively, Polish translation of the SDHS. The scale was translated from English into French and then back-translated from French into English (25). The same procedure was used in Polish. Although there is no validation study of this scale in French or Polish, this scale has been sucessfully used in other studies and showed a good internal consistency (25). In the current study, the internal consistency of the scale (Crobach's alpha) is 0.78.

Statistical Analyses

First, group comparisons on socio-demographic variables, type of online activities and scores on the CIUS, SDHS and S-UPPS-P were performed using Welch two sample *t*-test for continuous variables and Pearson's Chi-squared test with Yates' continuity correction for dichotomous variables. Second, correlation analyses were performed on the whole sample to examine the association between all the variables of interest using Spearman's Rho non-parametric tests. Third, multiple linear regression analyses were used to examine the relationships between PIU and socio-demographical variables (age, gender, level of education), group (Swiss vs. Polish participants), impulsivity traits as well as psychological well-being on the whole sample. All analyses were two-tailed, with a significance threshold set at 0.05. Regarding missing data, when one item was missing, a person-mean imputation was performed. When more than one item was missing, the subject has been removed from the analysis. Thus, the sample size decreases from 88 to 66 and from 176 to 171 participants in the correlation and regression analyses in the Swiss and Polish sample, respectively, because participants with too many missing data (>1) were excluded from the analyses.

Ethics

The study was carried out in accordance with the Declaration of Helsinki and was approved by the local Ethical Committees in both countries.

RESULTS

Group Comparisons

Demographic Data

Group comparisons indicate that the proportion of male and participants with an education at the university level was significantly greater in the Swiss sample than in the Polish sample whereas age was not significantly different between the groups (**Table 1**).

TABLE 1 | Demographical data.

	Swiss sample ($N = 88$)	Polish sample ($N = 176$)	Statistics	
Variables	**M (SD)**	**M (SD)**	***t* (174.9)**	***p*-value**
Age (years)	67.0 (5.90)	65.9 (5.90)	1.40	0.17
	%	**%**	**$\chi^2(1)$**	***p*-value**
Sex (male/female)	67/33	43/57	12.53	<0.001
Educational level (university/no university)	59/41	22/78	32.235	<0.001

Online Activities, CIUS, S-UPPS-P, SDHS

First, social media use and searching for information on the Internet were the two more frequently reported online activities by both groups. Group comparisons indicate that the proportion of participants who use internet for searching for information and buying was significantly greater in the Polish sample than in the Swiss sample. No other online activities reached statistical significance. Second, Swiss seniors reported a significantly greater score on the CIUS as well as on lack of premeditation and sensation seeking than the Polish participants, whereas the Polish seniors showed higher scores on negative urgency. No other comparisons reached statistical significance (**Table 2**).

Correlation Analysis

Correlation analysis between CIUS, socio-demographical variables, impulsivity traits and emotional well-being using Spearman's Rho on the whole sample indicates that PIU as assessed by the CIUS was significantly associated with a lower well-being on the SDHS ($\rho = -0.18$, $p < 0.01$), a greater level of negative urgency ($\rho = 0.19$, $p < 0.01$), lack of premeditation ($\rho = 0.17$, $p < 0.01$), as well as lack of perseverance ($\rho = 0.15$, $p < 0.05$). No other correlation reached statistical significance, including the correlation between level of education and CIUS ($\rho = 0.04$, $p = 0.59$).

Multiple Linear Regression

The multiple linear regression analysis performed on the whole sample indicates that a lower psychological well-being as well as being a Swiss participants were both significantly associated with a higher score on the CIUS, while age, level of education, gender and dimensions of impulsivity were controlled for, $F_{(10,221)} = 3.01$, $p < 0.01$, $adjR^2 = 0.08$ (**Table 3**).

DISCUSSION

This study aimed to compare Internet use and problematic use among seniors in Switzerland and Poland a well as to examine the relationships between PIU, impulsivity traits and psychological well-being. The main results showed that the two groups partly differed in their reported online activities in that Polish participants reported more searching for information and purchase compared to the Swiss sample. However, Swiss participants reported significantly greater PIU than the Polish participants. Finally, lower well-being and being Swiss participants were both significantly associated with PIU while age, gender, level of education, impulsivity traits were controlled for.

First, regarding Internet use, our results corroborate previous studies stressing that online activities have evolved over time and now focus more on social media and search for information. Indeed, internet constitutes a way to maintain or increase contacts with friends or family members, and this may be especially relevant for people with physical disabilities or when family members or friends live abroad. In this context, virtual communication could potentially prevent or reduce seniors' social isolation (26). The results also indicate that the Internet can enable a better access to information such as health-related information, news or access to medicine (13). Group differences stressed between Swiss and Polish seniors could be partly explained by sociodemographic differences (gender and education oportunities) inasmuach as the Polish sample is made of 2/3 by women aged over 60, and <1/4 of this sample reached university degrees. In this context, searching information online may be considered an attempt to close anonymously, affordably and fastly some knowledge gap, especially in the Polish sample. In addition, more frequent purchase on the Internet in the Polish sample may be associated with the economic status inasmuch as the participants could search for instance for sales or cheaper products and/or for products that can be found abroad only. On the whole, the group comparisons indicate that the main group difference resides in a more utilitarian use of Internet (information search and purchasing) by Polish seniors that cannot be accounted for by age, probably to overcome daily obstacles. Tentatively, these differences might also be due to an early stage of digital penetration in that when the Internet becomes more available for seniors, it mainly serves practical daily needs and purposes, whereas with continued availablity it evolves into a more leisure-oriented use. By contrast, young adults might be initially more driven by looking for fun activities online (e.g., gaming) than for practical activities (27). Further studies should more specifically examine the influence of some sociodemographical, geographical and cultural variables (e.g., economic status, religion, urban vs. rural area), as well as expertise with the Internet on types of online activities among seniors.

Second, Swiss seniors reported more PIU than Polish participants. Although in recent years access to the Internet has become increasingly widespread, it has started later for seniors in Poland (28). Indeed, PIU probably requires greater familiarity with the Internet, and ease and flexibility of movement on the web and may then become problematic if vulnerability factors are met. In this perspective, the significant relationships between PIU and psychological well-being suggest that participants use Internet mainly to cope with negative emotion or life dissatisfaction. Indeed, participants with dysphoric mood may search for virtual environments where they can momentarily decrease their negative feelings inasmuch as they can find an infinite amount of distracting online activities including social

TABLE 2 | Group comparisons on type of online activities, CIUS, S-UPPS-P, SDHS scores.

	Swiss sample	Polish sample		Statistics
Variables (dichotomic)	**%**	**%**	χ^2	***p*-value**
Social media (yes/no)	59/41	48/52	2.60	0.11
Information (yes/no)	36/64	68/32	22.14	<0.001
Videos (yes/no)	17/83	9/91	2.86	0.09
Gaming (yes/no)	11/89	7/93	1.05	0.31
Email (yes/no)	11/89	14/86	0.20	0.65
Professional (yes/no)	3/97	6/94	0.46	0.50
Buying (yes/no)	2/98	13/87	6.77	<0.01
Variables (continuous)	**M (SD)**	**M (SD)**	***t***	***p*-value**
CIUS total score	10.5 (8.8)	8.0 (8.6)	2.01	<0.05
S-UPPS-P Negative urgency	8.7 (2.6)	9.6 (2.9)	−2.44	<0.05
S-UPPS-P Positive urgency	10.0 (2.2)	9.9 (2.6)	0.43	0.67
S-UPPS-P Lack of premeditation	7.7 (2.5)	7.0 (2.0)	2.00	<0.05
S-UPPS-P Lack of perseverance	7.1 (2.8)	6.6 (2.4)	1.31	0.19
S-UPPS-P Sensation seeking	9.3 (2.3)	8.0 (2.7)	3.74	<0.001
SDHS	13.3 (3.2)	12.6 (3.2)	1.44	0.15

CIUS, Compulsive Internet Use Scale; S-UPPS, Short UPPS Impulsivity Behavior scale; SDHS, Short Happiness and Depression Scale.

TABLE 3 | Multiple linear regressions by groups on the CIUS total score ($N = 237$).

Variables	Estimate	Std.Err	*t*-value	*p*-value
Age	−0.07	0.10	−0.70	0.49
Sex (male)	0.87	1.13	0.77	0.44
Level of education (university)	−0.63	1.26	−0.50	0.62
Group (Swiss)	3.14	1.40	2.24	< 0.05
S-UPPS-P-Negative urgency	0.34	0.26	1.31	0.19
S-UPPS-P-Positive urgency	0.00	0.31	−0.01	0.99
S-UPPS-P-Lack of premeditation	0.02	0.36	0.05	0.96
S-UPPS-P-Lack of perseverance	0.08	0.31	0.25	0.80
S-UPPS-P-Sensation seeking	0.05	0.24	0.20	0.84
SDHS	−0.71	0.18	−3.90	< 0.001

S-UPPS, Short UPPS Impulsivity Behavior scale; SDHS, Short Happiness and Depression Scale.

media or videos (29, 30). However, in contrast to findings obtained in young adults (31), impulsivity traits were not significant predictors of PIU in seniors in our study. This result suggests that Internet may be use to cope with negative emotion, but that there is no addictive use pattern for most seniors. More generally, the mean level of PIU as assessed by the CIUS is much lower in our sample (10.5 and 8.0 for the Swiss and Polish seniors, respectively) than in a large sample of young adults (mean 24.63 years old) where PIU mean score was 16.03 (22). Taking into account the type of online activities could account for this discrepancy between young adults and seniors inasmuch as some activities carried out by the formers are potentially much more addictive than those carried out by the latters. In particular, online video gaming disorder is a common problem in adolescents and young adults and has been frequently associated with elevated level of impulsivity (32). In our study, gaming was only reported by 11 and 7% of the Swiss and Polish participants, respectively.

Some limitations to the study must be acknowledged. Indeed, the study is cross-sectional, and further research is required to longitudinally confirm the association between impulsivity traits, psychological well-being and/or age in problematic internet use. Furthermore, the sample is self-selected, limiting the generalizability of results to the entire population of older adults using the internet (33) and the representativeness of each sample could be impacted by the different ways the participants were recruited. Moreover, the study relies exclusively on self-reports which have been associated with various biases (e.g., social desirability and lack of insight). We also had a small sample size especially in the Swiss sample. Conclusions should thus be drawn only tentatively.

CONCLUSION

In conclusion, this is the first study to examine excessive Internet use in a sample of seniors. The results also underline the necessity to take into account cultural and socio-demographic background when examining internet use and misuse. The results also indicate that PIU may be present in a subgroup of seniors Internet users and that Internet can be used to cope with negative emotions or life dissatisfaction. Finally, as Internet users are constantly growing in number among seniors, further research are needed to better appraise the psychological, biological, social and cultural underpinnings of PIU in older adults, and to promote effective prevention strategies and tailored treatment.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article are available by the corresponding author, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethical Committee of Faculty of Psychology, Geneva, Switzerland. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SA, LR, MW-D, LZ-L, and SR designed the study, ran the research, discussed the results, and drafted the manuscript. YK participated to the design of the study. JG participated to ethical submission in Switzerland. PA participated to the study design and recruitment procedure for the polish sample. LC participated to the statistical analysis. All authors contributed to the article and approved the submitted version.

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Online Gambling's Associations With Gambling Disorder and Related Problems in a Representative Sample of Young Swiss Men

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Background and Aims: Internet gambling has recently grown in popularity, but relatively little is known about how online and the combination of online and offline (mixed) gambling are associated with gambling disorder (GD) and related problems. The present research examined in a cohort study sample of young Swiss men how their gambling activities and gambling-related problems differed across the spectrum from offline to online gambling.

Sample: A general-population based sample from the Cohort Study on Substance Use Risk Factors (C-SURF), consisting of 5,352 young Swiss men (mean age 28.26 years old).

Measures: The spectrum from exclusively offline to almost exclusively online (>90% of gambling money spent online) gambling was measured using one question about the proportion of gambling money spent online. Total money gambled and time spent on gambling were also assessed. GD severity (range 0–9) was measured using items reflecting the nine DSM-5 GD criteria. The number of gambling-related problems (e.g., financial difficulties, range 0–10), other addictive disorders and mental health problems were also inquired about.

Methods: We estimated a generalised linear model using a count model (negative binomial link function) for GD severity and gambling-related problems associated with the amounts and proportions of money gambled online and offline.

Results: The number of GD criteria were associated with money gambled online (IRR [95%CI] = 2.81 [2.43, 3.24]) and offline (IRR = 2.68 [2.40, 3.00]). This was also found for the number of gambling-related problems (IRR = 2.43 [2.13, 2.79] and IRR = 2.89 [2.59, 3.23]). Compared with exclusively-offline gamblers, mixed gamblers (26–90% of money gambled online) showed the highest levels of GD symptoms and gambling-related problems, followed by the almost-exclusively-online gamblers (≥91% money gambled online) and, overall, these associations were still significant after adjustment for overall involvement in gambling (time spent and money gambled). Levels of other addictive

disorders and mental health problems were higher among mixed gamblers than among offline-only gamblers, but levels among almost-exclusively-online gamblers were not.

Conclusions: Symptoms of gambling disorder and gambling related problems are highest among gamblers engaging in both offline and online gambling. Prevention efforts need to target the combination of offline and online gambling.

Keywords: online gambling, internet gambling, Switzerland, gambling disorder, gambling

INTRODUCTION

Gambling is a common leisure activity in Switzerland, with 69.0% of the general adult population being lifetime gamblers and 55.0% having gambled in the last 12 months (1). Classic gambling activities, like lotteries, betting, card games, and casino gambling, have recently been complemented by online gambling activities. The present research used a sample from a large cohort study of young Swiss men to investigate whether the proportion of online gambling activities was associated with symptoms of gambling disorder (GD), gambling-related problems, other addictive disorders and indicators of mental health. The legal gambling situation in Switzerland has evolved in recent decades. Casino gambling (except in games with very small stakes: a maximum of CHF 5) was forbidden from 1877 to 2000, which led to a long tradition of gambling in nearby casinos abroad. Furthermore, Swiss casino operators were not allowed to offer online gambling services until 2019, and these could only be offered by foreign gambling service providers (2, 3). After a decade-long legislative process, the tables have turned: access to online gambling services based outside Switzerland was outlawed in 2019 and, instead, domestic casinos were given licences to offer online gambling services (2). The first domestic online gambling services were launched half a year after the law was implemented (4).

Although most people do not develop any problems due to their gambling activities, some develop symptoms of GD (5). According to the DSM-5 (5), GD is characterised by repeated problematic gambling behaviour resulting in significant problems or distress. It defines nine criteria for the assessment of GD, e.g., the need to gamble with increasing amounts, chasing losses and unsuccessful efforts to control gambling (5). Indeed, GD is the only *behavioural addiction* currently fully recognised by the DSM-5 (5). The ICD-11 also includes a diagnosis for gambling, with specifiers for predominantly online or predominantly offline gambling disorder (6).

Internet gambling has received increasing interest recently. It allows easy access to many different betting options, instant feedback and continuous gambling with large amounts of money. Therefore, concerns are growing that it may pose a particularly high risk for GD and gambling-related problems (7–9). A review by Gainsbury (7) found that numerous studies had reported associations between internet gambling and gambling disorder. However, these associations were often no longer significant once other variables had been controlled for, notably, overall involvement in gambling (time spent or money gambled) and offline (land-based) gambling (7, 10). According to Gainsbury (7), people who engaged in both online and offline gambling appear to have greater risks of experiencing harm, and the relationship between online gambling and gambling problems may be confounded by land-based gambling. Thus, offline gambling activities and overall involvement in gambling are important factors to consider when assessing the risks related to online gambling. Gainsbury (7) concluded that "Internet gambling does not cause gambling problems in, and of, itself," but internet gambling is more common among highly involved gamblers and may contribute significantly to gambling problems for some of them. A recent study involving more than 9,000 adolescents (10) also concluded that when it came to problem gambling, overall involvement in gambling (time spent and diversity of gambling formats) should be considered rather than internet gambling *per se*. This viewpoint was supported by a study reviewing the gambling policies in 30 European countries. It found that there were no associations between online gambling regulations, gambling licencing systems and legal gambling opportunities, and the prevalence of GD (11). However, a recent study using propensity score matching for offline, online and mixed gamblers found that online gambling alone or in combination with offline gambling posed greater risks to gamblers than offline gambling alone (12).

Gambling is also known to be associated with substance use disorders and behavioural addictions, as well as mental health comorbidities such as major depression or anxiety (13, 14). Regarding the associations between online gambling and mental health comorbidities, findings are heterogeneous across studies (7). A number of studies found higher rates of mental health comorbidities among online gamblers than offline gamblers, whereas others found no such associations. Thus, associations between internet gambling and mental health issues remain unclear (7).

Aims

Internet gambling is a growing concern, but evidence about its association with GD is somewhat inconclusive. Furthermore, potential associations may actually be evolving quickly in conjunction with the development of new policies and online gambling opportunities and supply. Most of the studies that have assessed associations between online gambling and problem gambling only reported on gamblers categorised as offline, online and mixed gamblers, with no consideration of the proportion of their involvement in online gambling. The present study aimed to address this limitation by asking about the actual proportion of money gambled online. It investigated online vs. offline gambling from two complementary perspectives: one using the amount

TABLE 1 | Descriptive statistics for the whole sample.

	Total sample		Gamblers only[a]	
	N	%/mean (SD)	*N*	%/mean (SD)
N Total	5,352		1,526	
Age (years)		28.26 (1.27)		28.31 (1.26)
Linguistic region				
French-speaking	3,111	58.1%	940	61.6%
German-speaking	2,241	41.9%	586	38.4%
Gambling disorder in the past 12 months				
Gambling disorder score		0.09 (0.58)	1,526	0.32 (1.04)
Gambling disorder prevalence				
No (3 criteria or less)	5,311	99.2%	1,485	97.3%
Yes (4 criteria or more)	41	0.8%	41	2.7%
Money gambled per month (CHF; past 12 months)				
No gambling	3,826	71.5%		
CHF 1–50	1,134	21.2%	1,134	74.0%
CHF 51–100	196	3.7%	196	12.8%
CHF 100–200	106	2.0%	106	6.9%
CHF 201–500	59	1.1%	59	3.9%
CHF 501–1,000	20	0.4%	20	1.3%
More than CHF 1,000	11	0.2%	11	0.7%
Mean amount gambled per month (CHF; past 12 months)				
Total		20.74 (91.83)		72.74 (160.63)
Money gambled offline		15.58 (63.96)		54.64 (110.55)
Money gambled online		5.16 (51.79)		18.10 (95.81)
Proportion of money gambled online (past 12 months)				
No gambling	3,826	71.5%		
Offline gambling only	1,066	19.9%	1,066	69.9%
1–25% online	244	4.6%	244	16.0%
26–50% online	55	1.0%	55	3.6%
51–75% online	45	0.8%	45	2.9%
76–90% online	33	0.6%	33	2.2%
≥91% online	83	1.6%	83	5.4%
Gambling activities (days per year) in the past 12 months				
Lotteries		3.97 (16.92)		13.91 (29.43)
Electronic lotteries (tactilo)		0.61 (8.41)		2.14 (15.66)
Machines		0.57 (6.24)		1.99 (11.57)
Tables at a casino		1.05 (7.68)		3.69 (14.04)
Internet		1.69 (15.29)		5.95 (28.2)
Private		0.71 (6.17)		2.51 (11.36)
Other		0.46 (7.79)		1.61 (14.53)

[a]*Gamblers were defined as participants that reported any gambling the past 12 months.*

of money gambled online as a continuous predictor of GD and its related problems, and the other using a categorical approach involving the proportion of total gambling money gambled online.

Specifically, the study's first aim was to test associations between gamblers' involvement in online gambling (using amounts of money gambled online and offline as proxies) and GD symptoms and gambling-related consequences.

The second aim was to investigate online vs. offline gambling from a different approach, testing how GD symptoms and gambling-related consequences differed across the spectrum from offline to almost-exclusively-online gamblers. It would also look at the degree to which these associations were due to greater involvement in mixed and almost exclusively online gambling.

Finally, because findings regarding the associations between online gambling and mental health are relatively few and heterogeneous across studies (7), the study's third aim was to investigate whether other addictive behaviours and indicators of mental health were associated with offline and online gambling in our sample.

METHOD

Sample

Our sample came from the Cohort Study on Substance Use Risk Factors (C-SURF), designed to examine patterns of addictive behaviours and related factors among young Swiss men (15, 16). Enrolment for the baseline assessment in 2010 took place during the recruitment procedures testing fitness for military service, which are compulsory (17) for all young Swiss men, with rare exceptions for those with severe disability, for example. Thus, the sample can be considered to be representative of its source population. Young men were enrolled at three of the six national military recruitment centres (in Lausanne, Windisch and Mels), which cover 21 of Switzerland's 26 cantons. The Human Research Ethics Committee of the Canton of Vaud approved the research protocol for the C-SURF study (protocol 15/07). Overall, 7,556 participants gave their written informant consent to participate at the study after the enrolment procedure, and 5,854 participants were asked to fill out the fourth wave questionnaire on paper or online. A total of 5,368 participants replied to it between April 2019 and November 2020. A sampling flow chart with more details about the study design can be found at https://www.c-surf.ch/en/1.html. Sixteen were excluded because of missing values on main variables, resulting in a sample size of 5,352. Furthermore, 300 participants replied after 14 February 2020. Although their responses may have been affected by the COVID-19 crisis, after careful evaluation, we concluded that the non-response bias introduced by excluding these late-responders [who may differ from early responders; (16)] would have been at least equal to the bias introduced by the COVID-19 crisis and we decided to retain these participants in the sample. As a sensitivity analysis, we provide the main results (**Tables 1**, **2**) without the 300 participants that replied after 14 February 2020 in **Supplementary Tables 1, 2**.

Measures

Gambling-Related Measures

Participants that reported any gambling in the last 12 months were considered as gamblers. The frequencies of seven different gambling activities (internet, lotteries, electronic lottery, machines, tables at a casino, private, other) were measured using a tabular question format, with which participants could indicate how often they did these different activities. Response options were "never," "a few times per year," "multiple times per month," "multiple times per week," and "every day or almost every day." These answers were recoded into days per year.

TABLE 2 | Gambling disorder criteria, gambling problems (financial problems, mental stress, problems at work, etc), gambling frequency and money used by proportion of money gambled online (among gamblers, $N = 1{,}526$).

Proportion of online gambling	Offline gambling only	1–25% online	26–50% online	51–75% online	76–90% online	≥91% online
n	1,066	244	55	45	33	83
Gambling disorder criteria	0.12	0.56	1.29	1.11	1.52	0.69
Number of gambling problems	0.28	1.11	2.24	1.18	1.33	0.45
Hours of gambling per week	0.26	1.25	1.33	2.18	1.58	1.15
Total money (CHF) gambled per month	47.56	103.28	191.82	150.56	220.45	126.51
Money offline	47.56	89.85	118.93	55.71	37.48	5.69
Money online	0.00	13.43	72.89	94.85	182.98	120.81

Time spent gambling was measured using two questions asking subjects how often (recoded to days per week) they gambled in the last 12 months and how many hours they spent gambling on those days. The product of the answers to these two questions was calculated to estimate the hours spent gambling per week.

Just one question was used to ask the proportion of total money gambled online. Response options were "no money gambled online, only offline," "1–25% online," "26–50% online," "51–75% online," "76–90% online," "≥91% online." The proportion of money gambled was chosen as a proxy for the importance of gambling activities. This agreed with a study showing that online gamblers considered money limits to be one of their most important harm reduction strategies (above time limits) (18). Furthermore, numerous studies have reported on problems related to money and indebtedness among online gamblers (19–21). The proportion of total gambling money gambled online could thus be considered as a relevant proxy for assessing involvement in online gambling.

Money gambled was measured using one question asking subjects how much money they had spent monthly on average on gambling over the last 12 months. Response options were from CHF 1–50 to more than CHF 1,000, and these were recoded to CHF (about EUR 0.9 or USD 1.1) gambled per month.

The approximate amounts of money gambled online and offline were calculated in CHF by multiplying the total amount of money gambled by the proportion of money gambled online, using the following weightings: "only offline" (0% online; 100% offline), "1–25% online" (13% online; 87% offline), "26–50% online" (38% online; 62% offline), "51–75% online" (63% online; 37% offline), "76–90%" online (83% online; 17% offline) and "≥91% online" (95.5% online; 4.5% offline).

The primary outcome was GD severity, which was measured using the nine DSM-5 criteria (5) adapted from (22) in a *yes or no* format and with a total score ranging from 0 to 9.

Gambling-related consequences were measured using 10 questions asking how often subjects had experienced those criteria in the last 12 months (e.g., serious financial consequences for oneself or someone close due to gambling). The four response options were "never," "rarely," "sometimes," or "often," and these were recoded to *yes or no* for reasons of parsimony after verification that results were similar to if they had been used as continuous scores. These questions were adapted from the Finnish Gambling Harm Survey 2016 (23).

Other Addictive Behaviours

Alcohol use disorder over the last 12 months was assessed using 12 *yes or no* (scored 1 and 0, respectively) items representing the 11 DSM-5 alcohol use disorder criteria (5, 24, 25). The sum of the item scores, used for the analysis, ranged from 0 to 11.

Cannabis use disorder was measured using the ten-item Cannabis Use Disorders Identification Test [CUDIT-R (26); revised version of (27)], building a score ranging from 0 to 40.

Tobacco use disorder over the last 12 months was measured using the six-item Fagerström test for nicotine dependence (28, 29), forming a score ranging from 0 to 10.

Internet addiction was measured using the Compulsive Internet Use Scale (CIUS), consisting of 14 five-point Likert scale items (30–33). Summing their results built a score ranging from 0 to 56.

Gaming addiction over the last 6 months was measured using the seven-item (five-point Likert scale) Game Addiction Scale (34, 35), resulting in a score ranging from 0 to 28.

Participants were asked how often over the last 12 months they had used illicit substances (or substances not intended for consumption) from a list of 16 substances: ecstasy, cocaine, heroin, methadone, hallucinogens (multiple), khat, poppers, amphetamines, crystal meth, inhalants or solvents, ketamine, GHB, research chemicals, and spice. Response options were "never," "1–3 times" (recoded as 2), and "≥4 times" (recoded as 4), and their sum was built into an approximate frequency of illicit drug use, with a score capped at 20.

Mental Health Indicators

Symptoms of social anxiety disorder (SAD) during the past week were assessed using the Clinically Useful Social Anxiety Disorder Outcome Scale (CUSADOS), measured via 12 five-point Likert scale items, forming a score ranging from 0 to 48.

Life satisfaction was assessed using the Satisfaction with Life Scale (36), consisting of five items with response options from 1 (strongly disagree) to 7 (strongly agree). The sum of the items ranged from 5 to 35.

The severity of major depression over the last 2 weeks was assessed using the Major Depression Inventory [WHO–MDI;

TABLE 3 | Negative binomial regression (IRR [95% CI]) on gambling disorder symptoms, gambling problems, other addictive disorders and mental health variables by money (per CHF 100) gambled online and offline.

	Bivariate		Multivariable	
	Online	Offline	Online	Offline
Gambling disorder and related problems (negative binomial count regression; IRR [95% CI])				
Gambling disorder criteria	**2.81 [2.43, 3.24]**	**2.68 [2.40, 3.00]**	**1.87 [1.66, 2.12]**	**2.04 [1.82, 2.29]**
Gambling-related problems	**2.43 [2.13, 2.79]**	**2.89 [2.59, 3.23]**	**1.50 [1.35, 1.67]**	**2.44 [2.18, 2.72]**
Addictive disorders (negative binomial count regression; IRR [95% CI])				
Alcohol use disorder	**1.09 [1.02, 1.17]**	**1.11 [1.05, 1.17]**	1.05 [0.98, 1.13]	**1.09 [1.03, 1.16]**
Cannabis use disorder	1.06 [0.98, 1.16]	**1.12 [1.06, 1.18]**	0.97 [0.89, 1.06]	**1.13 [1.06, 1.20]**
Tobacco use disorder	**1.17 [1.10, 1.26]**	**1.21 [1.14, 1.30]**	**1.11 [1.04, 1.19]**	**1.17 [1.10, 1.25]**
Illicit drug use	**1.19 [1.10, 1.30]**	**1.17 [1.11, 1.24]**	**1.10 [1.01, 1.19]**	**1.14 [1.07, 1.21]**
Gaming addiction	**1.17 [1.08, 1.26]**	**1.12 [1.06, 1.17]**	**1.10 [1.02, 1.20]**	**1.08 [1.02, 1.14]**
Internet addiction	**1.12 [1.05, 1.20]**	**1.04 [1.00, 1.09]**	**1.11 [1.04, 1.20]**	1.01 [0.96, 1.06]
Mental health indicators (linear regression; b [95% CI])				
Major depression	**0.55 [0.14, 0.95]**	**0.47 [0.13, 0.80]**	**0.43 [0.02, 0.85]**	**0.38 [0.03, 0.72]**
Social anxiety disorder	**0.58 [0.16, 1.00]**	**0.63 [0.28, 0.97]**	0.41 [-0.02, 0.85]	**0.54 [0.19, 0.89]**
Life satisfaction	**-0.49 [-0.82,−0.17]**	**-0.43 [-0.70,−0.17]**	**-0.38 [-0.72,−0.05]**	**-0.36 [-0.63,−0.09]**

Bold coefficients are significant at p-value < 0.05. Adjusted for age and linguistic region. Bivariate analyses are only adjusted for age and linguistic region, with separate models for money gambled online and offline. In multivariable analyses, money gambled online and offline were entered into the model simultaneously.

(37, 38)], consisting of 12 items on a six-point Likert scale and used to form 10 criteria and a score ranging from 0 to 50.

Statistical Analysis

Descriptive statistics were calculated for the overall sample and by category of the proportion of money gambled online. For Aim 1, negative binomial regressions were used to test associations between the outcomes' GD criteria and gambling-related problems. In a first step, this was done bivariately, and in a second step, amounts of both online and offline money were entered into the regression model together. The resulting coefficients were multiplied by 100 and then log transformed to get an incidence rate ratio (IRR) per CHF 100 gambled (for better readability) and a *beta* per CHF 100 gambled for the linear regression models for other addictive disorders and indicators for mental health. For Aim 2, differences in GD symptoms and gambling-related problems across the spectrum from offline to online gambling were tested using negative binomial regressions, with offline-only gamblers being the reference group. IRRs are reported for negative binomial regressions. In a second step, these analyses were adjusted for the time spent and money gambled to account for differences in involvement in gambling. The prevalence for each of the 10 gambling related problems and of reporting any of the 10 problems was calculated separately for each category of the proportion of money spent online. Chi-square tests were performed to test whether these individual problems differed significantly across the spectrum from offline to online gambling. For Aim 3, the analyses made for amounts of money gambled online and offline (as in Aim 1) and for the spectrum from offline to online gambling (as in Aim 2) were repeated for addictive disorders (using negative binomial regressions) and mental health indicators (linear regressions). All analyses were adjusted for age and linguistic region (French vs. German) and carried out using SPSS 25 software.

RESULTS

Descriptive statistics are presented in **Table 3**. In the past year, 28.5% of the sample had gambled. The most frequent gambling activity was playing lotteries (3.97 days per year on average), followed by internet gambling (1.69 days per year). About 20% of the sample only gambled offline, 4.6% mostly gambled offline (1–25% of total money spent on gambling gambled online), 2.4% were mixed gamblers (25–90% of money gambled online), and 1.6% were almost-exclusively-online gamblers (≥91% of money gambled online). Of the total sample, 0.8% showed 4 or more DSM-5 GD symptoms, corresponding to 2.7% of gamblers.

Amount of Money Gambled Online and Offline

Table 1 shows the results of regression analyses for GD criteria and gambling-related problems as predicted by money gambled online and offline. The number of GD criteria was associated, in a similar magnitude, with money gambled online (IRR [95% CI] = 2.81 [2.43, 3.24]) and offline (IRR = 2.68 [2.40, 3.00]) and with gambling-related problems (IRR = 2.43 [2.13, 2.79] and IRR = 2.89 [2.59, 3.23]). These associations were somewhat attenuated if the amounts of money gambled online and offline were entered into the same model, indicating that they both contributed to some degree to GD and related problems in the same individuals. However, they both contributed significantly in the multivariate models. As regards addictive disorders and mental health indicators (except for cannabis use disorder), amounts of money gambled online and offline were significantly associated with higher levels of addictive disorders and mental health

TABLE 4 | Negative binomial regression (IRR [95% CI]) on gambling disorder criteria, gambling problems, other addictive disorders and mental health variables by proportion of money gambled online.

	Non-gambler	Offline only	1–25% online	26–50% online	51–75% online	76–90% online	≥91% online
n	3,826	1,066	244	55	45	33	83
Gambling disorder criteria (negative binomial count regression)							
Unadjusted	n.a.	ref.	**4.77 [3.60, 6.32]**	**11.46 [7.67, 17.11]**	**9.47 [6.06, 14.82]**	**13.12 [8.10, 21.24]**	**6.10 [4.14, 9.00]**
Adjusted for time spent and money gambled	n.a.	ref.	**3.83 [2.87, 5.13]**	**6.74 [4.39, 10.35]**	**6.21 [3.87, 9.96]**	**6.12 [3.56, 10.50]**	**3.80 [2.48, 5.81]**
Gambling-related problems (negative binomial count regression)							
Unadjusted	n.a.	ref.	**3.95 [3.17, 4.90]**	**8.29 [5.87, 11.70]**	**4.20 [2.76, 6.39]**	**4.89 [3.05, 7.84]**	**1.60 [1.06, 2.42]**
Adjusted for time spent and money gambled	n.a.	ref.	**3.43 [2.75, 4.28]**	**5.17 [3.58, 7.46]**	**2.56 [1.62, 4.06]**	**2.15 [1.25, 3.70]**	0.90 [0.56, 1.45]
Addictive disorders (negative binomial count regression)							
Alcohol use disorder	**0.76 [0.69, 0.83]**	ref.	1.07 [0.89, 1.29]	**1.56 [1.12, 2.17]**	1.21 [0.83, 1.78]	1.36 [0.88, 2.10]	0.96 [0.71, 1.30]
Cannabis use disorder	**0.83 [0.76, 0.90]**	ref.	1.10 [0.93, 1.31]	**2.11 [1.55, 2.88]**	0.80 [0.54, 1.19]	1.19 [0.78, 1.81]	1.14 [0.86, 1.50]
Tobacco use disorder	**0.77 [0.70, 0.84]**	ref.	**1.28 [1.07, 1.54]**	**1.61 [1.14, 2.27]**	1.04 [0.69, 1.57]	1.23 [0.77, 1.95]	0.91 [0.66, 1.25]
Illicit drug use	0.93 [0.84, 1.02]	ref.	**1.84 [1.54, 2.19]**	**2.96 [2.16, 4.05]**	**1.57 [1.07, 2.28]**	0.51 [0.28, 0.90]	1.17 [0.87, 1.59]
Gaming addiction	1.02 [0.94, 1.10]	ref.	**1.37 [1.16, 1.61]**	**2.12 [1.57, 2.87]**	**1.75 [1.25, 2.44]**	**1.60 [1.08, 2.37]**	1.21 [0.94, 1.58]
I nternet addiction	0.98 [0.91, 1.06]	ref.	1.11 [0.96, 1.28]	**1.51 [1.14, 2.01]**	**1.39 [1.02, 1.89]**	**1.66 [1.16, 2.38]**	**1.28 [1.02, 1.62]**
Mental health indicators (linear regression)							
Major depression	−0.15 [−0.69, 0.39]	ref.	**1.11 [0.01, 2.20]**	**4.09 [1.98, 6.21]**	1.21 [−1.14, 3.56]	2.18 [−0.52, 4.88]	1.09 [−0.65, 2.83]
Social anxiety disorder	−0.07 [−0.62, 0.48]	ref.	**2.10 [0.98, 3.23]**	**5.16 [2.99, 7.33]**	**3.40 [0.99, 5.82]**	**4.18 [1.41, 6.96]**	0.18 [−1.61, 1.97]
Life satisfaction	0.28 [−0.15, 0.71]	ref.	**−1.33 [−2.20,−0.46]**	**−2.48 [−4.18, −0.79]**	−1.39 [−3.26, 0.48]	−1.85 [−4.02, 0.32]	−0.70 [−2.10, 0.69]

Bold coefficients are significant at p-value < 0.05. Adjusted for age and linguistic region. N.a., not applicable because not assessed in non-gamblers.

problems, and with lower levels of life satisfaction. As a sensitivity analysis, we provided results for **Tables 1**, **2** without the 300 participants (of which 92 actually gambled in the last 12 months) that replied after 14 February 2020 in **Supplementary Tables 1, 2**. Overall, for the outcomes gambling disorder and gambling related problems, coefficients were slightly higher without these 300 participants, while they tended to be slightly lower (in some cases just below significance) for substance use disorders and mental health outcomes.

Differences Across Groups From Offline to Online Gamblers

Hours per week spent gambling and money gambled per year were lowest in the offline gambling group, peaked in the mixed group and were again a bit lower in the almost exclusively online gambling group (**Table 4**). **Figure 1** shows seven gambling activities across the spectrum from offline to online gambling. The most frequent gambling activity among offline gamblers was playing lotteries. The most frequent activity among mixed gamblers was also playing lotteries, but other activities such as playing tables at a casino were also more frequent than among offline-only gamblers. Among the almost exclusively online gambling group, playing lotteries was the only other somewhat regular gambling activity, with gambling at a casino or on machines being quite rare in this group.

Compared to exclusively-offline gamblers, numbers of GD symptoms were significantly higher among mostly-offline gamblers (1–25% gambling money spent online; IRR = 4.77 [3.60, 6.32]), mixed gamblers (26–50%: IRR = 11.46 [7.67, 17.11]; 51–75%: IRR = 9.47 [6.06, 14.82]; 76–90%: IRR = 13.12 [8.10, 21.24]), and almost-exclusively-online gamblers (IRR = 6.10 [4.14, 9.00]), with the peak being among mixed gamblers (see **Table 4** for means and **Table 2** for regression results). These coefficients were attenuated after adjustment for involvement in gambling (time spent and money gambled) but nevertheless remained high and significant. Results for numbers of gambling-related problems were similar, but the coefficient for almost-exclusively-online gamblers was no longer significant after adjustment for the time spent and money gambled. Individuals' gambling-related problems showed a similar pattern overall: they were lowest among offline gamblers, highest among mixed gamblers and in-between among almost-exclusively-online gamblers (≥91% money gambled online) (**Table 5**). Differences across categories of proportion of money spent online were significant for all 10 individual gambling related problems. The most frequently reported problems among almost-exclusively-online gamblers were reduced performance at school or work (8.4%), sleep problems (7.2%), serious financial problems for oneself (8.4%) and mental stress (7.7%). In contrast, interpersonal problems and serious financial problems for someone else were reported relatively rarely.

Regarding more distal correlates, offline gamblers showed significantly higher levels of alcohol, cannabis, and tobacco use disorder than non-gamblers, but not for illicit drug use, gaming and internet addiction, nor for indicators of mental health (**Table 5**). Compared to offline gamblers, there was a general tendency for mixed gamblers to show higher levels of addictive disorders, depression and social anxiety disorder; they also

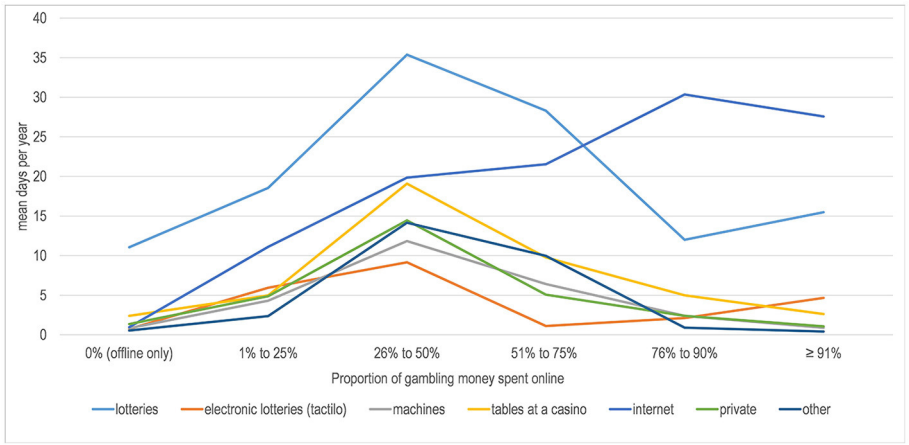

FIGURE 1 | Gambling activities (days per year in the last 12 months) by proportion of money gambled online.

TABLE 5 | Specific gambling-related problems (proportion at least once in the last 12 months) by proportion of money gambled online, and chi-square tests for overall differences across proportion of money spent online (among gamblers, $n = 1,526$).

	Offline gambling only	1–25% online	26–50% online	51–75% online	76–90% online	≥91% online	Total all gamblers	Chi-square (df = 5)	*P*-value
n	1,066	244	55	45	33	83	1,526		
Serious financial problems	3.3%	12.9%	21.8%	13.6%	24.2%	8.4%	6.6%	75.74	<0.001
Serious financial problems for someone close	3.4%	10.4%	23.6%	13.6%	12.1%	1.2%	5.6%	64.82	<0.001
Mental stress (depression, anxiety, etc.)	3.1%	13.3%	25.5%	13.6%	15.2%	7.2%	6.4%	80.14	<0.001
Relationship problems (with partner, family)	2.9%	12.1%	18.2%	13.6%	18.2%	1.2%	5.5%	69.40	<0.001
Serious health problems or injury	2.3%	9.6%	18.2%	9.1%	3.0%	1.2%	4.2%	57.46	<0.001
Serious problems at work or school	1.9%	8.3%	18.2%	11.4%	9.1%	2.4%	4.0%	60.80	<0.001
Reduced performance at work or school	2.3%	10.8%	20.0%	15.9%	12.1%	8.4%	5.3%	71.35	<0.001
Sleep problems	2.6%	9.6%	23.6%	11.4%	15.2%	7.2%	5.3%	70.92	<0.001
Increased tobacco use	4.2%	14.2%	30.9%	9.1%	15.2%	4.8%	7.2%	80.93	<0.001
Increased alcohol use	2.9%	11.3%	23.6%	9.1%	9.1%	2.4%	5.3%	69.30	<0.001
Any of the above problems	9.8%	28.3%	47.3%	24.4%	30.3%	18.1%	15.4%	108.92	<0.001

Questions were phrased as "How often did gambling games cause these problems in the last 12 months?".

showed lower life satisfaction, but this did not reach significance in all categories of mixed gamblers. Almost-exclusively-online gamblers (≥91% of money gambled online) generally showed few differences from offline-only gamblers, and this only reached significance for internet addiction.

DISCUSSION

The present study had three aims. First, to analyse the association between online and offline gambling involvement and GD symptoms and gambling-related problems. Second, to look at groups of gamblers according to their proportion of online and offline gambling on GD and problems, and third, to look at the associations between on- and offline gambling with other addictive behaviours and mental health.

Overall, our participants spent about three times as much gambling money offline than online. Two thirds of gamblers (69.9%; 19.9% of the total sample) gambled exclusively offline, and this group spent considerably less time gambling and gambled less money than those who also played online. Mixed gamblers (1–90% of gambling money spent online) represented

7.0% of the total sample (30.1% of gamblers), whereas almost-exclusively-online gamblers (≥91% of money gambled online) represented about 1.6% (5.4% of gamblers).

As regards our first aim, we found that both the amount of money spent on- and offline were associated with GD and gambling-related problems. These findings were consistent with a recent meta-analysis that found that both internet gambling and offline gambling activities were strong risk factors for problem gambling (39).

As regards our second aim we categorised participants into groups according to the proportion of money they gambled online and compared them (offline, mixed and almost-exclusively-online gamblers) with respect to gambling-related problems. Mixed gamblers spent a lot more time and more money on gambling than exclusively offline gamblers, and they showed higher levels of GD criteria and gambling-related problems. However, almost-exclusively-online gamblers (≥91% of money gambled online) fell in-between offline and mixed gamblers as regards time spent, money gambled, GD criteria and gambling-related problems. Thus, there appeared to be an inverse-U shaped association across the spectrum from offline to online gambling and gambling-related problems, with problems peaking among mixed gamblers. These findings were in line with the review by Gainsbury (7) and some newer studies (12, 40) reporting that gambling-related problems were highest in mixed gamblers. However, Gainsbury (7) conclusion that online gambling may be mainly related to GD through the greater involvement in gambling seen among online gamblers was only partly consistent with our results. In our first approach—the multivariate analysis of the amount of money gambled online and offline—online gambling remained a significant predictor of GD and gambling-related problems, even after adjustment for offline gambling. In our second approach, the differences between groups of gamblers, ranging from offline to online gamblers, were still significant after adjustment for involvement in gambling (money gambled and time spent), except for the almost-exclusively-online gamblers with respect to gambling-related problems. Thus, our results were partially consistent with earlier findings (7, 10) in that the association of internet gambling and GD is in part due to overall involvement in gambling. However, our study revealed that involvement in online gambling remained an important factor even after adjustments for money gambled offline and overall involvement in gambling. Thus, online gambling is a risk factor for GD, especially when combined with offline gambling.

Regarding specific gambling-related problems, it is noteworthy that almost-exclusively-online gamblers reported interpersonal problems and financial problems for someone close rarely especially compared to mixed gamblers. A possible explanation for this is that online gambling can more easily be kept secret from one's entourage and may be less noticeable; it may therefore create fewer interpersonal conflicts, especially for young men who have fewer social roles and responsibilities than older adults. In line with these findings about interpersonal conflicts, almost-exclusively-online gamblers did not have higher levels of social anxiety disorder than offline gamblers, whereas mixed gamblers did. This is particularly remarkable because one might expect individuals with higher levels of social anxiety disorder to tend to engage in solitary gambling activities online (41). However, based on our data, it could be hypothesised that mixed gamblers more often encounter interpersonal conflict, leading to greater feelings of shame in social interactions and thus symptoms of social anxiety disorder, whereas almost-exclusively-online gamblers report less interpersonal conflict and fewer symptoms of social anxiety disorder.

As regards our third aim, compared to offline gamblers, our sample's mixed gamblers (especially those gambling 26–50% of their money online) reported higher levels of other addictive disorders (alcohol, cannabis, tobacco, illicit drug use, gaming, and internet), major depression and social anxiety disorder, and they also showed lower life satisfaction. Almost-exclusively-online gamblers, however, only showed a significantly higher level of internet addiction, which is unsurprising given that online gamblers probably spend more time on the internet than offline gamblers.

Overall, both online and offline gambling are associated with gambling disorder, gambling-related problems, other addictive disorders and mental health problems. Compared to offline-only gamblers, gamblers engaging in both offline and online gambling appeared to be at a higher risk not only of GD and gambling-related problems but also of other addictive disorders and mental health problems. To date, findings in the literature about associations between gambling and mental health comorbidities have been heterogeneous, with some studies finding an increased risk for mental health comorbidities in online gamblers, while others did not (7). Thus, our findings add one more piece of evidence to the existing literature and point to the importance of considering subjects' degree of involvement in online and offline gambling when investigating associations between online gambling and mental health.

Limitations

Although our sample only included young Swiss men, young men are a group with a high risk of gambling-related problems. Our general population-based sample provided a different perspective from surveys among gamblers only. The case numbers of individuals with serious gambling problems were small, therefore any conclusions applicable to clinical practise should be done so with great care. Our study did not include detailed measurements of the precise gambling activities engaged in online and offline or the amounts of money gambled and time spent on those individual activities. Such information would be valuable to gain a better understanding of which specific gambling activities were most associated with gambling-related problems. Furthermore, the cross-sectional nature of our results precludes any inference as to the direction of causality, i.e., whether online gambling causes problem gambling or whether gamblers with existing problems tend to use online gambling more often as it is readily available. Finally, about 5% of our sample were late responders, replying to our survey after the onset of the COVID-19 crisis in Switzerland in February 2020, which may have affected their gambling behaviour. However, the time frame for the questions asked was "in the last 12 months," and we provided

a sensitivity analysis without these 300 participants and the results were overall similar, however, in some cases, coefficients were no longer significant without these 300 participants. Overall, the inclusion of these late responders did not alter the conclusions drawn from our study. We decided to use the full sample because excluding late responders (who may differ from early responders) (16) may introduce another type of bias.

Conclusion

We used two complementary analytical approaches to investigate the associations between involvement in online gambling and gambling-related problems in a large general-population sample of young Swiss men. In our first approach (Aim 1), online gambling and offline gambling both contributed to gambling disorder symptoms and gambling-related problems, and both were associated with other addictive disorders and mental health problems. Our second approach (Aim 2) showed that the peak involvement in gambling, gambling-related problems and mental health comorbidities (Aim 3) was among mixed gamblers. Thus, it appears that the combination of offline and online gambling is associated with most gambling-related problems. Prevention efforts should address both online and offline gambling, but they should also consider interactions between these two domains of gambling. Apart from their risks, online gambling environments may also provide good opportunities to promote responsible gambling using tools that can be personalised to the individual gambler (7). It could also be an environment in which to develop and offer a wide range of gambling-related harm-reduction strategies (18). From a public health perspective, it will be important to monitor further developments in online and offline gambling and to adapt future policies to reduce the impact of online and offline gambling on public mental health.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Human Research Ethics Committee of the Canton of Vaud. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SM contributed to the questionnaire design, conducted the data analysis, and wrote the initial draft of the manuscript. MW, GG, JS, and YK contributed to the questionnaire design, data analysis plan, interpretation of the results, and the writing of the manuscript. GG was responsible for the development of the questionnaire and supervised the data collection, and the writing of the manuscript. All authors approved the final version of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2021.703118/full#supplementary-material

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Impact of Advertising Campaigns Among Online Gamblers: The Role Perceptions of Social Support and Personality Traits

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Background: Few studies on problematic gamblers have focused on how environment and personality interact in gambling behavior. The aim of this research is to investigate how social support, dimensions of personality, and advertising campaigns are associated with gambling among problematic or moderate-risk gamblers and recreational gamblers and associated with online gambling (i.e., sport and poker).

Methods: One hundred nine participants (45% problematic or moderate-risk gamblers) answered an online survey including social support, five factor models of personality, typology of gamblers, and several sociodemographic variables.

Results: We found that problematic and moderate-risk gamblers were significantly more sensitive to gambling advertisements compared to light players. Social support was significantly lower among online gamblers compared to offline gamblers, but no association was found between social support and type of gamblers. Problematic and moderate-risk gamblers presented lower levels of extraversion compared with recreational gamblers. Notably, when the onset of gambling is before 18 years old, participants had more chances to recall more gambling advertisements as adults.

Conclusion: We propose that future longitudinal research should focus on characteristics of online gamers particularly regarding social support to understand this low level of adequacy compared to offline gamblers.

Keywords: social support, big five model, personality, gambling advertisements, online gambling

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INTRODUCTION

Filling the Gap About Cognitive Antecedents of Advertising Influence

Gambling encompasses a variety of games, from gaming machines, casino gambling, lotteries, poker, animals, to sports betting. In addition, the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition [DSM-5, (1)] reclassified gambling disorder as a pathology, indicating a better identification of the phenomenon and his importance. In France in 2020, a study in the general population indicated that 74% gambled at least one time during their life and 47% in the last 12 months (2). Few studies have been conducted on the impact of advertising for gambling, but as a first approximation [see (3)],

parallels can be drawn with advertising for other types of substances [see for example, (4)]. For example, studies on tobacco and alcohol showed that greater exposure to advertising is associated with more positive attitudes, intentions, and actual consumption (5). Adolescents seem particularly receptive to gambling campaigns. Minors report receiving numerous emails promoting the game; they recall television campaigns, and non-gamblers may be encouraged to gamble (6, 7). Advertising gambling campaigns on social media or mainstream media produce the same behaviors among young people (8). Among adults, recreational gamblers are less influenced by advertising campaigns than problem gamblers (8). Among problem gamblers, a Swedish study indicates that 25% of them felt a strong incentive to gamble after watching campaigns, and 50% felt a moderate incentive. Nonetheless, the study does find that gambling campaigns trigger impulsiveness to gamble (9). Promotional offers appear to be a factor that increases the incentive to gamble for all players. While these offers do not appear to drive recreational gamblers toward problem gambling (10), problem gamblers indicate that these promotional offers increase their gambling problems (11). Moreover, looking at long-term memory and declaration of recollection, discordant results are found in the literature: a correlation is sometimes found between the recall of advertising campaigns and gambling severity (12, 13) and sometimes not (10).

Hence, the bulk of these studies have focused on external determinants—such as the advertising environment—of gambling (3). To date, few studies focused on the relationship between exposure to gambling advertising and gambling attitudes, intentions, and behavior, but rather focused on gambling intentions. In this article, we provide novel, self-reported, observational data on how internal, self-regulatory factors influence gambling, that is (i) subjective, perceived social support and (ii) personality traits of gamblers on the severity of their gambling addiction and sensitivity to gambling advertising. All data was collected online.

Social Support and Personality Factors as Self-Regulatory Factors in Gambling

Self-regulation is defined as the ability to regulate emotional, cognitive, and behavioral responses, allowing individuals to select the most appropriate responses to external demands. Research shows that cognitive processing of emotional stimuli is involved in the etiology and maintenance of various psychopathologies. For example, anxiety is associated with an attentional bias toward threatening stimuli (14), and a decreased ability to self-regulate is associated with chronic anxiety (15) and the maintenance of addictive behavior (16). Thus, differences in self-regulatory abilities are likely to be involved in the perception and recall of advertisements representing relevant, appetitive stimuli for the participant [see (17–19)].

Here, we will focus on two factors influencing self-regulation: social support, in that it contributes to effective emotional regulation, and the influence of personality traits, particularly traits involved in emotional feeling (i.e., neuroticism, extraversion, and agreeableness).

Social support could be defined as the connections that individuals have with significant non-professional others in their social environments, the perceived social support resulting from the cognitive appraisal of being reliably connected to others, or the assistance that others realize when they help other people (20, 21). Social support seems to have a protective role in mental health, as it reduces anxiety and depression (22) and decreases the possibility of psychological distress. In the general population, some differences are noted: women usually report higher social support levels than men (23), with a greater socioeconomic situation that contributes to higher perceived social support (24). In the field of addiction, social support seems to be a protective factor, too. For alcohol-dependent people, social support perceived by friends and partners prevent risks against relapse, and for MacDonald (25), the higher the social support (i.e., number of individuals and quality of social support), the more abstinence is successful. A higher social support is predictive to an earlier onset of care, less relapse, and peers contribute to better emotion regulation.

Several studies looked at the link between social support and gambling. In a meta-analysis in adolescents and young adults' gamblers, social support appears to be a protective dimension of gambling addiction (26). Indeed, young problematic gamblers report having a lower social support (27, 28). Among adult gamblers, studies show a strong relationship between social support and problematic gambling (29). More precisely, problematic male gamblers tend to report less social support than occasional gamblers (30). With problem gamblers on treatment, social support is positively correlated with treatment success (21), gambling abstinence, and lower relapse rates (31). Social support can also be found among fellow players. Conversely, several studies indicate a lower prevalence among older people compared to younger (32). A study carried out among a population of older people living in a rural place shows that the more people gambled around tables, the more they reported having strong and quality social support (33). We emphasize here that social support is an individual variable in that it refers to an individual's perception of the quality and satisfaction with the social support received.

Eventually, since the 2000s, personality traits and pathological gambling have been extensively studied (34, 35). Pathological gamblers appear to have, on average, lower Consciousness and Agreeableness scores, and a higher Neuroticism score (34). In addition, other studies highlight a lower opening in non-pathological gamblers (36–38). Differences are noted between the type of game involved and personality traits. People who invest in card games, bingo, or dice games have higher levels of Extraversion and Agreeableness compared to other gamblers. People with lower agreeableness scores invest more in solitaire games such as slots or the lottery, which requires less social interaction (39). Furthermore, the ability to associate stimuli and form judgments about them depends in part on the participant's personal traits (40). The links between personality traits and the impact of advertising have been little investigated in the scientific literature. Nevertheless, insofar as certain personality traits are associated with a greater propensity to react negatively to stimuli and to feel these negative emotions (i.e., neuroticism), it is likely that this emotional feeling will influence the perception and memory encoding of stimuli. Similarly, because evaluative learning (i.e., the formation of judgments toward a neutral object)

depends primarily on contingency awareness, i.e., the ability to detect the co-occurrence of stimuli and associate them in memory [see (41) for a review], neuroticism is expected to play a central role in the recognition and recall of advertisements. As a first step in this direction, we focused on the impact of the Five-Factor Model on advertising influence.

Study Rationale

Overall, studies investigated the social support in a population of pathological gamblers with low perceived social support. Because emotion regulation and physiological stress is a modulator of executive functioning via its influence on vagal tone (42), stress, and emotion regulation can impact the memorization of advertising messages, and the perception of their content: individuals who are more vulnerable to stress are more likely to perceive messages including a relevant, gambling-related, stimulus, and show better memorization of these messages. Since social support improves emotion regulation, it can be assumed that better social support will lead to better emotion regulation and thus to reduced sensitivity to appetitive, advertising stimuli. A similar reasoning can be made about personality traits, which are involved in emotion regulation [see (43) for a review].

We focus mainly on young people and pathological gamblers who have started a therapeutic protocol. The present study is intended to capture social support among a variety of gamblers looking at problematic gamblers vs. none and looking at online vs. offline gamblers or both. Additionally, the multiplicity and diversity of protocols evaluating the impact of gambling campaigns complicates the understanding of this phenomenon. Through an original protocol using campaign slogans disseminated in 2018, the objective of this study is to understand the way in which gambling campaigns influence recall, incentive, and gambling behavior. Furthermore, we looked at personality traits across a diversity of sociodemographic and psychological variables that will increase knowledge in this domain. Hence, in this study, we first hypothesize that pathological gamblers perceived lower social support than moderate, or no risk gamblers, and online and mixed gamblers perceived lower social support than offline gamblers. We also expect that pathological gamblers show a higher score of Consciousness and Agreeableness and a lower score of Extraversion than no risk gamblers. Second, we expect a greater recall, incentive, and behavior intentions after watching or hearing an advertising campaign for (i) severe-risk gamblers vs. non-risk gamblers and (ii) for online and mixed gamblers vs. offline gamblers.

METHODS

Participants

Participants were recruited through the social media site Facebook and online gambling forums (poker-academie.com, clubpoker.net, communaute-forum.pmu.fr). Participants were required to be 18 years of age or older, have gambled at least one time in the 12 last months, and lived in France during that period. Excluded from the study were people who did not speak French. One hundred fourteen adults were recruited. Five respondents were excluded because three did not gamble for the last 12 months and two did not live in France for the last 12 months. Analyzes were conducted on 109 (77 men, 32 women). Participants are 35.8 years old on average (SD = 11.9). All demographics are reported in **Table 1**. Participants completed the study online.

TABLE 1 | Participants demographics.

	N (%)
Gender	
Men	77 (70.6)
Women	32 (29.4)
Level of education	
None	1 (0.9)
Under high school diploma	10 (9.1)
high school diploma or similar	23 (21.1)
high school diploma more 2 or 3 years	32 (29.3)
high school diploma more 4 years	43 (39.4)
Living space	
Own housing	91 (83.5)
To friends or family	16 (14.7)
To institution	2 (1.8)
City size	
Very small city (<5,000 citizens)	29 (26.6)
Small city (between 5,000 and 20,000 citizens)	24 (22)
Medium city (between 20,000 and 50,000 citizens)	16 (14.7)
Big city (more than 50,000 citizens)	40 (36.7)
Age	Mean (standard deviation)
	35.8 (11.9)

Procedure

Before accessing the questionnaires, participants were informed of the study objectives, the academic framework in which it is registered, the criteria for inclusion and exclusion, the anonymity of the information collected, and the possibility of stopping the filling at any time without any information being recorded. An email address has been created to answer participants' questions and disseminate results of the study. Once informed of the procedure, subjects agreed to participate in the study and began filling out the questionnaires. The study took around 15 min to complete. The data were collected between February and March 2019.

Self-Reported Measures

Canadian Problem Gambling Index ($\alpha = 0.84$)

We used the French version of the Canadian Problem Gambling Index (CPGI) to assess participants' level of gambling problems [nine items, (44)]. Participants answered on a four-point Likert scale being 0 (never) to 3 (almost always). In this study, participants were categorized in three categories: "non-risk gambler," "moderate-risk gambler," and "severe-risk gambler" (i.e., pathological gamblers).

Big Five Inventory—French Version

The Big Five Inventory—French Version (BFI-FR) scale contains 45 items that allow the five dimensions of personality to be assessed. To answer these questions, a five-point Likert scale is proposed ranging from 1 (strongly disapproves) to 5 (strongly approves)[1].

Social Support Questionnaire

The short version of the Social Support Questionnaire 6 (SSQ6) scale was used. The validated French version (46) aims at evaluating the resources of one's support network and its perceived adequacy. Participants indicated (i) the initials of the resource people (nine people maximum), then (ii) the quality of the relations with these people on a Likert scale going from 1 to 6 (very dissatisfied to very satisfied). We computed two scores: social network availability (i.e., the number of people that the individual questioned identifies, from 0 to 54) and an adequacy score (i.e., sum of the adequacy scores obtained, from 0 to 36). Both dimensions had excellent psychometric qualities ($\alpha_{\text{Availability}} = 0.90$, $\alpha_{\text{Availability}} = 0.93$).

Impact of Gambling Advertisement

An *ad hoc* questionnaire has been created to assess the impact of gambling advertisements. We selected nine slogans of three different game operators disseminated online and in public spaces in 2018 in France. Two false slogans had been included into the list. Each one of these slogans were presented to participants to evaluate their recall with two items: 0, "I don't remember," and 1, "I remember." The sum of these scores provides an average recognition index ranging from 0 to 11. When participants recalled seeing an advertisement, they were (i) asked to recall the name of the game operator that disseminated the slogan (correct answer = 1, wrong answer = 0). They were then asked (ii) whether they wanted to play after watching or listening (incentive score, binary, 0 or 1). We computed a binary incentive score and behavior score (each coded 0 and 1).

Sociodemographic and Gamble Practices

Participants indicated their gender, age, employment situation, highest level of education, place of residence, size of city of residence, and country of residence. An additional question was added to assess the age of gambling onset.

Analytic Strategy

Analyses were conducted using RStudio and JASP. Analyses have been conducted as follows. Following recent recommendations by **(author?)** (47), we conducted analyses following a Bayesian approach in addition to the classical frequentist approach. Bayesian analyses allow testing for the likelihood of either the alternative or the null hypothesis, hence distinguishing data showing no clear evidence whatsoever from data supporting the null hypothesis (48, 49). The Bayes factor (BF) compares the probability of the data under one model to that under another and provides evidence in favor of either the null hypothesis (BF_{01}) or the alternative hypothesis [BF_{10}; (50, 51)]. Inclusion BFs for the moderating effect of the number of persons available for social support and satisfaction regarding social support scores are reported across matched models. The Inclusion BF reflects the evidence for all models with a particular term, compared to all models without this particular term. For these analyses, Cauchy's prior was first set to 0.35, which means that 50% of the values from the prior distribution are comprised between $r = 0.35$ and -0.35. All analyses were conducted on JASP 0.14 (JASP Team, 2017).

We first conducted a multinomial regression model with the categories of gambler as the outcome and social support scores (availability and adequacy), personality scores, gender, age, diploma, type of housing, size of the city, and whether they started to play as a minor as predictors (model 1, see **Table 2** for all estimates). We then conducted a set of one multiple linear regression and two multiple ordinal regression model with categories of gambler as predictors recognition scores (model2a), incentive scores (model2b), and behavior scores (model2c), and categories of gambler, type of gambling (offline vs. online and mixed gamblers), social support scores (availability and adequacy), personality scores, gender, age, diploma, type of housing, size of the city, and whether they started to gamble as a minor as predictors (see **Table 3** for all estimates). We report results from analyses conducted with the classical, frequentist approach, and BFs and Inclusion BF.

RESULTS

Effect of Social Support and Personality on Categories of Gamblers

Model 1 was overall marginally significant, $\chi^2_{(30)} = 42.3$, $p = 0.06$, Akaike information criterion (AIC) = 221, R^2 McF = 0.212. Model 1 revealed a main effect of neuroticism on categories of gamblers, $\chi^2_{(2)} = 7.02$, $p = 0.03$. We did not find a significant difference between "non-risk" and "moderate-risk" gamblers, odds ratio (OR) = 1.07, standard error (SE) = 0.044, $p = 0.11$. However, we found a significant difference for "non-risk" and "severe-risk" gamblers, such that gaining one point on the neuroticism scale leads to a 23% increase in being in the "severe-risk" category, OR = 1.23, SE = 0.01, $p = 0.04$ (see **Figure 1**). We found a main effect of gender, $\chi^2_{(2)} = 6.80$, $p = 0.033$. We found a significant difference in gender between "non-risk" and "moderate-risk" gamblers, such that being a man leads to a 79% increase of being in the "moderate-risk" category OR = 0.21, SE = 0.67, $p = 0.025$. No other effect was significant ($p < 0.097$).

Bayesian analyses showed that the model including age, neuroticism, gender, and diploma yielded the strongest evidence for the alternative hypothesis compared to all other models, $BF_{10} = 72.71$. Inclusion BF showed small evidence for the alternative hypothesis for neuroticism, $BF_{\text{Inclusion}} = 2.92$, gender, $BF_{\text{Inclusion}} = 3.08$ and diploma, and $BF_{\text{Inclusion}} = 2.31$.

[1]A score is calculated for each dimension by averaging the items. This scale has good internal validity (α = Openness = 0.72, Conscientiousness = 0.79, Extraversion = 0.81, Agreeableness = 0.66, Neuroticism = 0.83), a consistent factor structure and a good distribution of items consistent with the initial American version (45).

TABLE 2 | Multinomial logistic regression.

Model fit measures						
				Overall model test		
Model	Deviance	AIC	R^2 McF	χ^2	*df*	*p*
1	157.28	221.28	0.21198	42.307	30	0.067

Effect of Categories of Gamblers on Advertisement Recognition (Model2a)

Model2a was overall marginally significant, $F_{(17,85)} = 1.60$, $p = 0.083$, $\eta^2_p = 0.23$. The analysis revealed a significant main effect of social support adequacy, $b = -0.05$, 95% CI [−0.10, 0.001], $t_{(85)} = -1.94$, $p = 0.039$, $\eta^2_p = 0.064$ so that lower adequacy predicted higher recognition. We also found a significant main effect of age, $b = -0.03$, 95% CI [−0.06, −0.001], $t_{(85)} = -2.11$, $p = 0.043$, $\eta^2_p = 0.075$, such that younger participants had higher recognition scores. Eventually, we found a marginally significant main effect of onset of gambling, $b = -0.66$, 95% CI [−1.39, −0.06], $t_{(85)} = -1.82$, $p = 0.06$, $\eta^2_p = 0.039$, such that the earlier the onset of gambling, the higher the recognition scores. We did not find any other effect ($ps < 0.07$).

Bayesian analyses showed that the model including age, social support adequacy, and onset of gambling yielded the strongest evidence for the alternative hypothesis compared to all other models, $BF_{10} = 92.71$. Inclusion BF showed substantial evidence for the alternative hypothesis for age, $BF_{Inclusion} = 5.19$; onset of gambling, $BF_{Inclusion} = 5.11$; and anecdotal evidence for diploma, $BF_{Inclusion} = 2$.

Effect of Categories of Gamblers on Perceived Incentive to Play (Model2b)

Model2b was overall significant, $\chi^2_{(19)} = 31$, $p = 0.04$, AIC = 94.5, R^2 McF = 0.362. Model2b revealed a marginally significant main effect of the category of gambler, $\chi^2_{(2)} = 4.65$, $p = 0.09$. We did not find a significant difference between "non-risk" and "moderate-risk" gamblers, OR = 1.95, SE = 0.93, $p = 0.47$ on perceived incentive. However, we found a significant difference for "non-risk" and "severe-risk" gamblers, such that being in the "severe-risk" category leads to a 1,400% increase in feeling incented to gamble, OR = 14.13, SE = 1.31, $p = 0.044$. No other effect was significant ($p < 0.097$).

Bayesian analyses showed that the model including only the category of gamblers factor yielded the strongest evidence for the alternative hypothesis compared to all other models, $BF_{10} = 111.41$. Inclusion BF showed strong evidence for the alternative hypothesis for category of gamblers, $BF_{Inclusion} = 17.23$.

Effect of Categories of Gamblers on Intention to Play (Model2c)

Model2c was overall not significant, $\chi^2_{(19)} = 25.3$, AIC = 119, R^2 McF = 0.243. The analysis revealed a significant main effect of social support availability, $\chi^2_{(1)} = 4.37$, OR = 1.07, SE = 0.03, $p = 0.042$ such that higher availability led to lower intention to play. We also found a significant main effect of the onset of gambling, such that a decrease of 1 year in the onset lead to an 80% increase in probability of reporting an intention to play after seeing an advertisement, OR = 0.21, SE = 0.74, $p = 0.036$. We also found a marginally significant effect of categories of gambler, $\chi^2_{(1)} = 5.27$. We did not find any significant difference between "non-risk" and "moderate-risk" gamblers, OR = 2.78, SE = 0.81, $p = 0.20$, but found a significant difference between "non-risk" and "severe-risk" gamblers, OR = 11.04, SE = 1.07, $p = 0.026$, such that being in the "severe-risk" group led to a 1,100% increase in probability of reporting having the intention to play. Eventually, we found a marginally significant effect of neuroticism, $\chi^2_{(1)} = 3.06$, OR = 0.91, SE = 0.05, $p = 0.09$, such that, surprisingly, a decrease of one point in neuroticism lead to a 10% higher probability of having the intention to play (see **Figure 2**).

Bayesian analyses showed little convincing evidence for any model. The model including onset of gambling, conscientiousness, social support availability factor, and category of gamblers yielded only moderate evidence for the alternative hypothesis compared to all other models, $BF_{10} = 9.87$. Inclusion BF showed acceptable evidence for the alternative hypothesis for the category of gamblers, $BF_{Inclusion} = 5.61$, and anecdotal evidence for onset of gambling, $BF_{Inclusion} = 2.8$.

DISCUSSION

This study investigated and compared how variables related to self-regulation, such as social support, dimensions of personality predicted perception, and memorization of advertising campaigns, and were associated with problem gambling among severe-, moderate-, and non-risk gamblers and associated with online gambling (i.e., sport and poker). The present protocol is based on the recall of different slogans diffused by French Gambling operators for the last 12 months before the study, the perceived encouragement to gamble, and the behavior. Overall, although some of our results are only marginally significant, there seems to be an effect of the variables associated with self-regulation (i.e., neuroticism and social support) on ad recognition, perceived incentive to play, and intention to play.

Does Gambling Severity Change Advertising Influence?

Notably, when the onset of gambling is before 18 years old, participants had more chances to recall more gambling advertisements when they were adults. Although the onset of gambling was not the primary hypothesis, this variable appears

TABLE 3 | Multiple regression with categories of gamblers as predictors recognition socials, intention and behavior.

Model 2a. ANOVA omnibus tests

	SS	*df*	*F*	*p*	η^2_p
Model	58.2232	17	1.59611	0.083	0.242
Age	11.2199	1	4.20057	0.043	0.074
Categories of gamblers	1.4490	1	0.54247	0.463	0.018
Mode of gambling	2.3944	1	0.89642	0.346	0.017
Gender	0.0157	1	0.00589	0.939	0.006
Diploma	8.1696	1	3.05856	0.084	0.017
House	0.1294	1	0.04845	0.826	0.005
Work	1.9558	1	0.73224	0.395	0.008
kind_residence	1.2153	1	0.45497	0.502	0.005
size_city	3.3642	1	1.25949	0.265	0.014
gamble_less18y	9.2900	1	3.47804	0.066	0.059
Availability	11.7944	1	4.41564	0.039	0.046
Satisfaction	0.7913	1	0.29627	0.588	0.006
Openness	3.4801	1	1.30291	0.257	0.016
Consciousness	0.0879	1	0.03291	0.856	0.000
Extraversion	0.7189	1	0.26913	0.605	0.003
Agreeability	2.1469	1	0.80378	0.372	0.010
Neuroticism	3.94e−4	1	1.47e−4	0.990	0.000
Residuals	227.0389	85			
Total	285.2621	102			

Model 2b. Binomial logistic regression

Model Fit Measures

Model	**Deviance**	**AIC**	R^2 **McF**
1	54.522	94.522	0.36232

Predictor	**Estimate**	***SE***	***Z***	***p***
Intercept	−2.7041984	5.615389	−0.481569	0.630
Age	−0.0719102	0.053545	−1.342978	0.179
Categories of gamblers				
Non-risk–moderate risk	0.6711522	0.931857	0.720231	0.471
Non-risk–severe risk	2.6489519	1.316277	2.012458	0.044
Mode of gambling				
Outline–online	−1.0152507	1.224167	−0.829340	0.407
Outline and online–outline	0.2604371	0.977093	0.266543	0.790
Gender	−0.5510260	1.185495	−0.464807	0.642
Diploma	0.0475954	0.344133	0.138305	0.890
House	0.2793072	0.877094	0.318446	0.750
Work	0.1249741	0.252195	0.495545	0.620
kind_residence	−0.6298236	1.510053	−0.417087	0.677
size_city	−0.0269201	0.366966	−0.073359	0.942
gamble_less18y	−0.8894833	0.897306	−0.991282	0.322
Availability	0.0137726	0.049983	0.275544	0.783
Satisfaction	0.0618115	0.076301	0.810100	0.418
Openness	−0.0065253	0.081765	−0.079806	0.936

(Continued)

TABLE 3 | Continued

Consciousness	0.1114438	0.086190	1.292998	0.196
Extraversion	−0.0154560	0.071490	−0.216197	0.829
Agreeability	−0.0846025	0.076920	−1.099869	0.271
Neuroticism	0.1162461	0.072626	1.600616	0.109

Model 2c. Classical regression/ANOVA

Model results

Loglikelihood ratio tests

Model Fit Measures

			Overall Model Test			
Model	**Deviance**	**AIC**	R^2_{McF}	X^2	**df**	**p**
1	78.9	119	0.243	25.3	19	0.150

Model Coefficients - cptt_score_bin

		95% Confidence Interval					95% Confidence Interval		
Predictor	**Estimate**	**Lower**	**Upper**	**SE**	**Z**	**p**	**Odds ratio**	**Lower**	**Upper**
Intercept	−2.89749	−11.15186	5.3569	4.2115	−0.6880	0.491	0.0552	1.43e-5	212.060
Online Gambling	0.38849	−0.49538	1.2724	0.4510	0.8615	0.389	1.4748	0.6093	3.569
Gender	0.22221	−1.42614	1.8706	0.8410	0.2642	0.792	1.2488	0.2402	6.492
Diploma	−0.02347	−0.51666	0.4697	0.2516	−0.0933	0.926	0.9768	0.5965	1.600
Housing	0.60371	−0.72969	1.9371	0.6803	0.8874	0.375	1.8289	0.4821	6.939
Work	−0.10551	−0.50083	0.2898	0.2017	−0.5231	0.601	0.8999	0.6060	1.336
Residence	−0.18582	−1.80701	1.4354	0.8272	−0.2246	0.822	0.8304	0.1641	4.201
City Size	0.25600	−0.31775	0.8297	0.2927	0.8745	0.382	1.2918	0.7278	2.293
Gambling as Minor	−1.56276	−3.02669	−0.0988	0.7469	−2.0923	0.036	0.2096	0.0485	0.906
Social Support Availability	0.06964	0.00245	0.1368	0.0343	2.0313	0.042	1.0721	1.0024	1.147
Social Support Satisfaction	−0.04720	−0.13636	0.0419	0.0455	−1.0378	0.299	0.9539	0.8725	1.043
BFI-Openness	0.00314	−0.10635	0.1126	0.0559	0.0562	0.955	1.0031	0.8991	1.119
BFI-Conscientiousness	0.07675	−0.04518	0.1987	0.0622	1.2337	0.217	1.0798	0.9558	1.220
BFI-Extraversion	0.05520	−0.05080	0.1612	0.0541	1.0207	0.307	1.0568	0.9505	1.175
BFI-Agreableness	−0.04567	−0.17632	0.0850	0.0667	−0.6852	0.493	0.9554	0.8383	1.089
BFI-Neuroticism	−0.08950	−0.19295	0.0139	0.0528	−1.6957	0.090	0.9144	0.8245	1.014
Typology of gamblers:									
Moderate Risk Gamblers-No-Risk Gamblers	1.02460	−0.56869	2.6179	0.8129	1.2604	0.208	2.7860	0.5663	13.707
Severe Risk Gamblers-No-Risk Gamblers	2.40168	0.29316	4.5102	1.0758	2.2325	0.026	11.0418	1.3407	90.941
Age	0.01208	−0.05463	0.0788	0.0340	0.3550	0.723	1.0122	0.9468	1.082
rgp typ jeu	0.81953	−0.87463	2.5137	0.8644	0.9481	0.343	2.2694	0.4170	12.350

Estimates represent the log odds of "cptt_score_bin = 1" vs. "cptt_score_bin = 0."

significant in our campaigns recall model. Several studies with adolescents and adults show a correlation between when the onset of gambling and problematic gambling (52, 53).

Overall, severe-risk (i.e., pathological) gamblers seem to be more prone to gamble after watching or hearing a campaign than the others. These results are both concordant and discordant with the literature. Regarding recall, some studies do not find effect among gamblers (10, 54), whereas others do (12). Concerning intentions and behavior, our results are similar to the literature. Different ads impact the intention of gambling and the behavior particularly for problematic gamblers (12, 55). Our results indicate the lack of relationships between the recall of gambling advertising and online gambling, whereas some research indicates that the exposure to campaigns is more important for online gamblers (55). All these elements indicate the absence of longitudinal and experimental studies and valid tools. Interestingly, there was no strong link between social support perceived and typology of gamblers.

Is Advertising Influence Different Depending on Personality Traits?

We also found that among personality traits, neuroticism appeared to have the most robust impact on the perception and recall of advertisements, and the propensity to treat

	Categories of gamblers						95% confidence interval	
	Predictor	Estimate	SE	Z	p	Odds ratio	Lower	Upper
Non-risk–moderate risk	Intercept	2.9812339	3.133627	0.951368	0.341	19.71212	0.0424019	9163.92712
	Openess	0.0034419	0.043512	0.079102	0.937	1.00345	0.9214196	1.09278
	Consciousness	−0.0116390	0.046293	−0.251422	0.801	0.98843	0.9026944	1.08231
	Extraversion	−0.0548527	0.042926	−1.277844	0.201	0.94662	0.8702402	1.02971
	Agreeability	0.0657378	0.049552	1.326643	0.185	1.06795	0.9691050	1.17687
	Neuroticism	0.0693150	0.044094	1.571997	0.116	1.07177	0.9830386	1.16852
	Availability	−0.0274505	0.029612	−0.927005	0.354	0.97292	0.9180631	1.03106
	Satisfaction	0.0454771	0.038187	1.190898	0.234	1.04653	0.9710586	1.12786
	Gender	−1.5164411	0.675266	−2.245694	0.025	0.21949	0.0584293	0.82453
	Diploma	−0.3370761	0.193766	−1.739607	0.082	0.71385	0.4882881	1.04362
	House	−0.3941985	0.644976	−0.611183	0.541	0.67422	0.1904570	2.38675
	Work	−0.1476413	0.154908	−0.953093	0.341	0.86274	0.6368288	1.16879
	kind_residence	0.7024568	0.637644	1.101644	0.271	2.01871	0.5785079	7.04428
	size_city	−0.3043217	0.218639	−1.391891	0.164	0.73762	0.4805393	1.13225
	gamble_less18y	−0.0123328	0.512625	−0.024058	0.981	0.98774	0.3616567	2.69769
	Age	−0.0593920	0.026725	−2.222341	0.026	0.94234	0.8942481	0.99301
Non-risk–severe risk	Intercept	−0.9656829	5.435252	−0.177670	0.859	0.38072	8.9974e−6	16110.30668
	Openness	0.0637241	0.080763	0.789024	0.430	1.06580	0.9097652	1.24859
	Consciousness	0.0148150	0.087641	0.169041	0.866	1.01493	0.8547391	1.20513
	Extraversion	−0.1322976	0.072565	−1.823158	0.068	0.87608	0.7599348	1.00998
	Agreeability	0.0663217	0.082299	0.805859	0.420	1.06857	0.9093892	1.25562
	Neuroticism	0.2099441	0.101988	2.058511	0.040	1.23361	1.0101013	1.50657
	Availability	0.0518783	0.058945	0.880119	0.379	1.05325	0.9383323	1.18224
	Satisfaction	−0.0064425	0.063407	−0.101605	0.919	0.99358	0.8774653	1.12506
	Gender	−2.0412368	1.317185	−1.549697	0.121	0.12987	0.0098245	1.71669
	Diploma	−0.6085220	0.400376	−1.519877	0.129	0.54415	0.2482685	1.19268
	House	0.1597823	1.118837	0.142811	0.886	1.17326	0.1309292	10.51354
	Work	0.2135471	0.253978	0.840810	0.400	1.23806	0.7525855	2.03671
	kind_residence	−1.4495956	1.814394	−0.798942	0.424	0.23467	0.0066994	8.21984
	size_city	−0.2867828	0.389564	−0.736164	0.462	0.75067	0.3498280	1.61083
	gamble_less18y	−1.1620299	1.037898	−1.119599	0.263	0.31285	0.0409144	2.39220
	Age	−0.0179531	0.044953	−0.399379	0.690	0.98221	0.8993721	1.07267

FIGURE 1 | Differences between categories of gamblers in terms of demographics and psychologic questions.

them as "appetitive" stimuli. This is not surprising insofar as neuroticism is associated not only with more frequent experience of negative emotions but also with a weaker ability to regulate these emotions. Although negative emotion regulation and neuroticism are distinct constructs, they nevertheless overlap to some extent, with neuroticism being associated with extraversion, in contrast to emotion regulation (56). A surprising finding is that neuroticism appears to be negatively associated with play, implying that the play stage is likely associated with positive emotions—and reinforcement. About personality traits, our results are not completely in line with the literature, as severe-risk gamblers presented higher levels of Neuroticism compared with "recreational" gamblers but did not present low scores of Conscientiousness and Agreeableness. We suggest that future studies should explore if subgroups of gamblers (e.g., online vs. offline, gamblers with morbidity vs. not) change regarding personality traits.

Does Social Support Hinders Advertising Influence?

Moreover, social support is significantly lower among online gamblers compared to offline gamblers, but no association was found between social support and type of gamblers. This finding is contrary to expectations but similar with few studies. A systematic review on psychosocial risks for gambling and problem gambling in Nordic countries, Nordmyr and Forsman (57) indicate that if social support could be a protective factor of problematic gambling but not in all studies but in two studies, social support is not associated with problematic gambling to young people (12, 58)].

In addition, social support is closely related not only to social network but also to loneliness (24). Family and peers may be protective factors of pathological gambling; more studies should assess what kind of support gamblers and particularly online gamblers defined as supporting past the adequacy of social support. Surprisingly, few studies focus on the effect of isolation on social and addictive behaviors, and consequently on gambling, even though it is a central variable in the study of social behavior in animal models, as the ability to voluntarily isolate oneself may allow for better management of daily stress (59). Future studies should address this issue in more detail.

LIMITATIONS

However, our conclusions are somewhat hindered by our relatively small sample size, which may explain some of our

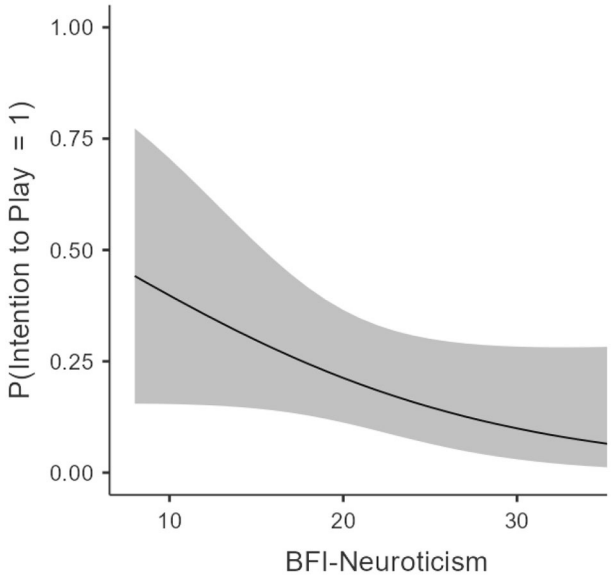

FIGURE 2 | Estimated Marginal Means between neuroticism and intention to play.

marginally significant results. Specifically, with social scale support, several participants canceled their answers due to the length of the questionnaire. Moreover, the number of responses tended to decrease between the first one answer and the last one.

CONCLUSION

This study is a unique contribution for several reasons. First, we used original memorization measures involving long-term memory rather than immediate recall. Second, we identified novel factors related to self-regulation that may be crucial in understanding how gamblers interact with their social environment and regulate their gambling behaviors. These first results pave the way for potential therapeutic management processes, particularly in the context of systemic therapies that take charge of the individual through his interactions with his social environment. Encouraging gamblers, initially, to shift their practices toward games where social interactions exist could allow low-addicted gamblers to avoid seeing their situation worsen. Gamblers in a more serious situation may also benefit from this type of approach. A second step would be to offer help and better social support to severely affected gamblers. This could be done, for example, by offering help—professionally, or via their social network—automatically triggered via smartphone when the gambler is exposed to or near stimuli that can trigger gambling behavior. Focusing on the social—and societal—aspect of advertising could help mitigate these effects. Eventually, on the other hand, the lack of a standardized protocol multiplies the development of new, non-validated methods.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors have read and approved the manuscript for submission to Frontiers in Psychiatry: Addictive Disorders: have made a substantial contribution to the conception, design, gathering, analysis and/or interpretation of data and a contribution to the writing and intellectual content of the article: and acknowledge that they have exercised due care in ensuring the integrity of the work.

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A Normative Feedback Intervention on Gambling Behavior—A Longitudinal Study of Post-Intervention Gambling Practices in At-Risk Gamblers

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Background: In problem gambling, normative personalized feedback interventions have demonstrated promising effects. Given the widespread increase in online gambling in recent years, internet-delivered normative feedback may serve as a promising intervention. This study aimed to examine whether such an intervention, delivered by a gambling operator and aiming to help problem gamblers decrease their gambling, may in fact be associated with lower gambling practices post-intervention.

Methods: Online questions on norms and beliefs about one's own and peers' gambling habits, derived from the Gambling Quantity and Perceived Norms Scale, were followed by personalized feedback, delivered online by the Swedish state-owned gambling operator. A total of 1,453 gamblers consented to participate in a pre-post measure of wagering levels.

Results: Wagering decreased significantly post-intervention (28 days) compared to pre-intervention (28 days prior). The decrease was significantly more pronounced in younger and online casino gamblers. In an 84-day follow-up, the decrease remained significant, although less pronounced.

Conclusions: An online normative intervention delivered by a state-owned gambling operator, addressing norms and beliefs about gambling levels, may lower risky gambling in the short term. Implications and further research needs are discussed.

Keywords: gambling disorder, online gambling, problem gambling, normative feedback, motivational intervention, behavioral feedback

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BACKGROUND

Problem gambling, including the diagnostic construct of a gambling disorder (1), affects a significant minority of the population worldwide, with prevalence estimations ranging up to ∼5% of the population (2, 3). A gambling disorder diagnosis is typically characterized by a gambling pattern involving increasing amounts of money, a "chasing losses" behavior (i.e., where a person returns to gambling primarily in order to try to win back the money lost), lying to family members and friends, and continued gambling despite negative consequences (1). Gambling disorder may

be associated with severe social and health consequences (4), including comorbid psychiatric diagnoses, psychological distress as a consequence of debts (5, 6), suicidal ideation (7), and an increased risk of suicide (8). Despite increasing scientific support for treatment involving cognitive–behavioral therapeutic approaches, treatment seeking for problem gambling has been described to be low (9, 10). In most settings, a majority of problem gamblers are men (2), although, in recent years, scholars have argued that high-risk gambling has become more acceptable among women and that the difference in the prevalence of gambling problems between men and women may be decreasing (6, 11–14).

In recent years, researchers have increasingly highlighted the role of gambling operators in primary and secondary prevention of problem gambling, through different responsible gambling measures. These may include interventions addressing problem gambling in close proximity to the gambling situation, such as through direct communication from a gambling operator detecting a pattern of problem gambling (15–17). One opportunity for brief intervention in problem gambling may be to address individuals' beliefs about their gambling in comparison to the gambling patterns of their peers. It has been suggested that, in the general population, when assessing beliefs about the extent of peers' gambling, problem gamblers report beliefs about more intense gambling in their peers than do non-problem gamblers (18). Studies have also shown that many college students tend to overestimate the gambling expenditure of their peers, and also that these overestimations are positively associated with the students' own frequency of gambling, their gambling expenditures, and gambling-related harm. Thus, discrepancies between perceived and actual norms for college gambling are of relevance to college students' gambling behaviors and gambling-related problems (19, 20). Personalized feedback interventions, addressing gamblers' beliefs about their own gambling compared to the gambling of their peers, have been reported to have promising effects on measures of problem gambling (21, 22).

The theory behind the intervention relies on the assumption that individuals may experience misperceptions about how much other people—in life situations similar to their own—gamble. This theory has previously been applied in the field of alcohol use disorders and has expanded to the field of problem gambling. The rationale of a personalized, normative feedback intervention in gambling is theoretically to help individuals reflect on their own levels of gambling, possibly in order to correct such misperceptions and in order to help them decrease their gambling (21).

Previous studies addressing normative interventions in gambling have included mainly university students or general young adult populations. Few studies have assessed these interventions among customers of a gambling operator (22–25). In a study on online interventions in poker gamblers, a brief personalized normative feedback was limited by high dropout in the study but showed acceptability comparable to more elaborate therapeutic interventions (26). In another study, Auer and Griffiths provided promising findings from a voluntary behavioral feedback intervention system at a gambling operator's site (15). Theoretically, when provided directly by a gambling operator, interventions aiming to help at-risk gamblers reduce or discontinue their gambling can be provided in closer temporal association with a gambling session than could any other motivational or therapeutic intervention, such as those provided by a service offering treatment or support. The opportunity for interventions in close association with the gambling situation is a potentially important part of the responsible gambling strategies of gambling operators. The concept of providing gambling, while maintaining primary and secondary preventive tools for gambling problems, has been described in a limited number of publications. Examples of such interventions include direct feedback and motivational contact from state-owned gambling operators to clients presenting a potentially hazardous gambling behavior (17) and gambling-reducing measures such as loss limits (27).

The present study aimed to address gamblers' norms and beliefs about their own gambling habits and those of their peers and thereby intended to assess whether interventional feedback on these beliefs has the potential to decrease gambling when delivered by a gambling operator as a responsible gambling intervention. This approach could potentially reach at-risk gamblers in direct association with their gambling and independent of treatment settings. The study intervention, consisting of a normative test intended to stimulate gamblers' own reflections and motivational processes, was delivered to clients of the state-owned Swedish gambling operator AB Svenska Spel, either because the clients were shown to be at risk of problem gambling or because they actively sought this kind of normative testing. More specifically, the study aimed to assess whether a normative test and the delivery of feedback may lower the level of wagering and which factors, such as gender, age, type of gambling, and the reason for taking the test, would be associated with decreased wagering post-intervention. The primary aim of the study was to address changes in wagering during a post-intervention period corresponding to the time frame studied pre-intervention (4 weeks). Additionally, this study examined whether a potential decrease in wagering may persist during 12 weeks after the intervention.

MATERIALS AND METHODS

Study Design

This was a longitudinal study measuring gambling patterns prior to and after an online-based intervention to clients of the state-owned gambling operator AB Svenska Spel. The study was conducted in a collaboration between Lund University and AB Svenska Spel. The present study was carried out in the subsection of AB Svenska Spel providing gambling on various types of sports betting, as well as an online casino, bingo, and poker (*Svenska Spel Sport & Casino*). The rationale for the analyses in these forms of gambling is the suggested high addictive potential of sports betting and online casino gambling in treatment-seeking patients in the present setting (28).

Setting

Following a new regulation in use since January 2019, the Swedish gambling market is a licensed market. Gambling operators are granted licenses from a governmental authority, provided they follow a number of universal responsible gambling policies including the adherence to a nationwide self-exclusion system, where a person can self-exclude from all licensed gambling operators in Sweden (29). AB Svenska Spel is the only gambling operator owned entirely by the state and operating under instructions from the Swedish government. In Sweden, online gambling has increased steeply during the past decade and represents the most common gambling modality in television advertisements (30) and the most commonly reported by treatment-seeking problem gamblers (28). Problem gambling has recently been reported to increase in the Swedish population, with the most pronounced increase seen among women (31). Gambling habits, as well as gambling problems, are known to differ substantially between women and men (6, 11–14). Likewise, it has been reported that the characteristics of problem gambling differ by age; problem gambling in the present setting is more common in the young (13), and personality factors, psychiatric comorbidity, and the overall clinical picture in problem gambling have been described to differ by age (32, 33).

The present study is based on a normative test provided as part of the responsible gambling tool *Playscan*, used by the state-owned Swedish gambling operator AB Svenska Spel. The *Playscan* tool has previously been described in scientific papers (34, 35). *Playscan* was a sub-department of AB Svenska Spel at the time of the study and a brand name describing a behavioral tracking tool that provides a weekly individual risk assessment, advice, and strategies on how to keep track of gambling behavior. The *Playscan* user interface holds several self-tests, related to responsible gambling, where users can investigate and reflect upon their gambling habits. The tool is accessible to the user on AB Svenska Spel's website and uses an on-site notification system to get the users' attention. The *Playscan* tool has been operating since 2007 and is fully owned by AB Svenska Spel and also has been applied by other gambling operators internationally during the past decade. In 2010, the French gambling operator La Française des Jeux added *Playscan*. A year later, it started to be used by the Swedish lottery Miljonlotteriet. In 2014, the state-owned Norwegian operator Norsk Tipping started to use *Playscan*. In 2019, Loterie Romande in Switzerland launched the tool to all its players.

Intervention

The present study assessed the change in gambling behavior following a normative feedback intervention that was a part of the preexisting responsible gambling tool *Playscan*. The normative test was taken at any time during the period January 28 through April 8, 2019. Players could enter the normative test through any of two pathways: (1) an on-site notification offered to players who had gambled with a theoretical loss (36) of at least 500 Swedish kronor (SEK, corresponding to ∼45 Euros) during the past 5 weeks and with no previous activity in *Playscan* (passive method) or (2) by actively clicking on any of several links to the test inside the *Playscan* user interface (active method). The former group included players with possible high-risk gambling behavior identified by *Playscan*'s weekly risk analysis. A gambling pattern associated with risk, according to *Playscan*, was defined as an escalation of time and/or money spent on gambling over time (35). In the test, the client was asked to report the gambling type that she/he wished to be compared for (sports bettor, bingo gambler, online casino gambler, poker gambler, or various) and her/his level of gambling experience (beginner, average, or advanced). Thereafter, the test consisted of the following questions derived from the Gambling Quantity and Perceived Norms Scale [GQPN, (37)]: the client's frequency of gambling (days per month), her/his gambling losses during a typical month, beliefs about peers' frequency of gambling and typical monthly loss for the same gambling type (ranging from <SEK 50 to >SEK 50,000), and the client's estimated loss during the past month. When the client had answered all the questions, feedback was presented in the form of a summary of her/his responses, which were then compared to actual data on the frequency of playing and average monthly loss for a typical player of the gambling operator's *Sports and Casino* sub-division.

Ethical Considerations

Data on wagers, winnings, and losses for all players who use the gambling web page are registered and stored by AB Svenska Spel. All players who entered the test were asked for consent to include this data, for the past 90 days and the following 90 days in relation to the consent, as well as data from the test, in the study. Players who declined to give consent could still take the full test, outside of the study. Entirely anonymized data were delivered to co-authors JB and AH for statistical analyses. The study was reviewed and approved by the regional ethics board, Lund, Sweden (file number 2018/699).

Study Periods

For each study participant, the amount of money wagered and the net win or loss were logged for 90 days prior to and 90 days following the intervention. However, data registration started on January 1, 2019, and the study started on January 28, 2019. This means that all study participants who were included earlier than the 90th day of 2019 (March 31) would have missing values for any gambling taking place before 2019. We therefore chose not to use any of the data prior to 28 days before the study started for each individual. Furthermore, due to the nature of the brief intervention and the hypothesized short duration of any potential effect, we limited the follow-up time to 28 days following the intervention. We used the amount of wager as the basis for our analyses because unlike net win or loss, which has negative values, a wager can be logarithmized. We thus used data on wager during the 28 days prior to and the 28 days following the intervention for each study participant. In a secondary analysis, the same pre-intervention period was applied (for the reasons stated above), whereas the post-intervention period studied included 12 weeks (84 days) post-intervention.

Outcome Variable: Average Daily Wager

The outcome measure used in the study was a change in wager following the intervention, i.e., the total amount of

money wagered per day for each study participant (in SEK). Because of the large proportion of days with no money spent on gambling (a total of 59.0% of all days for all study participants), the data had to be reduced in order to avoid an excessive number of zeroes in the model. We thus averaged the 56 days of observation for each participant into eight 7-day periods, four before the intervention (periods 1–4) and four after the intervention (periods 5–8), and calculated the average amount of money wagered per day within each period [average daily wager (ADW)]. In total, in only 18.8% of such periods did a study participant not spend any money on gambling.

The study participants might have started gambling at AB Svenska Spel's websites at any point prior to the intervention. We included only 97.1% of study participants who had at least one gambling occasion during the 28 days prior to the intervention (n = 1,411). We had no data on whether the clients' first gambling occasion during the study period was their first-ever gambling occasion at the *Sports and Casino* website. Eighty percent of this group of participants had their entry into the study (i.e., the first gambling occasion during the study period) in the first period and 10% in the second period. Because of the different pathways to inclusion in the study outlined above, there was a potential need to control for the effect of the pathway on the estimated association between the intervention and gambling behavior. More specifically, individuals who lost high amounts of money in a single session might have been included in the study immediately after the loss, and the subsequent absence of gambling might not have been related to the intervention but instead, for example, to a lack of money to wager. For this reason, we excluded all participants who had their first gambling occasion in the fourth period (n = 66). In order to handle potential outliers (i.e., study participants who wagered extremely high amounts of money compared to the median), we excluded all participants who were in the top 1% of the wagered amount in any of the eight periods. This corresponded to 3.9% (n = 53) of the individuals remaining after having been excluded for the reasons outlined above. The final number of study participants was thus 1,292, corresponding to 88.9% of the individuals who provided informed consent for participation in the study.

In order to model differences based on the period in which study participants had their first gambling occasion, we used a variable describing the first gambling period as a covariate in the regression model.

Finally, the ADW values were logarithmized in order to approach a normal distribution more suitable for use in a multiple regression model. Because the logarithm of 0 is negative infinity, a value of SEK 1 was added to all periods for all participants, with the exception of periods prior to the first period of gambling for each individual, which were excluded from the analyses.

All ADW values were calculated and reported in local currency (Swedish krona, SEK). For improved clarification of the magnitude of findings, values were translated into US dollars (USD), where nine SEK correspond to 1 USD.

Covariates

The covariates used in the present study were the following:

- Gender: female, male.
- Age at the intervention: we used data on birth year to calculate the approximate age for each participant based on the fact that all interventions took place during <3 months, so the errors should be minimal. Age was divided by 10 and centered at the median, 39, so that the estimated value in the regression model reflects the effect of each additional 10 years higher than the median.
- Method of entry into the study: method of entry was dichotomized into passive and active methods, with passive indicating a notification from the gambling site and active requiring that the participant sought out the intervention actively. The passive method was used as the reference because it was far more common.
- Intervention feedback: as described above, participants who completed all the questions in the intervention received feedback on their accuracy when estimating how much other people spend on gaming. We dichotomized the completers into two groups; those who estimated somewhat correct with respect to others' gambling behavior (estimation less than twice the actual value) and those who highly overestimated others' gambling behavior (twice or more than the actual value). A tripartite intervention feedback variable was thus created, with non-completers, average estimators, and overestimators representing the different categories.
- Self-assessed main type of gambling interest: the alternatives that players could indicate as their main type of gambling were sports betting, bingo, online casino, poker, and others. For purposes of the study, *sports betting* was defined as the reference because it was by far the largest category, and *casino* (the second largest category) and *other* (including all other types) were defined as dummy variables in order to be compared to sports betting.

Statistical Methods

In order to assess the change in ADW following the intervention, we first created a regression model that estimated the global association, without including any of the covariates of interest. This was a mixed model multiple regression model, with a random intercept for each individual, and will henceforth be referred to as the *structural submodel*.

The first set of analyses included a follow-up period of 4 weeks, corresponding to a pre-intervention period of the same duration. As described above, each individual had six to eight periods of measurement. The log ADW for each period was used as the dependent variable. The first independent variable in the structural submodel was *period*, ranging from 1 to 8, with 1–4 referring to the periods prior to the intervention and 5–8 to the periods following the intervention. The second independent variable, first *period*, was a categorical variable defined as the period in which each individual in the study population had his/her first gambling period in the data set, as described above. We devised two strategies to model the change associated with the intervention. The first strategy, *intervention mean change*,

was to estimate the shift of the intercept with a variable defined as 0 for all periods pre-intervention and 1 for all periods post-intervention. The second strategy, *intervention slope change*, was to estimate the shift of the slope of the curve following the intervention, and this variable was defined as 0 for all periods pre-intervention and 1–4 for the periods post-intervention. We then ran models with all combinations of *period*, first *period*, *intervention mean change*, and *intervention slope change* including at least one of the intervention variables and compared the resulting 12 models on the Akaike information criterion and Bayesian information criterion. Both methods favored the model with *period*, first *period*, and *intervention slope change* (**Supplementary Table S1**). The structural submodel can thus be expressed as in **Figure 1**:

log (ADW) = intercept + period + first period + intervention slope change + random intercept

All covariates were added to the structural submodel both as an estimate of the effect of the variable itself and as an interaction effect between the intervention and the variable in question, in order to assess whether the intervention had different effects across different levels of each variable. The full adjusted model thus included a total of 17 fixed variables (5 for the structural submodel, including the intercept, 7 for the covariates, and 7 for the interaction terms) and one random intercept.

In a secondary analysis, the same methodology as above was applied, although with a follow-up period of 12 weeks (84 days) after the intervention, instead of 4 weeks. As previously, the pre-intervention period included 4 weeks.

Three sensitivity analyses were performed on the full model involving the 4-week follow-up. In the first sensitivity analysis, individuals with a first gambling period other than 1 (15.9%, n = 206) were excluded from the analysis. In the second sensitivity analysis, all periods with an ADW of 0 were excluded (13.7%, 1,211 of 8,851 periods), and in the third sensitivity analysis, SEK 10 was added to ADW instead of SEK 1 as in the full model. In none of the sensitivity analyses was the estimate of the main intervention effect altered substantially, and neither were the interaction effects between intervention and age and between intervention and overestimation of others' gambling. In the second sensitivity analysis, the interaction effect between the intervention and preference for the online casino was diminished (from −0.15 to −0.06) and no longer statistically significant. The interaction effect between the intervention and female gender was diminished in all the three sensitivity analyses and no longer statistically significant (**Supplementary Table S2**).

All data management and analyses were performed in R 3.5.3 (38).

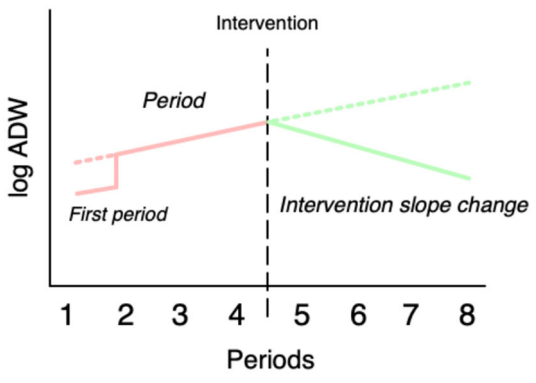

FIGURE 1 | Schematic illustration of the variables used in the main regression mode.

RESULTS

A total of 3,432 individuals entered the test and responded to the question about consent to include their data in the study. Of these, 1,453 individuals consented, after applying the exclusion criteria described in the *Methods* section. Among these, 84.1% had their first gambling day within the first period (22–28 days prior to the intervention), 10.7% within the second period (15–21 days prior to the intervention), and the remaining 5.3% within the third period (8–15 days prior to the intervention). Participants were predominantly male, with only 6.4% women. The median age was 39 years, ranging from 18 to 90 years with an interquartile range of 30–51 years. The most common method of entry into the study was by automated notification by the website (passive), accounting for 73.6% ($n = 951$) of the participants and 25.5% (n = 331) actively clicked on a *Playscan* link. A total of 11 participants had a different method of entry (notification by risk profiling) and were excluded from the main analysis.

The median ADW was SEK 74.1 (∼USD 8.2) in the 28 days prior to the intervention and SEK 57.7 (22% lower, ∼USD 6.4) in the 28 days following the intervention. The logarithmized ADW for the periods before and after the intervention is shown in the histograms in **Figure 2**. As can be seen in the figure, there is a spike of very low values (because SEK 1 was added to all values of ADW) in the periods prior to the intervention and a larger spike of zeroes in the periods following the intervention. The second and third sensitivity analyses described in the *Methods* section were performed for this reason.

In **Figure 3**, the mean logarithmized ADW is shown for all periods before and after the intervention, as well as a line representing the predicted values from the main regression model.

The results from the mixed model multiple regression models are shown in **Table 1**. In the second column, the results from the structural submodel are shown. The conditional R squared for this model was 0.382, and the marginal R squared was 0.033. In this model, there was a clear statistical effect of period, first period, and the intervention on the log ADW. The absolute statistical effect of the intervention was about equal in size to the effect of the period variable. In the full model, in which all covariates and interaction terms between the covariates and the intervention were included, the statistical effect of the intervention was considerably larger than the effect of period (−0.29 vs. −0.08). The conditional R squared for this model was 0.385, and the marginal R squared was 0.050.

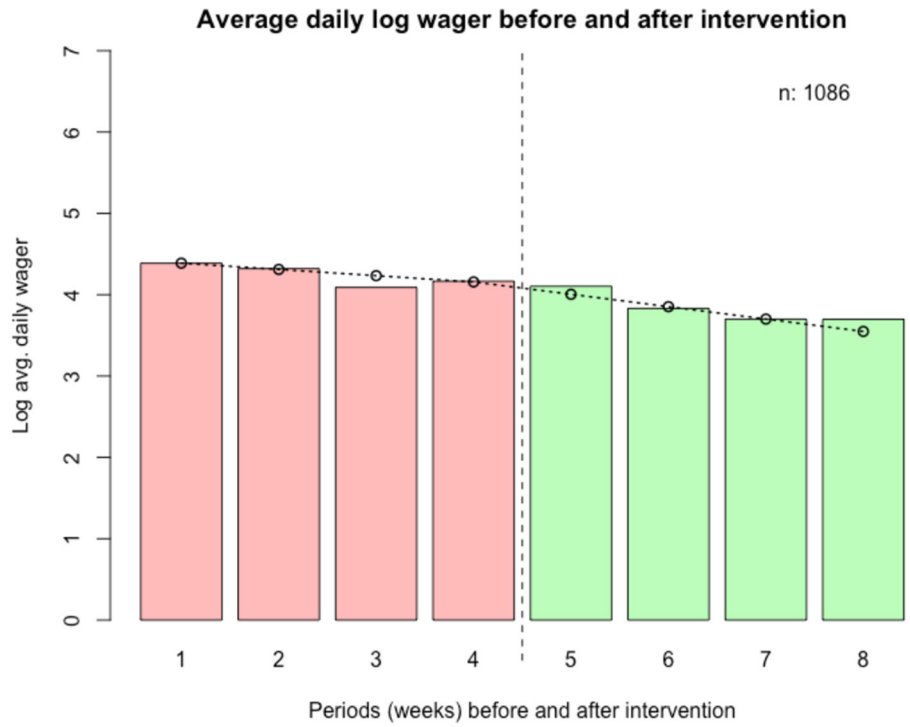

FIGURE 2 | Wager data pre- and post-intervention, logarithmized. Weeks before (weeks 1–4) and after (weeks 5–8) intervention.

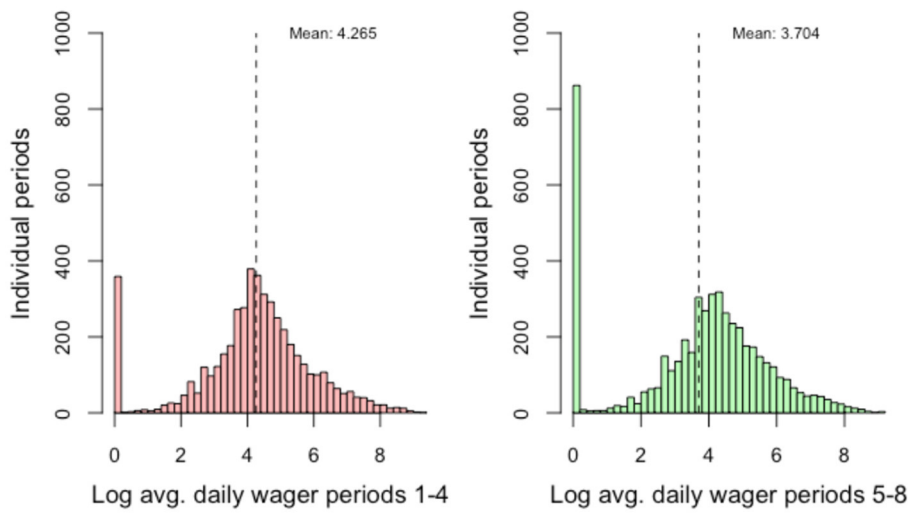

FIGURE 3 | Average daily log wager before (28 days) and after (28 days) intervention.

There was no linear association between log ADW and gender or age. However, there was a statistically significant interaction effect between the intervention and age; this was associated with an increase of the log ADW following the intervention with 0.05 per period (95% CI: 0.04, 0.07) for every 10 years of age in addition to the median age of 39, and, consequently, with −0.05 for every 10 years of age below the median age. Likewise, the interaction effect between the intervention and female gender was significant, with a decrease of log ADW of −0.10 (95% CI: −0.19, −0.02). Participants with casino as the preferred gambling type, compared to participants with sports betting as the preferred type, had a higher log ADW as well as a steeper decrease of log ADW at −0.15 (95% CI: −0.26, −0.04) per period following the intervention (interaction

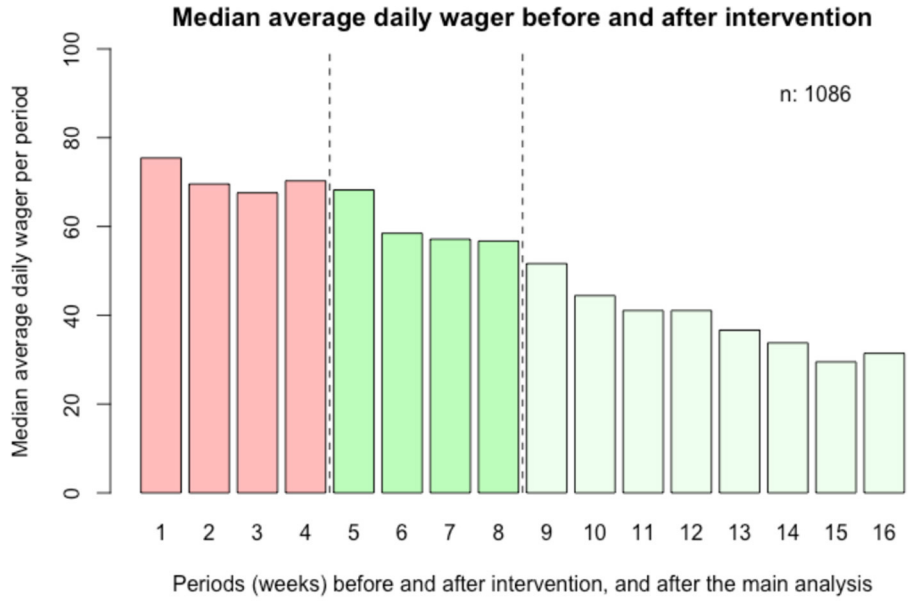

FIGURE 4 | Secondary analysis; average daily log wager before (28 days) and after (84 days) intervention. Weeks before (weeks 1–4) and after (weeks 5–16) the intervention.

effect). There were no statistically significant differences between participants with "other" as the preferred gambling type when compared to those who reported sports betting as the preferred type.

Study participants who overestimated how much others spend on gambling had a higher log ADW than those who made more moderate estimations (0.32, 95% CI: 0.10, 0.54), but neither overestimators nor non-completers had a significantly different effect of the intervention than the reference group.

In a *post-hoc* analysis, we created five equally sized groups based on ADW for the 28 days prior to the intervention (i.e., percentiles < 20, 20–40, 40–60, 60–80, and 80 and above). The median ADW in SEK for the groups was 35, 63, 98, 185, and 616. The median change following the intervention in SEK for each of the groups was −1 (3%), −9 (14%), −19 (19%), −56 (30%), and −233 (38%). When assessing the mean values, the result for the highest group is striking. In that group, the mean ADW prior to the intervention was SEK 922, and the mean change in ADW following the intervention was SEK 305 (i.e., a 33% decrease). This corresponds to a wagered amount of SEK 25,825 during the 4 weeks prior to the intervention and SEK 17,293 during the 4 weeks following the intervention.

Results from the 12-week follow-up are demonstrated in **Table 2** and **Figure 4**. Here, the overall decrease in ADW (intervention slope) remained significant ($p < 0.001$), but with a less steep slope (−0.11, 95% CI: −0.15, −0.07) than in the 4-week follow-up. In this model, online casino gambling was no longer significantly associated with decreased ADW. Also, the interaction of intervention slope and gender was no longer significant.

DISCUSSION

The present study demonstrated an association between an online intervention addressing norms and beliefs about gambling in individuals with a potentially hazardous gambling pattern, and a subsequent change in gambling behavior. The association between the intervention and the subsequent reduction in wagering, over 4 weeks post-intervention, was stronger in younger individuals and in online casino gamblers and lower in non-casino gamblers. However, while these interactions were statistically significant, they were diminutive when compared to the magnitude of the overall association between the intervention and the outcome measure. The sensitivity analyses, designed to assess the robustness of the results under various alternative conditions, did not alter this main finding substantially, which lends support to the validity of the association. In the longer analysis of 12 weeks post-intervention, the reduction in wagering remained significant but less pronounced than in the 4-week model, and a significant association between decreased wagering and online casino gambling was no longer seen.

In the present setting, online casino gambling has been shown to play a particular role in problem gambling in recent years. Online casino is the most common type of gambling reported by treatment seekers in a clinical setting (28), and in a recent survey, in a sample of online gamblers, recent online casino gamblers were considerably more likely to fulfill criteria for problem gambling, compared to online gamblers reporting other typologies of gambling (6). Thus, an online casino may have a closer link to problem gambling than other types and modalities of gambling, at least in a setting where gambling is predominantly

TABLE 1 | Mixed model regression models on log ADW as dependent variable.

Variables	Structural submodel	Full model	
	Estimate (95% CI)	Estimate (95% CI)	*p*-value
Period	−0.07 (−0.11, −0.04)	−0.08 (−0.11, −0.04)	<0.001
First period			
1 (reference)		*1*	
2	−0.44 (−0.67, −0.21)	−0.32 (−0.55, −0.09)	0.006
3	−0.72 (−1.04, −0.40)	−0.58 (−0.91, −0.26)	<0.001
Intervention slope change	−0.09 (−0.14, −0.03)	−0.29 (−0.39, −0.19)	<0.001
Female sex		−0.08 (−0.39, 0.23)	0.610
Age (per 10 years)		0.04 (−0.02, 0.09)	0.163
Entry method		−0.27 (−0.44, −0.09)	0.002
Preferred gambling type			
Betting (reference)		1	
Online casino		0.41 (0.01, 0.81)	0.046
Other		−0.12 (−0.33, 0.08)	0.237
Intervention feedback			
Moderate estimation		1	
Over-estimation		0.32 (0.10, 0.54)	0.004
Non-completer		0.15 (−0.07, 0.37)	0.187
Intervention x Sex		−0.10 (−0.19, −0.02)	0.021
Intervention x Age		0.05 (0.04, 0.07)	<0.001
Intervention x Entry		0.00 (−0.04, 0.05)	0.895
Intervention x Casino		−0.15 (−0.26, −0.04)	0.007
Intervention x Other		0.04 (−0.02, 0.09)	0.169
Intervention x Over-estimation		−0.05 (−0.11, 0.01)	0.120
Intervention x Non-completer		−0.02 (−0.08, 0.04)	0.457

Four-week follow-up post-intervention.

TABLE 2 | Mixed model regression models on log ADW as dependent variable.

Variables	Full model	
	Estimate (95% CI)	*p*-value
Period	−0.11 (−0.14, −0.08)	<0.001
First period		
1 (reference)	*1*	
2	−0.63 (−0.88, −0.39)	<0.001
3	−0.62 (−0.96, −0.28)	<0.001
Intervention slope change	−0.11 (−0.15, −0.07)	<0.001
Female sex	−0.19 (−0.52, 0.14)	0.259
Age (per 10 years)	0.06 (0.00, 0.12)	0.042
Entry method	−0.25 (−0.43, −0.07)	0.007
Preferred gambling type		
Betting (reference)	1	
Online casino	0.29 (−0.14, 0.71)	0.185
Other	−0.10 (−0.32, 0.11)	0.342
Intervention feedback		
Moderate estimation	1	
Over-estimation	0.26 (0.03, 0.49)	0.027
Non-completer	0.10 (−0.14, 0.33)	0.422
Intervention x Sex	0.00 (−0.02, 0.02)	0.894
Intervention x Age	0.02 (0.02, 0.03)	<0.001
Intervention x Entry	0.00 (−0.01, 0.01)	0.711
Intervention x Casino	−0.05 (−0.08, −0.02)	0.001
Intervention x Other	0.01 (−0.01, 0.01)	0.242
Intervention x Over-estimation	0.01 (−0.01, 0.02)	0.523
Intervention x Non-completer	0.00 (−0.02, 0.01)	0.662

Twelve-week follow-up post-intervention.

carried out online. The features of online gambling are known to be particularly addictive; return-to-player rates are high, and time between wagered money and the result, and to the next wagering, is minimal. Thus, loss of control may be particularly pronounced in this type of gambling. It remains to be understood why this type of gambling, where the level of wagering was higher, was associated with a larger decrease in wagering during the first weeks after the intervention, while it did not remain a significant predictor of decreased wagering later during the follow-up.

In the present study, gender was not significantly associated with wagering, and while there was a small interaction between the intervention and female gender, this association was diminished and not statistically significant in the sensitivity analyses, casting doubts on the validity of this result. Gender is a factor known to influence gambling and problem gambling to a large extent; women and men tend to gamble on different types of games and modalities (39), but also have different courses in the development of problem gambling, with a later onset (40) and higher psychiatric comorbidity in women (28, 41, 42). While problem gambling traditionally is more common in men than in women, some previous data suggest the opposite trend in the present setting when only online gamblers are studied (6). Based on the present findings, a normative intervention in online gambling appears to be promising for both genders, when controlling for the type of gambling reported and possibly associated with a slightly larger reduction in wagering in women.

Likewise, the reduction in wagering post-intervention was larger among younger individuals. Few comparable interventions, although not delivered in the same context as here, have been tested in studies where age has been used as a co-factor to control for (15), where findings have been conflicting (16), or where age has been aimed to be similar across intervention and control groups (17, 27). Thus, the present study finding of a larger reduction in wagering among younger individuals, following a normative feedback intervention, needs to be replicated in future studies. Problem gambling is common in the young, as shown in general population data from the present setting (43), and has been shown to be associated with poorer life satisfaction (44) and with other psycho-pathological features (45). This clearly underlines the importance of further intervention research addressing young gamblers, and where mental health and life satisfaction also can be addressed.

The mode of entry into the study was of no significant importance to the change in wagering. Thus, the change in gambling behavior following the studied intervention did not differ depending on whether the gambler herself/himself sought the risk assessment, which constituted the way into this intervention, or whether the intervention was initiated by the gambling operator identifying the potentially risky gambling behavior. This finding supports the possible use of the present intervention in both conditions. Also, the promising associations seen here, regardless of how the gambler was introduced to the intervention, lend support to the use of responsible gambling practices overall by a gambling operator. This may be particularly important given the low treatment seeking in gambling disorder (10), which leads to the rationale of using the gambling situation as a window of opportunity for motivational or supporting messages to the gambler.

An important aspect of the results is the degree of the clinical utility of the decreases in wagering demonstrated. The figures presented (SEK 74.1 and 57.7 before and after the intervention, respectively) are median values in a highly skewed distribution. The mean values pre- and post-intervention were SEK 261 (∼USD 29) vs. SEK 208 (∼USD 23), which can be translated to a monthly difference of about SEK 1,490 (∼USD 166). The magnitude of the decrease in wagering seen in the study should be seen in the context of the intervention being brief and automated and the short-term follow-up in the study. Thus, given the relatively limited intervention delivered here, it can be argued that a decrease of SEK 1,490 (∼USD 166) in wagering is relatively substantial. More studies are needed using this type of normative feedback intervention delivered by a gambling operator, but the decrease seen in association with the intervention here can be interpreted at least as promising. While the results should be interpreted with caution, the decrease seen in association with the intervention here can be interpreted at least as promising. More studies are needed, in other settings and with longer follow-up periods, using this type of normative feedback intervention delivered by a gambling operator.

Implications of the present study include the strengthened support for the feasibility of addressing gamblers' attitudes and beliefs about gambling in future interventions aiming to reduce at-risk gambling. Based on previous findings, the present study aimed to test the promising normative intervention model also when provided by the gambling operator itself. While this was found in this nonrandomized controlled study design, although with non-completers as a control condition, this proved to be at least promising for further study and further use by gambling operators as part of their responsible gambling strategies. In particular, the present findings may have implications for gambling operators in other settings with a high level of online gambling, i.e., where the intervention can be delivered—and measured—within the framework of online interaction. Although beyond the scope of the present study, it also supports further studies on normative feedback interventions particularly in online casino gamblers in treatment and support settings. It is known that individuals with problem gambling may seek treatment or help in many different ways and that this type of interactive online contact may represent one of these strategies (46).

The present study translates previously promising findings in normative feedback interventions to the setting of a gambling operator as part of its responsible gambling practices in their relationship with its customers, in contrast to previous studies addressing either university students or adults from the general population screening positive for problem gambling (22). Also, this study translates these previous findings into the present setting where gambling is online in many cases, and where the online setting provides an opportunity for intervention in close association with the gambling situation. This differs to some extent from previous studies; Neighbors and co-workers (21) studied a college student sample with primarily land-based gambling types, including playing cards for money, casino gambling, or lotteries. In the study by Hodgins and co-workers (23), an online intervention was delivered to a nontreatment-seeking sample among whom a majority reported gambling on electronic gambling machines. Theoretically, the strength of the intervention is to help individuals reflect on their level of gambling as perceived in comparison to the gambling of others and that the individuals may correct their misperceptions about how much others gamble (21). In this case, such a normative feedback intervention may be particularly helpful when provided directly by the gambling operator, thereby displaying—in close temporal association with the actual gambling situation—the true level of the individual's gambling on that operator's sites.

The present study has limitations: the first is that the results of the study cannot be compared to those of a formal control group, such as in a randomized controlled design, although non-completers were instead analyzed here as a control condition. Future studies should compare the present type of normative intervention to an "as-usual" condition or to another control group in order to better control for the possibility of the results being caused by regression toward the mean. It shall be borne in mind that despite the promising pattern seen after the normative intervention in the present study, it cannot be excluded that a decline in gambling, after a more intense gambling period, might be due to decreasing financial resources of the individuals, other barriers to gambling imposed by financial constraints or by families of the gambler, or other natural fluctuations in at-risk gamblers. For example, it has recently been shown that high-level gambling patterns may vary substantially over time (47), which is also in accordance with the fact that many individuals vary over time in their fulfillment of problem gambling definitions (13).

Moreover, the follow-up time in the study was limited. Several other intervention studies using real-world data on brief interventions carried out by the gambling operator have used follow-up periods that were as short, or shorter, compared to the present one. In contrast to the somewhat longer follow-up periods in studies carried out in other populations than in gambling operator clients (22), several studies using brief messages from a gambling operator have used short follow-up periods. These follow-up durations have included a number of days (16), or studied gambling outcomes in even closer proximity to the actual intervention (15). One study of an intervention of a loss-limit reminder from a Norwegian gambling operator included a 3-month follow-up, i.e., similar in duration to the secondary analysis of the present study (27). An exception is the 1-year follow-up of a telephone or letter intervention in Norway,

which thereby, however, can be assumed to represent a more in-depth intervention than the brief and automated ones described in the present study and elsewhere (17).

Although a 4-week study period prior to the intervention was maintained, a secondary analysis was conducted, involving 12 weeks of follow-up post-intervention. The pre-intervention period in that analysis was maintained at 28 days, as the number of included individuals with a full study period would otherwise be more limited; individuals who entered the study during the month prior to the intervention would otherwise be missing in a longer pre-intervention period. Although the pre- and post-intervention periods do not have the same duration and therefore cannot be readily comparable, this analysis demonstrates no tendency for ADW values to return to pre-intervention levels. While this further supports the impression of a downward trend in wagering following the normative feedback intervention, the largest decrease may occur during the first weeks after the intervention. Further studies should address whether normative feedback interventions may need to be repeated in order to maintain a decrease in gambling over a longer follow-up period.

Gambling through other companies than the present one cannot be detected in the study. Likewise, as no actual self-report data were available, no diagnostic criteria were available, and therefore, beyond the sole reporting of the risk level from the test, no other measures of problem gambling or gambling disorder could be included. The aim of the study was to test a model for intervention by a gambling operator in individuals with a theoretical at-risk gambling pattern, or an own interest in taking a risk gambling test, rather than a clinical intervention in individuals presenting with a manifest gambling problem. Likewise, the present intervention included one specific gambling operator and was conducted in one specific geographical setting, where problem gambling is predominantly online-based (28). Therefore, the findings cannot readily be generalized to other gambling operators or to settings where a higher percentage of problem gamblers report land-based gambling.

In conclusion, a normative feedback intervention, asking questions about an individual's gambling patterns and her/his beliefs about peer gambling, may be associated with a decrease in gambling in online gamblers hypothesized to have a potentially hazardous gambling pattern. While such an intervention previously has not been studied in its direct administration from a gambling operator, it here proved at least feasible in the context of a state-owned gambling operator, although its further use in other types of gambling settings may need to be tested. The association between the normative intervention and the reduction in wagering was stronger in younger individuals and stronger in the short term in online casino gamblers. In a longer time frame, following up individuals for 12 weeks post-intervention, the association with reduced gambling patterns may be less pronounced. These results can be seen as promising, and although they should be interpreted with caution, they call for future studies in larger study samples and in other settings, including longer follow-up durations.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because a request for study data would be sent for review by the Ethics Committee and the company owning the data. Requests to access the datasets should be directed to anders_c.hakansson@med.lu.se.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Regionala etikprövningsnämnden Lund (Regional ethics authority Lund), Sweden. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AH, AL, and KF were responsible of the overall project planning and data collection. Detailed study design was planned by AH, AL, KF, and JB. Statistical work was carried out by JB. JB and AH wrote the first drafts of the manuscript. TA, AL, and KF made substantial contributions to the text. Interpretation of data and results were made mainly by all authors. All authors approved the final paper and the submission.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.602846/full#supplementary-material

Table S1 | Model selection for the structural submodel.

Table S2 | Multivariate regression analyses.

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Conflict of Interest: AL and KF were employed by the state-owned Swedish gambling operator AB Svenska Spel, and work in the subdivision responsible of responsible gambling strategies, self-assessment tools etc. The study was carried out thanks to the overall support from this gambling operator. AH and his research group receive overall research funding from the same state-owned gambling operator. The company as such (except for the employees involved as co-authors) was not involved in the interpretation of data and the writing or editing of the paper.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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