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Exploring risk factors for depression: a network analysis



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ABSTRACT

Introduction: Depression is a frequent psychological problem in the general population. There are no single conclusive causes for its development; on the contrary, it arises from the interaction of other emotional disorders. Determining risk factors is a primary objective to identify vulnerable individuals and optimize prevention.

Objective: To analyze risk factors of the depression through network analysis in Peruvian adults from the general population.

Methods: Cross-sectional study with a quantitative approach. A total of 567 Peruvian adults who answered several instruments assessing depressive symptoms, insomnia, suicidal ideation and anxiety participated. An undirected network model with all psychological variables and a predictive path diagram was estimated to identify risk factors for depression. Measures of centrality, precision and stability were also analyzed. **Results:** The network structure showed that depression, insomnia, suicidal ideation, and anxiety were mutually associated. In terms of expected influence and predictability, depression obtained the highest value, followed by anxiety. In the prediction plot, all psychological variables were directly connected with depression, with anxiety having the highest connection. The tests of accuracy and stability ($CS = 0,75$), were robust.

Conclusions: The results of the study suggest that problems with insomnia, suicidal ideation, and anxiety, are considerable risk factors for depression. Identifying and intervening early on those risk factors in adults in the general population could help to prevent the development of depressive symptoms.

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Explorando los factores de riesgo de la depresión: un análisis de red

R E S U M E N

Palabras clave:

Depresión
Factores de riesgo
Adulto
Salud mental
Psicopatología

Introducción: La depresión es un problema psicológico frecuente en la población general. No existen causas únicas concluyentes para su desarrollo, por el contrario, surge de la interacción de otros desórdenes emocionales. Determinar los factores de riesgo es un objetivo primordial para identificar a las personas vulnerables y optimizar la prevención.

Objetivo: Analizar los factores de riesgo de la depresión mediante el análisis de redes en adultos peruanos de población general. **Métodos:** Estudio transversal con enfoque cuantitativo. Participaron 567 adultos peruanos que contestaron diversos instrumentos que evaluaban síntomas depresivos, insomnio, ideación suicida y ansiedad. Se estimó un modelo de red no dirigido con todas las variables psicológicas y un diagrama de ruta predictiva para identificar los factores de riesgo de la depresión. Las medidas de centralidad, precisión y estabilidad también fueron analizadas.

Resultados: La estructura de red demostró que la depresión, insomnio, ideación suicida y ansiedad se asociaron mutuamente. En términos de influencia esperada y predictibilidad, la depresión obtuvo el valor más alto, seguido de la ansiedad. En el diagrama de predicción, todas las variables psicológicas estaban directamente conectadas con la depresión, siendo la ansiedad con la mayor conexión. Las pruebas de precisión y estabilidad ($CS = 0,75$), fueron robustas.

Conclusiones: Los resultados del estudio sugieren que los problemas de insomnio, ideación suicida y ansiedad, son factores de riesgo considerables para la depresión. Identificar e intervenir anticipadamente aquellos factores de riesgo en adultos de población general, podría ayudar a evitar el desarrollo de los síntomas depresivos.

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Introduction

Depression is a common modern-day psychological problem in the general population that contributes significantly to the global disease burden, affecting approximately 280 million people worldwide.¹ The prevalence in Latin American and Caribbean countries places depression as the main disability problem, with an average of 7.8% in the 15–50-year-old age group, and Peru being the third most affected country (8.6%).² The figures are similar for Colombia, which ranks fifth (8.2%), and studies based on national mental health protocols highlight depression as the most common psychological problem, considering a lifetime prevalence of 4.3%.^{3,4} Depressive symptoms have repercussions on health, social and economic conditions. One systematic review and meta-analysis points out that depression is associated with higher direct costs (hospitalisation, emergency room visits, outpatient treatment and medication) and indirect costs (reduced/loss of productivity) in adolescents, adults and older adults, and these are of the same magnitude in people with comorbid depression.⁵ Given that depressive symptoms have a strong likelihood of recurrence and the financial costs involved in the intervention process are high, it seems obvious that preventing depression would be better than having to treat it clinically.

The evidence tells us that there is no single conclusive cause or set of causes for depression, and that, on the contrary, depressive symptoms can stem from the interaction of other psychological problems.^{6,7} The determining of risk factors is

of prime importance when it comes to identifying vulnerable people and optimising prevention. Risk factors complicate the course of a health problem and hinder access to optimal coping mechanisms, thus increasing the likelihood of negative outcomes when people face adversity.⁸ A new way of exploring psychopathology—in this case the risk factors for a particular psychological problem (depression)—is through network modelling, according to which psychopathology is a complex system arising from symptoms that interact with each other in a network.⁹

In the last decade, network models have been popular in psychological and psychiatric research for analysing emotional disorders (mental disorders), as they make it possible to extend the interaction at the level of symptoms and to discover patterns of conditional associations among the elements of a phenomenon. For example, network theory postulates that a psychological problem, such as depression, arises not from the presence of a latent cause, but from a process in which conditions or symptoms are related to each other.¹⁰ From this perspective, network models based on covariance estimation and statistical interactions in a Pairwise Markov Random Field (PMRF) can provide information on symptom relationships or on which symptoms connect to other clusters (network structure), clustering of physical (chronic diseases) and psychological symptoms, descriptive measures of the network (centrality, topology and network comparison) and stability measures of network inference.^{9,11} They are also particularly useful when analysing the links between different domains (comorbid variables or risk factors), as they help identify

bridge variables in the development of a psychopathological phenomenon.^{6,8}

A narrative review based on 56 studies on network models of depression found that depression often coexists with symptoms of other emotional disorders, such as anxiety, post-traumatic stress, obsessive-compulsive disorder, prolonged grief, autism and alcohol use, etc.⁷ A six-year prospective network analysis reported that insomnia is a risk factor that foreshadows depression, and this is due to the difficulty in initiating sleep.¹² Another study among adults in the general population of the United Kingdom identified that depression was related to anxiety, insomnia and post-traumatic stress.¹³ Meanwhile, another study in US military veterans reported that depression was associated with suicidal ideation, difficulty sleeping, anger and post-traumatic stress, and that depression was the second central variable in the network structure.¹⁴ Although recent studies have investigated risk factors for depression, it is unclear whether insomnia, suicidal ideation and anxiety, included in a single model and not in isolation, or the incorporation of other psychological variables that influence the network structure, are determining risk factors for depressive symptoms.

Therefore, our primary objective with this study was to analyse a network model in order to explore the associations between depression, insomnia, suicidal ideation and anxiety. In addition, a predictive path diagram was created to identify which variables were directly related to depression (risk factors) and the central variables of the network structure.

Material and methods

Participants

The study included 567 Peruvian adults, selected through convenience sampling. We used the following inclusion criteria: a) age from 18 to 60 years; b) place of residence in Metropolitan Lima; and c) agreeing to take part by giving informed consent. People who did not meet the criteria mentioned above were excluded from the research. For example, people were excluded if they did not give their informed consent ($n=2$), if they were outside the established age range ($n=33$) or if they resided in another part of Peru ($n=108$).

Of the sample, 426 were female (75.1%) and 141 were male (24.9%). The average age was 29 years with a standard deviation of 10.2 years. Also, the majority were single (80.6%), a smaller percentage were married (15.3%), and some said they were divorced (4.1%). Regarding academic level, 72% had university studies, 16.9% had attended a technical college, 10.9% had secondary studies and one person (0.2%) reported only having had primary education. Lastly, with respect to employment status, 53.6% stated that they had a job, while 46.4% reported that they were unemployed.

Tools

Patient Health Questionnaire-9 (PHQ-9)

The PHQ-9 evaluates depressive symptoms during the last two weeks and has adequate sources of evidence of validity in the Peruvian population.¹⁵ It consists of 9 items with 4 response

options, where high scores indicate greater depressive symptoms. In this study, an acceptable reliability was obtained with the coefficient omega (ω) = 0.89.

Athens Insomnia Scale (AIS)

The AIS consists of 5 items that assess insomnia symptoms over the past month with a frequency of 3 times a week. It presents psychometric evidence in Peruvian adults and the response system uses a Likert-type scale, where high scores indicate a greater severity of insomnia problems.¹⁶ In this study, we obtained an acceptable reliability of $\omega=0.83$.

Frequency of Suicidal Ideation Inventory (FSII)

The FSII is a brief tool that evaluates the frequency of suicidal ideation in the last 12 months and is adapted to the Peruvian population.¹⁷ The scale consists of 5 items, using a Likert-type response system and a total score range from 5 and 25 points, with high scores being an indicator of greater severity of suicidal ideation. The FSII has adequate reliability of $\omega=0.96$.

Generalised Anxiety Disorder-7 (GAD-7)

GAD-7 is a questionnaire consisting of 7 items with 4 response options, which assesses the severity of generalised anxiety symptoms during the past two weeks. The GAD-7 has been analysed psychometrically in the Peruvian population and high scores are an indicator of greater generalised anxiety.¹⁸ In this study, we obtained an acceptable reliability of $\omega=0.91$.

Procedure

Given that the state of emergency and restriction measures to counter SARS-CoV-2 are still in place in Peru, the data collection was performed online using a Google[®] form. The link was posted on the Facebook[®] and WhatsApp[®] social media platforms throughout the month of October 2021. The description of the questionnaire indicated the aim of the research, the confidentiality of the responses, the usefulness of the information for academic purposes, and the anonymity thereof. Informed consent for voluntary participation was also requested. Those who accepted had access to demographic profiling questions and questionnaires. Otherwise, they would not have access to any questions in the questionnaire and their participation would end.

Statistical analysis

Initially, descriptive analyses were performed of the demographic variables and of the total scores for each variable of the tools used. The absolute frequency of the participants, measures of central tendency and dispersion were analysed. Subsequently, a Gaussian graphical model (GGM) of an undirected, weighted network based on regularised partial correlations was estimated. To check for any spurious associations, the Least Absolute Shrinkage and Selection Operator (LASSO) was used, with a recommended tuning parameter of $\gamma=0.50$ and applying the Spearman correlation method.¹⁰ The structure consists of four nodes, which are the total scores for each variable (depression, insom-

Table 1 – Descriptive analysis, centrality measure and predictability.

	Mean	Standard deviation	Expected influence	Predictability
Depression	6.38	5.51	1.34	0.76
Insomnia	3.99	2.97	0.43	0.42
Suicidal ideation	7.50	4.22	0.46	0.51
Anxiety	5.75	4.49	0.74	0.67

nia, suicidal ideation and anxiety). A connection between two nodes indicates a partial correlation between two variables after conditioning all the other variables in the network structure. Blue edges indicate positive partial correlations and red edges indicate negative correlations. The broader and more saturated the edge, the stronger the partial correlation. The network structure was visualised using the Fruchterman-Reingold algorithm, which locates the strongest correlations in the centre and the weakest correlations at the periphery.¹⁹

To examine which variables are directly related to depression, a predictive path diagram was estimated. This type of diagram places a node of interest (in this case depression) as the source node on the left-hand side and then lists the nodes that have a connection to depression on the right, creating a vertical network of connections to the source node, the nodes that are connected to the nodes connected to the source node, and so on.¹⁰ The shortest predictive path can be defined as the path that connects the destination node to the source node, whilst controlling for all other variables in the network.

To quantify which node is more influential in the network structure, the expected influence was analysed as a measure of centrality. In the centrality analysis, we also analysed predictability, which provides evidence of the relevance of each node in the network model, by calculating the explained variance (R^2), which varied from 0 to 1.²⁰ In the network model graph, predictability can be seen as the blue area or circle around each node.

Finally, to verify that the results were reliable, we performed the following two analyses. The first was related to the accuracy of the network model, analysing the accuracy of the structure using the non-parametric bootstrapping method based on 1,000 samples to calculate the 95% confidence intervals (CI) of the network edges. The second analysis examined the stability of the expected influence centrality measurement by sampling different bootstrap-based data subsets. In relation to this, the correlation stability (CS) coefficient indicates what proportion of participants can be eliminated in order to retain a correlation of at least 0.70, with 95% probability, based on the original sample with the generation of a subset of samples. The CS should not be less than 0.25 and should preferably be greater than 0.50.¹⁰

All analyses were performed using R statistical software, version 4.1.1.²¹ The networks were constructed and visualised using the qgraph package version 1.9 and mgm version 1.2,^{22,23} with the bootnet package version 1.5,¹⁰ being used for precision and stability, the psych package version 2.1.9 and MBESS version 4.8.1,^{24,25} for the descriptive analysis and reliability of each tool, cowplot package version 1.1.1 for the combination of figures, and the joycon package version 0.1.0²⁶ for colour selection.

Ethical considerations

The research was carried out based on the guidelines of the Declaration of Helsinki and the code of ethics of the Colegio de Psicólogos del Perú (CPsP) [College of Psychologists of Peru], described in chapter 3, dedicated to research.^{27,28} Neither the names of the participants nor any other aspect likely to identify them were requested. The study did not involve any risk to their physical or mental integrity, and all participants gave their informed consent.

Results

Descriptive analysis and network structure

Table 1 shows that the mean was between 3.99 (insomnia) and 7.50 (suicidal ideation). The largest standard deviation was found in depression and the smallest in insomnia. The average predictability was 59%, while the highest predictability was found in depression (76%). Predictability is shown in Fig. 1, represented as the blue area or circle around each node. The highest value of expected influence is located in depression (1.34), followed by anxiety symptoms (0.74).

The network model of depression and risk factors in Peruvian adults is shown in Fig. 1. It can be seen that all the node correlations were positive, and stronger correlations were found between depression and anxiety symptoms ($r=0.60$), and between depression and suicidal ideation ($r=0.46$). In the predictive path diagram, depression is directly related to all the variables, showing a strong connection with symptoms of anxiety and suicidal ideation, but to a lesser extent with insomnia problems.

Network model accuracy and stability of centrality

Overall, the CIs were quite narrow and mostly non-overlapping, indicating reliable results. The expected influence centrality estimate was stable (CS=0.75). This suggests that 75% of the data could be removed to retain 95% certainty (a correlation of 0.70 with the original data set) (Fig. 2).

Discussion

This study used a network approach to explore the associations and predictive path diagram between depression, insomnia, suicidal ideation and anxiety in a sample of Peruvian adults from the general population. In particular, it was shown that the psychological variables included in the general network model and predictive path were positively connected. The results were robust to tests for accuracy and stability.

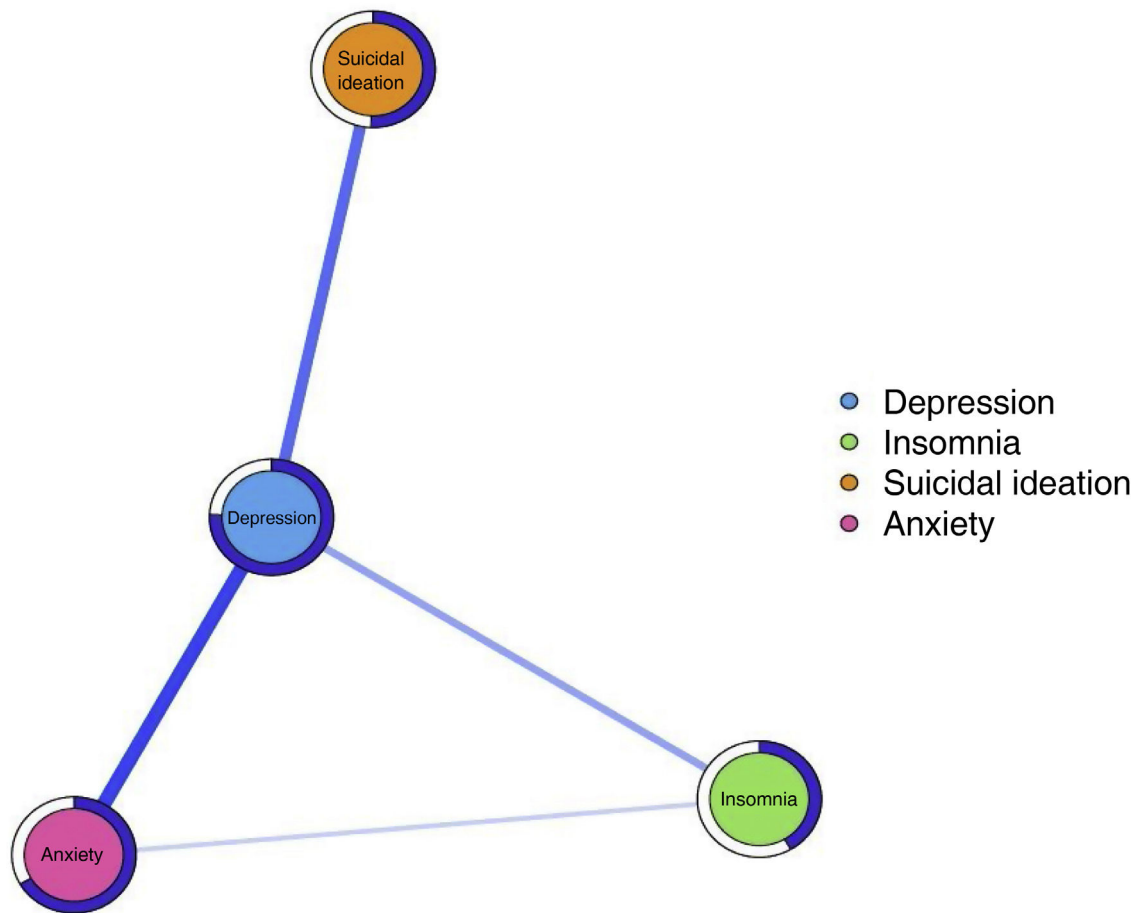


Fig. 1 – Network structure of depression and risk factors in Peruvian adults.

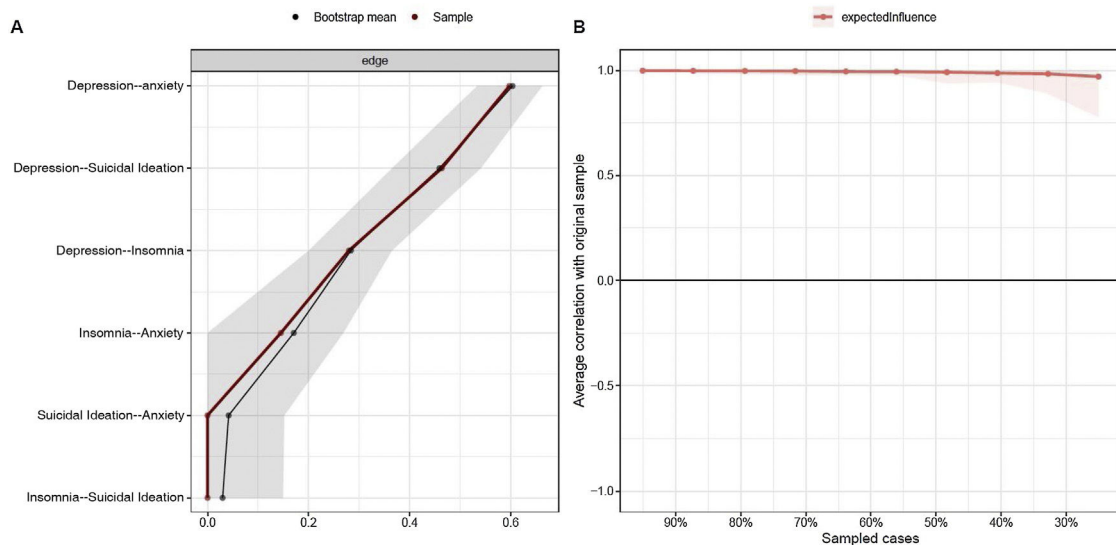


Fig. 2 – (A) Non-parametric bootstrap confidence intervals of estimated edges for the network structure of depression and risk factors. (B) Stability of the expected influence centrality index.

The contributions, clinical implications and limitations are discussed below.

In the general network model, depression was found to be positively associated with insomnia, suicidal ideation and

anxiety, although the association was strongest with anxiety. These findings are consistent with other previous instances of network research that included depression and reported its association with various psychological problems, includ-

ing the variables proposed in this study.¹²⁻¹⁴ An important aspect in the results is that anxiety showed the strongest association with depression. Comorbidity between symptoms of anxiety and depression has been widely documented in network analyses and reviews on network models based on 56 studies conducted between 2014 and 2020.^{7,8} This indicates that people who experience anxiety symptoms are likely to have depressive symptoms. In fact, a study based on Peruvian adults from the general population found that “uncontrollable worry” was associated with “anhedonia”, while “nervousness” was associated with “sad mood”, highlighting the concurrence of both psychological problems.²⁹

The expected influence centrality may play an important role in finding symptoms that activate or maintain psychopathological networks, as well as providing potential targets for intervention. In the network structure, depression was the node with the highest centrality, indicating that depression plays an important role in activating and maintaining the network model. In other words, interventions targeting depression could alleviate problems with insomnia, suicidal ideation and anxiety. This result is consistent with the predictability analyses, where depression also obtained the highest value. A recent study in military veterans in the USA also identified depression as a central variable in a network structure of post-traumatic stress, anger, suicidal ideation and sleeping difficulties,¹⁴ while another study in the Spanish population reported depression as a central node in terms of strength.³⁰

In the predictive path diagram, depression was directly related to insomnia, suicidal ideation and anxiety. The fact that depression is connected to multiple psychological variables reflects that it is a complex phenomenon. The connection between depression and anxiety had the strongest correlation coefficient of all the direct connections in the structure. This result is consistent with the literature on the high comorbidity between anxiety and depression; even incorporating other emotional disorders, the connection is still maintained.^{8,13} Among adults in the general population, studies have shown that loss of pleasure, worry and depressed mood are the most common bridge symptoms between anxiety and depression,²⁹ although, in patient populations, agitation or psychomotor retardation were found to be the bridge explaining this comorbidity.³¹ The connection between depression and suicidal ideation also has a strong direct relationship. A network analysis of depressive symptoms in Peruvian adults identified that thoughts of death correlated with psychomotor problems, feelings of worthlessness, changes in appetite and depressed mood, and were the central symptom for developing a depressive episode.³² A direct connection between depression and insomnia was also found. Another network study reported that insomnia correlates with depression and this is likely due to the difficulty in initiating sleep, specifically in the sleep-wake cycle, either for sleep onset or at any time thereafter during the night.^{12,13}

Overall, the study results suggest that insomnia, suicidal ideation and anxiety are significant risk factors for triggering depressive symptoms. From the perspective of complex adaptive systems, emotional disorders such as depression arise from attractor states that cause an individual to become

stuck in a particular state (depressed state) at a tipping point in the system. However, the state of attractors can change over time and place the individual in stable alternative attractors (healthy state), this being called phase transition; to explain the transitions between one attractor and another.³³ Therefore, depression can be understood as the transition between a depressed and a healthy attractor. However, attractor states arise and are maintained from interactions between various processes (for example, biological, psychological, social), which are constantly evolving.³⁴ Network models provide relevant information on the study of psychopathology, where the phenomena are multifactorial. To prevent rather than treat depression, it is necessary to identify the risk factors. Identifying insomnia, suicidal ideation and anxiety as risk factors allows the intervention pathway to be established. For example, a systematic review and meta-analysis showed that cognitive-behavioural therapy is very effective for depression and anxiety,³⁵ and the same results have been found for insomnia and suicidal ideation.^{36,37} Furthermore, these interventions have also been effective in remote health services (telehealth) and relapse prevention, as they provide individuals with adequate psychological resources (for example, problem solving, coping strategies, etc.) to improve their lifestyle.³⁵⁻³⁷

Our research findings therefore reflect the importance of strengthening mental health prevention and monitoring programmes in the general population, especially in adults living in Metropolitan Lima. In primary prevention measures, it would be important to incorporate the assessment of anxiety, insomnia and suicidal ideation in mental health screenings. In view of the state of emergency and the restrictions caused by the pandemic, it would be best to use technological tools for screening. As the scientific literature and the results of the study suggest that these symptoms are considerable risk factors for depression, when mild cases are identified, online sessions should be scheduled or phone calls with available psychologists, whilst moderate or severe cases should immediately be referred to a mental health centre for in-person care.^{7,29}

Another strategy would be coordination between Lima's local district councils and community mental health centres to organise specific virtual health campaigns, in order to provide self-care guidelines in situations of anxiety, education on sleep hygiene, and information on health centres, organisations and communication and support numbers if people are presenting with suicidal ideation. All of this should be done with the purpose of offering education, guidance and sufficient tools to handle adverse situations individually. This would help to decongest the healthcare system.²

Despite the contributions made by this study, the results should be interpreted whilst taking certain limitations into consideration. A first limitation is the sampling method: as recruitment was carried out online and through social media platforms, the participants present a particular characteristic of interaction with this type of platform with no difficulties in responding to an online survey, which will not be representative of the general population. Secondly, the current analysis was based on cross-sectional data and it is not therefore possible to infer causality, such as the direction of the con-

nections. Future studies could seek to confirm the exploratory results with the estimation of a directed acyclic graph (DAG), which makes it possible to incorporate information on the likely direction of the conditional dependence relationships between the variables. Thirdly, psychological variables were assessed from self-report scores, which may limit the capture of a clinical phenomenon. Fourthly, there was greater participation by females compared to males, which may bias the results. Furthermore, the age group considered does not allow us to generalise the conclusions to other stages of life such as adolescence, childhood and older adults. Finally, the network structure of risk factors for depression could be expanded by considering other psychological variables, in order to provide more information about its complexity.

Conclusions

Overall, the results of the study suggest that insomnia, suicidal ideation and anxiety are significant risk factors for triggering a depressive episode. Centrality and predictability measures indicated that depression is the most central variable in the network structure, followed by anxiety. Identifying and intervening early on these risk factors in adults in the general population could help prevent the onset of depressive symptoms.

Ethical responsibilities

No experimental procedure was performed in the study that would harm or put participants at risk. The research was carried out based on the guidelines of the Declaration of Helsinki and the code of ethics of the Colegio de Psicólogos del Perú (CPsP) [College of Psychologists of Peru], described in chapter 3, dedicated to research. Neither the names of the participants nor any other aspect likely to identify them were requested. The study did not involve any risk to their physical or mental integrity, and all participants gave their informed consent.

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Declaration of competing interest

The author has no conflicts of interest to declare.

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