Network analysis of PTSD and depressive symptoms in 158,139 treatment-seeking veterans with PTSD

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RESEARCH ARTICLE

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Network analysis of PTSD and depressive symptoms in 158,139 treatment-seeking veterans with PTSD

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Abstract

Background: In recent years, a new framework for analyzing and understanding posttraumatic stress disorder (PTSD) was introduced; the network approach. Up until now, network analysis studies of PTSD were largely conducted on small to medium sample sizes (N < 1,000), which might be a possible cause of variability in main findings. Moreover, only a limited number of network studies investigated comorbidity.

Methods: In this study, we utilized a large sample to conduct a network analysis of 17 symptoms of PTSD (DSM-IV), and compared it to the result of a second network consisting of symptoms of PTSD and depression (based on Patient Health Questionnaire-9 [PHQ-9]). Our sample consisted of 502,036 treatment-seeking veterans, out of which 158,139 had fully completed the assessment of symptoms of PTSD and a subsample of 32,841 with valid PCL and PHQ-9 that was administered within 14 days or less.

Results: Analyses found that in the PTSD network, the most central symptoms were feeling distant or cut off from others, followed by feeling very upset when reminded of the event, and repeated disturbing memories or thoughts of the event. In the combined network, we found that concentration difficulties and anhedonia are two of the five most central symptoms.

Conclusion: Our findings replicate the centrality of intrusion symptoms in PTSD symptoms' network. Taking into account the large sample and high stability of the network structure, we believe our study can answer some of the criticism regarding stability of cross-sectional network structures.

KEYWORDS
depression, network analysis, PTSD

1 | INTRODUCTION

In recent years, a new framework for analyzing and understanding psychopathology was introduced; the network approach (Armour et al., 2017; Borsboom, 2008; Fried et al., 2016; McNally, 2016). This theoretical framework suggests that mental disorders, including posttraumatic stress disorder (PTSD; Armour et al., 2017; Borsboom, 2008; Fried et al., 2016; McNally, 2016), can be conceptualized as emerging from causal interactions of symptoms, rather than resulting from the presence of an underlying latent construct (for more elaboration on that aspect, see Borsboom, 2008; McNally et al., 2017). Thus, this approach embraces the complexity of mental disorders by focusing on interactions of symptoms instead of reducing the symptoms' complexity to symptom clusters (e.g., like factor analysis) or a single symptom severity score. Under the network approach, each symptom is represented as a node in a graph, and the relations between nodes as edges (or links). The structure of the resulting network as a whole and the individual relations can be described formally by different kinds of metrics.

One possibility to describe the structure of a network is to assess the centrality of each individual node. This can be measured in different ways, but all are basically assessing how central a specific node in the network is. A growing body of research has examined the network structure of PTSD (Birkeland et al., 2020) Regarding symptom centrality, most studies consistently reported psychogenic amnesia as the least central symptom. There was, however, considerable variation among the most central PTSD symptoms. Still, a set of highly central symptoms emerged, namely recurrent thoughts of trauma, diminished interest in activities, and feelings of detachment from others (Birkeland et al., 2020). Although the applied technique to estimate these networks is built upon regularization to decrease the number of false-positive identified edges (Epskamp et al., 2018; Fried et al., 2018) the small to medium sample size of most of these studies (*N* < 1,000) limited the precision of their results. This may, among other reasons, partly explain the reported differences between studies in findings regarding the centrality of specific symptoms.

In daily clinical practice, however, patients with mental disorders often present with comorbidities, with depression being the most comorbid disorder among PTSD patients (Gros et al., 2010; Ikin et al., 2010). From a network approach perspective, comorbidities of disorders can be understood by symptom overlap of two disorders or by causal relations among their symptoms (for more detail, see Cramer et al., 2010). Until the time of writing, several investigations of comorbidity networks of PTSD, for example, with depression and alcohol use disorder, have also been undertaken (Afzali et al., 2017; Choi et al., 2017; Lazarov et al., 2019).

The present study had two main goals. To test the replicability of PTSD network analysis using large sample size and second, to examine the effect of adding depressive symptoms to the network. We analyzed the data in three steps: first, we conducted a network analysis of PTSD symptoms of 158,139 US veterans who entered their first episode of PTSD treatment at VA medical centers and whose symptoms were assessed with the 17-item PTSD Checklist (PCL; Weathers et al., 1993). Second, we estimated a comorbidity network of symptoms of PTSD and depression in a subsample of 32,841 veterans, who completed the Patient Health Questionnaire-9 (PHQ-9). Third, a split-half investigation (estimating the network in one half of the sample and assessing fit statistics of the resulting network in the other half) was used to test the reliability of both networks. Finally, we discuss differences between PTSD only and the PTSD-depression comorbidity network.

2 | METHODS

2.1 | Data and sample

Our sample was comprised of 502,036 veterans newly diagnosed with PTSD who were entering PTSD treatment at the Department of Veteran Affairs (VA) between October 1, 2007 and September 30, 2012. PTSD diagnosis was established by a mental health professional, based on ICD-9, and had to be associated with at least two outpatient visits or one inpatient visit. Data were obtained from the VA PTSD registry national database. Demographic, PCL, PHQ-9, and diagnostic data on comorbidities were obtained from the US national administrative VA databases. This study was approved by the Institutional Review Board.

Out of the total sample, 159,597 had completed an assessment with the PCL, 158,139 of them had full PCL data, whereas 1,438 (0.9%) of patients had some missing data and were therefore excluded from further analysis. From those 158,139, we extracted a subsample of 33,282 patients, whose depressive symptoms were assessed with the PHQ-9 within 14 days after the initial PCL administration. Of these patients, 441 patients (1.3%) were excluded due to missing data regarding their PHQ-9 assessment. This resulted in a final sample size of 32,841 for the analysis of the combined symptoms of PTSD and depressive symptoms network (Figure 1). To investigate potential differences between the total sample and the 159,597 patients who were administered with the PCL-M questionnaire, we compared the mean age and proportion of gender in each.

2.2 | PTSD symptom severity

Symptoms of PTSD were assessed using the PTSD Checklist (PCL-M). The PCL is a 17-item questionnaire assessing symptoms' severity of PTSD in the past month using a five-level Likert scale (1–5) and based on DSM-IV (Weathers et al., 1993). PCL-M has a test-retest reliability of 0.7, with internal consistency (measured using Cronbach's α) of above .8 in different veteran samples (Wilkins et al., 2011). Cronbach's α in the current sample was .92. The questionnaire items are presented in Table 1.

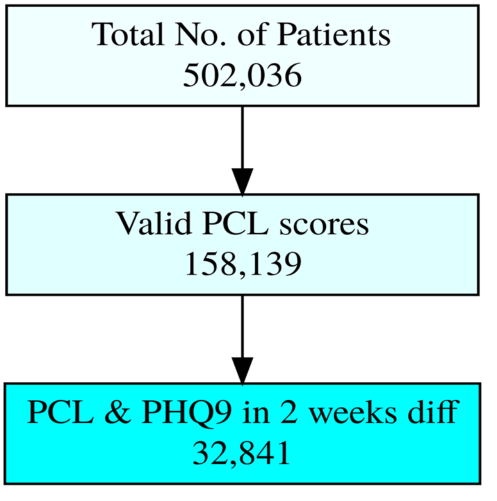

FIGURE 1 Schematic of patients population in the study. PHQ9, Patient Health Questionnaire-9

TABLE 1 PCL-IV (military) and PHQ-9 items

Item	PCL-M	PHQ-9
1	Repeated, disturbing memories, thoughts, or images of a stressful military experience	Little interest or pleasure in doing things
2	Repeated, disturbing dreams of a stressful military experience	Feeling down, depressed, or hopeless
3	Suddenly acting or feeling as if a stressful military experience were happening again (as if you were reliving it)	Trouble falling/staying asleep, sleeping too much
4	Feeling very upset when something reminded you of a stressful military experience	Feeling tired or having little energy
5	Having physical reactions (e.g., heart pounding, trouble breathing, sweating) when something reminded you of a stressful military experience	Poor appetite or overeating
6	Avoiding thinking about or talking about a stressful military experience or avoiding having feelings related to it	Feeling bad about yourself or that you are a failure or have let yourself or your family down
7	Avoiding activities or situations because they reminded you of a stressful military experience	Trouble concentrating on things, such as reading the newspaper or watching television
8	Trouble remembering important parts of a stressful military experience	Moving or speaking so slowly that other people could have noticed. Or the opposite; being so fidgety or restless that you have been moving around a lot more than usual
9	Loss of interest in activities that you used to enjoy	Thoughts that you would be better off dead or of hurting yourself in some way
10	Feeling distant or cut off from other people	
11	Feeling emotionally numb or being unable to have loving feelings for those close to you	
12	Feeling as if your future will somehow be cut short	
13	Trouble falling or staying asleep	
14	Feeling irritable or having angry outbursts	
15	Having difficulty concentrating	
16	Being "super-alert" or watchful or on guard	
17	Feeling jumpy or easily startled	

Abbreviation: PHQ-9, Patient Health Questionnaire-9.

2.3 | Depression symptom severity

Depressive symptoms in the past 2 weeks were assessed using the PHQ-9 (Kroenke et al., 2001). Cronbach' α for the PHQ-9 in the current sample was .93. The questionnaire items are presented in Table 1.

2.4 | Data analysis

We estimated two distinct networks of: (a) PTSD symptoms based on a sample of 158,130 veterans; and (b) a comorbidity network of PTSD and depressive symptoms based on data of 32,841 veterans. We conducted network estimation, inference accuracy, and stability assessment as long as half-split investigation to each of the two networks. Finally, the two networks were compared.

2.5 | Network estimation techniques

We estimated the structure of two networks using the R-packages *qgraph* and *bootnet* (Epskamp et al., 2012, 2018). The estimated network is a Gaussian Graphical Model (GGM). In a GGM, nodes represent symptoms and edges represent partial correlation between the symptoms. With 17 symptom nodes (17 PCL items), 136 pairwise association parameters were estimated. With 26 symptom nodes (17 PTSD and 9 depression), 325 pairwise association parameters were estimated. As this dataset is very large, we used an unregularized method to estimate the network (Williams et al., 2018). In this paper, results will be presented based on estimation using the *ggmModSelect* method in the *bootnet* package in R. Shortly, this method fits a GGM without regularization, iterating a few times to achieve best fit (for details on ggmModSelect please see: http://psychosystems.org/qgraph_1.5). Moreover, since both PCL and PHQ share several similar questions, especially those items related to sleep and concentration (PCL13-PHQ3 and PCL15-PHQ7), we conducted a redundancy test using the *goldbricker* function from the *networktools* R package (Jones, 2018). We used a method previously presented by Hittner et al. (2003) to establish a data-driven decision whether one of the items should be omitted from our analysis. The use of this method yielded a recommendation to leave all nodes in the analysis (for detailed results of this test, see Supplementary Information Material).

2.6 | Model testing

Different estimation routines for GGMs are recommended in different circumstances. As this is one of the first times a GGM was estimated with such a large cross-sectional dataset, we conducted robustness analyses with alternative estimation routines to see if they impact on the resulting network structures. These routines include regularized and nonregularized estimation, as well as Bayesian estimation techniques. Correlations between all the adjacency matrices of all networks were high (ranging between $r = .92$ and $r = .99$). Detailed results of the different estimation techniques can be found in the Supplementary Information Material.

2.7 | Confirmatory analysis

Recently, new confirmatory estimation routines were added to the network psychometric toolbox. This allows us to conduct an additional test of robustness: split-half reliability. We, therefore, estimated a GGM in a randomly drawn half of the dataset, and then fit a confirmatory network model to the second half. We conducted this analysis for both the PTSD network and the comorbidity network, using the recently developed *psychonetrics* package in R (Epskamp, 2019).

2.8 | Network inference

Building upon previous studies, we decided to focus on two main tools to assess nodes. Expected Influence sums all edges of a node with other nodes (not in absolute value). Predictability is the upper bound of the variance of a given node explained by all its neighbors, measured as R^2 (Haslbeck & Fried, 2017; Robinaugh et al., 2016). Predictability was assessed using the *mgm* package in R.

2.9 | Accuracy and stability estimation

Due to a large number of parameters, network models require a considerable sample size for reliable estimation. We estimate parameter stability following well-established estimation routines explained in detail elsewhere (Epskamp et al., 2018). In sum: (a) we bootstrapped 95% confidence intervals of the edge weights; (b) examined the stability of the order of the centrality estimation by subsetting bootstrap; and (c) tested differences between edges and centrality. The full implementation of these methods using R and the *bootnet* package (Epskamp et al., 2018) is described in a recent paper (Epskamp & Fried, 2018).

2.10 | Availability of data and materials

The analytic code for all analyses performed in this study is available in the Supplementary Information Material and online at https://osf.io/48m2t, along with supplemental figures, tables, and correlation matrices. The original data cannot be shared because of restrictions of the clinical institutions in which they were gathered; further details on how to apply for the data are available from the corresponding author on request.

3 | RESULTS

3.1 | Sample characteristics

Patients' age ranged between 18 and 107 years, mean age 41.1 ($SD = 15.1$). PCL-M scores ranged from 17 to 85, with a mean 57.7 ($SD = 13.8$), a PCL score of 30 and above is considered a cutoff point for possible PTSD. Within the PCL-PHQ-9 dataset, PHQ-9 scores ranged between 0 and 27 with a mean score of 14.5 ($SD = 6.3$). Within the combined PCL and PHQ-9 sample, PCL scores ranged from 17 to 85 with a mean score of 57.78 ($SD = 14.13$). The proportion of females in this sample was 9%.

The sample of all other veterans who did not fill the PCL (342,439) had an age range of 17–109 with a mean of 49.11 ($SD = 16.03$). The proportion of females in this sample was 8.5%.

3.2 | PTSD network

The PTSD symptom network is shown in Figure 2a. The most central nodes (expected influence [EI]) of this network were; “feeling distant or cut off from others” (PCL10, standardized EI 1.17), “feeling very upset when reminded of the event” (PCL4, 1.05), “repeated disturbing memories or thought of the event” (PCL1, 1.02), “Having physical reactions when something reminded you of a stressful military experience” (PCL5, 1.02), and “loss of interest in activities that you used to enjoy” (PCL9, 01.00). The centrality of all nodes is shown in Figure 2b. Average node predictability was 0.46, with “feeling distant or cut off from others” (PCL 10) having the largest shared unique variances with other nodes (0.61) followed by “repeated disturbing memories or thoughts of the event” (PCL1, 0.56). When testing for significant differences of node expected influence estimates, we found that “feeling distant or cut off from others” (PCL10) and “feeling very upset when reminded of the event” (PCL4) were significantly stronger than all other nodes. Next, “repeated disturbing memories or thoughts of the event” (PCL1) and “having physical reactions when something reminded you of a stressful military

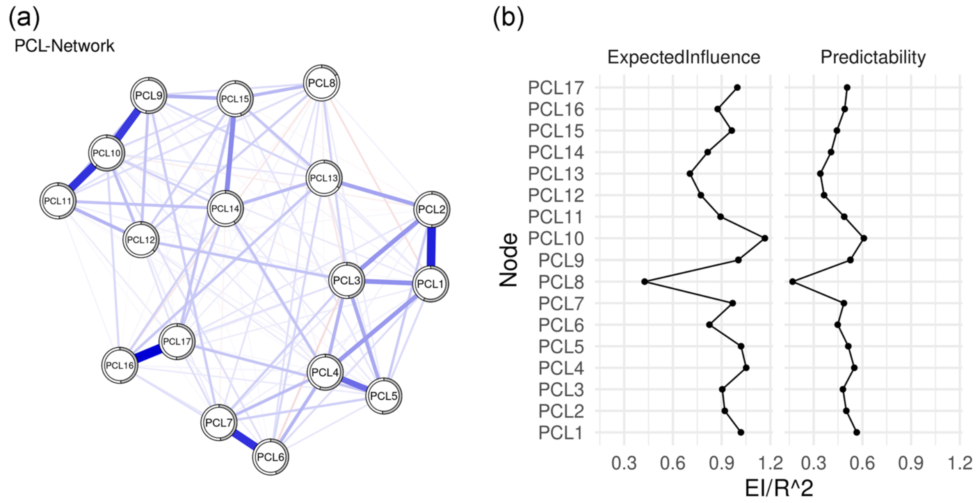

FIGURE 2 (a) Graph pertaining to the partial correlation (LASSO) between PCL symptoms. Stronger correlations are presented using higher saturation and wider lines. The filled part of the circle around each node depicts predictability: the variance of the nodes explained by all its neighbors. (b) Expected influence (EI) and predictability measures of the PTSD network. PTSD, posttraumatic stress disorder

experience" (PCL9) were not significantly different from each other, but were different from all other nodes. Lastly from the top five most central nodes, "loss of interest in activities that you used to enjoy" (PCL9) was no different from "feeling jumpy or easily startled" (PCL17), but was significantly different from all others (Figure S1).

The strongest edges were between "being 'super-alert' or watchful or on guard" (PCL16) and "feeling jumpy or easily startled" (PCL17) with a partial correlation of 0.43. The second strongest edge was between "repeated disturbing memories or thoughts of the event" (PCL1) and "repeated, disturbing dreams of a stressful military experience" (PCL2) with a partial correlation of 0.38. The third edge was between "avoiding thinking about or talking about a stressful military experience or avoiding having feelings related to it" (PCL6) and "avoiding activities or situations because they reminded you of a stressful military experience" (PCL7) with a partial correlation of 0.35 between the two. Using bootnet's difference function to test significant differences between the edges, we have found that the edge between PCL16-PCL17 was significantly different from all other edges. The edges between PCL1-PCL2 and PCL6-PCL7 were not different from each other, but significantly different from all others (Figure S2).

Network stability was found to be very high (see Figure S5a,b for details).

3.3 | PTSD and depressive symptom network

The combined PTSD and depressive symptom network is shown in Figure 3a with centrality measurements of the network shown

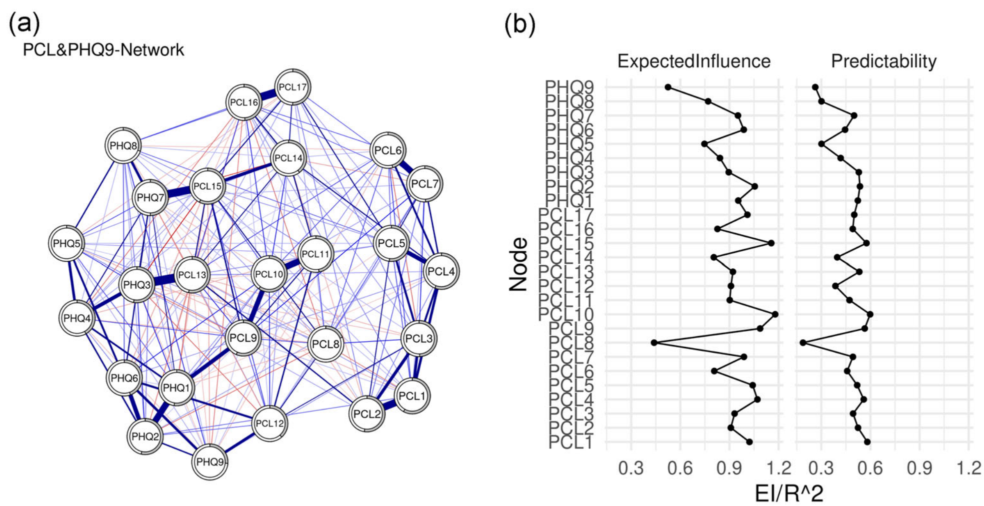

FIGURE 3 (a) Graph pertaining to the partial correlation (LASSO) between PCL symptoms and PHQ-9 items of depression. Stronger correlations are presented using higher saturation and wider lines. The filled part of the circle around each node depicts predictability: the variance of the nodes explained by all its neighbors. (b) Expected influence (EI) and predictability measures of the PTSD network and depressive symptoms' network. PHQ9, Patient Health Questionnaire-9; PTSD, posttraumatic stress disorder

in Figure 3b. The most central edges (EI) of this network were "feeling distant or cut off from others" (PCL10, standardized EI 1.18), "having difficulty concentrating" (PCL15, 1.15), "loss of interest in activities that you used to enjoy" (PCL9, 1.09), "feeling very upset when reminded of the event" (PCL4, 1.07) and "feeling down, depressed, or hopeless" (PHQ2, 1.05). Average node predictability was 0.47, with "feeling distant or cut off from others" (PCL10) having the largest shared unique variances with other nodes (0.59) followed by "suddenly acting or feeling as if the event was happening again" (PCL1; 0.58). Analyzing the significant difference between the node expected influence, we have found that "feeling distant or cut off from others" (PCL10) was not significantly different from "having difficulty concentrating" (PCL15) but both were significantly stronger from all the rest. "Loss of interest in activities that you used to enjoy" (PCL9) was not significantly different from "feeling very upset when reminded of the event" (PCL4), but was different from everything else. "Feeling down depressed or hopeless" (PHQ2) was no different from feeling very upset when reminded of the event (PCL4) and having physical reactions when something reminded you of the event (PCL5), but was different from all else (Figure S3).

The strongest edges were between "trouble falling or staying asleep" (PCL13) and "trouble falling or staying asleep, or sleeping too much" (PHQ3), with a partial correlation of 0.48. The second strongest edge is between "being 'super-alert' or watchful or on guard" (PCL16) and "feeling jumpy or easily startled" (PCL17) with a partial correlation of 0.44. The third was between "having difficulty concentrating" (PCL15) and "trouble concentrating on things, such as reading the newspaper or watching television" (PHQ7) with a partial correlation of 0.43. The first two edges were significantly different from all others. The third edge (concentration) was not significantly different from the edge between "repeated, disturbing memories, thoughts, or images of a stressful military experience" (PCL1) and "repeated, disturbing dreams of a stressful military experience" (PCL2; with a partial correlation of 0.4; Figure S4).

Network stability was found to be very high (see Figure S6a,b for more details on stability measurement for this network).

3.4 | Comparing the networks

Comparing the differences in predictability between the PTSD only and PTSD with depressive symptoms' networks reveal small differences. The correlation between the predictability of PTSD nodes in each network was 0.85. Noticeable is also the higher shared variance of symptoms related to concentration and sleep in the comorbidity network, compared to the PTSD one (e.g., the predictability of PCL13—trouble falling or staying asleep was 0.34 in the PTSD symptom only network and 0.53 in the comorbidity network). Figure 4 describes predictability and EI in the two networks together—for ease of comparison.

3.5 | Split-half investigation

We conducted two split-half investigations using confirmatory network analysis on both PTSD and comorbidity networks. The results suggested a good fit, with root mean square error of approximation

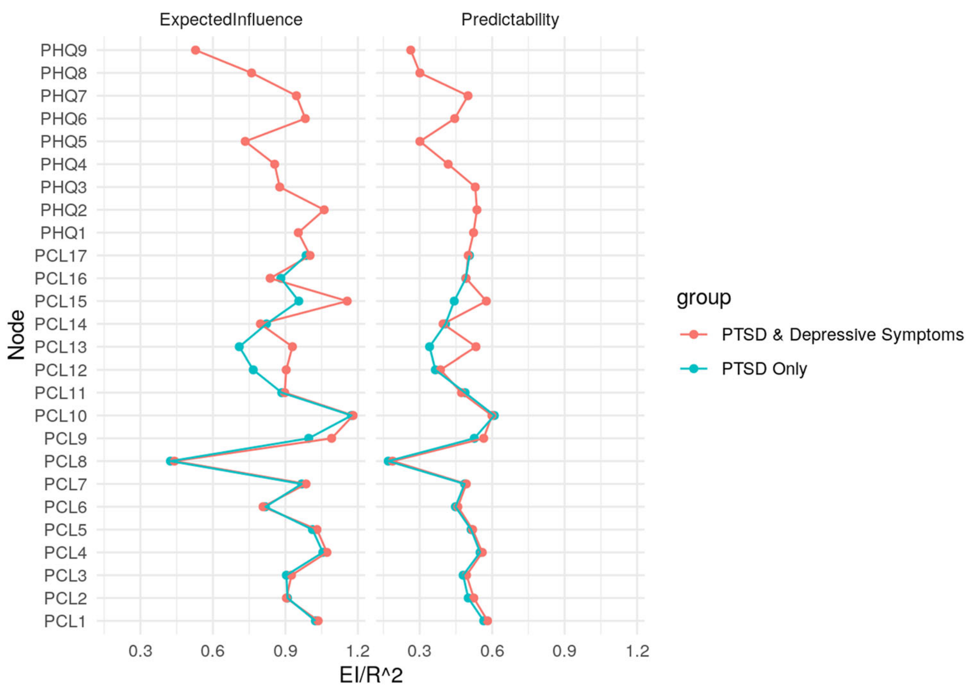

FIGURE 4 Expected influence and predictability measures of PTSD symptoms, and PTSD and depression symptoms. EI, expected influence; PTSD, posttraumatic stress disorder

(RMSEA; Hu & Bentler, 1999) of 0.012 (95% confidence interval [CI]: 0.011–0.013) for the PTSD network, and 0.015 (95% CI: 0.015–0.017) for the comorbidity network, respectively. Comparative fit index (Bentler, 1990; Hu & Bentler, 1999) was 1 in both analyses. Detailed fit statistics are shown in Table S2.

4 | DISCUSSION

The goal of our study included the estimation of a PTSD symptom network and a PTSD and depression comorbidity network with a very large dataset and thus unprecedented stability of estimates in PTSD network literature. Moreover, we compared the predictability of PTSD symptoms in both networks with each other to assess the effect of depressive symptoms on PTSD symptom predictability.

Network analysis of the "PTSD only" symptoms revealed that "feeling distant or cut off from others" was the most central node, with re-experiencing symptoms following. As discussed before, there is high heterogeneity between studies regarding the centrality of symptoms, yet, in most studies, re-experiencing symptoms and detachment have been found to be pivotal (Armour et al., 2017; Birkeland et al., 2020; Fried et al., 2018), which is replicated and extended to treatment-seeking veterans with PTSD.

Results of a "PTSD and Depression" network showed a similar pattern, with the exception of higher centrality estimates for concentration-related symptoms. Nevertheless, when looking at predictability, results were similar to the "PTSD only" network and replicating prior work (Armour et al., 2017; Birkeland et al., 2020). Again, psychogenic amnesia was the least central in both networks.

A significant contribution of the presented work is the split-half investigation showing a good fit. This suggests that the estimated networks are highly stable across the whole dataset. To date, network structure studies have had high heterogeneity of the results, and we hope that this one will move us forward in solving the discrepancies between different analyses and studies, as the size and network stability of this data are highly different than previous ones, hence presenting greater stability. This, in part, can answer one of the main criticisms on cross-sectional network analysis (Robinaugh et al., 2019).

The fact that "feeling distant or cut off from others" was found to be the most central node in the PTSD only and the PTSD with depressive symptoms' network demands a careful evaluation of that symptom. Although other studies have found it to be one of the top central in smaller samples, it was never before found to be the most (Armour et al., 2017; Birkeland et al., 2020; Fried et al., 2018). This result may be strongly linked to findings that lack of social support is a known risk factor for developing PTSD (C. R. Brewin et al., 2000; Ozer et al., 2003). Social support, in general, was also found to be associated with PTSD symptom severity (Nickerson et al., 2017; Stanley et al., 2019; Tsai et al., 2012), even symptoms severity as measured the next day after exposure (Dworkin et al., 2018).

When conducting the analysis with depressive symptoms, concentration difficulties were found to be the most central symptom along with feeling distant or cut off from others. Changes in the predictability of concentration might be in part, due to similar items in PCL-M and PHQ-9 questionnaires. This was taken into consideration to some extent (using a data-driven approach) but serves as a limitation in this study. Research has debated for a long time whether PTSD and depression comorbidity is present mainly due to symptom overlap or it represents a specific subtype of PTSD. A recent review by Flory and Yehuda (2015) discusses these two options. As DSM definition of PTSD has markedly changed over the years, while major depression episode definition did not, Flory and Yehuda (2015) showed that comorbidity levels remained similar, thus suggesting that overlapping of symptoms is not the main explanation. Some specific joint biological mechanisms might support the hypothesis of a specific subtype of PTSD as a more valid explanation, such as hypothalamic–pituitary–adrenal axis dysregulation and lower ACC gray matter volume (Flory & Yehuda, 2015; Kasai et al., 2008).

Consistent with most previous research, psychogenic amnesia was found to be the least central node (Armour et al., 2016; Birkeland et al., 2020; Fried et al., 2018; Lazarov et al., 2019; Moshier et al., 2018). This is in accordance with factor analytic studies of PTSD (Armour et al., 2016; Birkeland et al., 2020) that showed a consistently low factor loading, which suggests that amnesia might not serve as a core symptom in PTSD. In that respect, as this is one of the most stable findings across all studies, it is reasonable to consider the relevance of this symptom to PTSD diagnosis, although this subject is still debated (Brewin, 2004; McNally, 2004, 2007).

This study has some limitations worth mentioning. First, this is a study that used administrative data from the VA, with the majority of the population being men (91%). These two specific characteristics of the sample (being ex-military and mostly men) certainly limit the generalizability of our findings to other populations. However, veterans account for a substantial share of individuals affected by PTSD and focusing solely on this population might increase generalizability to other veteran populations. Second, our data were based on self-report questionnaires, rather than clinician-administered interviews, which are considered gold-standard. If the structure of PTSD networks is affected by the way the symptom assessment was investigated by Moshier et al. (2018) who compared the structure of networks based on data collected with PCL and with the Clinician-Administered PTSD Scale. They found that the network of those two different ways of measurement was "highly similar" (Moshier et al., 2018). Still, this question was identified needing further investigations (Armour et al., 2016; Birkeland et al., 2020). Third, we used the DSM-IV definition of PTSD. Although this hinders generalization to samples assessed with the newer DSM 5 criteria, it still enables comparison to most of the network studies of PTSD, as they also used DSM-IV symptoms of PTSD. Fourth, given that the population investigated in this study was treatment-seeking and thus had increased PTSD symptom burden, Berkson's bias could apply to our results. Berkson's bias could have led to affect the edges' weights and thus also the centrality measures. Unfortunately, there is no method to correct for this bias. For more information on Berkson's bias in psychological networks, please see de Ron et al. (2019).

Notwithstanding these limitations, this study utilized the largest sample size used in a network analysis of PTSD and its comorbidity with depression. Moreover, a confirmatory split-half analysis indicated excellent reliability of our results across our sample. In line with existing literature, PTSD symptoms from the intrusion cluster had the highest centrality, whereas amnesia had the lowest centrality in both networks, findings show some difference in centrality of symptoms between the PTSD and PTSD and depressive symptoms' network, such that in the latter, symptoms of concentration appear to be more central. Further research is needed to assess the DSM-5 PTSD network both alone and in combination with depressive symptoms, and to evaluate the stability of network structures over time.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

DATA AVAILABILITY STATEMENT

As the matter of open science is important to us and we are dealing with confidential data, we have decided to submit all of our analyses code to the Open Science Foundation webpage, as well as all network matrices, so any researcher will be able to use the data and assess our analyses. All these materials can be found here: https://osf.io/48m2t/. For any questions, please contact the corresponding author.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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