International Journal of Mental Health and Addiction
https://doi.org/10.1007/s11469-023-01199-4

ORIGINAL ARTICLE

A Network Approach of Gambling Disorder Profile with and Without Related Illegal Acts

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Accepted: 8 November 2023

Abstract
Gambling disorder (GD) is a complex mental health condition that can cause many severe psychological, physical, and social impairment. Illegal acts have been recognized in quite a few cases because of the debts related with the gambling activity. This study used network methodology to visualize the relationships among patients seeking treatment for gambling related problems, separately for the patients with and without illegal behaviors. The aim is to identify the diverse and differentiate mechanisms, as well as the central nodes, that occur within GD patients depending on the presence/absence of illegal acts. The sample included $N = 401$ patients (age range 18 to 80 years). Network analysis was performed considering the nodes that measure gambling features (the core symptoms based on the DSM-5 taxonomy, global symptom severity, and forms of gambling), psychopathology distress, substance use (tobacco, alcohol, and illegal drugs), and personality traits. Two separate networks were adjusted for patients with illegal acts ($n = 105$) and without these behaviors ($n = 296$). The most relevant nodes among patients with GD plus illegal acts were self-transcendence and the GD DSM-5 symptom "A7-lies to conceal the extent of gambling" (these variables were also identified as the *bridge* nodes, those with the highest linkage capacity). Among the patients with GD without illegal acts, the node with the greatest authority was the GD DSM-5 symptom "A5-often gambles when feeling distressed" (this was also the variable with the highest linkage capacity). The study provides empirical evidence of the most relevant features and the linkage capacity among patients seeking treatment for problematic gambling, which can support the development of precise plans for treatment and prevention of the risk of GDRIA.

Keywords Illegal acts · Gambling disorder · Network · Nodes · Personality

Introduction

The latest version of the *Diagnostic and Statistical Manual of Mental Disorders* DSM-5 (American Psychiatric Association, 2013) defines gambling disorder (GD) as a behavioral addiction disorder characterized by persistent and recurrent problematic gambling activity,

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leading to clinically significant distress, and not better explained by a manic episode. The presence of GD in this taxonomy is based on exhibiting four (or more) behaviors from a list of 9 symptoms (needs to gamble with increasing amounts of money, restless/irritable when attempting to stop gambling, unsuccessful efforts to control/stop gambling, frequent preoccupations with gambling, gambling to cope with distress, chasing, lies related with gambling activity, impact on social areas, and relies on others to relieve financial situations caused by gambling).

GD has long been associated with serious clinical and social functional impairment and with poor quality of life (Ioannidis et al., 2019). It has been observed that some patients report the presence of illegal acts (behaviors that are observed constituting legal problems) in the progression of the GD, such as forgery, fraud (for example writing bad checks/paying bills from accounts that contain no funds), theft, or embezzlement to finance gambling activity (Grant & Chamberlain, 2023). But despite the strong link between illegal behaviors with GD, the Pathological Gambling Committee that developed the DSM taxonomy decided to remove illegal acts and lower the cut-off score from five to four criteria in the list of symptoms from the latest version of the manual (American Psychiatric Association, 2013). These changes raised clinical and scientific interest. Research on the impact of the removal of illegal acts concluded that it had little impact on the identification of problematic gambling and the diagnosis of GD, since patients who reported gambling disorder-related illegal acts (GDRIA) usually reached the cut-off point regardless, due to the presence of the other criteria (Petry et al., 2013; Weinstock et al., 2013). However, studies also concluded that the elimination of GDRIA from the DSM-5 diagnostic criteria for GD did not justify its exclusion from the assessment of problematic gambling due to the severe clinical and legal consequences (Granero et al., 2014; Temcheff et al., 2016). Studies in this line conclude that even if GDRIA is not an independent diagnostic criterion, it should be considered a measure of the severity of GD and the prognosis of the disorder (Jiménez-Murcia et al., 2019; Mestre-Bach et al., 2018, 2021; Turner et al., 2016). Studies have also suggested that illegal behaviors are associated with earlier onset of gambling problems, higher psychopathology levels (including depression, anxiety and substance use), and poorer quality of life (Gorsane et al., 2017; Grant & Chamberlain, 2023). GD patients with a history of illegal acts have also presented more dysfunctional personality traits in comparison with GD without criminal behavior, concretely higher levels of novelty seeking, and lower levels of reward dependence, persistence, self-directedness, and cooperativeness (Mestre-Bach et al., 2021).

The presence of these gambling-related crimes has been estimated to range from anywhere between 23 and 89% (Folino & Abait, 2009). This huge disparity is largely due to the lack of consensus on the definition of "crime" and to sample composition (clinical or population-based). Studies have also suggested that very low prevalences of illegal acts among samples of patients seeking treatment for GD could be the consequence of inadequate assessment methods/tools that could lead to underreporting crime acts due to social desirability bias (Rash & Petry, 2016). Sex and age are also potential factors explaining the large differences in the prevalence estimates. Since illegal acts are more prevalent in males and young age individuals, the frequency of these behaviors tends to increase for samples with a large number of men with ages within adolescence to young adulthood (Kryszajtys et al., 2018).

A current systematic review concluded that GDRIA are generally non-violent and motivated by the need to obtain gambling funds and/or recoup financial shortfalls (Adolphe et al., 2019). Like other research, this review also outlined that even supposing that the relationship between gambling activity and illegal behavior could be explained by financial

motivations (Laursen et al., 2016), the pathways explaining the concurrence of problematic gambling and crime remain uncertain, and that the complex underlying processes are doubtlessly mediated by a large number of features (Dennison et al., 2021). In whatever case, GDRIA has a negative impact on the patients' clinical state, on the families' perception of safety, and on the individuals' local environment (May-Chahal et al., 2017).

The association of GDRIA with a clinical profile characterized by greater severity and poorer functions has suggested that illegal activity could interfere with the effectiveness of the therapy, concretely increasing the likelihood of poor treatment outcomes. Studies such as that by Ledgerwood and colleagues suggest that when the presence of illegal behavior is identified, treatments should be intensified because the severity of these behaviors may interfere with adherence to the guidelines and affect outcomes (Ledgerwood et al., 2007). The more recent research by Vintró-Alcaraz and colleagues also observed that the presence of illegal behaviors is associated with a more severe clinical profile at baseline (specifically with greater comorbidity of other mental disorders, substance use, more maladaptive personality traits, and higher levels of impulsivity), and that these factors could predict a higher risk of dropout and relapse during interventions (Vintró-Alcaraz et al., 2022). However, none of the previous studies provides specific guidelines on how to intervene among the complex structure of interrelations in the patients' clinical profile when illegal behavioral conduct is present. Thus, one of the therapeutic targets should be to identify the underlying mechanisms of patients who report the presence of these acts and to apply adequate intervention plans to eliminate them. These programs should also be able to identify subjects that are highly vulnerable to illegal acts during the progression of the disorder, with the aim of employing specific prevention plans.

Although the limited empirical data on GDRIA, the published studies notice that illegal behaviors are common in patients with problematic gambling, and that these criminal acts are mostly linked with more severe clinical profile and worse quality of life. But it is unknown how the presence of illegal acts impacts the underlying complex structure of the GD profile, the treatment outcomes, and the trajectory of the disease. Moreover, since illegal behaviors are not defined as a specific diagnostic criterion for GD in the reference diagnostic taxonomies (such as the DSM), validated scales, in-person assessments, and specific treatment actions are limited and/or unstandardized procedures (Gorsane et al., 2017; Laursen et al., 2016). The main objective of this study was to perform network analysis to visualize the relationships between a set of nodes containing information on the clinical profile (including the core symptoms of GD, psychopathology distress, substance use, and personality dimensions) of patients seeking treatment for GD who reported the presence of illegal acts. The secondary objectives of the study were (a) to visualize separate networks obtained among patients' treatment seeking for GD who reported and not the presence of illegal acts that was performed and (b) to identify the central nodes (those of greatest relevance and linking capacity in the graph) and to explore the existence of empirical clusters of nodes (also known as modules or communities) in the two separate networks. The new results obtained in this work will provide evidence for designing new measurement tools and treatment plans for patients' treatment seeking for GD who report illegal behaviors associated to their gambling activity.

This study explored the complex system of reciprocal interactions including variables from different functional dimensions using a network approach, a procedure based on graph theory that is useful for visualizing intricate multifaceted phenomena (Borsboom, 2017; Borsboom et al., 2018; Borsboom & Cramer, 2013; Epskamp et al., 2018; Hevey, 2018; McNally, 2016). This methodology provides an image of the underlying interactions between connected variables (which can represent diverse biological, psychological and social features)

(Boschloo et al., 2015; Goekoop & Goekoop, 2014). The aforesaid structure is displayed with two components: (a) the nodes (shown as circles) containing the symptoms and other sociodemographic and clinical variables and (b) the edges (shown as connecting lines) depicting the relationships between the nodes-variables (Borgatti et al., 2009). The values of the edges represent the effect sizes of the associations between the nodes, which is visualized by the thickness of lines (for example, a large effect size is reflected with a thick edge, while two unrelated variables are reflected by two unconnected nodes). Centrality coefficients are the indexes used and interpreted for determining the relevance of the nodes in the network. Concretely, the highest centrality capacities are the most relevant in the graph (they are typically labeled "central nodes") (Fried et al., 2017; Fried & Cramer, 2017). And nodes with the highest linkage capacity are described as those facilitating the paths between structures (usually labeled "transition/bridge" nodes) (Braun et al., 2018; Cramer et al., 2010). Compared with other classical multivariate analytical procedures, network is a graphic-based approach particularly useful to estimate and visualize the structure of the relationships among complex systems. Applied to the study of psychiatric conditions, network allows conceptualizing mental unhealthy phenomena as dynamic structures of mutually reinforcing nodes, which represent multiple inter-connected constructs (typically symptoms but also other functional measures such as personality traits) (Bringmann & Eronen, 2018). Instead of passive underlying latent entities, psychopathological states are conceptualized in the network theory through a set of pathways linking variables pertaining to different functional areas (Jones et al., 2021). The organization of the nodes based on their location in the net-structure (defined as the relevance-centrality) provides valuable information about their capacity for generating local or global connectivity, and therefore allows a better understanding of the etiology of mental phenomena. Also relevant network recognizes that certain parts of the structure are categorized into clusters of nodes (also termed "communities"), that could be interpreted as a higher level of structural organization (like upper-level functional systems) (Goekoop & Goekoop, 2014). The interpretation of both nodes and communities with high connectivity capacity should be considered important targets for designing reliable assessment tools and precise treatment plans (Robinaugh et al., 2016). While network analysis has not been widely applied for the study of mental health states, this approach is especially salient in this area because psychopathological phenomena are theorized to depend upon a large number of variables interacting in a dynamic way (Hevey, 2018).

To our knowledge, this is the first study to explore the network structure among patients with GDRIA; hence, we were unable to define empirical hypotheses regarding the most central nodes or the presence of communities of nodes. However, considering a theoretical model of psychopathology states based on the interaction between multi-level mechanisms contributing to the onset and course of mental diseases (Robinaugh et al., 2020), we expected: (a) the identification of central nodes that would represent different information according to the presence-absence of GDRIA and (b) the existence of distinct empirical classes of nodes (more densely connected to each other than to the rest of the network) and of different compositions depending on the presence-absence of GDRIA. The fulfillment of these hypotheses will imply new empirical evidence regarding the heterogeneity of the GD and the manifestation of multiple profiles.

Material and Methods

Participants

This study analyzed the data of $N = 401$ consecutive treatment-seeking patients at the Behavioral Addictions Outpatient Unit, Bellvitge University Hospital (Barcelona, Spain), between January 2021 and December 2022. This unit is a tertiary service for the treatment of behavioral addictions, including gambling disorder.

The inclusion criteria for the study were age 18+ years and treatment for GD-related problems. The exclusion criteria were the presence of other behavioral addictions, or an organic mental disorder that prevents the use of measurement tools due to the potential low reliability of responses (for example, intellectual disability or neurodegenerative disorder [such as Parkinson's disease]). The use of substances was not considered an exclusion criterion in this work.

All the individuals included in the study were patients seeking treatment for GD. The whole sample was classified according to the presence/absence of illegal acts, resulting in $N = 105$ patients in the GDRIA+ and $N = 296$ in the GDRIA-.

Materials

Diagnostic Questionnaire for Pathological Gambling (According to DSM Criteria) (Stinchfield, 2003)

This tool includes 19 items coded on a binary scale (yes-no). It was originally developed to assess the presence of GD according to the DSM-IV-TR (American Psychiatric Association, 2000). The scale was adapted to assess the nine DSM-5 diagnostic criteria for GD (American Psychiatric Association, 2013). In this work, this diagnostic tool was used to assess the presence/absence of the nine DSM-5 criteria for GD, as well as the presence (or absence) of illegal acts as defined in the DSM-IV-TR ("have committed illegal acts, such as forgery, fraud, theft, or embezzlement, in order to finance gambling"). The Spanish adaptation used in this study presented adequate psychometric indexes (Jiménez-Murcia et al., 2009). The internal consistency for this scale in the study sample was excellent (Cronbach's alpha equal to $\alpha = 0.901$).

South Oaks Gambling Screen (SOGS) (Lesieur & Blume, 1987)

This tool includes 20 items developed to identify the presence of gambling behavior, including probable, problem, and non-problem gambling. The total score for the scale has usually been used as a measure of gambling symptom severity. The adapted Spanish language version used in this study presented adequate psychometric indexes (Echeburúa et al., 1994). The internal consistency in this study was adequate, $\alpha = 0.784$.

Symptom Checklist-Revised (SCL-90-R) (Derogatis, 1994)

This tool includes 90 items developed to assess the presence/level of a large set of psychological symptoms. The adapted Spanish language version used in this study presented adequate psychometric indexes (Gonzalez De Rivera et al., 1989). This study used global psychological distress measured with the global severity index (GSI), which obtained excellent internal consistency in the sample ($\alpha = 0.981$).

Temperament and Character Inventory-Revised (TCI-R) (Cloninger et al., 1994)

This tool includes 240 items developed to assess personality profile based on Cloninger's multidimensional model. It is structured into 4 dimensions of the individual's temperament (novelty seeking, harm avoidance, reward dependence, and persistence) and 3 dimensions of the individual's character (self-directedness, cooperation, and self-transcendence). The adapted Spanish language version used in this study presented adequate psychometric indexes (Gutiérrez-Zotes et al., 2004). The internal consistency in the study sample was between adequate ($\alpha = 0.748$ for reward dependence) and very good ($\alpha = 0.857$ for persistence).

Semi-Structured Clinical Interview

This tool is used in the treatment unit to assess additional information, including sociodemographic and clinical variables. The complete instrument has been described elsewhere (Jiménez-Murcia et al., 2006). In this study, the socioeconomic variables analyzed were sex, marital status, level of education, employment status, and social status, calculated according to Hollingshead's Four Factor Index (Hollingshead, 2011) (based on four domains: marital status, retired/employed status, educational attainment, and occupational prestige). The semi-structured interview also allowed measurement of a set of gambling related variables: age of onset and duration of the problematic gambling, the presence of accumulated debts related to the gambling activity, the presence of GDRIA, gambling preferences (only non-strategic, only strategic, or mixed), type of gambling (only offline, only online, or mixed), and the use of substances (patients reported the consumption of tobacco, alcohol, or other illegal drugs). The non-strategic form of gambling is a category that includes little decision-making or skill, and hence participants have no influence on the outcome/s (slot-machines, bingo, and lotteries) (Jiménez-Murcia et al., 2020). Strategic forms of gambling belong to a category in which gamblers attempt to use their ability to predict outcome/s (such as poker, sports/animal betting, and craps).

Ethics

The research was carried out in accordance with the Declaration of Helsinki of 1975, as revised in 2000. It was approved by the Ethics Committee of Bellvitge University Hospital (ref: PR338/17 [CSI 18/04]). All the patients provided informed consent (the acceptance

rate was 100% of all the consecutive patients from the treatment unit who met the inclusion criteria).

Procedure

Data analyzed in this study correspond to the measurement at baseline (on arrival in the treatment unit). In addition to assessment of the clinical and sociodemographic variables included in the semi-structured interview, the clinicians involved in the recruitment of the sample helped the participants to complete the self-report questionnaires to guarantee that they fully understood all the items and completed the tools properly. All the clinicians were specialized in the treatment of behavioral addictions and had extensive experience in the assessment and treatment of patients with problematic and disordered gambling. The assessments were run in single sessions, with a mean duration of between 90 to 120 min.

Statistical Analysis

In this study, two networks were obtained for the subsamples GDRIA+ ($N = 105$) and GDRIA- ($N = 296$). A set of 24 nodes was considered for analysis: the nine key DSM-5 criteria for GD, the GD severity level (as measured by the total SOGS and debts related with the gambling activity), gambling preference (only strategic versus strategic or mixed), the type of gambling (only land-based versus online or mixed), global psychological distress (SCL-90 GSI), the presence of substance use (tobacco, alcohol, or illegal drugs), and personality profile (as measured with the seven TCI-R dimensions). The justification for selecting many nodes was to visualize a more realistic profile based on different functional areas, including the core criteria for GD (as defined in the DSM-5), other gambling activity measures, and psychological performance (psychopathology and personality). In addition, this study used direct comparison based on the visualization of the two network structures generated from the two independent data sets (patients with and without illegal acts, GDRIA+ *versus* GDRIA-), the identification of the nodes with the highest centrality measures within each graph, and the identification of the clustering of nodes.

Many network analysis methods have been developed to be implemented in generic software such as MATLAB, Stata or R-open-source. Also, specialized network packages are now available, such as Gephi (Bastian et al., 2009), an open-source system with some interesting benefits including large data structures (i.e., over 20,000 nodes) and a powerful spatialization process for a range of algorithms (including parameters of centrality, linkage, density, and modularity-clustering). The Gephi 9.2 version for Windows was used in this work (available at http://gephi.org).

Various statistical procedures can estimate the effect sizes for edges visualized with Gephi, including the partial correlations matrix, adjusted regression coefficients, adjusted odds ratio coefficients, and factorial loads (adjusted coefficients must be obtained to avoid biases due to the impact of possible confounding variables) (Bringmann et al., 2013; Clifton & Webster, 2017; Hevey, 2018). This study defined an undirected network (nodes have a connecting line representing mutual relationship but with no arrowheads to indicate the direction of the effect), and its edges represented partial correlations between nodes after controlling for all other nodes in the network (these coefficients also provided the signal of the adjusted size for edges). The initial data structure for the network resulted

in 25 nodes and 300 potential edges, most of which had very low weights (partial correlations around 0). To simplify this initially complex structure, edges that did not reach significance ($p < 0.05$) were excluded, resulting in a final structure consisting of 91 edges (around 30.3% of all potential connectors). This selection of the edges yielded a more parsimonious graph (with fewer connections between nodes), with the advantage of representing only the most relevant empirical relationships in the data and with the consideration that the absence of an edge is not evidence that the association between the nodes is exactly zero (Epskamp et al., 2017).

Centricity indexes were estimated with Brandes' algorithm (Brandes, 2001). The relevance of each node in the network was calculated with the eigenvector centrality, which is obtained as the weighted sum of the centrality scores of all the other nodes connected to a concrete node. High eigenvector centrality is interpreted as highly valuable information for the whole graph.

The linkage capacity of each node was calculated by closeness centrality, which is calculated as the reciprocal of the sum of the length of the shortest paths between each node and all the other nodes in the graph (and interpreted as how close the node is to all the other nodes). High closeness values suggest a short average distance between one node versus all the other nodes. Nodes with high closeness are characterized by a high capacity to promote relevant changes in other parts of the graph, while these nodes are also highly vulnerable to the impact of modifications to any part of the whole structure.

The presence of empirical clusters of nodes (also called communities or modules) was automatically identified based on the Blondel's modularity algorithm (Blondel et al., 2008), and clustering coefficient metric is based on Latapy's algorithm (Latapy, 2008). The empirical clusters in Gephi represent groups of nodes that are well connected to the other nodes in the same cluster but sparsely connected to the rest of the graph.

Additional graph distance coefficients obtained and interpreted in the study were (a) the (average) path length, calculated as the mean of the shortest paths between all pairs of nodes (and interpreted as a measure of the efficiency of information transport in the network) and (b) the diameter, calculated as the greatest distance between the two furthest nodes (and interpreted as the maximum eccentricity of any vertex in the graph) (Brandes, 2001). The density of the graph was also calculated, concretely as the ratio between the number of edges in the graph divided by the potential number of connections (this index provides a measure of how close the network is to being complete, that is, a graph with all possible edges and achieves [a density measure equal to 1]).

Results

Descriptive for the Sample

Out of the total sample ($N = 401$), most patients were single (54.6%), employed (56.9%), men (91.5%), with a primary education (56.9%), and belonging to a mean-low to low social status indexes (80.5%). Mean age was 41.9 (SD = 15.4), mean age of onset of the GD-related problems was 30.01 (SD = 13.34), and mean duration of the GD problems was 6.8 years (SD = 6.84). The most frequent form of gambling in the study was non-strategic (42.6%) and off-line (77.3%). The prevalence of patients who reported tobacco use was 51.1%, alcohol use was reported by 15.0%, and other illegal drugs by 13.5%.

Table 1 Descriptive of the variables of the study

Sociodemographic features	*Total* (*N* = *401*)		*GDRIA-* (*N* = *296*)		*GDRIA+* (*N* = *105*)		
	n	%	*n*	%	*n*	%	*p*
Sex							
Women	34	8.5%	30	10.1%	4	3.8%	**.046***
Men	367	91.5%	266	89.9%	101	96.2%	
Marital							
Single	219	54.6%	155	52.4%	64	61.0%	.236
Married	129	32.2%	102	34.5%	27	25.7%	
Divorced	53	13.2%	39	13.2%	14	13.3%	
Education							
Primary	228	56.9%	173	58.4%	55	52.4%	.195
Secondary	145	36.2%	100	33.8%	45	42.9%	
University	28	7.0%	23	7.8%	5	4.8%	
Employed							
Unemployed	173	43.1%	128	43.2%	45	42.9%	.945
Employed	228	56.9%	168	56.8%	60	57.1%	
Social position							
Mean-high to high	39	9.7%	28	9.5%	11	10.5%	
Mean	39	9.7%	32	10.8%	7	6.7%	.462
Mean-low to low	323	80.5%	236	79.7%	87	82.9%	
Age, onset, and duration of GD	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*p*
Age (yrs-old)	41.86	15.41	43.46	15.86	37.35	13.11	**.001***
Onset of GD related problems (yrs-old)	30.01	13.34	31.69	13.94	25.27	10.13	**.001***
Duration of GD related problems (yrs-old)	6.01	6.84	5.33	6.54	7.93	7.34	**.001***
GD severity symptom level and debts	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*p*
SOGS total score	10.75	3.64	10.21	3.66	12.27	3.12	**.001***
Debts due to the gambling activity (euros)	9173	14471	8314	14134	11594	15190	**.046***
GD symptoms based on the DSM-5	*n*	%	*n*	%	*n*	%	*p*
A1 gambling with increasing amounts of money	299	74.6%	213	72.0%	86	81.9%	**.044***
A2 restless-irritable when stop gambling	279	69.6%	203	68.6%	76	72.4%	.467
A3 repeated efforts to control-stop gambling	357	89.0%	260	87.8%	97	92.4%	.201
A4 preoccupied with gambling	317	79.1%	231	78.0%	86	81.9%	.403
A5 often gambles when feeling distressed	328	81.8%	239	80.7%	89	84.8%	.359
A6 chasing one's losses	333	83.0%	243	82.1%	90	85.7%	.396
A7 lies to conceal the extent of gambling	349	87.0%	249	84.1%	100	95.2%	**.004***
A8 has lost relationships, job, education	315	78.6%	221	74.7%	94	89.5%	**.001***
A9 relies related with financial issues	300	74.8%	210	70.9%	90	85.7%	**.003***
Forms of gambling	*n*	%	*n*	%	*n*	%	*p*
Preference							
Only non-strategic	171	42.6%	133	44.9%	38	36.2%	.240
Only strategic	158	39.4%	114	38.5%	44	41.9%	
Mixed	72	18.0%	49	16.6%	23	21.9%	
Modality							
Only land-based	310	77.3%	231	78.0%	79	75.2%	.696

Table 1 (continued)

Sociodemographic features	*Total* (*N* = *401*)		*GDRIA-* (*N* = *296*)		*GDRIA+* (*N* = *105*)		
	n	%	*n*	%	*n*	%	*p*
Only online	43	10.7%	32	10.8%	11	10.5%	
Mixed	48	12.0%	33	11.1%	15	14.3%	
Substances use	*n*	%	*n*	%	*n*	%	*p*
Tobacco	205	51.1%	151	51.0%	54	51.4%	.942
Alcohol	60	15.0%	44	14.9%	16	15.2%	.927
Illegal drugs	54	13.5%	35	11.8%	19	18.1%	.106
Psychopathology and personality	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*p*
SCL-90R global distress (GSI)	1.18	0.76	1.16	0.75	1.23	0.77	.374
TCI-R novelty seeking	109.91	11.99	108.71	12.12	113.28	10.99	**.001***
TCI-R harm avoidance	100.72	16.61	101.31	16.77	99.05	16.11	.230
TCI-R reward dependence	94.94	13.25	95.25	13.23	94.06	13.32	.427
TCI-R persistence	110.50	17.73	110.51	17.59	110.46	18.21	.978
TCI-R self-directedness	125.93	19.01	126.87	19.28	123.28	18.05	.096
TCI-R cooperativeness	129.09	15.10	130.50	14.61	125.10	15.82	**.002***
TCI-R self-transcendence	63.93	14.70	64.71	14.32	61.73	15.60	.074

GD gambling disorder, *GDRIA* gambling disorder related illegal acts, *SD* standard deviation

*Bold: significant comparison

Table 1 contains the distribution of all the variables in the study and the comparison between patients with and without GDRIA. The GDRIA+ group was characterized by a higher proportion of men, younger patients, earlier onset of the GD-related problems, and longer duration of the problematic gambling. This group also reported higher prevalence for the DSM-5 criteria for GD "A1-gambling with increasing amounts of money," "A7-lies to conceal the extent of gambling," "A8-loss of relationships, job, or education due to the gambling activity," and "A9-relies on others to relieve financial issues." Regarding personality profile, GDRIA+ achieved a higher mean score in the novelty seeking dimension and a lower mean score in the cooperativeness dimension.

Network Study

Figure 1 presents the networks obtained in the study (Tables S1 and S2, supplementary material, include the full statistics for these analyses). The network for the GDRIA+ group was defined for 80 edges, resulting in a density of 0.29, a diameter value equal to 4, and the average path length was 2.297. For the GDRIA- subsample, the network included 113 edges, with a density of 0.409, a diameter of 3, and an average path length equal to 1.594.

The first bar chart in Fig. 2 shows the nodes ordered by eigenvector centrality (which depicts the importance of each variable in the network), and the second bar chart presents the closeness centrality (which provides the linkage capacity). In the GDRIA+ subsample, the most relevant node was the one for TCI-R self-transcendence, followed by the DSM-5 criterion "A7-lies to conceal the extent of gambling." The self-transcendence trait was also identified as the *bridge* node in this group (the nearest node to all the others). In the

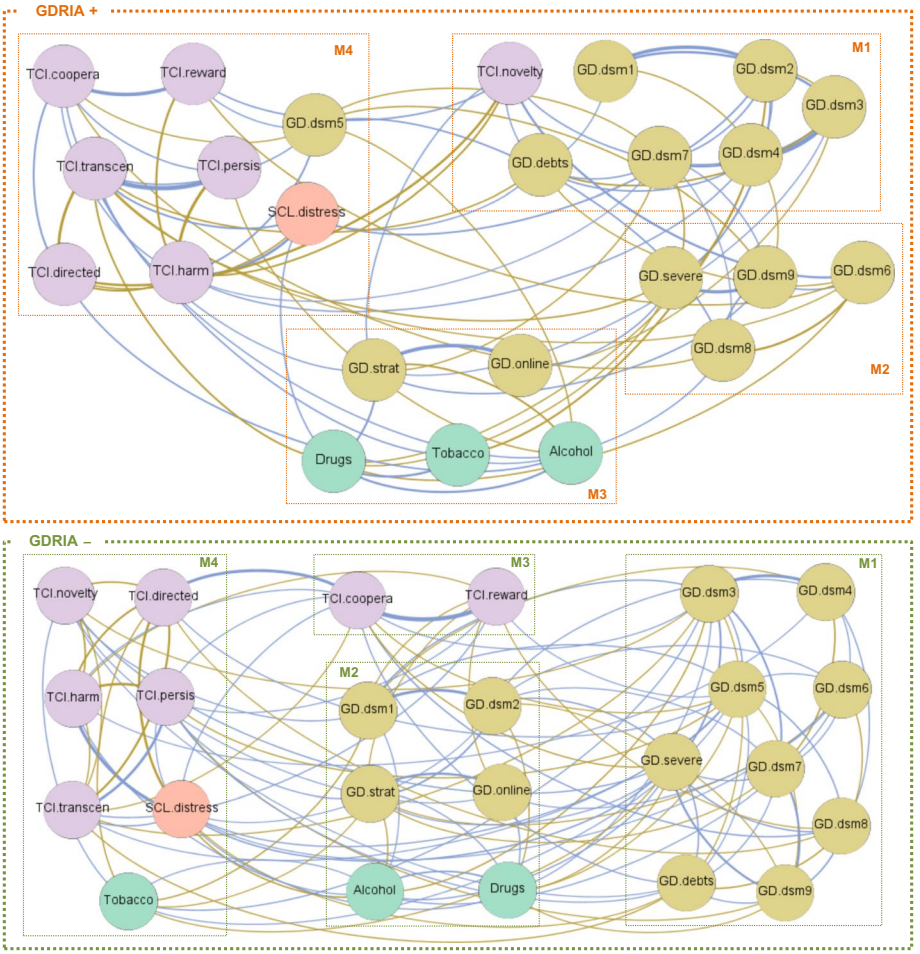

Fig. 1 Visualization of the networks for the subsample with illegal acts. Note: Positive edges are represented by blue lines and negative edges by brown-ochre lines. The thicker the edge, the stronger the connection weight. Nodes are plotted in colors depending on the dimension: personality (purple), psychopathology distress (orange), gambling related measures (ochre), substances (green). Nodes: DSM-5 symptoms for gambling disorder (GD.dsm1 to GD.dsm9), debts related with gambling (GD.debts), GD symptom level (GD.sogs), strategic preference gambling (GD.strat), online modality gambling (GD.online), global psychopathology distress (SCL.distress), substances (tobacco, alcohol, and drugs), novelty seeking (TCI.novelty), harm avoidance (TCI.harm), reward dependence (TCI.reward), persistence (TCI.persis), self-directedness (TCI.directed), cooperativeness (TCI.coopera), and self-transcendence (TCI.transcen). M1 to M4 group the nodes into the latent classes identified in each network

GDRIA- subsample, the most important node in the whole graph was the DSM-5 criterion "A5-often gambles when feeling distressed," which was also recognized as the *bridge* node (the closest node to all the others).

Four modules (communities or clusters of nodes) were identified in each network, but the nodes included in each latent cluster differed among patients with and without GDRIA. For the group of patients in the GDRIA+ sample, the composition of latent classes was: Module 1 (M1) included novelty seeking plus the DSM-5 criteria for GD A1, A2, A3, A4,

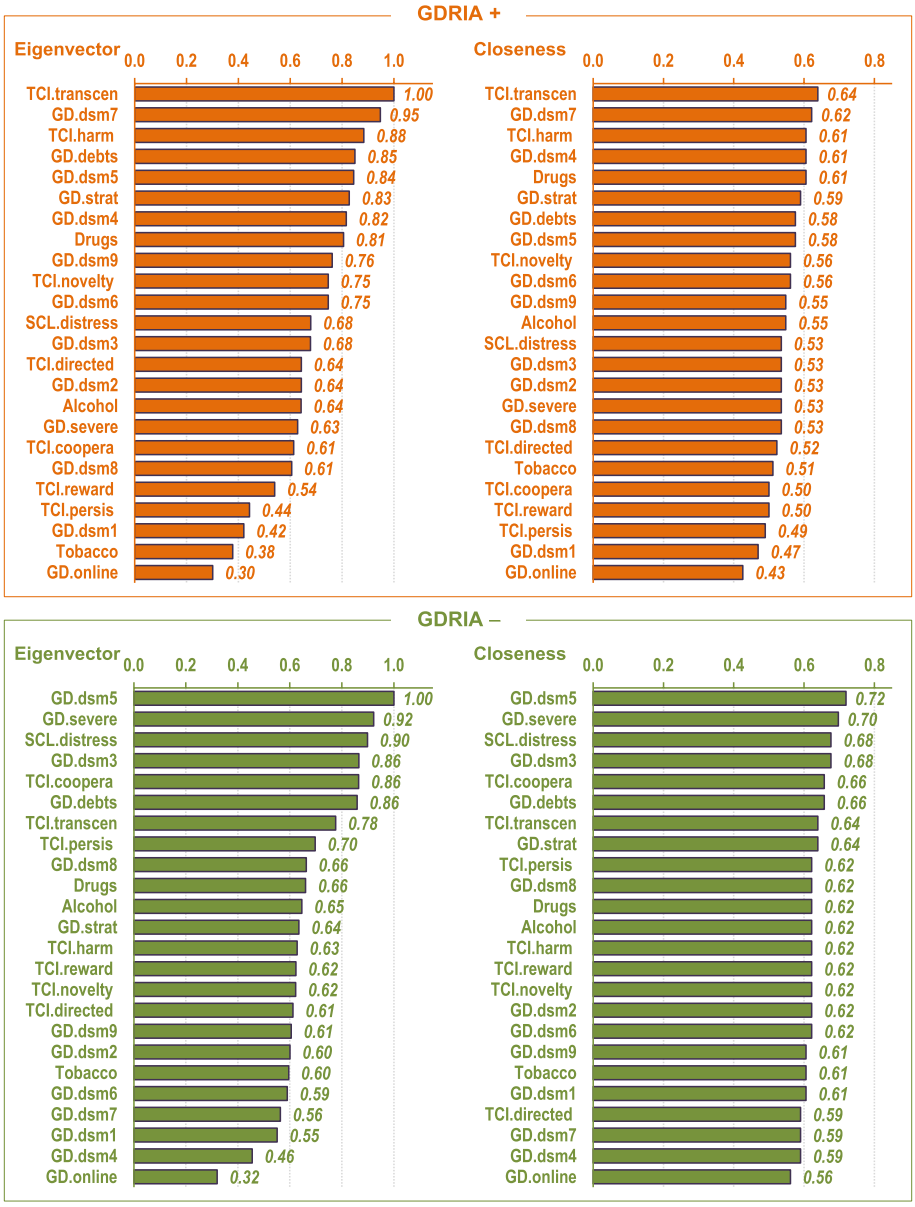

Fig. 2 Relevance of the nodes in the networks. Nodes: DSM-5 symptoms for gambling disorder (GD.dsm1 to GD.dsm9), debts related with gambling (GD.debts), GD symptom level (GD.sogs), strategic preference gambling (GD.strat), online modality gambling (GD.online), global psychopathology distress (SCL. distress), substances (tobacco, alcohol, and drugs), novelty seeking (TCI.novelty), harm avoidance (TCI. harm), reward dependence (TCI.reward), persistence (TCI.persis), self-directedness (TCI.directed), cooperativeness (TCI.coopera), and self-transcendence (TCI.transcen)

and A7, debts related with the gambling activity; M2 included the DSM-5 criteria for GD A6, A8, A9, and the GD severity level; M3 included the gambling preference, the type of gambling, and substance use; and M4 included the personality profile (except for novelty seeking), the DSM-5 criterion for GD A5, and the global psychopathology distress. For the patients in the GDRIA- group, the composition of the latent classes of nodes was: M1 including the DSM-5 criteria for GD (except for A1 and A2), GD severity level, and debts related with the gambling activity; M2 including the DSM-5 criterion for GD A1 and A2, the gambling preference, the type of gambling, and the use of alcohol and drugs; M3 including cooperativeness and reward dependence; and M4 including the remaining personality profile, the global psychopathology distress, and tobacco use.

Figure 3 shows the main linkage for the nodes with the greatest centrality in the study (eigenvector and closeness). In the GDRIA+ group, activation of the self-transcendence

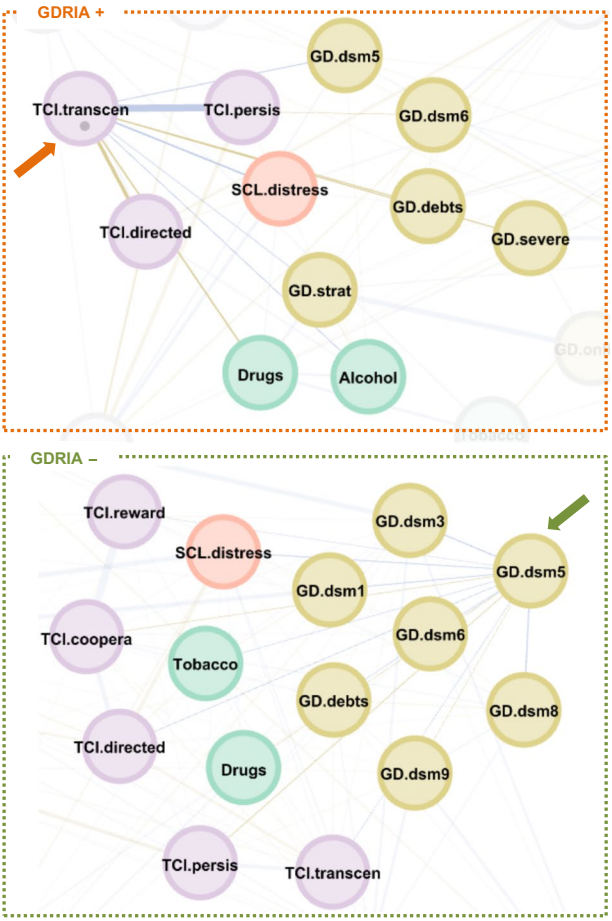

Fig. 3 Main linkages for the variables with the highest centrality. Nodes: DSM-5 symptoms for gambling disorder (GD.dsm1 to GD.dsm9), debts related with gambling (GD.debts), GD symptom level (GD.sogs), strategic preference gambling (GD.strat), online modality gambling (GD.online), global psychopathology distress (SCL.distress), substances (tobacco, alcohol and drugs), novelty seeking (TCI.novelty), harm avoidance (TCI.harm), reward dependence (TCI.reward), persistence (TCI.persis), self-directedness (TCI.directed), cooperativeness (TCI.coopera), and self-transcendence (TCI.transcen)

node had a major impact on the persistence and self-directedness personality traits, global psychopathology distress, the DSM-5 criteria for GD A5 and A6, gambling severity, debts related to gambling activity, and alcohol and drug use. In the GDRIA- sample, the activation of the node defined for the DSM-5 criterion A5 impacted the personality profile (except for novelty seeking), the consumption of tobacco and drugs, global psychopathology distress, the DSM-5 criteria for GD A1, A3, A6, and A8, and debts related to the gambling activity.

Discussion

This study provides empirical evidence for the network structure of the core symptoms of GD, other gambling measures (gambling preferences and gambling related debts), emotional distress, substance use, and personality profile, among patients seeking treatment for gambling-related problems. The most central nodes were self-transcendence (among patients with GDRIA+) and the DSM-5 criterion for GD "A5-often gambles when feeling distressed" (among patients with GDRIA-). Four latent classes of nodes were identified in each network, each module including variables with information measuring different functionality domains.

The node of greatest relevance and closeness in the GDRIA+ group was the personality trait self-transcendence. Our results are consistent with previous studies suggesting that illegal acts can be implied in the pathways between some personality traits (including self-transcendence) and GD severity (Jiménez-Murcia et al., 2019; Mestre-Bach et al., 2021). Self-transcendence is a complex transpersonal construct (Garcia-Romeu, 2010) that is largely related with certain aspects of psychopathology, including substance and behavioral addictions (Er & Buzlu, 2022; Pettorruso et al., 2021; Spalletta et al., 2007; Vitali et al., 2016), with implications for etiology and treatment. The measure used in the study was registered with the TCI-R questionnaire (Cloninger et al., 1993), and therefore, the self-transcendence construct assessed facets such as self-forgetfulness, unconscientiousness, and dissolution of the self in experience (Schimmenti et al., 2017). Some research has observed that compared with control samples with normal scores for self-transcendence, high levels for this trait are typical of individuals with high levels of negative emotions and introversion (Anglim et al., 2020; Rezaei et al., 2020), psychotic tendencies and paranoid-schizotypal traits (Galindo et al., 2016), and strange perceptions (such as delusions and bizarre-unconventional beliefs) (Miskovic et al., 2018).

The contribution of self-transcendence to the presence of GD and some of its severe correlates has also been evidenced, concretely with illegal acts and criminal behavior (Adolphe et al., 2019; Granero et al., 2015; Martinotti et al., 2006). Studies have found that self-transcendence plays a mediational role between leisure activities (such as video gaming) and aggressive antisocial behavior (Espinosa & Clemente, 2013). Research in this area suggests that patients with dysfunctional scores for self-transcendence could evidence certain characteristics related to dispositional traits like high anger and hostility (Giumetti & Markey, 2007; Zillmann & Weaver, 2007) and even aggression (Benish-Weisman, 2015; McGinley & Carlo, 2007). Based on this hypothesis, individuals with high levels of self-transcendence may be motivated toward activities such as gambling because there is less social interaction (Svrakic et al., 2002). Specifically, it has been postulated that the relationship between leisure activity and antisocial behaviors could be explained by a deficit in social interactions and role-taking opportunities. Deficits in socialization could

also be related to an inability to predict the consequences of behavior and to understand other people's proposals (needs, intentions, and desires). This characteristic is observed in individuals with an egocentric bias, a key component of self-transcendence. And how does this hypothesis apply to the outcome of this study? In the subsample of patients with GDRIA+, self-transcendence was identified as the most central node. Activation of this node could explain the inability of the subjects to understand the possible consequences of their actions on others (they have a restricted social perspective). And since the interaction provided by the gambling activity is clearly simplified (compared with "real" social contexts), patients with dysfunctional self-transcendence may tend to only consider the effects on themselves, and long-term consequences could also be perceived as irrelevant. The craving to gamble (which could even be the consequence of an underdeveloped and self-centered social perspective) contributes to a restriction in the source of interaction with the activity, further limiting one's own social perspective and problem-solving capacities. In these situations, illegal acts (such as forgery) might be perceived as an easy way to finance gambling activity.

In the GDRIA- group, the most central node was the DSM-5 criterion "A5-often gambles when feeling distressed." It is well established that negative emotional states predict a poor capacity to respond to environmental stressors (even daily events). Individuals with high negative emotional feelings could become anxious and emotionally unstable and perceive any event as potentially stressful. These individuals might use unhealthy behaviors to cope with these negative states (Zhou et al., 2017).

Interestingly, previous studies have observed that individuals who use gambling activity as a way to handle with adverse psychological conditions could experience greater gambling problems, regardless of their levels of impulsivity and other psychological-contextual constraints (Sharma & Sacco, 2015). This evidence could suggest that since negative moods can trigger externalizing behaviors, gamblers with high likelihood to cope uncomfortable feelings may increase the risk of more severe gambling consequences, including financial losses, bankruptcy, and even illegal acts. But studies have evidenced that the relationships between motivation to gambling and gambling-related problems are complex, and multiple moderator and mediation variables must be considered (Canale et al., 2015). For example, it has been found that gambling, to cope with adverse psychological states, could be a moderator into the link between the presence of stressful life events and gambling severity (Wang et al., 2020): among participants who report coping as high motivation to gambling, stressful life events may achieve low contribution on the perceived GD severity levels, and this could advise that individuals regularly turn to gambling to cope as a way to detract from their negative emotions regardless of what is going on in their lives and without the requirement of additional severe adverse consequences (such as illegal behavior).

The strong relationship between the experience and control of negative emotions with GD has suggested a potential classification that groups individuals with gambling disorder according to the nature of their emotion regulation motivations. The classical pathways model proposed by Blaszczynski and Nower suggested that problematic gambling could be the consequence of the complex connections between early life stressors, emotion regulation, and gambling incentives (Blaszczynski & Nower, 2002). These authors formulated the first etiological classification of gamblers into three separate pathways based on the primary motivations for gambling and the trajectories of the gambling activity, which has been highly validated in next studies (Nower et al., 2022): (a) "behaviorally conditioned" cluster, grouping individuals who initiated gambling behaviors for recreation or socialization reasons, with low levels of psychopathology at the beginning of the gambling and who progressed to GD due to conditioning effects and/or biased cognitions about winning;

(b) "emotionally vulnerable" cluster, grouping individuals who reported onset on gambling as a way primarily to escape aversive mood states, and who progressed to GD based due to poor stress-coping and problem-solving skills, problematic family backgrounds, and traumatic life events; and (c) "antisocial impulsivists" cluster, grouping individuals who related onset on gambling activity due to high levels in impulsivity, and who progressed to GD due to antisocial personality traits. The presence of illegal acts should be associated to the 3-pathways of this scheme.

Regarding the cope with negative psychological states as a motivation for the gambling activity, current literature has also related negative states characterized by boredom and/or numb discomfort as a reason for the onset in the gambling behaviors for the progression to the problematic gambling (without the need of severe gambling consequences, such as illegal acts), particularly among young age individuals with a personality characterized by low levels in persistence (Thompson et al., 2015). Current studies have also distinguished between the cluster labeled "action seekers" or "over-stimulated" gamblers (individuals with high levels of sensation seeking use gambling for thrills and to experience adrenaline) versus the cluster labeled "escape seekers" or "understimulated" gamblers (individuals with high levels of depression/anxiety use gambling to escape from negative emotions) (Milosevic & Ledgerwood, 2010; Moon et al., 2017). In recent years, studies focused on how emotion regulation contributes to the onset and progression of GD have even proposed that this disorder may be conceptualized within the process of emotion regulation (Rogier & Velotti, 2018): gambling could be viewed as a strategy that subjects use to cope with psychological distress, shifting their attention from anxiety/depression/fears/worry to an alternative leisure activity. In this line, a recent systematic review concluded that different associations exist between GD and emotion regulation deficits, including the nonacceptance of negative emotional states, and lack of control in reaction to these negative emotions (Velotti et al., 2021). Neurobiological research in GD has linked negative emotion-driven impulsivity with emotional suppression and increased middle frontal gyrus activation and pre-motor cortex (brain activation should be addressed to regulate negative emotions) (Navas et al., 2017).

Related with the study of the dysfunctional coping-motivated behaviors, some studies carried out in other clinical and population-based samples have identified diverse behavioral addictions as escaping motives. For example, the network study of Wei and colleagues in a large sample of young adults recruited from the general population concluded that excessive smartphone use should be conceptualized as a compensatory coping strategy for depressed emotions (Wei et al., 2023). This study also identified as bridge symptoms "escaping negative moods" and "concentration problems," closely linked to both the depression and the addictive behavior levels. Other works have also positively related the severity of gaming internet addiction with negative-avoidance coping motives (Lin et al., 2021; Moudiab & Spada, 2019) and have concluded that the correlation between coping by gaming and negative mood states (stress, anxiety, or depression) might suggest a bidirectional association and therefore coping motive as a transdiagnostic trigger.

The exploration of the modules in this study enabled the identification of different separate communities (empirical clusters or classes of nodes). The classification procedure of nodes in network is quite different from the conventional classification procedures, such as the k-means or the latent class analysis (these classification methods are used for grouping individuals based on the level of similarity/difference between the set of components). The aim of the network module package is the identification of empirical groups of nodes (in this study, variables) based on the linkage capacity of the edges and the identity relationships between the empirical classes.

The visualization and characterization of empirical community structures in network-graphs have received special attention in the last two decades (Silverman & Loscalzo, 2012), since these groups provide a segmental/modular view of the network's dynamic (Radicchi et al., 2004). The detection of clusters of nodes could be of significant clinical importance, as it reveals the existence of topological sub-areas representing highly interlinked regions (Girvan & Newman, 2002). These structures within the network could denote separate processes that perform different functions with some degree of independence (Barabási et al., 2011). In this study, groups of nodes appeared containing information on different constructs-domains (such as the group of concrete DSM-5 criteria for GD and some personality trait/s), and these structures could relate to global aspects of the patients' profiles, or even be the result of more complex bio-psycho-social structures that might contribute to the specific behaviors measured and analyzed in this study. It is essential to emphasize that the nodes included in a specific module may be closely interacting with nodes pertaining to other modules, and therefore the high intra-cluster and between-cluster linkages evidence the strong connection between the global set of underlying processes.

Finally, and interestingly, there is evidence of clusters of nodes that do not specifically correspond to the DSM-5 classification or the measurement tools (for example, the different TCI-R scales were not grouped within the same cluster). It should be noted that classical disease classification systems (such as the categorical DSM) tend to neglect the interconnected nature of diseases (Fried et al., 2017). The system-based network framework is a powerful alternative paradigm that views endophenotypes as the systems-driven result of a series of related sub-networks, which incorporate the multiple factors ([neuro]biological, psychological, and environmental) contributing to the onset and progression of diseases (Borsboom, 2017; Boschloo et al., 2015). Complex clinical structures, such as comorbid-concurrent diseases, seem best visualized and conceptualized from the network perspective (Cramer et al., 2010).

The results of this study referred to the clusters of nodes that are a starting point for the conceptualization of the diverse, complex profiles of patients seeking treatment for GD based on the presence (or not) of concurrent illegal acts. For example, the empirical modules of this study include not only nodes of some symptoms/criteria for GD as defined in the DSM-5 taxonomy, but also nodes measuring other features related with the functional profile (substances use, global psychological distress of personality). And also interesting, since the activation of a node belonging to a module can transcend the cluster itself increasing the likelihood of activating related nodes belonging to other modules (e.g. "bridge nodes"), our network analysis allows the identification of variables that are likely to interact with other specific targets (potential "transdiagnostic symptoms"). In the case of GD patients who report the presence of illegal acts (GDRIA+ subsample), it seems particularly important to implement treatments focused on the self-transcendence trait and the DSM-5 symptom 7 ("lies to conceal the extent of involvement with gambling"), with the aim to modify the global psychopathology distress, the substances use, and other severe consequences related to the gambling activity (debts and total gambling symptom level as measured by the SOGS). In this context, the clusters of nodes identified in this network analysis could be interpreted as specific phenotypes within the subsamples of GDRIA+ and GDRIA- patients with and without illegal acts, with different vulnerabilities to the many correlates of this complex disorder, and therefore with different needs that should be addressed in precise intervention plans.

Limitations

Some limitations should be considered when interpreting the results. First, while the networks were defined for a large set of nodes that contained multiple aspects of the psychological and functional areas (this is a strength of the study), it was not possible to include additional nodes that might be related to the presence of GDRIA (such as sociocultural factors [including negative attitudes, values, or beliefs], history of family violence, or early and repeated anti-social behavior).

Second, the sex distribution was asymmetrical (the proportion of women was particularly low compared to men), but this distribution is consistent with the female/male ratio observed in clinical settings. It must be argued that while the limited proportion of women considered in the study needs to be considered for generalization purposes, the inclusion of women also provides ecological validity to our research.

Regarding the impact of the sample size on the statistical procedures, it should be noted that our study modeled a large number of nodes and edges, and this could impact the capacity to estimate accurate parameters. We should stress that the number of participants was relatively limited in this study due to the recruitment period for the sample. Because of major sociocultural changes in recent years (including the COVID-19 pandemic), we chose to only include patients who visited the treatment unit in 2021 and 2022, when the restrictions due to the pandemic had been relaxed and healthcare had returned to normal in our country. It should also be pointed out that there is no agreed standard on the optimal number of participants to ensure the reliability and validity of network approaches. A recent simulation study observed that sample requirements for this method are very broad ranging depending on different design factors, such as network architecture, network connectedness, number of nodes, and type of data (Constantin et al., 2022). In any case, the empirical evidence produced by this study should be interpreted with caution, for it is a pioneering study whose results will need to be corroborated/refuted by future studies with larger samples.

Finally, due the cross-sectional nature of the data, undirected edges were defined within the networks, so the results cannot be interpreted in causal terms. And the lack of previous research on the subject (network analyses to visualize the underlying pattern of relationships among patients with and without GDRIA) did not provide a solid theoretical framework with which to contrast and contextualize the new empirical evidence generated by this study.

Conclusions

This is a pioneering study focused on analysis of the centrality (relevance and linkage) of the nodes containing information on the profiles of patients with and without GDRIA. The identification of different network structures in the groups considered in the study (with and without illegal acts), the recognition of different nodes that achieved the highest centrality indexes, and the detection of distinct latent classes, support the hypothesis of high heterogeneity within the GD condition. The diverse, complex processes sustaining the clinical profile of these patients make it very hard to conceptualize the disorder as a well-defined nosological entity (as defined by the DSM-5 taxonomy). On the contrary, our results suggest that the clinical phenotype of GD patients could be the result of a complex network that includes sociodemographic features, psychological symptoms, personality traits, and other functional measures, and that the different graphs/structures could explain the presence of crucial correlates such as illegal acts.

The objective of this study was not to assess the network of core criteria for GD as described in the categorical taxonomy DSM-5 but to identify the network of these symptoms plus other sets of variables measuring personality profile, substance use, and other gambling-related indicators among patients with GDRIA. The identification of the most central nodes (in terms of relevance, linkage capacity, and clustering in modules) provides new evidence on GD endophenotypes, as well as a paradigm shift in the way that patients are diagnosed and treated. The pioneering study by Ledgerwood and colleagues observed that the group of GD patients with illegal acts presented poorer treatment outcomes compared with the group of patients without gambling-related offenses and suggested the need for longer, more intense treatments to achieve a reduction in GD symptomatology among gambling-related offenders (Ledgerwood et al., 2007). Our study provides new evidence to develop intervention plans focused on the specific clinical population of individuals with GDRIA.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11469-023-01199-4.

Author Contribution Conceptualization: Roser Granero, Susana Jiménez-Murcia, Fernando Fernández-Aranda; methodology, data curation, and formal analysis: Roser Granero; funding acquisition: Susana Jiménez-Murcia and Fernando Fernández-Aranda; project administration: Rocío-Elena Ayala-Rojas, Javier Tapia-Martínez, and Magda Rosinska; supervision: Susana Jiménez-Murcia and Fernando Fernández-Aranda; validation and visualization: Susana Jiménez-Murcia and Fernando Fernández-Aranda; writing—original draft preparation: Roser Granero, Rocío-Elena Ayala-Rojas, and Gastón Vinet-Valdebenito; writing—review and editing: Roser Granero, Roser Nadal, Susana Jiménez-Murcia, and Fernando Fernández-Aranda

Funding Open Access funding provided thanks to the CRUE-CSIC agreement with Springer Nature. This manuscript and research were supported by grants from the Delegación del Gobierno para el Plan Nacional sobre Drogas (2021I031), Ministerio de Ciencia e Innovación (PDI2021-124887OB-I00), Instituto de Salud Carlos III (ISCIII) (FIS PI20/00132), and co-funded by FEDER funds/European Regional Development Fund (ERDF), a way to build Europe. CIBERObn is an initiative of ISCIII. Dr. Roser Granero was supported by The Catalan Institution for Research and Advanced Studies (ICREA Academia Program). The funders had no role in the study design, data collection, and analysis, decision to publish, or preparation of the manuscript.

Data Availability The data that support the findings of this study are available on request from the corresponding author.

Declarations

Ethics Approval and Consent to Participate The research was carried out in accordance with the Declaration of Helsinki of 1975, as revised in 2000. The research was approved by the Ethics Committee of Bellvitge University Hospital (ref: PR338/17 [CSI 18/04]). All the patients provided informed consent (the acceptance rate was 100% of all the consecutive patients of the treatment unit who met the inclusion criteria).

Conflict of Interest FFA and SJM received consultancy honoraria from Novo Nordisk and FFA editorial honoraria as EIC from Wiley. The rest of the authors declare no competing interests.

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