



Network analysis of the relationships between conspiracy beliefs towards COVID-19 vaccine and symptoms of fear of COVID-19 in a sample of latin american countries

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Abstract

The present study examined how conspiracy beliefs about COVID-19 vaccines specifically relate to symptoms of fear of COVID-19 in a sample of four South American countries. A total of 1785 people from Bolivia, Colombia, Ecuador, and Peru participated, responding to a sociodemographic survey, the Fear of COVID-19 scale (FCV-19 S) and the Vaccine Conspiracy Beliefs Scale-COVID-19 (VCBS-COVID-19). Network analysis identified the most important symptoms of fear and conspiracy beliefs about COVID-19 vaccines (nodes) and the associations between them (edges). In addition, the robustness of the network of these indicators of centrality and the possible differences in the structure and connectivity of the networks between the four countries were evaluated. The results suggest that the nodes with the highest centrality were items 2 and 5 of the FCV-19 S and item 2 of the VCBS-COVID-19. Likewise, item 6 is the belief that most predicts conspiracy beliefs about vaccines against COVID-19; while item 6 was the symptom that most predicts fear of COVID-19. The findings strongly support cross-cultural similarities in the networks across the four countries rather than differences. Although it was expected that a higher presence of symptoms of fear of COVID-19 may lead people to compensate for their fear by believing in conspiratorial ideas about vaccines and, consequently, rejecting the COVID-19 vaccine, the results do not clearly show this relationship. This could lead other researchers to generate evidence to explain the differences between Latin American countries and countries in other contexts in terms of vaccination rates. This evidence could be useful to develop policies favoring vaccination against COVID-19 that are more contextualized to the Latin American region, characterized by social instability and economic recession during the pandemic.

Keywords Network analysis · Conspiracy beliefs · Fear of COVID · Vaccines

Introduction

Since the first months of 2020, the world has been facing the COVID-19 pandemic (O'Brien et al., 2020; Scrima et al., 2022), which, to date, has caused more than 6 million deaths. To try to mitigate the impact of COVID-19, all governments

of the world have taken actions such as the implementation of quarantines, restrictions on the movement of people, as well as the closure of schools, churches, stores, and different industrial activities (Lazarus et al., 2020). However, it has been suggested that these activities have had a significant impact on the mental health of the population worldwide (Matranga et al., 2020). To date, the implementation of mass vaccination programs is considered to be the most effective strategy to overcome the pandemic and protect the population, reducing the mortality and morbidity rate, in addition to reactivating the world economy (Graham,

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2020). Vaccination campaigns have generated two types of reactions. On the one hand, there is a part of the population inclined to be vaccinated against COVID-19 that ranges between 24% and 97% worldwide (Sallam, 2021); while, in Latin America and the Caribbean (LAC), the percentage of people who intend to be vaccinated against COVID-19 varies between 54% and 96.94% of the population (Caycho-Rodríguez, Valencia et al., 2022). On the other hand, a sector of the population refuses to receive the vaccine. It is estimated that 20% of people worldwide do not intend to be vaccinated against COVID-19 (Lazarus et al., 2021). This same percentage of people has been reported in a study of 20 LAC countries (Urrunaga-Pastor et al., 2021). The population that refuses to receive the vaccine justifies its decision based on denials and conspiratorial beliefs (Bertin et al., 2020; Sallam et al., 2021).

Conspiracy beliefs are defined as “attempts to explain the ultimate causes of significant social and political events and circumstances with claims of secret plots by two or more powerful actors” (Douglas et al., 2019, p. 4). They are also responses to the psychological need to understand threatening events that are difficult to understand and predict (Douglas et al., 2017; Franks et al., 2013). These types of beliefs appear when people and societies are threatened (van Prooijen, 2018; van Prooijen & Douglas, 2017). Indeed, during the current pandemic, conspiracy beliefs are important in public discourse, as are approval ratings (Freeman et al., 2020). A significant number of people do not believe in the existence of COVID-19 and do not accept that a “type of flu” is life-threatening; there is also the idea that COVID-19 is a business of health care workers, as well as a conspiracy of pharmaceutical companies to sell their drugs, that 5G technology transmits the virus and that the virus is a man-made biological weapon, among other beliefs (Ullah et al., 2021).

Regarding vaccines, it is believed that they do not work and are harmful, causing autism, autoimmune diseases, and infertility, among other consequences. In addition, vaccines are believed to be means of implanting traceable microchips (Ullah et al., 2021). Recently, a study reported that, in Latin America, 13 countries evaluated had, for the most part, some degree of disagreement with conspiracy beliefs about vaccines against COVID-19 (Caycho-Rodríguez, Ventura-León et al., 2022). However, some degree of agreement with conspiracy beliefs about vaccines would lead to a decline in immunization rates. Due to health threats, it is important to examine some correlates of conspiracy beliefs. In this regard, initial findings have suggested that COVID-19-related fear is related to conspiracy beliefs (Jovančević & Milićević, 2020). Likewise, conspiratorial beliefs mediated the relationship between fear of COVID-19 with high levels of existential anxiety, which decreased the intention

to vaccinate against the disease (Scrima et al., 2022). From the dual defense process model, it is suggested that when people experience fear they can deal with it by directly and rationally eliminating the negative stimulus; while, if fear activates more distant defenses, irrational and unrealistic beliefs can appear, such as conspiracies, which help people make sense of their fear (Scrima et al., 2022). The latter is related to the idea that people who fear COVID-19 the most tend to adopt conspiratorial beliefs to mitigate their fears and justify the uncertain situation (Stephens, 2020). In Latin America, studies on fear of COVID-19 have indicated that countries such as Colombia, Ecuador, El Salvador, Mexico, and Paraguay have shown insignificant or small differences when comparing their fear levels, while Argentina and Uruguay have been the countries that have reported the least fear of COVID-19 (Caycho-Rodríguez, Valencia et al., 2021). Another more recent study reported the presence of a moderate level of fear of COVID-19, which predicted the presence of symptoms of anxiety and depression in 13 Latin American countries (Caycho-Rodríguez, Tomás et al., 2021). In addition, it has also been reported that 14.3% of Argentines, 10.2% of Peruvians, and 5.7% of Mexicans had high rates of fear of COVID-19 (Moya-Salazar et al., 2022).

A network analysis approach is a methodology that would allow a better understanding of the relationship between conspiracy beliefs and fear of COVID-19. Traditionally, symptoms (e.g., depressive or fear symptoms) have been considered observable expressions of a single underlying disorder (Borsboom & Cramer, 2013). However, this generates practical problems, since it does not consider the causality, development, and heterogeneity of the symptoms, as well as the interrelationships between them (Fried & Nesse, 2015). Network analysis has gained popularity in recent years as a method to explore, understand, and visualize mental health problems as a complex system where symptoms form interrelated networks (Borsboom, 2017; Robinaugh et al., 2020). Therefore, in network analysis, symptoms are not considered to be results of an underlying mental health problem. Both the symptoms and their relationships are the problem (McNally et al., 2015). Network analysis makes it possible to graphically represent mental health variables as networks made up of “nodes” that represent symptoms and “edges” that represent statistical relationships between them. In this sense, certain nodes or symptoms may be strongly related to each other, may be significantly related to other symptoms within the network, and/or be bridges between other symptoms. Likewise, relationships between two symptoms may be stronger and more influential than others (Mullarkey et al., 2019). Likewise, “centrality indices” can be calculated to infer the degree of importance of each node in the network, based on the strength of the relationships with other nodes. From a therapeutic perspective,

it is suggested that the more central and connected nodes in the network will generate greater changes in the entire network. It is expected that network analysis will allow the identification of those symptoms that are most important in the development of a mental health problem (Zavlis et al., 2021) and are important starting points in a therapeutic intervention (Gijzen et al., 2021).

In network analysis, the strong interconnectedness between symptoms may mean that the relationships between them can be self-sustaining and continue to reinforce each other synergistically (Borsboom, 2017). This feedback loop initiates and maintains mental health problems that can lead to a major crisis. Thus, a network approach would help make theoretical sense of the relationships between conspiracy beliefs about COVID-19 vaccines and fear of COVID-19 based on cognitive-behavioral models of health anxiety, pandemics, and fears (Taylor & Asmundson, 2004; Taylor, 2019). In these models, the presence of negative beliefs or expectations, such as concern about COVID-19 infection, leads to information seeking related to the severity of COVID-19 and how to cope with it. However, this has generated the dissemination of false information about the origin and treatment of COVID-19, such as information about the non-existence of the virus or the presence of microchips in vaccines with the aim of controlling people (Ortiz-Sánchez et al., 2020). This information can confuse people and create health threats. Identifying this type of misinformation can exacerbate concerns about the threat of COVID-19, leading people to find new fear-inducing information that increases their initial concerns (Taylor, 2019; Taylor et al., 2020).

Based on the above, the present study examined how conspiracy beliefs about COVID-19 vaccines are specifically related to COVID-19 fear symptoms in a sample of four South American countries, which make up the so-called Andean Community of Nations (CAN). Specifically, it seeks to: (a) identify the main nodes and the relationship between them; and (b) compare the networks among the participating countries. The study was conducted in the CAN member countries, which currently have more than 11,232,000 cases and more than 403,000 deaths from COVID-19, representing almost 18% and 25% of cases and deaths, respectively, in Latin America due to COVID-19. In addition, a recent study involving these countries indicated that Peru had the highest average score of conspiracy beliefs about COVID-19 vaccines compared to Colombia, Ecuador, and Bolivia. In addition, in all four countries, the belief that vaccinating children against COVID-19 is negative had the lowest degree of acceptance; while, in Colombia, Ecuador and Peru, the conspiratorial belief about the invention of the safety of vaccines against COVID-19 has the highest

degree of acceptance (Caycho-Rodríguez, Gallegos, Valencia, Vilca et al., 2022).

On the other hand, the relevance of this study lies in the fact that, although research has been carried out, with network analysis, that has analyzed conspiracy beliefs about COVID-19 (e.g., Ahmed, Vidal-Alaball et al., 2020; Ahmed, Seguí et al., 2020) and on fear of COVID-19 (e.g., Mertens et al., 2021) independently, there have been no studies using this methodology to evaluate the relationship of both variables in a set of Latin American countries. In addition, it is known that both conspiracy beliefs about COVID-19 vaccines (Caycho-Rodríguez, Valencia, Vilca et al., 2022) and fear about COVID-19 (Caycho-Rodríguez, Valencia et al., 2021, Caycho-Rodríguez, Tomás et al. (2021); Moya-Salazar et al., 2022) may vary between different countries. Therefore, it is important to identify the most central nodes or symptoms that define a network and report them to participating countries so their sanitary authorities focus their interventions on these symptoms. Finally, the COVID-19 pandemic is not over yet, but it could end gradually as the proportion of people immune to COVID-19 increases (Kwok, McNeil, Tsoi, Wei, Wong, & Tang, 2021). However, although new mutations of the SARS-CoV-2 virus, such as the Delta and Omicron variants, appear to spread rapidly once again (Tegally et al., 2022; Wang, & Han, 2022) people may no longer be willing to follow all the necessary protective measures and may be very hesitant to receive new doses of vaccines against the disease (Dafogiani et al., 2022). This comes at the same time as the upcoming release of more effective COVID-19 vaccines (McLean et al., 2022). Therefore, convincing people to get vaccinated against COVID-19 is an important task to defeat the pandemic. For this, different governments need to know about the factors related to the decision of getting vaccinated, such as fear of COVID-19 and anti-vaccine conspiracy theories. Previous studies have demonstrated the negative impact of fear of COVID-19 and conspiracy theories on the intention to vaccinate against COVID-19 (Bok et al., 2021; Scrima et al., 2022). This information could be an important part of the actions of the governments of the participating countries to avoid further refusal of vaccination against COVID-19 keeping the population safe during the current pandemic.

Method

Participants

A total of 1,785 residents of Ecuador, Peru, Bolivia, and Colombia participated, selected by snowball convenience sampling. The inclusion criteria were: (1) to be of legal age in each of the countries, (2) to be natural and live in one of

Table 1 Sociodemographic characteristics of the four countries

	Bolivia	Colombia	Ecuador	Perú
N	564	461	438	322
Sex				
Female	421 (74.60)	322 (69.80)	311 (71.0)	224 (69.60)
Male	143 (25.40)	139 (30.20)	129 (29.0)	98 (30.40)
Age (M[SD])	38.71 (11.53)	27.27 (12.05)	29.68 (10.71)	27.01 (8.07)
Age (Range)	18–80	18–73	18–71	18–59
Marital status				
Single	245 (43.44)	367 (79.61)	289 (65.98)	251 (77.95)
Married	222 (39.36)	61 (13.23)	98 (22.37)	45 (13.98)
Cohabitant	31 (5.5)	23 (4.99)	22 (5.02)	21 (6.52)
Divorced	58 (10.28)	8 (1.74)	25 (5.71)	4 (1.24)
Widowed	8 (1.42)	2 (0.43)	4 (0.91)	1 (0.31)
Educational level				
Primary	545 (96.63)	302 (65.51)	345 (78.77)	276 (85.71)
University	19 (3.37)	159 (34.49)	93 (21.23)	46 (14.29)

the participating countries and (3) to provide informed consent to be part of the study. During the pandemic, snowball sampling has been widely used since it allows for a greater number of responses (Roy et al., 2020). A Monte Carlo simulation method was used to determine the sample size a priori (Constantin et al., 2021), which suggested a minimum of 300 participants. Therefore, in the present study, the suggested number of participants was greatly exceeded. Table 1 presents the sociodemographic characteristics of the study samples.

Instruments

Sociodemographic data

An Ad Hoc sociodemographic form was constructed for this study to collect information on gender (male and female), age, marital status (single, married, cohabiting, divorced, widowed), and educational level (primary and secondary).

Fear of COVID-19 (FCV-19 S)

The FCV-19 S (Ahorsu et al., 2020) consists of seven items measuring the level of fear of COVID-19. All items were positively worded and completed on a five-options Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). In this study we use the Spanish version validated in a group of Latin American countries (Caycho-Rodríguez, Valecia et al., 2021) which suggests a two-dimensional structure (emotional and physiological reactions). The sum

of the item scores results in a total score for each dimension, where higher scores indicate higher levels of emotional and physiological fear.

Vaccine conspiracy beliefs Scale-COVID-19 (VCBS-COVID-19)

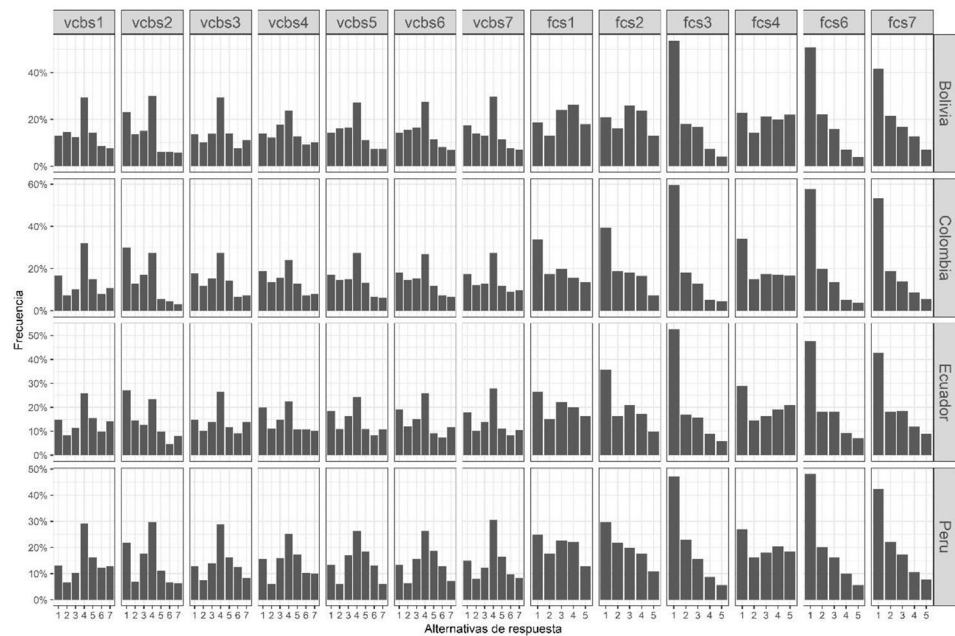
The VCBS-COVID-19 was developed by Caycho-Rodríguez, Valencia, Ventura-León et al. (2022) and aims to assess the degree of agreement with a set of conspiracy beliefs about COVID-19 vaccines. It is a measure with adequate psychometric properties among Latin American countries, consisting of seven items, which have seven response alternatives ranging from 1 (strongly disagree) to 7 (strongly agree). The VCBS-COVID-19 total score is obtained from the sum of the scores of the seven items. Thus, higher scores would indicate greater agreement with conspiracy beliefs.

Procedures

Data were collected simultaneously and with the same procedure in the four countries between September 15 and October 25, 2021. An online questionnaire was used that included the sociodemographic form, the FCV-19 S and VCBS-COVID-19 scales. The questionnaire was sent to participants who met the inclusion criteria through different social media platforms. These participants then recommended other potential participants. After reading the objectives and giving their informed consent, the people participated voluntarily in the research. The study followed the ethical recommendations of the Declaration of Helsinki (World Medical Association, 1964) and the protocol received the approval of the Ethics Committee of the Universidad Privada del Norte, with registration number 20,213,002.

Data analysis

All analyzes were performed with R software in its RStudio environment. (RStudio Team, 2022) and network graphics with the program ‘qgraph’ 1.9 (Epskamp et al., 2012). The recommendations of Fried et al. (2018) were followed for multisample estimation: (1) network estimation; (2) network stability evaluation; (3) network inference evaluation and; (4) network comparison. In addition, the reporting recommendations for cross-sectional psychological networks were followed (Burger et al., 2020). In this sense, the R codes and data are available in the open access repository OSF: <https://osf.io/v9ctw/>.

Fig. 1 Response rates for both tests

Network estimation

The networks were jointly estimated using the fused graphical lasso method (FGL) with the EstimateGroupNetwork 0.3.1 package (Costantini et al., 2019). Optimal lambda values were performed by “cross-validation”; specifically, with k-fold with a seed set in 2022. The four individually estimated networks were inserted into a list. The communalities of the nodes were estimated considering the spinglass algorithm.

Network stability

Network stability analysis of the four networks was implemented with the bootnet 1.5 package (Epskamp et al., 2018). For such purposes, a nonparametric case-type bootstrapping based on 1000 resamples was used. The correlation stability coefficient (CS) was used suggesting the maximum number of cases that can be removed, with 95% probability, to retain a correlation of at least 0.70 between the original network-based statistic and the statistic calculated with fewer cases. The CS should not be less than 0.25 and preferably greater than 0.50 (Epskamp & Fried, 2018).

Network inference

Network centrality is estimated based on node strength. However, a modified version is used assuming that nodes are weakly connected, which is referred to as bridging strength (Bereznowski et al., 2021). The bridge strength is a

product of the sum of the absolute values of the edges of a given node to all other nodes.

The mgm 1.2–11 package (Haslbeck & Waldorp, 2020) was used. Given, the ordinal nature of the data the normalized precision predictability (“nCC”) was used which indicates how much a node can predict all, neighboring nodes (Haslbeck & Waldorp, 2018).

Network comparison

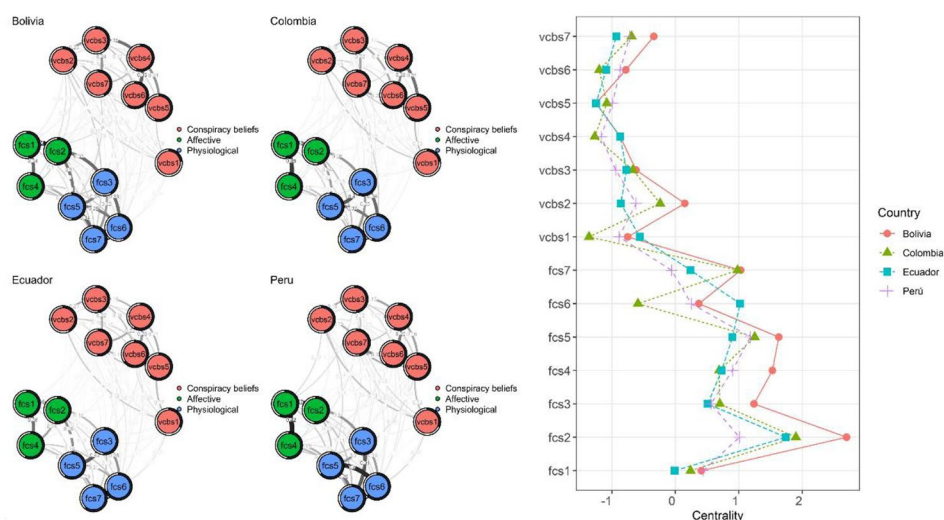
The NetworkComparisonTest 2.2.1 (NCT) library (van Borkulo et al., 2022) was used for network comparison. A seed set in 2022 was used. An omnibus test was performed to investigate whether all network edges are identical. The NCT works with a two-tailed permutation test, where the difference between groups is the product of performing 1000 repetitions, for each person, randomly regrouped. Both networks are equal when the significance is less than 0.05.

Results

Descriptive statistics

The response rates of the items in each country are shown in Table 1. It can be seen that in the case of the conspiracy thinking test questions, alternative 4 (Neither agree nor disagree) tends to be frequently chosen, and in the case of the COVID-19 fear test, there is a clear tendency towards low response alternatives, with the vast majority choosing

Fig. 2 Networks according to the countries under study



alternative 1 (Strongly disagree). These response patterns are frequent in all four countries.

Network estimation

Figure 2 shows the four networks estimated jointly. The density of the network was 0.60 (55/91 edges), 0.63 (57/91 edges), 0.63 (57/91 edges), and 0.65 (59/91 edges) for the Bolivia, Colombia, Ecuador, and Peru networks respectively. The mean absolute edge weights were 0.06 for the four country networks. The spin-glass algorithm detected three communities in the four country networks. The first community is composed of conspiracy beliefs; the second and third of affective and physiological fear responses to COVID-19. The intra-community connectivity is composed of consistent edges; whereas the inter-community connectivity, i.e., the conspiracy belief community has little connection with the COVID-19 fear clusters (see Fig. 2).

Concerning centrality indexes, it is observed that the nodes with the highest connectivity in the fear of COVID-19 are fcs2 (I get uncomfortable thinking about COVID-19) and fcs5 (When I see news and stories about COVID-19 on social media, I get nervous or anxious). Similarly, the node with the highest centrality in conspiracy beliefs about COVID-19 vaccines was vcb2 (Vaccinating children against COVID-19 is harmful and this fact is concealed). The centrality of the nodes is clearer in Bolivia.

Network stability

The lack of width of the confidence intervals around the edge weights indicates that the four networks are stable. The values of the correlation stability coefficients were higher than the recommended minimum ($CS > 0.25$) for

the network of Bolivia ($CS = 0.75$), Colombia ($CS = 0.75$), Ecuador ($CS = 0.75$), and Perú ($CS = 0.59$).

Network inference

In all four countries, the bootstrap edges had small 95% bootstrap CIs, meaning that the variations between resamples were not significant.

The predictability analysis demonstrated that the item vcb6 (People are misled about the safety of COVID-19 vaccines) is the most predictable item in conspiracy beliefs (average predictability equals 61.9%) and item fcs6 (I can't sleep because I worry about having COVID-19) was the most predictable fear node toward COVID-19 (average predictability equals 53.5%). The average predictability for Bolivia, Colombia, Ecuador, and Peru was 45.3%, 50.3%, 54%, and 54.2%, respectively.

Network comparison

Initially, the correlation coefficient for the edge weights was calculated. It is observed that between all pairs of comparisons between the different countries there is a relationship greater than 0.70. Furthermore, the p-values were in all cases greater than 0.05, indicating that the networks are invariant and that at the level of connectivity (Global Strength) the networks are almost identical (see Table 2).

Discussion

In recent years, network analysis has been used to identify and analyze statistical relationships between different multivariate mental health data (Borsboom et al., 2021). To the best of our knowledge, this study is the first to characterize

Fig. 3 Stability of the networks of the four countries considering centrality indices

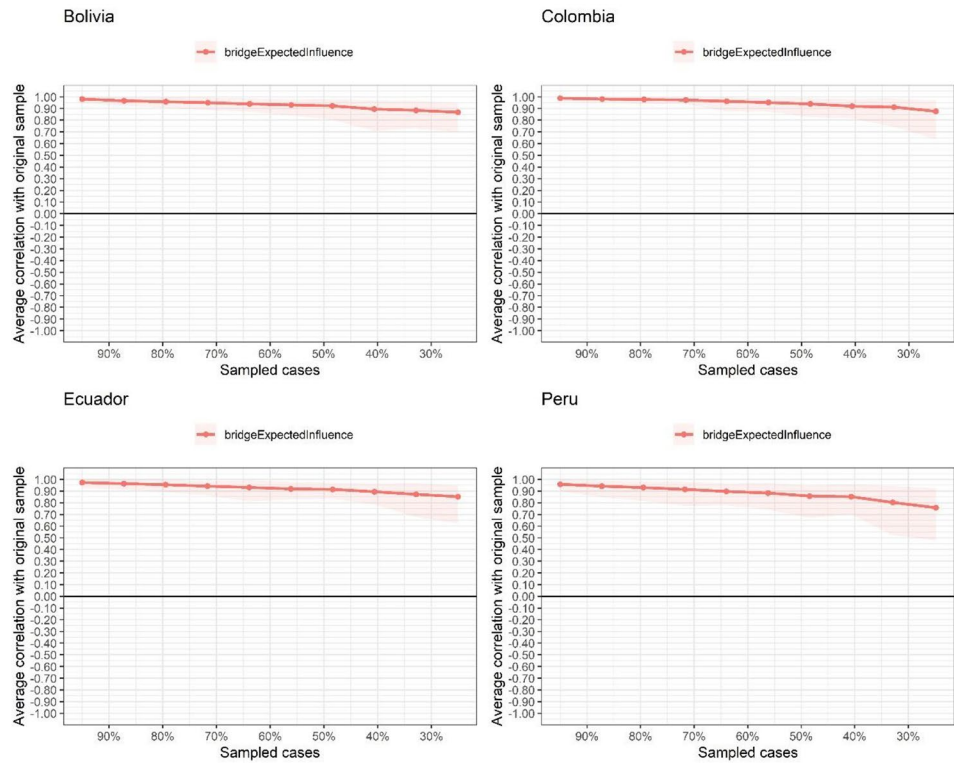
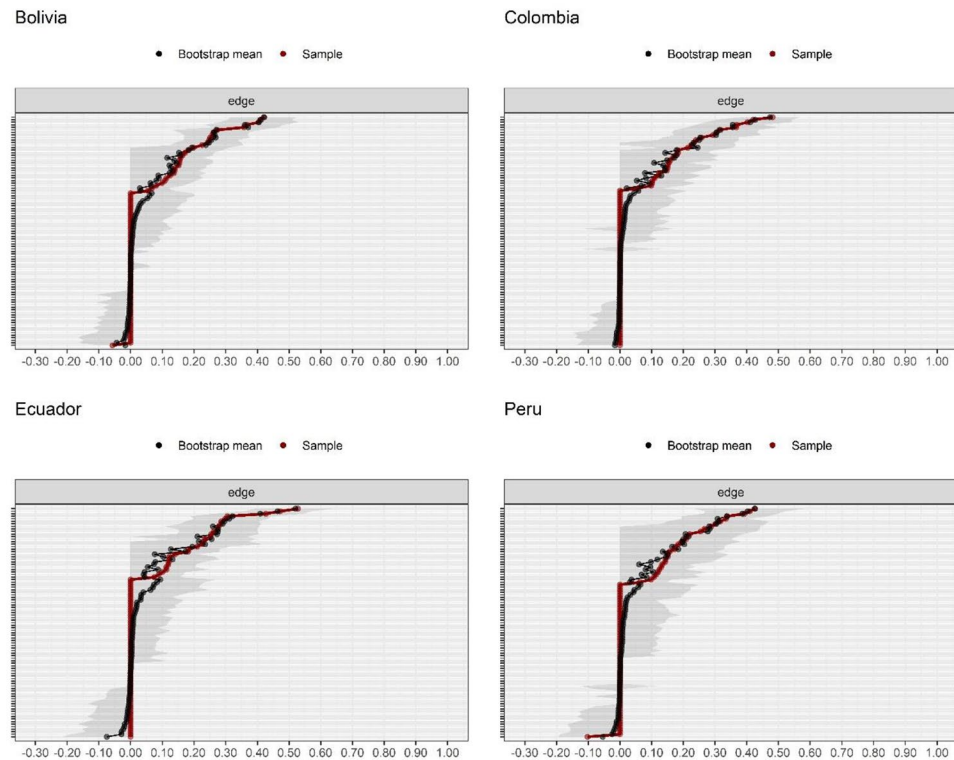


Fig. 4 Accuracy of the networks of the four countries



COVID-19 fear symptom networks and conspiracy beliefs about vaccines against the disease in the general population of a group of South American countries.

In this regard, the interconnectedness between nodes was first identified. Network theory in mental health emphasizes symptom interconnectivity; therefore, stronger edge weights

Table 2 Correlation and significance values of the pairs of compared networks

Paises	Spearman Coefficient				Network Invariance Test				Global Strength				
	1	2	3	4	1	2	3	4	1	2	3	4	
1			0.78	0.72	0.78		0.66	0.80	0.71		0.14	0.05	0.70
2				0.71	0.85			0.07	0.80			0.37	0.32
3					0.79				0.27				0.14

Noea. 1: Bolivia; 2: Colombia; 3: Ecuador; 4: Perú

between symptoms were expected. However, in the present study, conspiracy beliefs are found to have little connection with fear clusters toward COVID-19 in each of the countries. Also, when comparing the networks according to the country of residence of those evaluated, it was reported that, in general, the networks do not vary and the matrices are similar. However, there are also some important differences to mention. For example, the relationship between the belief *Information about the safety of COVID-19 vaccines is often made up* and the physiological fear symptom *I can't sleep because I worry about having to get vaccinated against COVID-19* is low in Ecuador and Peru, very low in Bolivia, and null in Colombia. These findings are not related to previous studies that have suggested a relationship between fear of COVID-19 and conspiracy beliefs (Jovančević & Miličević, 2020; Stephens, 2020).

Although it would be expected that the high presence of symptoms of fear of COVID-19 could lead people to compensate for their fear by believing in conspiracy ideas about COVID-19 vaccines and, consequently, rejecting them, the results do not show this relationship clearly. However, our findings may be useful to identify possible variables that could be mediating the relationship between the variables analyzed in this study. In this way, our findings could lead other researchers to generate evidence to explain the difference between what is reported in Latin American countries and countries in other contexts. This evidence could be used to develop policies favoring vaccination against COVID-19 that are more contextualized to the Latin American region, characterized by social instability and economic recession during the pandemic. Thus, for example, the findings seem to suggest that both fear of COVID-19 and conspiracy beliefs about vaccines may impact intentions to vaccinate independently and are not necessarily related in these Latin American countries. It appears that when people in Ecuador, Bolivia, Peru, and Colombia experience fear, they cope with it by directly and rationally eliminating the dangerous stimulus (in this case, vaccination against COVID-19) and without the need to activate more distal defenses, such as the presence of irrational beliefs (Scrima et al., 2022). Also, it appears that people who believe in conspiracy theories in these countries are less likely to perceive COVID-19 as a health risk, generating less fear of disease (based on the theory that the virus does not exist) and dangerous health consequences (Desta & Mulugeta, 2020). This is related to evidence that people in Latin America are hesitant to receive the COVID-19 vaccine due to structural, attitudinal, and informational factors (Bates et al., 2022). For example, in Colombia, people seem to be more afraid of hunger, unemployment, violence, or lack of education than of COVID-19 infection (Idrovo, 2021). In Peru, it has been reported that approximately 78.70% of people have low and medium

levels of risk perception concerning COVID-19 (Monge-Rodríguez et al., 2021). In Ecuador, the average perceived risk of COVID-19 infection was 34% (Boonsaeng et al., 2021). A study in Bolivia, it has been reported that the perception of risk before COVID-19 was low or moderate in 65.70% of people (Zeballos Rivas et al., 2021). In addition, other studies have suggested the presence of an unclear relationship between fear of COVID-19 and conspiracy beliefs, where negative (Desta & Mulugeta, 2020) or positive (Jovančević & Miličević, 2020; Stephens, 2020) relationships between the two variables are reported. All of these previous studies have reported relationships, either positive or negative, based on direct score correlations, however, the present study allows us to observe the true relationship between conspiracy beliefs and COVID-19 fear symptoms from a regularized method such as network analysis.

Vaccination programs that fail to consider the possible independence between conspiracy beliefs about vaccines and fear of COVID-19 could exacerbate existing disparities for COVID-19 vaccines rather than placate them. Also, to address the fact that people tend not to perceive COVID-19 as a health risk, communication strategies that address misconceptions about vaccination may be necessary. In addition, to ensure compliance with COVID-19 prevention behaviors by the general population and full vaccination against the disease, information campaigns should emphasize that the fight against COVID-19 is not yet over. In general, the findings call for further studies that allow a better understanding of this relationship, which seems to be not entirely clear in these four countries.

On the other hand, we sought to identify the central and most predictable nodes in the network. In this way, the results indicated that, in the FCV-19 S, the most central nodes, which are more closely related to the other symptoms of fear of COVID-19, were “I get uncomfortable thinking about COVID – 19” and “When I see news and stories about COVID – 19 on social networks, I get nervous or anxious”. These symptoms may thus be likely candidates for triggering or maintaining the other symptoms of fear of COVID-19. Regarding this, it has been shown that the unprecedented amount of real-time information about COVID-19 that is available to individuals may generate greater fear about the consequences of the disease, in addition to other mental illnesses (Gao et al., 2020; Naeem, 2021; Rubin & Wessely, 2020). Indirect exposure to mass trauma through the media may increase initial rates of post-traumatic stress disorder symptoms and the formation of risk perceptions (Choi et al., 2017; Neria & Sullivan, 2011). This finding also seems to suggest that, the content of COVID-19 information in the media with which people interact is important for the generation of discomfort in having thoughts associated with fear of COVID-19. It has been suggested that feeling

uncomfortable is one of the most significant indicators of fear of COVID-19 (Barrios et al., 2020; Carreon et al., 2021). This is visible in all the countries evaluated, but even more so in Bolivia, where it has been indicated that greater exposure to information about Covid-19 in social networks was associated with a greater perception of risk and fear of the disease (Zeballos et al., 2021). Future studies should analyze in more detail the use of the media during pandemic situations in all countries involved (Wheaton et al., 2021). Some suggest that restrictions be placed on the duration and frequency of media use and that people be kept informed through official websites of health institutions to distinguish facts from rumors (Bendau et al., 2021).

Likewise, the item referring to “I can’t sleep because I worry about having COVID – 19” was the most predictive node of fear toward COVID-19. The predictability analysis can be interpreted as the clinical relevance of the correlations between the nodes (Ramos-Vera et al., 2021). A previous study that evaluated the FCV-19 S through a network analysis did not perform a predictability analysis but did conclude that this same item is one of the most networked items in a sample of Peruvian adults (Ramos-Vera, 2020). This finding would indicate that sleep problems due to concern about being infected with COVID-19 could be a clinically important indicator to identify people at risk of developing COVID-19 fear symptoms and also could probably be considered for psychological treatment of fear symptoms. This is even more important considering that Latin America and the Caribbean is the region with the worst sleep health compared to Europe, Central Asia, Sub-Saharan Africa and North America during the COVID-19 pandemic (Yuksel et al., 2021). Pre-pandemic studies have also suggested a high prevalence of sleep problems in the Latin American population (Blanco et al., 2004; Bouscoulet et al., 2008). In this sense, sleep health might have been a problem even before the COVID-19 pandemic.

Another explanation for this finding is that when a person is afraid of catching COVID-19, there is brain stimulation and excitement that causes difficulty sleeping, as well as reduced physical and cognitive performance (Siddique et al., 2021). Sleep problems have been common during the COVID-19 pandemic (Alimoradi et al., 2021). In this context, it has been suggested that fear of COVID-19 reduced life satisfaction and increased sleep disturbances through psychological distress (Duong, 2021). In addition, according to cognitive-mediated theory, fear can generate stress symptoms, which lead to sleep quality problems (Siddique et al., 2021). On the other hand, people’s negative cognitive evaluations of their physical health condition are associated with increased fear of COVID-19, which in turn generated problems sleeping, leading to other psychological problems (Ahorsu et al., 2020). Although the study does not allow us

to know exactly whether the fear of COVID-19 generated sleep problems or whether the sleep problems generated the fears about COVID-19, it has been suggested that this relationship is probably bidirectional (Alvaro et al., 2013; Narmandakh et al., 2020).

On the other hand, in the case of the VCBS-COVID-19, the most central node was *Vaccinating children against COVID-19 is harmful and this fact is hidden*. This belief about vaccines could trigger or maintain the other. Different pediatric societies have recommended vaccination of children aged 5 years and older, which should reassure the population and parents regarding fears about pediatric vaccines (Gallegos, Morgan et al., 2022, Gallegos, Caycho-Rodríguez et al., 2022). However, there is still a large group of people who do not want to vaccinate children. Having some degree of agreement with the belief that withholding information about the harms of vaccinating children could affect children's health (Caycho-Rodríguez, Gallegos, Valencia & Vilca, 2022). Problems related to the safety and efficacy of vaccines against COVID-19 and the lack of information on the importance of vaccination have complicated the decision of parents' to vaccinate their children. (Benin et al., 2006; Rudan et al., 2021). The comparison of networks indicated that the belief "Vaccinating children against COVID-19 is harmful and this fact is hidden" had a low relationship with the node "I am very afraid of getting vaccinated against COVID-19" in Colombia, Bolivia, and Peru; however, this relationship was nonexistent in Ecuador. It is possible that, in Ecuador, this relationship may be mediated by other variables such as the perception of control over vaccination against COVID-19, family support received, having children with up-to-date vaccinations, the age of the child, the time of exposure to information about vaccination against COVID-19, among others (Fani et al., 2022).

Likewise, the item referring to "People are deceived about the safety of vaccines against COVID-19" was the node with the highest predictive capacity among conspiracy beliefs about vaccines. Thus, this belief is the one most closely associated with the other conspiracy beliefs and the one that would be an important indicator for identifying people at risk of believing in conspiracies about COVID-19 vaccines. This finding is expected since, negative perceptions against the COVID-19 vaccine emphasizing its adverse effects and concerns about its safety are important reasons to doubt vaccination (Neumann-Böhme et al., 2020) and further support conspiracy beliefs (Chaudhary et al., 2021). The efficacy and safety of COVID-19 vaccines are due to side effects and doubts due to the perceived rush with which people believe vaccines were developed (Wonodi et al., 2022). The success of novel vaccines, such as those developed against COVID-19, is based on ensuring their safety. As trials of COVID-19 vaccines have progressed,

so have various claims about their safety, many of which are false. While various national and international health institutions have tried to debunk these misleading claims, the time between the emergence of such information and its debunking, in addition to the limited reach they may have had, may have led to the emergence of populations vulnerable to doubts about COVID-19 vaccines (Islam et al., 2021). This finding provides further support for the suggestion that improved acceptance of the COVID-19 vaccine will depend on the implementation of awareness campaigns and messages in the four countries evaluated that are supported by solid evidence of vaccine safety and efficacy (Hussain et al., 2016).

Limitations and strengths

Although the study has important findings, it also has some limitations. First, the selection of participants was done by non-probabilistic snowball sampling, which does not allow for the generalization of the results. However, in some cases, it is difficult to employ probability sampling, so the use of non-probability sampling techniques is preferred (Fricker Jr et al., 2019), even more so during the current pandemic. Second, the number of participants is different in each country due to the sampling technique; therefore, it is recommended that future studies work with equivalent groups. Third, the results were based on general population samples in each of the participating countries, where there were people with low levels of fear of COVID-19 and low belief in conspiracy ideas about vaccines.

Future studies should analyze the association networks between these variables in people with higher degrees of acceptance of conspiracy beliefs about vaccines. Fourth, in all countries the majority of participants were women and young people; therefore, the findings should be interpreted with caution. Fifth, it is important to note that network analyses, within prospective studies such as the present study, suggest but do not determine causality. This does not make it clear whether the most central symptom was the cause of other symptoms or vice-versa or both. The presence of significant edges could suggest causal relationships, but it is necessary to use longitudinal designs to establish causality between variables. In this sense, the results of network analysis could be a source of hypotheses about complex causal relationships between variables, which can be evaluated more specifically with appropriate designs. Sixth, both the FCV-19 S and VCBS-COVID-19 contain items whose wording refers to the presence of fear symptoms and conspiracy beliefs during the pandemic. This generated a retrospective assessment, which may have caused method bias. Seventh, it has not been verified whether the participants had a history of mental health problems, which could have

interfered with the network findings. Eighth, the study used data derived from self-report measures. This made possible the presence of a social desirability bias and limited the objectivity of the measurement (Fried & Cramer, 2017). In the future, studies should analyze the relationships between different variables through structured clinical interviews, which can identify specific symptoms during the COVID-19 pandemic.

Despite the limitations, the study presents important strengths. First, rather than considering fear of COVID-19 and conspiracy beliefs about COVID-19 vaccines as unitary constructs, this study presents a more complex view of how the fear symptoms and conspiracy beliefs of people in four Latin American countries are related. Second, although the study has been conducted in the context of the COVID-19 pandemic and four countries, its pattern of relationships is likely to be similar in non-pandemic contexts and other Latin American countries. This allows the findings to help understand the co-occurrence between fear of COVID-19 and conspiracy beliefs about COVID-19 vaccines in general. Third, the study included a relatively large sample of people, which contributed to the precision, stability, and robustness of the network estimates. Previously, it has been indicated that the low stability of the network may be a result of the presence of small sample sizes (Jiang et al., 2020).

Conclusion

The present study is, to the best of our knowledge of current literature, the first to use network analysis to assess the relationships between conspiracy beliefs about COVID-19 vaccines and COVID-19 fear symptoms. The results indicated that the nodes with the highest centrality were “I get uncomfortable thinking about COVID – 19” and “When I see news and stories about COVID – 19 on social networks, I get nervous or anxious” for the FCV-19 S scale and “Vaccinating children against COVID-19 is harmful and this fact is hidden” for the VCBS-COVID-19 scale. Likewise, the item referring to “People are misled about the safety of COVID-19 vaccines”, is the most predictable feature in conspiracy beliefs about COVID-19 vaccines; whereas, the node “I can’t sleep because I worry about having COVID – 19” was the most predictable of fear towards COVID-19. In this sense, the above nodes may constitute central features for the development and/or maintenance of conspiracy beliefs about COVID-19 vaccines and fear of COVID-19 within the four countries.

Although conspiracy beliefs about COVID-19 vaccines and fear of COVID-19 may be considered to intervene in the acceptance or rejection of vaccination against the disease (Seddig et al., 2022; Scrima et al., 2022), timely

interventions targeting the bridging characteristics (nervousness or anxiety about COVID-19 information, and lack of sleep due to worry about COVID-19) would have a positive impact on symptoms of fear of COVID-19 and conspiracy beliefs about vaccines. Our findings also suggest that the country may have some influence on fear symptoms and conspiracy beliefs. However, the findings strongly support cross-cultural similarities in the networks across the four countries rather than differences. Still, more studies are needed that include the role of other variables, such as personality traits, to properly understand the relationship between fear of COVID-19 and the presence of conspiracy beliefs about COVID-19 vaccines.

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Declarations

Data availability The R codes and data are available in the open access repository OSF: <https://osf.io/v9ctw/>.

Declaration of competing interest The authors declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all individual participants included in the study.

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