

Original

Network analysis of relationships between symptoms of depression and anxiety in samples from three South American countries

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A B S T R A C T

Depression and anxiety are among the most prevalent and disabling mental health problems worldwide. Traditionally, symptoms of mental disorders have been conceptualized as reflecting common underlying illnesses or causes. In recent years, there has been an increased interest in the application of network analysis in psychopathological research. Network analysis identifies core and bridging symptoms, which are useful for triggering and maintaining a network of disorders, which may be potential targets for intervention. The present study aimed to investigate the relationships between symptoms of depression and anxiety using network analysis. A total of 1561 participants from Bolivia, Paraguay, and Peru, selected from a non-probability convenience sample, were included in the investigation. The Patient Health Questionnaire-4 (PHQ-4) was employed to assess anxiety and depression symptoms. The examination of the depression and anxiety symptom network encompassed the identification of core and bridging symptoms as well as network stability across the aforementioned countries. The examination of the depression and anxiety symptom network encompassed the identification of core and bridging symptoms as well as network stability across the aforementioned countries. The findings revealed that depressed mood and uncontrollable worry were the most central symptoms in the network. Moreover, symptoms of depression and anxiety exhibited a greater connectivity with other symptoms within the same disorder rather than with symptoms between different disorders. However, it is noteworthy that symptoms of depressed mood and uncontrollable worry could potentially link anxiety and depression. Lastly, the network structure was found to be consistent across the assessed countries.

Análisis en red de las relaciones entre síntomas de depresión y ansiedad en muestras de tres países de América del Sur

R E S U M E N

La depresión y la ansiedad se encuentran entre los problemas de salud mental más prevalentes e incapacitantes en todo el mundo. Tradicionalmente, los síntomas de los trastornos mentales se han conceptualizado como

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reflejo de enfermedades o causas subyacentes comunes. En los últimos años, ha habido un mayor interés en la aplicación del análisis de redes en la investigación psicopatológica. El análisis de redes identifica síntomas centrales y puente, que son útiles para desencadenar y mantener una red de trastornos, que pueden ser objetivos potenciales de intervención. El presente estudio tuvo como objetivo investigar las relaciones entre los síntomas de depresión y ansiedad mediante análisis de redes. Se incluyó en la investigación un total de 1561 participantes de Bolivia, Paraguay y Perú, seleccionados de una muestra no probabilística por conveniencia. Se empleó el Cuestionario de salud del paciente-4 (PHQ-4) para evaluar los síntomas de ansiedad y depresión. El examen de la red de síntomas de depresión y ansiedad abarcó la identificación de síntomas centrales y puente, así como la estabilidad de la red en los países antes mencionados. El examen de la red de síntomas de depresión y ansiedad abarcó la identificación de síntomas centrales y puente, así como la estabilidad de la red en los países antes mencionados. Los hallazgos revelaron que el estado de ánimo deprimido y la preocupación incontrolable eran los síntomas más centrales en la red. Además, los síntomas de depresión y ansiedad mostraron una mayor conectividad con otros síntomas dentro del mismo trastorno que con síntomas entre diferentes trastornos. Sin embargo, cabe señalar que los síntomas de estado de ánimo deprimido y preocupación incontrolable podrían vincular potencialmente la ansiedad y la depresión. Por último, se encontró que la estructura de la red era consistente en todos los países evaluados.

Introduction

Depression and anxiety are among the most prevalent and disabling mental health problems worldwide (Liu et al., 2020). A systematic review indicated that, globally, Africa has the highest prevalence rate of depression (45%), followed by South Asia (34%) and Latin American countries (32%), and South Asia has the highest level of anxiety (41%), followed by African countries (37%) and Latin America (32%) (Zhang & Chen, 2021). Another meta-analysis and systematic review indicated a higher prevalence of mental health symptoms (anxiety, depression, and distress) in South America (36%) than in Central America (28%, $p < 0.001$). Mental health problems in Latin American countries have been exacerbated by different social and economic challenges related to weak poor health systems, and deep inequalities (Borges et al., 2020; Tausch et al., 2022). Gaps in the prevention, care, and rehabilitation of various mental health disorders within and between countries in the Americas have become significant public health issues. This is due to limited resources, such as insufficient infrastructure, equipment, and healthcare personnel, which are distributed unevenly and adversely impact mental healthcare in each country (Carrasco et al., 2022; Kohn et al., 2018; Sapag et al., 2021). To provide specific interventions and strategies to facilitate the prevention and treatment of anxiety and depression in the populations of different Latin American countries, it is important to understand the mechanisms that increase the risk of these disorders.

Traditionally, mental disorders have been conceptualized based on reflective models of psychopathology, which rely on the hypothesis that symptoms are indicators of underlying latent variables (Borsboom, 2008; Schmittmann et al., 2013). For instance, under this conceptualization, it is postulated that symptoms such as sad mood, anhedonia, and insomnia are caused by or reflect a depressive disorder (Fried, 2015). Reflective models underpin the practice of summing individual scores to create a total score that describes the severity of psychopathological disorders (Fried & Nesse, 2015). However, using total scores as indicators of anxiety and depression levels does not allow for differences and interactions between symptoms to be observed, and would create a misleading picture of the prevalence of depression and anxiety (Fried & Nesse, 2015). An alternative conceptualization of reflective models in psychopathology is to understand disorders as an integrated network (Borsboom & Cramer, 2013). Network models is based on the assumption that symptoms are not products of underlying latent variables but that they reinforce (or inhibit) each other, leading to the development of mental disorders (Borsboom 2017). For example, a person who has experienced an embarrassing episode of

public speaking may experience physical and cognitive symptoms of anxiety, such as sweating, increased heart rate, or catastrophic thoughts. This would result in a person experiencing more stress when anticipating similar social situations, which would increase the likelihood of avoiding them. In this regard, symptoms of stress, avoidance, and physical and cognitive symptoms can persist over time or exacerbate each other, leading to social anxiety (Van den Bergh et al., 2021).

Network analysis has been suggested as a suitable method for understanding the symptomatology of different psychiatric disorders by providing useful information for their prevention and treatment (Fonseca-Pedrero, 2017; Levinson et al., 2018). This method allows for a graphical representation of the complex relationships between symptoms, which can be understood as partial correlations (Golino & Epskamp, 2017; Hevey, 2018). Network analysis also enables the identification of the most central symptoms, which are more strongly correlated with other symptoms within a disorder, and bridge symptoms, which increases the likelihood that the activation of one disorder's symptoms may trigger a group of symptoms from another disorder (Borsboom, 2017; Borsboom & Cramer, 2013). Bridge symptoms are useful in understanding the presence of comorbidities (Cramer et al., 2010). Traditionally, comorbid mental problems are understood as different underlying entities (Heeren et al., 2018; Kaiser et al., 2021); however, the network model posits that two disorders coexist because of the interactions between their bridge symptoms, which, as mentioned, transmit activation from one disorder to another (Borsboom & Cramer, 2013; Cramer et al., 2010; Fried & Cramer, 2017).

Network analysis is an increasingly used method for assessing the dynamics of anxiety symptoms and depression in different groups, mainly from European or Asian contexts. However, few studies have assessed the relationship between anxiety and depression symptoms based on network analysis in Latin American countries (Ventura-León et al., 2022a; Ventura-León et al., 2022b), and there are no studies comparing anxiety and depression symptom networks between different Latin American countries. It is known that the clinical patterns and characteristics of depression and anxiety may vary according to the different characteristics of participants, including country and sociocultural context (Jenkins et al., 2013; Marques et al., 2011). The assumption that results from one group (in this case country), based on network analysis, are applicable to other groups (countries) is not fully justified; therefore, the network structures of anxiety and depression symptoms should be analyzed separately and then compared (Bai et al., 2021).

Therefore, the present study assessed the relationship between anxiety and depression symptoms in general population samples

from three Latin American countries using a network analysis approach. Specifically, we sought to (1) estimate the network structures of depression and anxiety symptoms in samples from three South American countries; (2) identify core and bridging symptoms within the depression-anxiety network, which could be valuable for preventing and treating depression and anxiety in the population of the participating South American countries; and (3) compare network structures across the three participating countries. Despite evidence of comorbidity between depressive and anxiety symptoms, network analysis could provide insights into the mechanisms of how people might move from experiencing one set of symptoms to another (Langer et al., 2019). Cross-cultural studies on the symptoms of anxiety and depression can be useful to inform about the most central symptoms of these disorders. This will facilitate more accurate epidemiological research, theoretical approaches, and treatments (Marques et al., 2011). It has been suggested that future revisions of the DSM should consider those symptoms most closely linked to a culture or country, so that mental health professionals are more aware of these characteristics and consider them to improve diagnostic systems and treatment outcomes (Lewis-Fernandez et al., 2011).

Methods

Participants

A total of 1561 people from three South American countries (Bolivia, Paraguay, and Peru) participated and were selected from a non-probabilistic convenience sample based on the following inclusion criteria: residing in one of the countries evaluated, being of legal age and give informed consent. The selection of countries for this study was based on the interest of the researchers from each country in participating and the possibility of meeting the requirements of the study design. The number of participants was determined using a Monte Carlo simulation method for network analysis (Constantin et al., 2023), which suggested a minimum of 710 participants. The final number of participants exceeded the minimum recommended number.

The number of participants per country ranged from 267 (Bolivia) to 923 (Paraguay). Their average age also ranged from 31.42 years (Paraguay) to 39.35 years (Bolivia). In all three countries, most participants were female (>70%), single (>50%), employed (>40%), university-educated (86%), urban (>80%), and free of chronic diseases (>82%). Further details of the sociodemographic characteristics of the participants in each country are presented in Table 1.

Measures

Patient Health Questionnaire-4 (PHQ-4; Kroenke et al., 2009). The PHQ-4 aims to measure the frequency of depressive and anxiety symptoms. It consists of four items. Two items correspond to the DSM-IV diagnostic criteria for major depressive disorder (loss of interest and depressed mood), and the other two items correspond to symptoms of generalized anxiety disorder (nervousness and worry). The four items of the PHQ-4 have four Likert-type response options, ranging from 0 ("not at all") to 3 ("almost every day"). The total score of the PHQ-4 is calculated from the sum of the scores of each item and ranges from 0 to 12, and the specific scores for anxiety and depression symptoms range from 0 to 6. Higher scores indicate a higher frequency of anxiety and depression symptoms. In this study, the Spanish version by López Guerra et al. (2022) was used, demonstrating a good fit for the two-factor model (CFI = 0.996,

GFI = 0.996, NFI = 0.996, RMSEA = 0.087) and adequate reliability for both the total scale ($\alpha = 0.879$; $\omega = 0.880$) and its two factors: anxiety ($\alpha = 0.838$; $\omega = 0.838$) and depression ($\alpha = 0.779$; $\omega = 0.780$). In this study, the two-dimensional factor structure was appropriate for Bolivia (CFI = 1.00, RMSEA = .00 [IC del 90%: .00-.10], SRMR = .002), Paraguay (CFI = 1.00, RMSEA = .00 [IC del 90%: .00-.04], SRMR = .001) and Perú (CFI = 1.00, RMSEA = .06 [IC del 90%: .00-.16], SRMR = .005). Furthermore, acceptable reliability was evident for Bolivia ($\omega_{Ansiedad} = .86$, $\omega_{Depresión} = .84$), Paraguay ($\omega_{Ansiedad} = .86$, $\omega_{Depresión} = .89$) and Perú ($\omega_{Ansiedad} = .86$, $\omega_{Depresión} = .86$). Table 2 shows that the internal structure shows strict invariance for the three countries according to the incremental ($\Delta CFI < .010$) and absolute index ($\Delta RMSEA < .015$; $\Delta SRMR < .030$) (Chen, 2007). Therefore, the PHQ-4 proved to be invariant across the three countries. That is, the two-factor model of the PHQ-4 was replicated in the three countries evaluated. The verification of measurement invariance allows us to assume that the different results of comparative cross-cultural studies on anxiety and depression symptoms, measured with the PHQ-4, may be valid (Table 2).

Table 1. Demographic characteristics of participants in each country.

	Bolivia (n = 267)	Paraguay (n = 923)	Peru (n = 371)
Gender (%)			
Female	188 (70.4)	701 (75.9)	252 (67.9)
Male	78 (29.2)	219 (23.7)	119 (32.1)
Transgender/ No binary	1 (0.4)	3 (0.4)	--
Age (M \pm SD)	39.35 \pm 14.55	31.42 \pm 10.89	31.65 \pm 10.92
Civil status (%)			
Single	136 (50.9)	606 (65.7)	241 (64.9)
Married	84 (31.5)	210 (22.7)	70 (18.9)
Divorced	32 (12)	28 (3)	17 (4.6)
Partnered	10 (3.7)	72 (7.8)	41 (11.1)
Widowed	5 (1.9)	7 (0.8)	2 (0.5)
Employment status (%)			
Fixed employment	112 (41.9)	511 (55.4)	155 (41.8)
Temporal employment	61 (22.8)	156 (16.9)	77 (20.7)
Unemployed	94 (35.2)	256 (27.7)	139 (37.5)
Tertiary education (%)			
No	13 (4.9)	102 (11)	21 (5.6)
Yes, technician level ^a	15 (5.6)	22 (2.4)	29 (7.9)
Yes, university level ^a	239 (89.5)	799 (86.6)	321 (86.5)
Area of residence (%)			
Urban	258 (96.6)	815 (88.3)	329 (88.7)
Rural	9 (3.4)	108 (11.7)	42 (11.3)
Chronic disease (%)			
Yes	47 (17.6)	149 (16.1)	46 (12.4)
No	220 (82.4)	774 (83.9)	325 (87.6)

^aThis study encompassed individuals who had either attained or were yet to complete their tertiary education..

In addition, an ad hoc sociodemographic questionnaire was developed to obtain information on sex, age, marital status, work, educational level, area of residence, and presence of chronic disease.

Procedures

The study was conducted in each country using an anonymous online questionnaire developed using Google Forms, which was divided into three parts. First, the study objective and informed

Table 2.
Measurement invariance of the PHQ-4 according to countries

Model	X ²	df	p	CFI	RMSEA	SRMR	ΔCFI	ΔRMSEA	ΔSRMR
Configural	1.95	3	.582	.999	.001 [IC 90%: .000-.007]	.001			
Metric	16.63	7	.019	.999	.014 [IC 90%: .000-.057]	.012	.000	-.013	-.011
Scalar	24.26	19	.186	.999	.000 [IC 90%: .000-.004]	.004	.000	-.014	.008
Strict	24.26	19	.186	.999	.000 [IC 90%: .000-.004]	.004	.000	.000	.000

consent form were presented. Only participants who provided consent could access the subsequent sections. The second part consisted of a sociodemographic questionnaire, and the third part included four items of the PHQ-4. The online questionnaire was distributed via social media (e.g., Facebook, Instagram, WhatsApp) and email, following the recommendations of the Checklist for Reporting Results of Internet E-Surveys (CHERRIES; Eysenbach, 2004; López-Rodríguez, 2019). The study received ethical approval for non-experimental research from the Faculty of Medical Sciences of the National University of Asunción (Ethical Opinion: 003_006_2023) and adhered to the ethical guidelines of the Declaration of Helsinki, including guarantees of anonymity, voluntary participation, data confidentiality, and the possibility of withdrawing from the study at any time. The study data are available in a permanent file at the following link: <https://osf.io/7awp4>.

Data analysis

In the first stage, the demographic characteristics of each country were explored using frequencies and descriptive statistics. Subsequently, the internal structure of the PHQ-4 was evaluated using confirmatory factor analysis (CFA). In the CFA, the robust weighted least squares mean and variance adjusted estimator (WLSMV) and a polychoric matrix were applied, considering the overall model fit with the comparative fit index (CFI > .95) and absolute indices such as the root mean square error of approximation (RMSEA < .08) and standardized root mean square residual (SRMR < .08) (Jordan, 2021). Reliability was also analyzed using the omega coefficient (ω), and factorial invariance was tested through a sequence of hierarchical variance models at the configural, metric, scalar, and strict levels. The comparison of hierarchical models was based on differences in the incremental index (Δ CFI < .010) and absolute indices (Δ RMSEA < .015; Δ SRMR < .030) (Chen, 2007). In the preliminary network analysis, the topological overlap of nodes was examined, considering redundancy over 25% with a p-value of .05 (Jones, 2021).

In the second stage, a network was constructed using a pairwise Markov random field (PMRF), where variables were represented by nodes connected by edges (blue lines for positive correlations, red lines for negative correlations, and the thickness of the edges describing the magnitude of the correlation) representing the conditional association (Isvoranu et al., 2022). The PMRF was non-generalized using the ggmModSelect algorithm and Spearman correlation method (rs) (Isvoranu and Epskamp, 2021). Additionally, the Fruchterman-Reingold algorithm was used for the graphical representation of the network (Fruchterman and Reingold, 1991).

In the third stage, local and global properties are analyzed. Regarding local metrics, node centrality was estimated through expected influence and predictability using normalized correction (nCC) (Haslbeck and Waldorp, 2018). Density (D), transitivity (Δ), and average path length (APL) were calculated as global metrics (Isvoranu and Epskamp, 2021). Additionally, the small-world index ($SW > 1$) was estimated to assess the degree of association between the nodes (Isvoranu et al., 2022).

In the fourth stage, precision and stability analyses of the estimated network model were conducted. For precision, a non-parametric bootstrap method based on 1000 samples was applied. Meanwhile, the stability analysis for expected influence was performed using a case-dropping bootstrap, where the correlation stability coefficient (CS) must be above .25 (Isvoranu et al., 2022). Finally, to examine network differences between countries, a network comparison test (NCT) using 1000 random permutations was applied (van Borkulo et al., 2022). This process is based on the invariance of the network structure and the overall strength (van Borkulo et al., 2022). In both tests, the Holm-Bonferroni correction (HB) was used, where a p < .05 indicates differences between two underlying networks (van Borkulo et al., 2022). The similarity of the networks was analyzed using the rs correlation (Isvoranu et al., 2022).

All statistical analyses were carried out in Rstudio version 4.1.1 using the packages bootnet, qgraph, psych, mgm, ggplot2, summarytools, NetworkComparisonTest, and networktools (Epskamp et al., 2018; Haslbeck & Waldorp, 2020; Jones, 2021; Revelle, 2018; van Borkulo et al., 2022).

Results

Local and global network properties

Table 3 shows that the highest arithmetic mean (M) was for nervousness in all three countries. Conversely, the lowest mean was for anhedonia in Peru and Paraguay, whereas in Bolivia, it was for uncontrollable worry. Regarding the standard deviation (SD), the highest value in Bolivia was for anhedonia, in Paraguay for depressed mood, and in Peru for uncontrollable worry.

Figure 1 shows the network structure of each country. Notably, there was no suggestion of redundancy in the topological overlap. Conditional associations were positive in all countries. The symptoms of anhedonia and depressed mood had the strongest associations in Paraguay ($r = .65$) and Peru ($r = .55$), while in Bolivia, it was nervousness and uncontrollable worry ($r = .60$). Similarly, in Paraguay and Peru, there were associations between nervousness and uncontrollable worry ($r = .56$ and $r = .52$), and to a lesser extent between nervousness and depressed mood ($r = .23$ and $r = .25$), respectively. In Bolivia, associations were observed between anhedonia and depressed mood ($r = .51$) and, to a lesser extent, between uncontrollable worry and depressed mood ($r = .30$).

Regarding local properties, high values of expected influence (EI) and predictability were noted for depressed moods in Paraguay and Peru. In Bolivia, this is uncontrollable. Concerning global network properties, the values were appropriate, and small-world properties were evident for each network (Table 3).

Accuracy of network structure and stability of the centrality index

In general, the non-parametric bootstrap confidence intervals (CIs), resampled 1000 times for the edges of the networks in the three countries, were narrow and mostly nonoverlapping (Figure

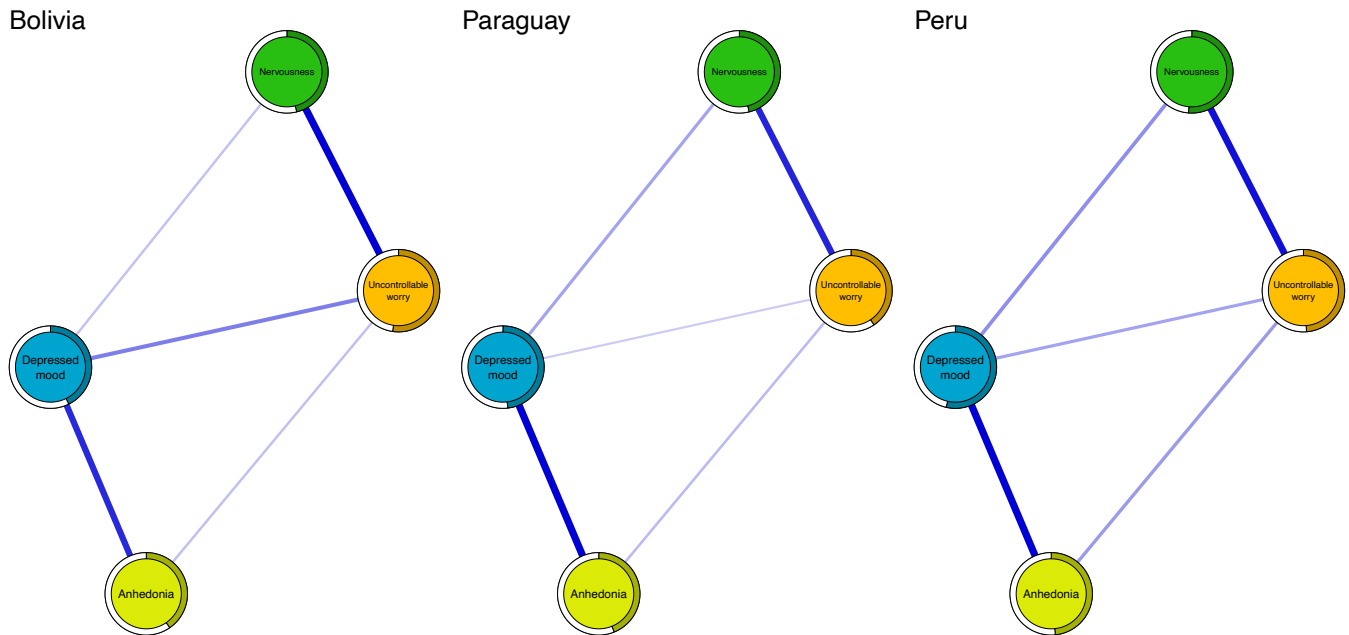


Figure 1. Network structure of depressive symptoms and generalized anxiety in three Latin American countries.

2). The estimation of the expected influence (EI) index exceeded the acceptable stability values in all countries, specifically Bolivia (CS ≈ .52), Paraguay (CS ≈ .28), and Peru (CS ≈ .28) (Figure 3). This indicates that the EI for each country was stable and interpretable.

Comparative analysis of networks by country

In the network structure invariance test, no statistically significant differences were found between Bolivia and Paraguay (M = .14, p = .23), Bolivia and Peru (M = .11, p = .61), and Paraguay and Peru (M = .10, p = .51). In terms of global strength invariance, no statistically significant differences were observed between Bolivia and Paraguay (S = .05, p = .12), Bolivia and Peru (S = .04, p = .39), and Paraguay and Peru (S = .01, p = .62). The similarity of edge weights correlated moderately between Bolivia and Paraguay (rs = .71) and between Bolivia and Peru (rs = .71), although it was high between Paraguay and Peru (rs = .99).

Discussion

In the current study, a network structure of anxiety and depression symptoms was estimated in samples from three South American countries, which allowed the identification of symptoms that could explain the comorbidity between anxiety disorders and depression. The network estimate revealed complex interactions between anxiety and depressive symptoms, suggesting that some symptom relationships are stronger than others and that symptoms are not of equal importance across the networks of the participating countries. Moreover, edge and centrality strengths remained stable. Specifically, depressive symptoms (anhedonia and depressed mood) and anxiety symptoms (nervousness and uncontrollable worry) exhibited strong conditional associations across countries. However, no strong association was observed between depression and anxiety. This finding supports the notion that while anxiety and depression share common features, such as general negative affect,

Table 3. Descriptive statistics, local and global network properties.

Countries	Statistics	Local network properties				Global network properties			
		Nervousness	Uncontrollable worry	Anhedonia	Depressed mood	D	C ¹	APL	SW
Bolivia (n = 267)	M	1.26	1.09	1.10	1.15	.28	.75	1.17	1.42
	SD	.98	.92	1.02	1				
	IE	.75	1.06	.66	.96				
	P	46.2%	52.3%	40.4%	42.7%				
Paraguay (n = 923)	M	.95	.88	.84	.88	.29	.75	1.17	1.42
	SD	.98	.98	.99	1.02				
	IE	.79	.86	.82	1.01				
	P	46.2%	40.6%	43.9%	48.1%				
Peru (n = 371)	M	1.01	.93	.92	.94	.29	.75	1.17	1.42
	SD	.93	.98	.97	.94				
	IE	.76	.94	.77	.99				
	P	51.3%	48.8%	48.4%	53.6%				

Note. M: mean; SD: standard deviation; IE: expected influence; P: predictability. D: density; C¹: transitivity; APL: average shortest path length; SW: small-world index.

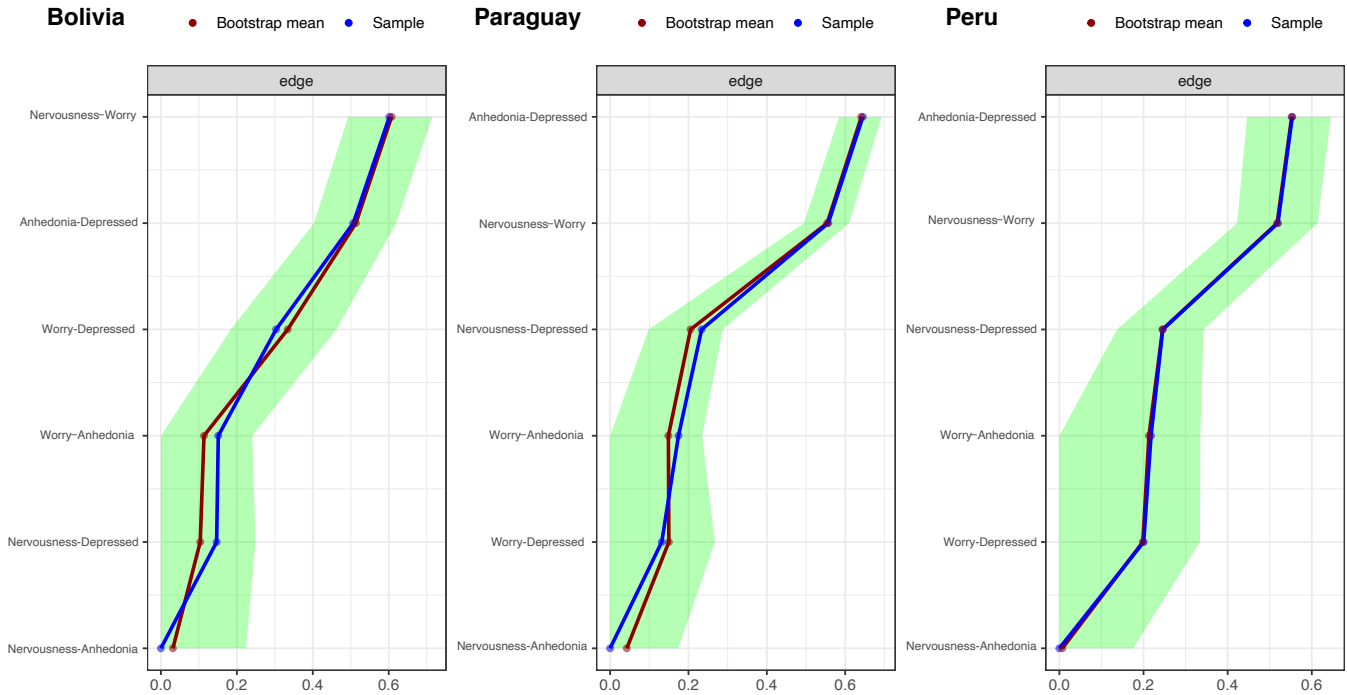


Figure 2. Non-parametric bootstrapping confidence intervals of estimated edges for the network structure of each country.

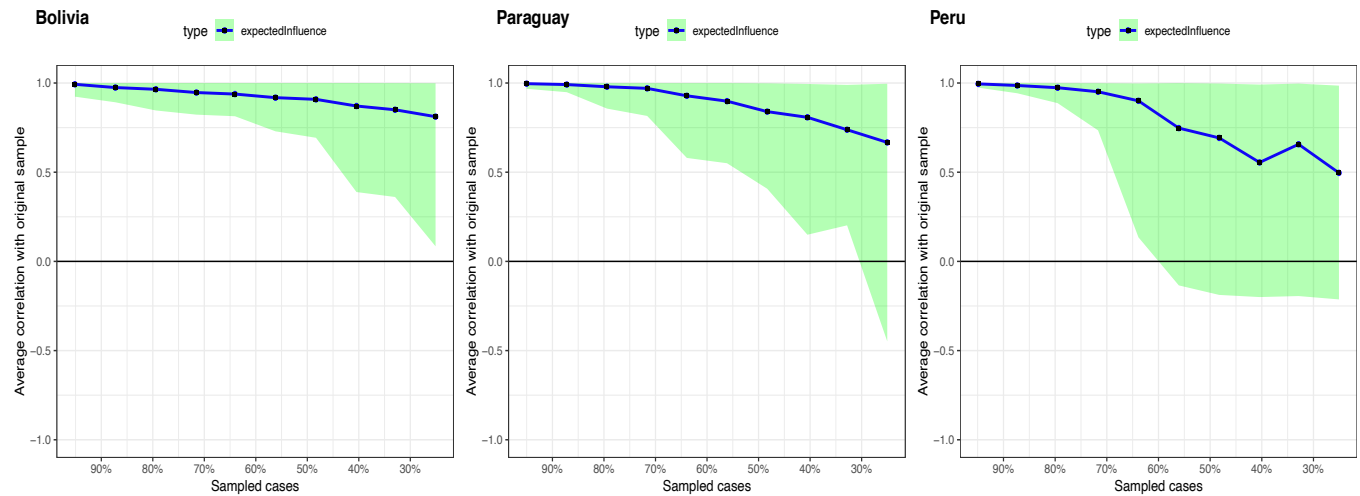


Figure 3. Stability of the expected influence centrality index for each country.

they also exhibit unique symptoms, such as disturbing thoughts in the case of anxiety and negative self-evaluation in the case of depression (Endler et al., 1998). This is crucial, as it suggests that potential correlations between anxiety and depressive symptoms do not reflect a complete overlap between disorders (Murphy et al., 2000; Renner et al., 2018).

Despite the weak link between anxiety and depression symptoms in the countries evaluated, it is possible to observe some central and bridging symptoms that may help maintain the comorbidity between anxiety and depression. The network structure appears to suggest that depressed mood and uncontrollable worry may be central and bridge symptoms linking anxiety and depression. This implies that both symptoms could contribute to the activation of other symptoms and the maintenance of the depression-anxiety

network in participants from the evaluated countries. This result was observed in previous studies (Bai et al., 2021; Beard et al., 2016; Cai et al., 2024; Kaiser et al., 2021; Liu et al., 2022; McElroy et al., 2018). The presence of the “depressed mood” symptom is one of the central criteria for diagnosing depressive disorder according to the DSM-5 (American Psychiatric Association, 2022), which is characterized by the presence of negative moods, such as feelings of sadness, fear, loneliness, crying, and self-disdain—perceptions of failure (Danhauer et al., 2013). Moreover, depressed mood is considered a common risk factor for various comorbid emotional disorders, such as depression and anxiety (Naragon-Gainey, 2019). Similarly, excessive and uncontrollable worry is the main symptom of generalized anxiety disorder (American Psychiatric Association, 2022).

The relationship between both symptoms can be explained by sustained arousal generated by worry, leading to emotional exhaustion and feelings of bad mood (Cummings et al., 2014), which in turn would be associated with experiencing depressive symptoms, such as feelings of worthlessness (McElroy et al., 2018). Moreover, these symptoms seem to express global negative affective states that, from a neuroscientific perspective, may reflect the neurobiological mechanisms underlying negative valence (Woody & Gibb, 2015), or within a cognitive-behavioral model, may express central appraisals associated with perceived threats. Additionally, worry may be associated with uncertainty about financial stability and employment issues following periods of crisis, such as the COVID-19 pandemic, characterizing many Latin American countries (Guerra & Eboime, 2021; Kim & Loayza, 2022; Mathieu et al., 2022). These findings support the current consideration that depressed mood and uncontrollable worry are two symptoms necessary for diagnosing anxiety and depression disorders, and the potentially strongest pathway of the relationship between the two disorders (Peng et al., 2022). However, the small observed relationship does not allow for a complete conclusion, as the symptoms of sad mood and worry are internal mental states that are difficult to observe clearly and unequivocally.

Depressed moods had greater centrality and predictability in Paraguay and Peru. A previous study in Peru also indicated that depressed mood was one of the central and most prevalent symptoms in groups of people with mild-to-moderate to severe symptoms (Villarreal-Zegarra et al., 2023). Peru has a specific social, cultural, and economic context, where the existence of a mental health treatment gap, lack of resources, and limited training of health personnel may influence the presence and prevalence of certain depressive symptoms (Diez-Canseco et al., 2018; Villarreal-Zegarra et al., 2020). In the case of Paraguay, it has been indicated that approximately 34.4% of the general population has experienced severe symptoms of depression (Torales et al., 2022a, 2022b) and was one of the countries with the most negative results in the Mental Health Vulnerability Index during the pandemic (Canavire-Bacarreza & Recalde-Ramírez, 2022). However, studies on depression in Paraguay have focused on the overall scores and not on symptom levels. Like Peru, mental health services in Paraguay receive a limited budget to assess and treat mental disorders in high-risk populations, there is a scarcity of professionals, and there are no specific policies to optimize the mental health of the population, which would be related to the presence of depressive symptoms (Aboja et al., 2022). By contrast, in Bolivia, uncontrollable worry maintained the highest centrality and predictability in the underlying network. The results indicated that, in Bolivia, symptoms of generalized anxiety were found to be more important within the depression-anxiety network. While a recent study reported that depression is the most prevalent mental health problem (García-Rojas et al., 2023), our findings would indicate that anxiety symptoms would be valuable for triggering and maintaining the depression-anxiety network among the population of Altiplano. These results indicate a significant comorbidity between depression and anxiety (García-Rojas et al., 2023). Similar to previous countries, Bolivia has a limited, well-structured care network for treating mental disorders (Solis-Soto et al., 2019), leading to little information on the prevalence of mental disorders in the country (Jaen-Varas et al., 2014).

Network models have been criticized for their limited replicability across different samples (Forbes et al., 2017). However, in the present study, the structural invariance and global strength-based tests reported no statistically significant differences between the countries assessed. This indicates that network structures are similar in Bolivia, Paraguay, and Peru, which is important for exploring how anxiety and depression

symptoms manifest in different countries. To date, no study has compared anxiety and depression symptoms according to the PHQ-4, based on network analysis in the Latin American context. This finding is auspicious, even more so if one considers the different ways in which a given culture influences the personal experiences of different psychological symptoms. One possible explanation for this result is that the symptoms selected by Kroenke et al. (2009) represent global symptoms of anxiety and depression that are present across cultures (Lenz & Li, 2022). Evidence of the invariance in anxiety and depression symptom networks across countries is important when considering comorbidities and outcomes related to mental health symptoms (Degehardt et al., 2019; Teismann et al., 2018).

Limitations

This study has several limitations. First, the study design was cross-sectional and was based on an undirected network model. Future studies could confirm our hypotheses using longitudinal data and directed acyclic graphs (DAGs), a network model in which edges are directed and direct relationships between nodes are established, as feedback loops are not allowed (Lipsky & Greenland, 2022; Tennant et al., 2021). This would enable the identification of dependency probabilities among pairs of generalized anxiety and depression symptoms. Second, the data in this study were limited by the symptoms chosen to define anxiety and depression in the network structure. Thus, the inclusion of additional symptoms can result in a different network structure. It is hoped that future studies on the presence of additional symptoms will test the findings presented here. Third, participants were recruited through non-probability sampling, limiting the generalizability of the findings to the general population of the three countries involved. Fourth, self-report measures, which may have generated social desirability biases, were used to assess anxiety and depressive symptoms. This limitation may have been reduced because of the anonymity of the data-collection process. Fifth, the number of participants varied across countries, limiting their ability to capture similar levels of variability in the expression of anxiety and depression symptoms.

Sixth, the samples from each country were unbalanced. For example, women may be more prone to experiencing anxiety and depression disorders (Farhane-Medina et al., 2022; Gutiérrez-Rojas et al., 2020; Javaid et al., 2023). Similarly, participants from all evaluated countries were mostly single, employed full-time, had a university education, and resided in urban areas. This is significant considering that being divorced/separated and unemployed is significantly associated with the presence of depression (Gutiérrez-Rojas et al., 2020), and living in urban areas is associated with higher rates of anxiety (Javaid et al., 2023). This also limits the generalizability of the findings to the general population of the countries involved. Therefore, future studies should use more balanced samples regarding various sociodemographic variables associated with the risk of anxiety and depression. Seventh, although the sample size may be considered large relative to the total sample size (>500), it may be small for within-country analyses in Bolivia and Peru. This explains some of the variations reported across countries in this study. However, as in this study, small or moderate sizes per country are common in social sciences and psychology studies (Martí-Vilar et al., 2020). Eighth, only three countries (Bolivia, Paraguay, and Peru) in South America participated. This does not allow for a comprehensive view of the relationships between anxiety and depression symptoms across all of South America. Therefore, including more South American countries in future

studies would help ascertain more about the international comparisons of anxiety and depression symptom networks in this American region.

Strengths and implications

Despite these limitations, this study has several strengths and significant implications. Among the strengths, this study included samples from different South American countries and used modern analytical techniques to evaluate the networks of anxiety and depression symptoms, such as precision estimates, network stability, and network structure invariance.

Theoretically, the results demonstrate the utility of network analysis in advancing the understanding of the interaction between anxiety and depression symptoms in participating countries. Several studies have confirmed the relationship and comorbidity between anxiety and depression in Latin America (Kohn et al., 2018; Mejia et al., 2023; Prina et al., 2011). However, most studies are based on traditional models of mental health issues, in which the coexistence of symptoms is due to an underlying common cause (Schmittmann et al., 2013). Unlike traditional models, network analysis provides information about the coexistence of anxiety and depression symptoms in South American countries due to the presence of direct relationships between symptoms and uncommon causes. Therefore, the relationships between symptoms and their direct influence on each other are the substance of mental problems (Borsboom & Cramer, 2013), and they have their own neural and psychological foundations (Beard et al., 2016).

Practically, the results provide information on the importance of certain specific symptoms for the maintenance of anxiety and depression in the South American context (Guo et al., 2023). Moreover, identifying central and bridge symptoms (depressed mood and uncontrollable worry) is therapeutically relevant, as it allows us to understand which symptoms are more closely related and can be targets for interventions to reduce other symptoms and alleviate psychological burden. For example, interventions aimed at reducing depressed mood could help to diminish other symptoms of depression and anxiety. In this sense, symptom-focused interventions such as cognitive-behavioral therapy could be effective, as they have been shown to reduce symptoms of anxiety and depression (Bauer et al., 2012; Etzelmueller et al., 2020; Hofmann et al., 2012; Powers et al., 2017).

Additionally, the results lead to recommendations for the implementation of specific screening tests for central and bridge symptoms, such as PHQ-2. It has been demonstrated that early and rapid detection of mental health symptoms is a cost-effective strategy as it reduces the number of years that could be lost due to negative psychological burden (Villarreal-Zegarra et al., 2023). This approach not only provides insights into the immediate needs of individuals, but also guides healthcare systems towards more effective and targeted mental health interventions.

Conclusion

In conclusion, depressed mood and uncontrollable worry were the central symptoms of depression and anxiety in the countries assessed. These symptoms could be prime candidates for future longitudinal and experimental studies to confirm their causal roles. Although anxiety and depression symptoms were more closely related within a disorder than between disorders, the same symptoms of depressed mood and uncontrollable worry were identified as potentially linking anxiety and depression.

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