The network structure of psychopathological and resilient responses to the coronavirus pandemic: A multi-country study of general population depression and anxiety symptoms

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Article

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Posted Date: October 27th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-2189648/v1
The network structure of psychopathological and resilient responses to the coronavirus pandemic: A multi-country study of general population depression and anxiety symptoms

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Abstract

Commonly identified trajectories of psychological distress in response to adverse events, like the COVID-19 pandemic, include Resilience, Delayed distress, Recovery and Sustained distress. The current study aimed to analyse these four distinct response patterns during the pandemic using network analysis. Anxiety and depression symptom data collected across four European countries over the first year of the pandemic were analysed (N = 3594). Participants were firstly categorised into one of the four aforementioned response patterns. Networks of symptoms were then estimated in each of these groups, and they were compared in relation to network connectivity and symptom clustering. Informed by network theory, it was hypothesised that greater levels of resiliency would be characterised by lower symptom connectivity and fewer symptom clusters. Two-thirds (64%) of the sample were categorised as displaying a pattern of Resilience. The connectivity hypothesis was partially supported: the Sustained distress group show higher connectivity than the Recovered group; however, the Resilient group showed higher connectivity than the Delayed distress group. Regarding symptom clustering, non-random clusters were identified in the Recovered and Sustained groups only, and, in contrast to the initial hypotheses, more clusters emerged in the Recovered group (three) than in the Sustained distress group (two). Our results replicated findings that resilience was the most common mental health pattern over the first year of the pandemic. Moreover, they suggested that high network connectivity may be indicative of a stable mental health response over time, whereas fewer symptom clusters may be indicative of a pattern of sustained distress. Although exploratory, the network perspective provided a useful tool to examine the complexity of patterns of psychological responses to adverse events, and if replicated, could be used to help identify indicators of protection against, or vulnerability to, psychological distress in future.

Keywords: resilience, network analysis, recovery, COVID-19, pandemic, connectivity, clusters, NetworkComparisonTest, walktrap algorithm
Introduction

Psychological reactions to potentially traumatic events (PTEs) are highly heterogeneous; commonly identified trajectories include: (1) low to moderate distress which increases over time (i.e., delayed distress), (2) elevated distress and functional impairment followed by a gradual decrease or return to normal baseline over time (i.e., recovery), (3) moderate or severe distress that remains stable over time (i.e., sustained distress), and (4) a stable state of little-to-no distress (i.e., resilience) (Bonanno et al., 2011).

Despite reports that there has been an overall increase in psychological distress in the general population during the COVID-19 pandemic (Santomauro et al., 2021), these established mental health trajectories have also been identified in the general population during this time (e.g., Ahrens et al., 2021; Chen & Bonanno, 2020; Gambin et al., 2021; Kimhi et al., 2021; Pierce et al., 2021; Shevlin et al., 2021a, 2021b; Valiente et al., 2021). These studies have shown that the most common pattern in the general population during COVID-19 is resilience, characterised by low levels of psychological distress and dysfunction over time, consistent with the broader research on PTE exposure (Galatzer-Levy et al., 2018).

Network analysis is an analytic approach that has grown in popularity in the field of psychology over the last decade (Contreras et al., 2019; Robinaugh et al., 2019). From this perspective, mental health conditions can be conceptualised as a dynamic network structure of symptoms (represented by nodes) and their mutual associations (represented by edges) (Borsboom, 2017). The Network Theory of Mental Disorders postulates that both symptom activation and network structure play key roles in the onset and maintenance of psychological distress; symptoms in strongly interconnected networks (i.e., higher connectivity) are more likely to be activated by their neighbours than those belonging to a network with low connectivity (Robinaugh et al., 2019). Thus, from this perspective, resilience could be seen as a stable state in which relatively few symptoms are activated or in which low connectivity prevents active symptoms from triggering others (Borsboom & Cramer, 2013; Boschloo et al., 2015; Robinaugh et al., 2019). Additionally, clusters of densely connected nodes (i.e., communities or subgroups of symptoms) can also be examined using network analysis (Borsboom, 2017). However, few studies have examined resilience from a network perspective generally (Kalisch et al., 2019; Lunansky et al., 2021), or how symptoms may cluster as a function of it.
It seems plausible that as psychopathology severity increases, the association between symptoms may become more specific and more clusters would appear (McGorry & Van Os, 2013). Recent studies have applied network analysis to study psychopathology during the COVID-19 pandemic (Gibson-Miller et al., 2022; Taylor, 2020; Williamson et al., 2021; Zavlis et al., 2021); however, these studies have focussed on symptomology in the general population broadly, rather than in the distinct groups known to emerge in response to PTEs (i.e., resilience, delayed distress, recovered, and sustained distress). Therefore, the aim of the current study was to model and visualise the complex symptom-to-symptom associations underlying these four groups to examine whether they reflect distinct psychological response patterns during the SARS-CoV-2 pandemic. Specifically, networks of psychological distress (i.e., symptoms of depression and anxiety) were modelled for each of the four symptom-based response patterns and differences in terms of connectivity (aim 1), and psychopathological symptoms clustering (aim 2) were examined. For these network comparisons, the Resilient and Delayed distress groups (i.e., the two groups characterised by the absence of distress at Time 1), and Recovered and Sustained distress groups (i.e., the two groups characterised by the presence of distress at Time 1) were compared to one another. Based on network theory, densely connected networks with high symptom activation are considered to give rise to psychopathology. Therefore, we hypothesised for aim 1 that with increasing levels of resilience, mental health networks would be less densely connected (connectivity hypothesis). In other words, the connectivity of the network from the Resilient group would be lower compared to the Delayed distress group, and, similarly, the connectivity of the Recovered group network would be lower compared to the Sustained distress group. Regarding aim 2, consistent with the literature, we anticipated that, with increasing levels of resilience, fewer symptom clusters would be identified in the networks and, instead, anxiety and depression symptoms would be represented as more unified and homogeneous constructs (clustering hypothesis). Specifically, we expected that fewer symptom clusters would be observed in the Recovered and Resilient networks compared to the Sustained Distress and Delayed Distress networks, respectively.
Established in March 2020, the COVID-19 Psychological Research Consortium (C19PRC) Study is a longitudinal, multi-country study which aims to monitor and evaluate the psychological, socio-economic, and political impacts of the SARS-CoV-2 pandemic on the lives of adults living in the UK, Ireland, Spain, and Italy (McBride et al., 2021). Participants were recruited via online research panels and completed the survey online. All participants gave their informed electronic consent to participate in the survey and ethical approval was sought in each country. The current study used data that had been collected over the course of the first year of the COVID-19 pandemic. To categorise patterns of psychological responses during this time, only individuals who participated in the first survey wave in each country (Time 1 [T1]; UK, Ireland: March 2020, Spain: April 2020, Italy: July 2020) and the most recent follow-up survey (Time 2 [T2]; UK, Ireland: March 2021, Spain, Italy: April 2021) were included. This resulted in a combined sample of $N = 3594$ (UK: $n = 1162$; Ireland: $n = 390$; Spain: $n = 1498$; Italy: $n = 544$).

Sample characteristics are depicted in Table 1. See Supplementary Material SM1 and SM2 for a detailed description of the sample, fieldwork procedures and survey timelines.

**Measures**

The depression, anxiety and COVID-19 anxiety items used to estimate the networks were measured at T1 in each country.

**The Patient Health Questionnaire-9 (PHQ-9; Kroenke & Spitzer, 2002)**

The PHQ-9 is a 9-item scale assessing the severity of depressive symptoms over the last 2 weeks. Responses are on a 4-point Likert scale, ranging from 0 (“not at all”) to 3 (“nearly every day”). The internal consistency of this scale was excellent ($\text{Cronbach’s } \alpha = .902$).

**The Generalized Anxiety Disorder Scale (GAD-7; Spitzer et al., 2006)**

The GAD-7 is a 7-item scale whereby respondents are asked to report how often they have been bothered by the anxiety symptoms listed, over the last 2 weeks. Responses are on a 4-point Likert scale, ranging from 0 (“not at all”) to 3 (“nearly every day”). The internal consistency of this scale was excellent ($\text{Cronbach’s } \alpha = .935$). Both the PHQ-9
and the GAD-7 scores have shown measurement invariance in the UK, Ireland, Spain, and Italy (Shevlin et al., 2022).

**COVID-19 anxiety**

Participants were asked to report their degree of specific anxiety about the SARS-CoV-2 pandemic with one single item “How anxious are you about the coronavirus/COVID-19 pandemic?”. Responses were on a slider scale from 0 (“not at all anxious”) to 100 (“extremely anxious”).

**Open Science practice**

The current study was pre-registered via the OSF (https://osf.io/95m4j/).

Furthermore, data and R-code can be found in the Supplementary Materials (SM).

**Data analysis**

*Psychological responses during the pandemic categorisation*

Psychological responses during the pandemic were categorised following the previous symptom-based definition of resilience (Valiente et al., 2021) according to two criteria (distress and time). Firstly, we categorised participants according to whether they showed absence/presence of distress (i.e., whether they met the standard cut-off scores of ≥10 for depression on the PHQ-9 or anxiety on the GAD-7) and, secondly, based on the time of the assessment (i.e., T1 and T2). The combination of these two variables provided four different categories describing the pattern of responses following traumatic events (Bonanno, 2004; Galatzer-Levy et al., 2018): 1) Resilience — absence of distress at T1 and T2: n = 2284, 63.6%; 2) Delayed distress — absence of distress at T1, presence at T2: n = 364, 10.1%; 3) Recovered — presence of distress at T1, absence at T2: n = 359, 10.0% and 4) Sustained distress — presence of distress at T1 and T2: n = 587, 16.3% (See Supplementary Material SM2 for further details).

Given that the network comparison technique used can be influenced by sample size (Boschloo et al., 2015; Terluin et al., 2016), before groups could be compared, random subsamples were drawn from the Sustained and Resilient groups to match the sample size, controlling for age and gender, of the Recovered (n = 359) and Delayed (n = 364) groups, respectively. All network analyses in the main manuscript were conducted using these age and gender-matched samples (for a detailed description see Supplementary Material SM3).
Validation of patterns of response categories with levels of impairment

Following previous work (Valiente et al., 2021), an objective, evidence-based validation of the groups’ classification was conducted by analysing levels of disturbance experienced by the subgroups, measured using the International Trauma Questionnaire (Cloitre et al., 2018). We conducted a 4 (Group: Resilient, Delayed distress, Recovered and Sustained distress) × 2 (Time: T1, T2) repeated-measures ANOVA in SPSS v.22 (IBM Corp, 2013), with Group being a between-subject factor and Time a within-subject factor (a detailed description and results are provided in Supplementary Material SM4).

Network estimation and visualisation

A network structure consists of nodes (representing observed variables or symptoms in this case) and edges (lines indicating the degree of association between nodes).

Networks were estimated for each of the four age and gender-matched groups. Networks included all the PHQ-9, GAD-7 and COVID-19 anxiety items as nodes and were estimated using a Gaussian Graphical Model (GGM) in which edges represent partial correlation coefficients (Epskamp, Borsboom, et al., 2018).

Analyses were conducted in R Studio (R version 4.1.0). The Fruchterman-Reingold algorithm (Fruchterman & Reingold, 1991) was used to visualise the networks using the qgraph package (version 1.6.9), which places nodes that are strongly connected closer together. Thicker edges indicate a stronger connection. Blue edges indicate positive correlations and red indicates negative ones. To avoid spurious edges and to produce a more parsimonious network, regularization techniques were used (Epskamp, Borsboom, et al., 2018; Epskamp, van Borkulo, et al., 2018). Specifically, the graphical Least Absolute Shrinkage and Selection Operator (LASSO, Friedman et al., 2008) was employed to shrink small edges to exactly zero, meaning only the most relevant edges were present. The ‘tuning’ hyperparameter gamma (γ), was selected using the Extended Bayesian Information Criteria (EBIC). The default (γ = 0.5) was selected to ensure a more conservative network estimation. Networks were estimated using the R package bootnet (version 1.4.3). For ease of visual comparison, all four networks have been constricted to an ‘average layout’.
A number of additional network tests were conducted specifically related to our two initial aims:

**Aim 1. Does network connectivity vary as a function of resilience?** To compare the overall network connectivity and structure between (i) Resilient and Delayed distress subgroups and (ii) Recovered and Sustained distress, we relied on the NetworkComparisonTest package (version 2.2.1). Differences in network structure were assessed with the network invariance test, while global strength was estimated by comparing the summed edge weights within a network (i.e., invariant global strength) (van Borkulo, 2018).

**Aim 2. Does psychopathology symptom clustering vary as a function of resilience?** To detect the presence of clusters within each network, we applied the walktrap algorithm (Pons & Latapy, 2005), implemented in the igraph package (version 1.2.6). Briefly, this algorithm finds similar nodes based on random walks over the network’s edges, searching for densely connected sections of that network (Newman & Girvan, 2004). We also calculated the modularity ratio (Q-index) to evaluate the goodness of fit of these communities; Q-index values typically fall between 0.3 – 0.7, with higher values reflecting strong community structures (Newman & Girvan, 2004), and values below 0.3 are considered most likely random. We compared the number and content of clusters between the Resilient and Delayed, as well as Recovered and Sustained groups.

**Supplementary analyses**

Supplementary analyses relating to network expected influence centrality and network robustness were also carried out. A detailed description of the procedure and results is provided in SM5 and SM6, respectively.

**Results**

Mean symptom scores for each psychological response group are provided in Table 2. Network models for each of the psychological response groups are presented in Figures 1 and 2. Overall, in all four network structures, symptoms were mostly positively connected. The networks also showed the presence of a negative association between Covid-19 anxiety and appetite problems (PHQ-5) and between Covid-19 anxiety and Suicidal ideation (PHQ-9) in the Resilient network, and the latter negative association was also replicated in the Recovered group network structure.
**Aim 1. Does network connectivity vary as a function of resilience?**

Firstly, we compared Resilient (57% of potential edges above zero; edge weights ranged from -0.13 - 0.42) and Delayed distress (49% of potential edges above zero; edge weights ranged from 0.01 - 0.23) subgroups (see Figure 1). The network invariance test showed no differences in the network structure \((M = 0.19, p = 0.47)\). Conversely, in terms of connectivity, results from the global strength invariance test showed significant differences between both groups \((S = 1.25, p = 0.02)\). Global strength values per group revealed that the connectivity in the Resilient group was higher \((global\ strength = 6.48)\) than in the Delayed group \((global\ strength = 5.23)\).

Secondly, we compared the Recovered (34% of potential edges above zero; edge weights ranged from -0.03 - 0.33) and Sustained distress (48% of potential edges above zero; edge weights ranged from 0.002 - 0.39) groups (see Figure 2). The network invariance test showed no differences in the network structure between these groups \((M = 0.14; p = 0.72)\). However, in terms of connectivity, results from the global strength invariance test showed significant differences between both groups \((S = 1.06, p = 0.03)\), revealing that connectivity in the Sustained group \((global\ strength = 6.59)\) was higher than in the Recovered group \((global\ strength = 5.52)\). Therefore, the connectivity hypothesis was partially supported since the Recovered group showed lower connectivity than the Sustained distress group. However, the Resilient group did not show lower connectivity than the Delayed distress group as expected, instead, the opposite was observed.

**Aim 2. Does psychopathology symptom clustering vary as a function of resilience?**

In the Resilient group, four clusters emerged (see Figure 3): the first one was composed of the PHQ-9 items measuring reductions in mood, interest and energy (both physical and cognitive; see red colour); the second comprised the PHQ-9 items of restlessness and self-image thoughts (purple colour); the third was composed of the PHQ-9 items of loss of appetite, suicidal ideation and the COVID-19 anxiety item (brown colour); the forth community comprised all the GAD-7 items (see green colour). Analysis of modularity suggested a most likely random clustering \((Q = 0.24)\). In the Delayed group, we observed two communities (see Figure 3): one composed of the COVID-19 anxiety item and the majority of GAD-7 items (see green colour), except for restlessness and
irritability, which together with all PHQ-9 items formed a second community (see red
colour). The $Q$-index also suggested a most likely random clustering ($Q = 0.28$).

For the Recovered network, three communities emerged (Figure 4). In this case, PHQ-9
items were divided into two separate communities. One community contained the first
five items of the scale, while the second the remaining four. A third community was made
up of the COVID-19 anxiety item and GAD-7 symptoms. For the Sustained network, two
communities emerged: one was composed of all the PHQ-9 items, while the other
included all the GAD-7 items and the COVID-19 anxiety item, just like in the Recovered
group. $Q$-index analyses revealed that clustering in both network structures were non-
random ($Q = 0.45$ and $Q = 0.37$ for Recovered and Sustained distress networks,
respectively). Overall, therefore, the clustering hypothesis, which predicted that fewer
symptoms clusters would be observed with increasing levels of resilience, was not
supported.

**Discussion**

The present study aimed to analyse the distinct patterns of psychological responses to
the SARS-CoV-2 pandemic in several European countries. To this end, we followed
previous research that empirically identified four trajectories of psychological responses
(i.e., Resilient, Delayed distress, Recovered and Sustained distress) and utilised network
analytical techniques to study symptom-level expression within each these groups and
compare them in terms of connectivity (aim 1) and clustering (aim 2). It was expected
that with increasing levels of resilience, mental health networks would be less densely
connected (aim 1) and comprise fewer symptom clusters (aim 2).

The SARS-CoV-2 pandemic has posed a major threat to the well-being of individuals,
although it is best conceptualized as a distressing or PTE (Samuelson et al., 2022).
Mounting evidence has indicated that being exposed to a PTE can lead to a wide variety
of psychological responses, ranging from showing no distress to experiencing a
substantial number of symptoms (Bonanno, 2021). Results from the current study
showed that, out of the 3,594 individuals, almost two-thirds of the sample exhibited a
Resilient response pattern ($n = 2,284, 64\%$), understood as the absence of anxiety and
depression over time (i.e., one year in this case), while 16\% of the sample showed a
Sustained distress pattern over time ($n = 587$). These results echo existing empirical
evidence indicating that in the aftermath of a PTE, a large proportion of participants showed no symptoms (Bonanno, 2021) which other COVID-19 studies have also confirmed (Ahrens et al., 2021; Chen & Bonanno, 2020).

The combination of the two suggested core features defining resilience (i.e., presence/absence of distress and time) also provides a useful insight into other psychological trajectories following a distressing experience. Reflecting the dynamic aspect of individual psychological functioning, we found that 10% showed Delayed distress ($n = 364$), while another 10% showed a Recovered pattern ($n = 359$), suggesting that responses to the global pandemic vary as a function of time.

**Network connectivity**

Our findings partially supported our hypothesis about network connectivity. Firstly, the NCT for *structural invariance* (i.e., network structure) indicated the Resilient group did not significantly differ from the Delayed group, nor did the Recovered and Sustained groups, suggesting that there are no significant differences in the symptom structure of psychological responses. In line with the hypotheses, the NCT for *global strength* (i.e., the sum of edge weights or connectivity) revealed that the Sustained distress group had a more strongly connected network than the Recovered group. However, this result was not replicated with the Resilient and Delayed networks, with the former being more highly connected than the Delayed network. Thus, increased symptom connectivity was observed amongst the Resilient and Sustained groups, compared to the Delayed distress and Recovered groups, respectively. Both of these groups showed consistent or stable patterns of mental health throughout the study period (i.e., although the Resilient group showed an absence of distress and the Sustained group showed the presence of distress, both groups maintain their responses over a year).

Network theory postulates that, if an event activates a network of elements that are strongly connected (e.g., symptoms), this activation might remain even after the event generating it is no longer present, known as *the hysteresis* phenomenon (Borsboom, 2017). According to theory, if a network is active despite the absence of the triggering event, it means that the network has high connectivity, and might reflect a psychological problem (Borsboom, 2017). Following this rationale, non-pathological networks would not be connected strongly enough to maintain this psychopathological response. In sum, connectivity is suggested to be a benchmark of pathological networks. Contrary to this
proposal, our longitudinal data suggest that connectivity may function as an indicator of response stability (i.e., stable pattern over time, disregarding whether the trajectory includes the presence or absence of distress), rather than a direct indicator of psychopathology (i.e., presence or absence of distress). While this finding did not align with the network theory-informed connectivity hypothesis, it may be interpretable from a latent variable perspective, which would suggest that correlations among variables may stay similar irrespective of level of severity.

Our findings show some similarities with those obtained by previous studies applying NCT (McGlinchey et al., 2021). For example, van Borkulo et al. (2015), compared the connectivity of networks of depressive symptoms among individuals with persistent and remitted major depressive disorder (MDD) over the course of two years. The authors found that the network of those with persistent MDD (they do not provide information on those individuals who persist without symptoms) showed greater connectivity than those whose MDD had remitted after two years. Although van Borkulo’s findings align with the network theory proposal that pathological networks may be strongly connected, they may also indicate that those individuals who maintain the same pattern of response over time (stability of depressive symptoms after two years) have the highest connectivity. Hence, the findings related to connectivity in the current study may suggest that the concept of hysteresis could apply to network models of individuals who show a stable pattern of psychological response (which includes resilient individuals).

Strikingly, when visually inspecting the networks more precisely, we found a specific negative association between the COVID-19 anxiety item and suicidal ideation item, present in both the Resilient and Recovered networks (see Figures 1 and 2). This negative association means that the more anxiety about the pandemic individuals report, the lower the score on suicidal ideation (or vice versa), and it could be interpreted as a common characteristic shared by those individuals showing no distress at one year after the pandemic outbreak. Recent evidence has revealed that individuals with dysfunctional COVID-19-related anxiety engage in high levels of suicidal ideation and functional impairment (Lee, 2020). Altogether, these findings might suggest that only those individuals showing a symptomatological response (e.g., presence of distress) would show a positive association between COVID-19 anxiety and suicidal ideation. Furthermore, given that this particular feature was shared by these two groups only (i.e.,
Resilience and Recovered groups), its presence could be interpreted as a potential predictor of a long-term resilient response (protective factor). However, given the exploratory nature of this study, this latter proposal should be considered as a tentative hypothesis to be further explored. Future research is needed to clarify the potential role that specific association might have for positive prospects for mental health recovery and/or resilience.

Node clustering
Contrary to the proposed hypothesis, our results revealed that mental health networks did not comprise fewer symptom clusters with increasing levels of resilience. In this study, the Resilient and Recovered group networks showed more symptom clusters than the networks from the Delayed and Sustained distress groups, respectively. It is important to note, however, that only the clusters that emerged in the Recovered and Sustained networks were considered to have satisfactory goodness-of-fit (i.e., non-random). Although previous literature suggests that more severe levels of psychopathology might be associated with specificity (i.e., more clusters) (McGorry & Van Os, 2013), recent exploration of this phenomenon using network analysis has not supported this position (Groen et al., 2019). Instead, similarities in the number and structure of communities were observed in four groups along the severity continuum of psychopathology (Groen et al., 2019). Our results did not support this pattern either, as we found that the groups showing high levels of distress at one year presented a smaller number of clusters than those showing no distress. Despite a lack of support for this hypothesis, our findings revealed a few interesting patterns when comparing Recovered and Sustained distress network structures.

Firstly, we observe that all GAD-7 items clustered together with the COVID-19 anxiety item, reflecting that the pandemic outbreak triggered a wave of general anxiety symptoms. Secondly, differences in the community structure of depression items were observed between these two aforementioned groups. In the Recovered group, depression items formed two distinct clusters, one comprising items related to affect, sleep, fatigue, and appetite, while the other comprised cognitive items, as well as psychomotor and concentration items. However, although strong evidence for both one- and two-factor models of the PHQ-9 exists (Lamela et al., 2020), the two depression clusters in the Recovered group did not match previously reported factor structures (Lamela et al.,
Whilst in the Sustained network, items perfectly clustered into depression (all PHQ-9 items) and anxiety (all GAD-7 and Covid-19 anxiety items). Interestingly, these two clearly defined communities found in the Sustained network are almost replicated in the Delayed network. This similar pattern of clustering between the two groups showing high levels of distress one year into the pandemic could indicate alignment with current diagnostic classifications such as the Diagnostic and Statistical Manual of Mental Disorders (DSM), where there are symptoms clustered within different psychological domains (e.g., depressive disorders, anxiety disorders). However, it is worth mentioning that while the modularity of the Recovered and Sustained group suggests non-random clusters, the Q-index indicated that the communities in the Resilience and Delayed group were most likely random. Therefore, firm conclusions cannot be drawn from this finding, and further research is needed to examine how symptoms cluster as a function of resilience.

On balance, a large body of literature suggests that indices proposed by network analysis such as node centrality (i.e., those nodes of greatest importance in the network; McNally, 2016) could function as predictors of psychopathology. However, the present study suggests that indicators of specificity such as connectivity and clustering may also function as predictors of the stability of psychological responses (higher connectivity) and long-term high levels of distress (fewer clusters) to potentially adverse events such as the COVID-19 pandemic.

**Limitations**

Although the strategy of matching subsamples between groups made them more homogenous, the networks presented are based on a between-subjects design so caution should be taken when generalizing results to individuals or groups that might not be homogeneous. Moreover, we adopted a dynamic perspective by considering two time-points to create the psychological response groups, however, the data modelled in the network are cross-sectional (from T1) and thus, precludes inferences about causal relationships being drawn. Future research would benefit from adding more time points assessments, or utilising intensive longitudinal data, which would allow the application of, for instance, panel data analysis (Mertens et al., 2017) or temporal network approach (Blanchard et al., 2022) respectively, that could reveal temporal prediction closer to causality.
Finally, this study should be considered exploratory and the networks of the response trajectories are estimated only from symptoms of anxiety and depression. Future research replicating these findings, and also examining other relevant aspects that might be implicated in resilient responses such as personality, socio-economic and demographic factors, community characteristics, life history or past and current stressors (Bonanno, 2021; Chen & Bonanno, 2020; van der Wal et al., 2021) is needed. Applying novel metrics proposed to study risk and protective factors that might affect the resilience of the network such as Expected Symptoms Activity (ESA) and Symptoms Activity Stability (SAS; Lunansky et al., 2021) would be extremely useful to gain knowledge to predict resilient responses over time.

**Strengths**

We adopted an Open Science Practice perspective and preregistered the study on the OSF. Also, to encourage replicability, all the materials such as data and scripts have been included as part of the supplementary materials. Furthermore, we followed the current theoretical perspective which incorporates the combination of two core aspects (presence/absence of distress and stability over time) when defining resilience, which might overcome limitations from previous conceptualizations (Denckla et al., 2020). Moreover, the data analysed in this study are diverse and nationally representative of the four countries involved. In addition, the application of the network approach allowed us to adopt a symptom-level perspective, providing a fine-grained picture of the component-to-component association within and between the four mental health trajectories which, ultimately, may be useful to identify potential indicators associated with resiliency and other psychological responses to PTEs. Finally, following recommendations in the field (Espkamp et al, 2018), we applied several approaches to test the robustness of our analysis (see SM).

**Conclusion**

To our knowledge, this is the first study examining four types of psychological trajectories during the pandemic at the symptom-level using a network approach. Although these findings are preliminary, the present study suggests that greater network connectivity may be a predictor of stable responses (regardless of the level of distress),
while fewer clusters might be a feature characterising long-term distress. This analytic strategy afforded the opportunity to identify differences in these distinct response patterns of anxiety and depression, which, if replicated, may help us better understand the onset, maintenance and course of psychological distress during a time of great uncertainty and, in the long-term, how best to intervene and treat such distress. If replicated, these results could assist with the early identification of different psychological trajectories, through the examination of symptom configurations and therefore could contribute to public mental health policies.

Acknowledgements
We are grateful to the participants who complete the assessments for their collaboration. We also would like to thank all members of the COVID-19 Psychological Research Consortium (C19PRC) Panel Study for their joint efforts. This research was supported by grants from the Ministry of Science and Innovation (PSI2016-74987-P) and Instituto de Salud Carlos III (COV20/00737) to Carmen Valiente and funds from the UCM for consolidated research groups (GR29/20) to Carmelo Vazquez.

Conflict of Interest
The authors declare that they have no conflict of interest.

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Figure 1.

Combined plot comparing network connectivity between Resilient and Delayed distress groups

See image above for figure legend
Figure 2

Combined plot comparing network connectivity between Recovered and Sustained distress groups

Recovered sample network N=359
Sustained sample network N=359

See image above for figure legend
Figure 3.

Plot comparing communities between Resilient and Delayed distress groups

Figure 3
See image above for figure legend
Figure 4.

*Plot comparing communities between Recovered and Sustained distress groups*

Figure 4

See image above for figure legend

**Supplementary Files**

This is a list of supplementary files associated with this preprint. Click to download.

- Table1MP.pdf
- Table2MP.pdf
- NetworkTrajectoriesSupplementaryInformationMP.pdf