A network analysis of posttraumatic stress symptoms among help-seeking refugees in Kenya

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ARTICLE INFO

ABSTRACT

We analyzed the network structure of DSM-IV PTSD symptoms among 2792 help-seeking Central and East African refugees in Kenya exposed to multiple, severe traumatic events and on-going stressors. To some extent, our results reproduced structures identified among clinical populations in Europe, including strong links within traditional symptom clusters, such as between avoidance of thoughts and situations, and hypervigilance and startling. However, we found substantial differences in most central symptoms, with detachment and disinterest far less and emotional numbing and concentration problems more central in our analyses. Our networks did not reproduce the common finding of particularly low centrality of amnesia. We further noted substantive similarities in network structure, but also differences, between refugees living in an urban environment and in refugee camps. Concentration problems were most central among mainly Somali refugees at a refugee camp, and associated with amnesia and sense of foreshortened future, while emotional numbing was the most central symptom among majority Congolese refugees in Nairobi. Our findings highlight the importance of contextual and cultural factors for PTSD symptomatology, and are informative for assessment and treatment among help-seeking refugees.

1. Introduction

The network approach to psychopathology argues that instead of being observable reflections of some underlying discrete disease mechanism, psychiatric symptoms are better characterized as directly causing each other, often by forming feedback loops (Borsboom, 2017). Psychiatric disorders are thus constituted of causal interactions between symptoms in alternate, pathological stable states of strongly connected networks. This network approach appears well suited to describing and studying posttraumatic stress disorder (PTSD). Instead of being locally independent indicators of an underlying disorder, different posttraumatic stress symptoms (PTSS) do often seem to cause and especially maintain each other quite directly, e.g., when unpleasant emotional reactions to trauma reminders lead to avoidance of thoughts and situations related to the trauma (McNally et al., 2015). PTSS may have a particularly strongly connected network structure, as they appear to sustain and feed into each other long after the triggering external event that set them in motion has passed.

McNally et al. (2015) first applied the network approach to PTSS. Among Chinese earthquake survivors, network structures reproduced the classic PTSD symptom clusters of avoidance/numbing, re-experiencing, and hyperarousal presented in diagnostic manuals such as the DSM-IV (APA, 1994), but also presented novel insights about other strong links and symptoms most central to the network structure of PTSS. Since then, more than 20 network analyses of PTSS have been carried out in a variety of settings (reviewed in Skogbrott Birkeland, Greene, & Spiller, 2020). However, many earlier analyses are constrained by inadequate sample sizes. Their results must therefore be

interpreted with great caution (Fried & Cramer, 2017).

In one notable exception to inadequate samples, a seminal study by Fried et al. (2018) employed four data sets involving 2782 patients being treated for PTSD across Europe and a novel method of estimating several network structures jointly (Danaher, Wang, & Witten, 2014). They observed substantial similarities between the data sets in terms of network structures and the most central symptoms identified, but also some differences. Reactivity to trauma reminders, intrusive memories, detachment, and disinterest in activities emerged as consistently central symptoms, while the most variable connections in network structures were identified between intrusions and flashbacks, intrusions and reactivity, and being startled and hypervigilance.

Fried et al. (2018) called for follow-up work to study reproducibility and differences in network structures and symptom centrality in different types of populations, encouraging additional cross-sample analyses. Network structures of PTSS may indeed differ substantially for people with dissimilar experiences (e.g., Benfer et al., 2018). One of the samples in the Fried et al. (2018) study involved treatment-seeking refugees, but generally taken, network analyses of PTSS among civilians directly affected by war are rare indeed. To our knowledge, the only previous stand-alone study with adult refugees is that of Spiller et al. (2017), where unsatisfactory stability of estimated networks and low power were problems. Here, we use and expand upon the methods pioneered by Fried et al. (2018) to examine the network structures of PTSS in two large samples of help-seeking refugees, living in humanitarian contexts, dealing with the effects of multiple, severe traumatic events, as well as significant on-going stressors.

In the sample of refugees ($n = 965$), mainly from Arabic-speaking countries, permanently resettled into Denmark, Fried et al. (2018) found the strongest links between sleep problems and nightmares, intrusions and flashbacks, and avoidance of thoughts and situations, while detachment, concentration problems, and flashbacks were the most central symptoms. Further, among refugee minors resettled into Germany, Pfeiffer et al. (2019) found the strongest connections between DSM-5 symptoms for psychological and physiological reactivity, irritability/anger and self-destructive/reckless behaviour, as well as intrusions and nightmares, while the most central symptoms were nightmares, physiological and psychological reactivity, and concentration problems. These analyses form important points of comparison for our study to examine the extent to which the network structures of PTSS they identified reproduce among Central and East African refugees of different backgrounds and ages living in Kenya.

Most armed conflicts and humanitarian crises in the 21st century take place outside the cultural environments where DSM and ICD nosologies have been developed (Cavallera et al., 2016; UNHCR, 2017). As culture crucially organizes systems of meaning and interpretation, differences in posttraumatic phenomenology are likely in different cultural environments. Indeed, a wide variety of what the DSM-5 calls *cultural constructs of distress* (American Psychiatric Association., 2013) have been documented in settings with high rates of exposure to traumatic events, including parts of East Africa (Im, Ferguson, & Hunter, 2017; Mendenhall et al., 2019; for a review, see (Rasmussen, Keatley, & Joscelyne, 2014)). However, geographic and cultural diversity in network analyses in PTSS is limited, and we are not aware of any previous network analyses of PTSS among Central or East African people. Even when studied using North American and European concepts, analyzing how PTSS interact with each other in different cultures and environments may help us interpret culturally proscribed symptom expressions, the roles and prominence of particular symptoms, and even response styles. This may contribute to providing appropriate and effective interventions in diverse environments and inform dialogue and exchange between scientific and lay concepts of mental disorders (Kirmayer & Pedersen, 2014).

In the present study, we have two principal aims. First, we explore the ways in which network structures of PTSS among help-seeking refugees are similar and different at two clinical sites in Kenya, where clients differ in cultural and religious background and living conditions. Second, we assess whether the network structures among help-seeking refugees from Central and East African countries reproduce those observed by Fried et al. (2018) in European clinical populations overall and among refugees resettled into Europe, in particular.

2. Method

2.1. Participants

Participants in this study were 2792 clients of the Center for Victims of Torture (CVT) rehabilitation program in Kenya during the years 2010–2016 who entered the mental health services program of the center either in Nairobi or at the Dadaab refugee camps. All were refugees from outside Kenya.

The first sample ($n = 1767$), from Nairobi, consisted of refugees who had resettled in Nairobi and entered programs operating in the neighborhoods of Eastleigh, Kayole, or Riruta. These clients were majority Christian (73.6 %) and female (65.3 %), with most coming from the DRC (56.5 %), followed by Somalia (20.1 %), Burundi (9.2 %), Rwanda (6.1 %), and Ethiopia (6.0 %). They ranged in age from 12 to 81, with a mean age of 30.88 ($SD = 11.31$).

The second sample ($n = 1025$), from Dadaab, consisted of refugees living in the Dadaab refugee camps who entered programs operating in the Ifo or Ifo II camps. These clients were majority Muslim (69.0 %) and female (64.5 %), mostly from Somalia (65.3 %), but included people from Ethiopia (18.4 %), Sudan (8.0 %), the DRC (4.5 %), and Burundi (3.0 %) as well. They ranged in age from 16 to 82, with a mean age of 36.40 ($SD = 11.64$).

2.2. Procedure and measures

The data were collected during intake assessments for the CVT programs. Clients were identified through referrals by community leaders or workers, other service providers, or through self-referrals following community education or word of mouth. Criteria for services included experiencing mental health symptoms related to traumatic experiences, having functional difficulties coping with symptoms, and being willing and able to participate in counseling. Services were targeted at adults, but adolescents functioning in adult roles, such as young mothers, were also included. Once an individual was identified as a client, a detailed intake assessment was conducted, typically over several meetings, by a trained local paraprofessional counselor. CVT staff conducted assessments in English, Kiswahili, Somali, and Nuer, with assessment forms available in these languages. If the client did not comfortably speak any of these languages, interpreters trained in mental health participated in the assessment. On the spot translation of items on the assessment forms was sometimes necessary. Cultural liaisons who understand the client's culture and context were also employed where necessary.

2.2.1. Posttraumatic stress symptoms

The intake assessment battery included 17 questions assessing posttraumatic stress symptoms, based on the Posttraumatic Stress Diagnostic Scale (PDS; Foa, Cashman, Jaycox, & Perry, 1995). Each item was scored on a scale from 1 (*not at all*) to 4 (*often*). We used the mean of all 17 items as an index of overall symptom severity. Estimates indicated good to excellent internal consistency in both the Dadaab ($\alpha_{ordinal} = .95$, $\omega_h = .80$, $\omega_{total} = .96$) and the Nairobi samples ($\alpha_{ordinal} = .91$, $\omega_h = .75$, $\omega_{total} = .93$).

Two separate questions assessed physiological and emotional reactivity to trauma reminders, in line with the DSM-IV (APA, 1994). For our main analyses, we used all 17 symptoms as nodes, including the two reactivity items. However, in order to be able to compare our network structures with those reported by Fried et al. (2018) directly, we also estimated networks with 16 symptom nodes, including just one node for reactivity. For these analyses, we combined the two reactivity questions,

using the higher score of the two items for each participant, in line with what Fried et al. (2018) did for two of their samples with 17-item measures.

In the Nairobi sample, measurements were missing entirely for twelve clients, so they were excluded for a final sample of 1,767. We used pairwise deletion for handling the few missing data for individual items (26 items in the Dadaab sample, 0.15 %, and 27 items in the Nairobi sample, 0.09 %).

2.3. Statistical analyses

We carried out all analyses using *R* 3.4.3 (R Core Team, 2017) and a variety of *R* packages. We list the packages used with exact version numbers and citations and include the R input script and additional statistics in the Supplementary Material. We followed the approach taken by Fried et al. (2018) in conducting our analyses in four steps: estimation, inference, stability, and comparisons. We estimated networks of partial correlation coefficients, also called Gaussian graphical models (Lauritzen, 1996). In such a network, each edge (link) and its associated coefficient represent a partial correlation between two nodes (here, symptoms), conditioned on all other variables. As the data consisted of Likert-type items, we used polychoric correlation matrices as input.

We used the graphical lasso variant of the least absolute shrinkage and selection operator for regularization. For our main analyses, we employed the fused graphical lasso extension (Danaher et al., 2014), which allows for estimating multiple Gaussian graphical models in a joint manner, improving network estimates by taking advantage of existing similarities between several samples. We selected the tuning parameters used to regulate penalties (λ_1, λ_2) empirically through *k*-fold cross-validation, using the *EstimateGroupNetwork* R package (Costantini & Epskamp, 2017). This approach is detailed elsewhere (Danaher et al., 2014; Fried et al., 2018). In some analyses where methods for jointly estimated networks are not yet available and for purposes of comparison, we also estimated the networks separately with the *bootnet 1.1.0* R package (Epskamp, Borsboom, & Fried, 2018) using regular graphical lasso and the extended Bayesian information criterion to select the λ_1 regularization parameter.

For making inferences about the estimated networks, we used standardized node strength as the estimate for relative node centrality (Epskamp et al., 2018) and predictability, the shared variance of each node with its neighbors (Haslbeck & Fried, 2017), as an absolute measure of interconnectedness.

We assessed the stability of the estimated networks using *bootnet*. Here, we examined the stability of corresponding separately estimated networks. We calculated 95 % confidence intervals around the edge weights using bootstrapping. We further estimated correlation-stability coefficients for centrality metrics using the case-dropping subset bootstrap, with values above 0.5 indicating good stability and interpretability of centrality indices (Epskamp et al., 2018). We also ran the edge-weights difference test and the centrality difference test for each network.

We used several methods to compare the estimated networks. First, we assessed the correlation of edge weights as well as symptom centrality across networks. Second, for the two networks based on our data sets we carried out formal tests of differences in network structures using the *NetworkComparisonTest 2.0.1* R package (van Borkulo, Epskamp, & Millner, 2016) to determine which, if any, of the edges differed, and whether the global strength estimates of the two networks were similar. Third, we estimated and graphed the cross-sample overall network structure using average edge weights, employing the extended Bayesian information criterion. Fourth, we estimated a cross-sample variability network, where edges represent standard deviations of each edge across the two networks.

2.4. Ethical issues

Informed consent was requested from the clients for collecting and utilizing information about them and for entering the mental health services program. An IRB exemption approved by University of Minnesota, Human Subjects Committee, determined that the study is exempt from review under guidelines for existing data (Study Number: 1501E59322).

3. Results

3.1. Descriptive statistics

The clients had experienced a variety of severe traumatic experiences, including capture (42 % in the Nairobi sample and 68 % in the Dadaab sample), torture (59 % and 91 %, respectively), and having family members captured (49 % and 73 %), tortured (52 % and 90 %) or killed (74 % and 90 %). In the Nairobi sample, 22 % of clients had lived at a refugee camp.

Mean overall symptom severity was higher in the Dadaab sample than in the Nairobi sample (3.39 vs. 3.12, 95 % CI$_{\text{diff}}$ [0.22, 0.30], t (2149.6) = 12.96, $p < .0001$). Table 1 presents the mean levels and standard deviations of each individual symptom in the two samples. Very high negative correlations between symptom means and standard deviations suggested ceiling effects ($r = -.96$ for the Dadaab data, $r = -.93$ for the Nairobi data, both $p < .0001$). For the Dadaab sample, 79/1025 clients (7.7 %) endorsed all symptoms at the highest level. The same was true for 15/1767 (0.8 %) in the Nairobi sample. Despite ceiling effects, we considered the sample sizes large enough to provide adequate variability for network analyses.

A high positive correlation between order of mean symptom levels in the two samples ($r = .74$, p = .0003) suggested substantial similarities. The highest overall means were observed for intrusions (3.74 in the Dadaab data and 3.56 in the Nairobi data) and emotional reactivity (3.58 in the Dadaab data, 3.47 in the Nairobi data), while amnesia had the lowest means (2.78 in the Dadaab data, 1.93 in the Nairobi data).

3.2. Network structure

Fig. 1 presents the jointly estimated networks. For ease of comparison, the layout of nodes for both visualizations is identical and based on the average layout of the two networks when estimated separately. Shared strong edges in the two networks included the connections between avoidance of thoughts and avoidance of situations (.69 in Nairobi

Table 1
Average symptom levels for different posttraumatic stress symptoms in two samples of help-seeking Central and East African refugees in Kenya.

| No.	Label	Symptom	Nairobi data		Dadaab data	
			M	SD	M	SD
1	Intru	Intrusions	3.56	0.65	3.74	0.50
2	Night	Nightmares	3.21	0.87	3.64	0.63
3	Flash	Flashbacks	3.03	0.95	3.46	0.73
4	EmRea	Emotional Reactivity	3.47	0.71	3.58	0.64
5	PhRea	Physiological Reactivity	3.35	0.88	3.45	0.75
6	AvTho	Avoidance of Thoughts	3.29	0.85	3.61	0.69
7	AvSit	Avoidance of Situations	3.25	0.88	3.64	0.62
8	Amnes	Amnesia	1.93	1.11	2.78	1.17
9	Disin	Disinterest in Activities	3.06	0.91	3.43	0.69
10	Detac	Feeling Detached	2.95	1.01	3.36	0.80
11	EmNum	Emotional Numbing	3.42	0.73	3.46	0.66
12	Short	Sense of Foreshortened Future	2.79	1.03	3.06	0.96
13	Sleep	Sleep Problems	3.45	0.81	3.55	0.71
14	Irrit	Irritability	3.07	1.02	3.36	0.85
15	ConPr	Concentration Problems	2.98	0.99	3.03	0.96
16	HyVig	Hypervigilance	3.10	0.97	3.26	0.89
17	Start	Exaggerated Startling	3.20	0.96	3.26	0.92
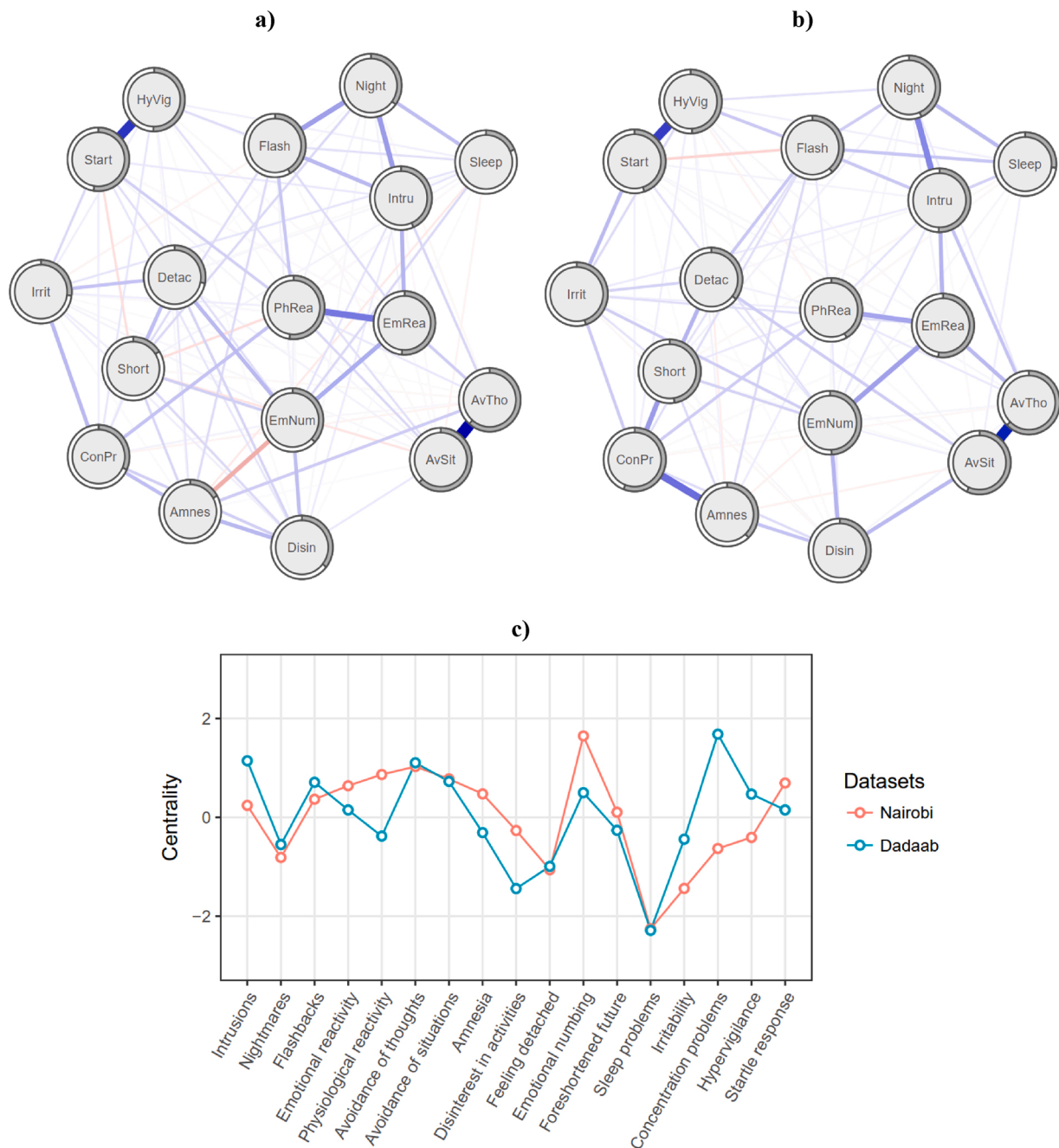
Fig. 1. Jointly estimated Gaussian graphical models of posttraumatic stress symptoms for help-seeking Central and East African refugees exposed to multiple, severe traumatic events **a)** resettled in Nairobi and **b)** living in the Dadaab refugee camps. Edge thickness represents association as partial correlations, blue (solid) edges indicate positive association, and red (dashed) edges indicate negative association. Gray area in rings around nodes depicts predictability, i.e., variance of the node explained by all its neighbors. **c)** Centrality of the different symptoms in the two networks, as estimated by standardized node strength. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

sample, .62 in Dadaab sample), as well as between hypervigilance and exaggerated startling (.55, .52). Moderately strong edges similar to both networks included links between intrusions and nightmares (.27, .33) and physiological and emotional reactivity (.36, .25). Two other edges reached .25 in strength, those between emotional reactivity and emotional numbing (.22 in Nairobi, .25 in Dadaab), and between nightmares and flashbacks (.26, .13). However, there were also some differences in network structure. In particular, in the Dadaab sample, concentration problems were strongly connected to amnesia (.40) and moderately strongly associated with a sense of foreshortened future (.26), while concentration problems were much less weakly interconnected in the Nairobi sample. The only moderately strong negative

edge was observed between amnesia and emotional numbing in the Nairobi sample (-.23).

3.3. Inference

Fig. 1c presents node strengths as centrality estimates. The order of centrality correlated across the two networks ($r = .57$, $p = .016$). Sleep problems, disinterest in activities, detachment, irritability, and nightmares had low centrality estimates below zero in both samples. However, there were also substantial differences. In particular, the most central symptoms differed, with emotional numbing emerging as most central in the Nairobi data (1.65), while concentration problems were

most central in the Dadaab data (1.68). The difference in centrality of concentration problems was particularly striking, being the most central symptom in the Dadaab sample, but among the less central symptoms in the Nairobi sample (-0.63). Avoidance of thoughts (1.03 in Nairobi, 1.11 in Dadaab) and avoidance of situations (0.78, 0.73) were central to both networks. The most endorsed symptoms were not the most central, as we did not find significant correlations between mean symptom levels and node strength ($r = .32$, $p = .216$ for Nairobi, $r = .13$, $p = .625$, for Dadaab).

Mean node predictability was 38.9 % in the Nairobi data and 45.5 % in the Dadaab data. Node predictability was moderately correlated with node strength in the Nairobi sample ($r = .57$, $p = .017$) and highly correlated in the Dadaab sample ($r = .84$, $p < .0001$). We observed the highest predictabilities for avoidance of situations (.62), avoidance of thoughts (.62), and startling (.53) in the Nairobi sample and avoidance of thoughts (.62), avoidance of situations (.57), and concentration problems (.56) in the Dadaab sample. Node predictability correlated highly between the two samples ($r = .61$, $p = .009$).

3.4. Stability

Edge weights with confidence intervals for separately estimated networks are presented in the Supplementary Fig. S4. Networks appeared to be accurately estimated, as confidence intervals around edge weights were moderately sized and the correlation-stability coefficient for node strength was 0.59 in the Nairobi sample and 0.52 in the Dadaab sample, above the suggested threshold for stable network estimation of 0.50 and similar to previous network analyses (Epskamp et al., 2018; Pfeiffer et al., 2019). Results of edge weight and centrality difference tests are presented in Supplementary Figs. S6 and S7.

3.5. Inter-network comparison

The edge weights of the two jointly estimated networks correlated with each other strongly ($r = .61$, $p < .0001$). Still, according to the NetworkComparisonTest omnibus test, the two networks differed significantly from each other in at least one edge weight ($p < .0001$). Post hoc tests for individual edges indicated that five out of 136 edges
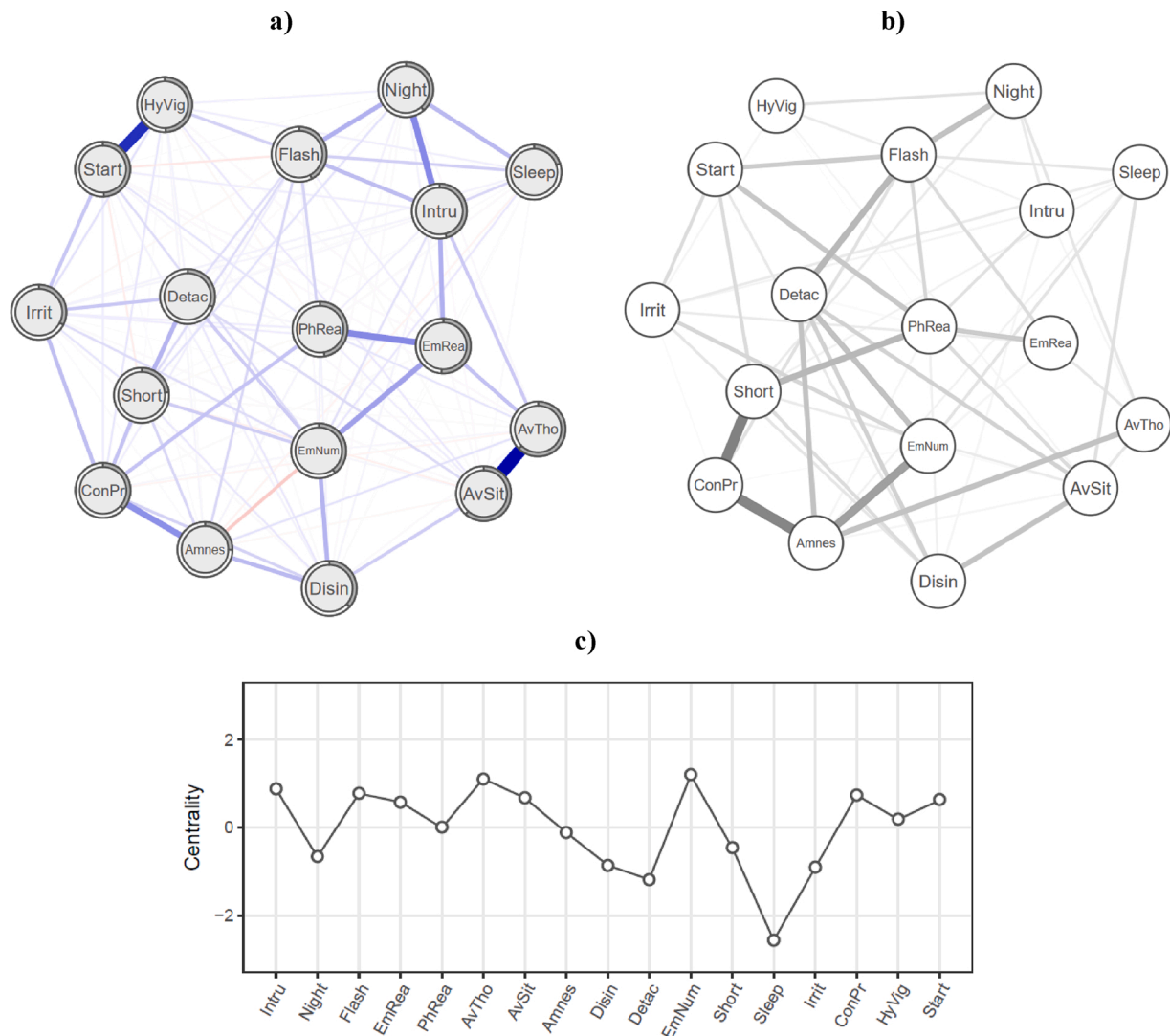

Fig. 2. **a)** A combined Gaussian graphical model of symptoms based on averaged coefficients from two samples of help-seeking Central and East African refugees exposed to multiple, severe traumatic events. Edge thickness represents association as partial correlations, blue (solid) edges indicate positive association, and red (dashed) edges indicate negative association. Gray area in rings around nodes depicts predictability, i.e., variance of the node explained by all its neighbors. **b)** Variability network of the combined sample. Edge thickness represents variability of the edge. **c)** Centrality, as estimated by standardized node strength, of different posttraumatic stress symptom in the combined network. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

(3.7 %) differed significantly between the two networks (all with Holm-Bonferroni corrected $p < .0001$). The differing edges were those between nightmares and avoidance of thoughts; physiological reactivity and sense of foreshortened future; avoidance of situations and sleep problems; amnesia and concentration problems; and concentration problems and sense of foreshortened future. Global strength values of the two networks did not differ significantly (7.98 for Nairobi sample, 7.64 for Dadaab sample, $p = .335$).

Fig. 2 presents the combined cross-sample network, its variability network and node strength centrality estimates. The strongest edges in this combined network were found between avoidance of thoughts and

avoidance of situations (.65), hypervigilance and startling (.54), emotional and physiological reactivity (.30), intrusions and nightmares (.30), as well as amnesia and concentration problems (.28). The most central symptoms were emotional numbing (1.19), avoidance of thoughts (1.11), intrusions (0.88), flashbacks (0.78), and concentration problems (0.74), while sleep problems were by far the least central symptom (-2.56). The most variable edges were between concentration problems and sense of foreshortened future (0.17), concentration problems and amnesia (0.16), and amnesia and emotional numbing (0.14).
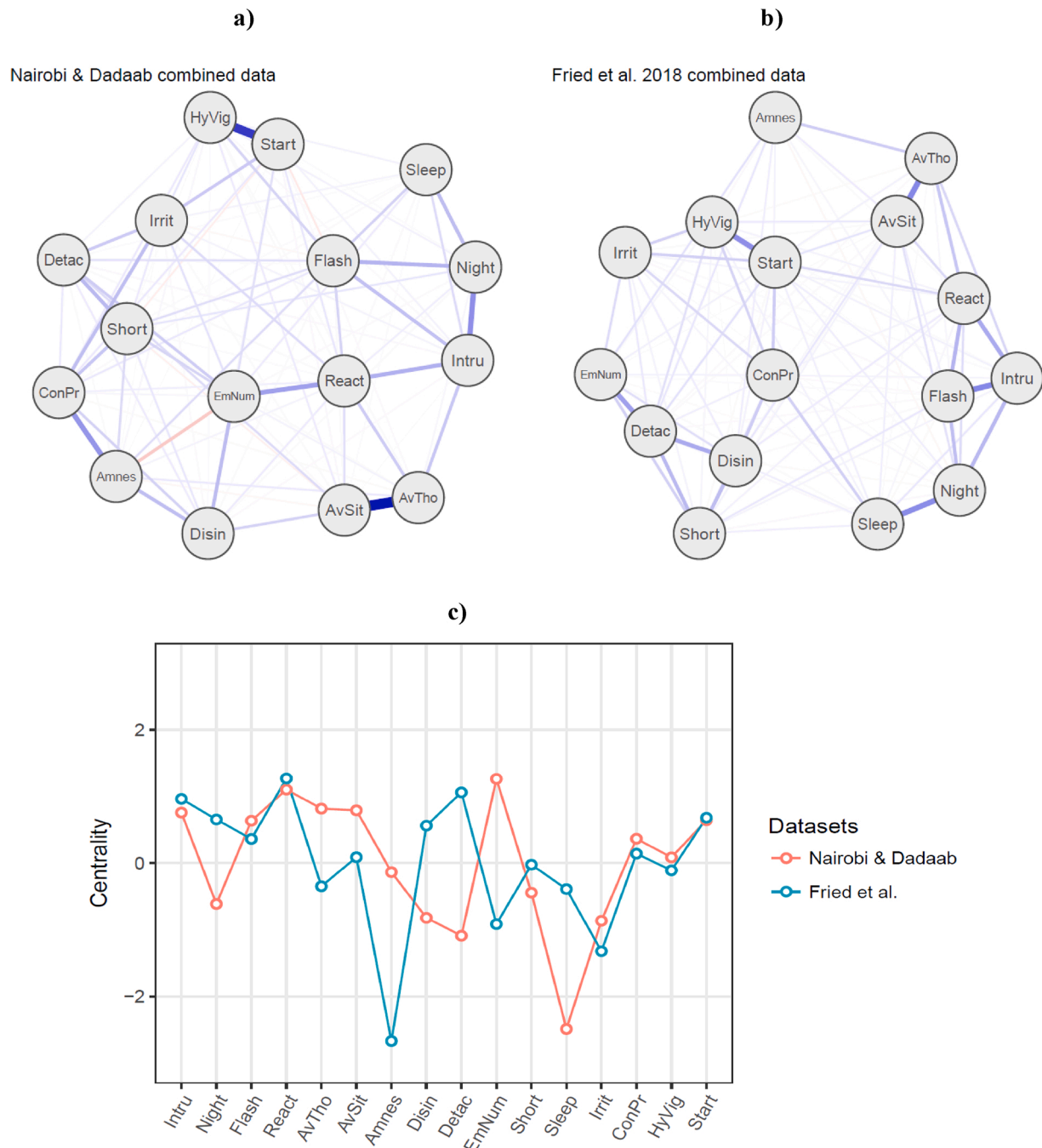

Fig. 3. Comparing cross-sample Gaussian graphical models of posttraumatic stress symptom networks based on **a)** two samples of help-seeking Central and East African refugees exposed to multiple, severe traumatic events, and **b)** four samples of treatment-seeking traumatized people in Europe (Fried et al., 2018). Edge thickness represents association as partial correlations, blue (solid) edges indicate positive association, and red (dashed) edges indicate negative association. **c)** Centrality, as estimated by standardized node strength, for these two cross-sample networks. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

3.6. Comparison to *Fried et al. (2018)*

Fig. 3 compares a 16-item version of our averaged network to the combined network presented by Fried et al. (2018) based on four European samples of traumatized patients. We found a moderate correlation between edge weights ($r = .53$, $p < .001$), but no significant correlation between orders of centrality estimates ($r = .11$, $p = 673$). Reactivity was a highly central symptom in both networks (1.10 for our network, 1.27 in Fried et al.). However, the centrality of other symptoms differed radically. For instance, our most central symptom, emotional numbing (1.26), had the third lowest and negative centrality estimate in Fried et al. (−.92), while the second most central symptom for Fried et al., detachment (1.06), had the second lowest and negative centrality estimate in our network (−1.09). Differences were also large for sleep problems, amnesia, and disinterest.

Further, edge weights of both our averaged 16-item network ($r = .48$, $p < .0001$) and a 16-item Nairobi network ($r = .49$, $p < .0001$) correlated moderately with those of Fried et al.'s Network 4, which involved 965 treatment-seeking refugees resettled into Germany, while correlation with a 16-item Dadaab network was somewhat lower ($r = .34$, $p = .00015$). Notably, none of our three networks correlated substantially with Fried et al.'s Network 4 involving only refugees in terms of centrality estimates ($r = −.09$, $p = .738$ for averaged network; $r = -.10$, $p = .705$ for Nairobi network; $r = .22$, $p = .410$ for Dadaab network).

4. Discussion

We jointly estimated networks of posttraumatic stress symptoms in two samples of help-seeking refugees in Kenya. The clients reported exposure to such highly traumatic experiences as torture, capture, and abuses against or death of family members, together with very high average levels of PTSS endorsement. We compared the network structures of PTSS that emerged to each other, as well as to earlier results based on clinical populations in Europe.

We were able to estimate network structures of PTSS with satisfactory stability and accuracy and noted substantial similarities. The strength of associations between the symptoms and the order of centrality and predictability of symptoms were moderately to highly correlated between the two samples, suggesting notable similarities in structure. The global strength and mean node predictability of the two networks were also fairly similar.

The strongest direct connections between different symptoms in the combined, cross-sample network were between avoidance of thoughts and avoidance of situations, hypervigilance and exaggerated startling, intrusions and nightmares, as well as physiological and emotional reactivity. These links fit the traditional DSM-IV symptom clusters of PTSD of avoidance, intrusions, and hyperarousal, and are in line with previous network analyses (Skogbrott Birkeland et al., 2020). Robustly demonstrating that these links hold even in highly distinct populations of trauma survivors shows that they may form the shared backbone in otherwise diverse posttraumatic reactions.

The additional strong connection between amnesia and concentration difficulties could reflect cognitive difficulties associated with severe traumatization or a more dissociative symptom manifestation for some clients. The moderately strong positive link between emotional reactivity and emotional numbing is surprising, but could reflect the use of avoidant coping and excessive emotional downregulation in situations of continuous traumatic stress among those who experience stronger psychological reactions to trauma reminders (Stevens, Eagle, Kaminer, & Higson-Smith, 2013). This interpretation is supported by the moderate further associations with disinterest and detachment.

Concerning the most central symptoms, the combined, cross-sample network indicated emotional numbing, avoidance of thoughts and situations, intrusions and flashbacks, as well as concentration problems to be the most central to the network structure of PTSS in these samples. Sleep problems were by far the least central symptom.

We also observed some differences between networks based on the two samples. In the Nairobi sample, emotional numbing emerged as most central symptom, while in the Dadaab sample, concentration problems were the most central. Differences between the samples were particularly striking for concentration problems. In the Dadaab sample, concentration problems were strongly connected to amnesia and moderately strongly associated with a sense of foreshortened future, while these links were significantly weaker in the Nairobi sample according to network comparison tests. The majority of the clients in the Dadaab sample were from Somalia and Ethiopia. These links might reflect how individual suffering may be strongly located within narratives of collective dispossession and victimization, as identified among Ethiopian Somali refugees by Zarowsky (2004). She noted yearning for homeland and community and loss expressed as chronic sadness and rumination, as well as hopelessness and demoralization to permeate survivors' expressions of distress. Such ruminative sadness and hopelessness could help explain this constellation of symptoms around concentration problems and sense of foreshortened future. Further, common endorsement of a sense of foreshortened future, although in contrast to what McDonald, Im, Green, Luce, and Burnette (2019) found among Somali youth in Nairobi, and its stronger links to concentration problems and physiological reactivity, are certainly understandable for clients living in one of the world's most protracted refugee situations with no solution or viable possibility to return home in sight. In these conditions, severe daily stressors may affect cognitive performance and push people into a daily struggle for survival, limiting their ability to imagine the future.

Emotional numbing, the most central symptom in the Nairobi sample and in the combined network, was linked to disinterest, detachment, sense of foreshortened future, and emotional reactivity. A model of PTSD with a separate cluster of numbing symptoms has been found to have the best fit among female survivors of sexual violence in the DRC (Michalopoulos et al., 2015). Numbing symptoms are also particularly linked to depression (Asmundson, Stapleton, & Taylor, 2004). That such symptoms might be central to PTSS here is not surprising, given the very high comorbidity between depression and PTSD among both refugees and trauma survivors more generally (Nickerson, Schick, Schnyder, Bryant, & Morina, 2017; Rytwinski, Scur, Feeny, & Youngstrom, 2013), as well as the conditions of continuous traumatic stress experienced by urban refugees and torture survivors in Africa (Higson-Smith, 2013). Network analyses including both PTSS and depressive symptoms can contribute to understanding the overlap between PTSD and mood disorders and identifying symptoms that may act as bridges between them, which may be important for developing and delivering effective interventions. Though beyond our scope here, we have plans for future analyses of PTSD and depression comorbidity and possible bridging symptoms for the present data.

The other connections between symptoms that differed substantially between the samples were between nightmares and avoidance of thoughts and avoidance of situations and sleep problems. These links were stronger in the Dadaab sample. Avoidance, which was central to the clients' symptomatology, driving symptoms into the night time could contribute to the high level of symptomatology in the Dadaab sample.

We observed no significant correlation between symptom endorsement and centrality. The difference was particularly notable for sleep problems, which were very commonly endorsed by clients, but the least central symptom in network analyses. Sleep problems may be prevalent among these refugee populations independent of PTSD symptomatology due to daily stressors and poor living conditions not conducive to rest. These findings highlight the added information network analyses can provide about the roles of particular symptoms.

Comparing the identified network structures with both the overall network Fried et al. (2018) estimated from four samples of traumatized patients in different parts of Europe and with the network they estimated for treatment-seeking refugees in Denmark, we found considerable

correspondence in links between symptoms. This provides some evidence for universality in how PTSS associate and cause each other even in such different populations. The strongest common edges were located within traditional DSM-IV symptom clusters. Meanwhile, we observed no correlation between the most central symptoms we identified and those identified by Fried et al. (2018). This striking finding suggests that among African refugees dealing with severe symptoms due to multiple traumatic events, as well as on-going stressors, the symptoms most central to the network structure of PTSS were quite different from those identified in Europe, even including among refugees resettled into Europe. Emotional numbing was far more central in our networks, while disinterest, detachment, and sleep problems were far less central. These findings are in contrast to the fact that Fried et al. (2018) found symptom centrality in their network structures to moderately correlate with those of McNally et al. (2015) who also studied a very different population, Chinese earthquake survivors. However, reactivity and intrusions were central to network structures in both our samples and those of Fried et al. (2018), and a central role for concentration problems did emerge in their refugee sample, as well.

Reasons for these differences remain speculative but could include the very severe level of PTSS among clients and their difficult living environments. The on-going hardship and daily struggles might explain why concerns such as disinterest in formerly pleasurable activities and detachment from others might not be as central to the clients' symptomatology, although they did report them frequently (Higson-Smith, 2013). The high centrality of emotional numbing could, as discussed above, indicate a more pronounced role of comorbid depression and hopelessness in response to the clients' difficulties. Fried et al. (2018) did note that some of the symptoms identified as most central in their analyses, disinterest and concentration problems, were also linked to depressive disorders.

Comparing with the study of Pfeiffer et al. (2019) among refugee minors resettled into Europe, we reproduced their findings on strong links between intrusions and nightmares and emotional (psychological) and physiological reactivity, as well as the central roles of concentration problems, reactivity, and emotional numbing / restricted affect. On the other hand, nightmares and sleep problems were less central in our analyses, and we did not reproduce the very low centrality estimates for hypervigilance, amnesia, or internal avoidance Pfeiffer et al. (2019) observed. These substantial differences support the view that, despite some shared core links, PTSS may affect and maintain each other quite differently among refugees settled into different environments and of different ages. The pronounced role for concentration problems identified in both previous refugee samples and in our analyses is a notable point of consistency, however.

Amnesia regarding the traumatic event was the most rarely endorsed item in our study, in line with findings in Europe (Fried et al., 2018) and globally (Michalopoulos et al., 2018). However, amnesia was not the least central symptom, as most previous network analyses among refugees (Fried et al., 2018; Spiller et al., 2017) and other populations have found (Skogbrott Birkeland et al., 2020). We found amnesia to associate somewhat with other PTSS, most strongly with concentration problems in the Dadaab sample, where overall levels of PTSS were particularly high. This could indicate a higher prevalence for something resembling a dissociative subtype of PTSD there. Anecdotal evidence from stakeholders and partners in Dadaab does suggest higher levels of dissociative disorders there compared with other contexts. It is, however, possible that the amnesia item here represents more general forgetfulness or cognitive problems. Clients had experienced numerous traumatic events and adversities, and for many a long time had elapsed since their most traumatic experience, which may have contributed to endorsement of amnesia. In some cases, "not remembering" could also be related to intentional forgetting to maintain family or community harmony, as family discord has been reported as an aspect of posttraumatic symptomatology in Sub-Saharan Africa (Michalopoulos et al., 2018).

4.1. Central symptoms and interventions

The most central symptoms may be core antecedents that lead to many other symptoms or crucial links in feedback loops that maintain them (Benfer et al., 2018; Fried et al., 2018). As such, they might be important targets for initial treatment of PTSS or, alternatively, noteworthy "harbingers of relapse" (McNally et al., 2015, p. 845) that signal the need for intervention if they reappear. If this is the case, our findings support targeting intrusions, reactivity, and avoidance in highly symptomatic refugee populations exposed to multiple, severe traumatic events, too, as is typical in first-line trauma-focused treatments (Cusack et al., 2016). However, our results also tentatively suggest cognitive and emotional symptoms such as emotional numbing and concentration problems might be useful targets in the treatment of PTSS among refugees, although they may also present additional challenges (Asmundson et al., 2004). A few previous studies support the idea that concentration problems might be more central to the PTSS of refugees than the PTSS of other types of survivors (Fried et al., 2018; Pfeiffer et al., 2019). Attempts to affect PTSS and especially re-experiencing symptoms through direct training for cognitive problems such as attention biases or executive function have found some, rather modest, success (e.g., Bomyea, Stein, & Lang, 2015; Fonzo et al., 2019; Khanna et al., 2015). We are not aware of any studies among refugees, however.

Several caveats apply to the idea that central symptoms are good targets for interventions. First, all edges in our networks are adirectional. Assessing possible causal influences from undirected networks is problematic, as multiple types of directed processes might result in similar networks (Dablander & Hinne, 2019). Second, some central symptoms may indeed be important causes of other symptoms, but less amenable to change by their nature. Finally, doubt has begun to mount about whether node strength, currently the most widely used, but clearly suboptimal, centrality metric, is an appropriate and useful guide for intervention targets, especially in the presence of conceptually overlapping and non-interchangeable nodes (Bringmann et al., 2019; Dablander & Hinne, 2019).

4.2. Strengths and limitations

The two large samples employed are a strength of this study setting it apart from many previous network analyses. Further, the study concerns civilian populations with experiences of war, who remain severely understudied in the field of psychological trauma and its effects, as compared with non-war-related trauma and military veterans.

As for limitations, possible inconsistencies and uncertainties in data collection must be taken into account. The data were collected over a long period of time by a large number of counselors working in highly challenging conditions. Challenges in translation and interpretation of the meaning of particular items in different languages might constitute a source of bias. The exclusive reliance on self-reported PTSS without clinical evaluation by an expert is also a clear limitation.

The very high mean levels of symptoms may also form a limitation. Though participants were not selected based on a cut-off PTSD score, avoiding direct Berkson's bias, spurious negative edges could still be a concern (de Ron, Fried, & Epskamp, 2019). The results can only be generalized to highly symptomatic and help-seeking individuals. Further, considerable ceiling effects reduced variability in the data. Despite this, we were able to estimate network structures with adequate accuracy and stability due to the large sample sizes compensating for this issue, though accuracy was somewhat lower for the Dadaab sample.

Network analyses rest on the assumption that the symptoms included represent crucial components of the psychopathology successfully and at the right level (Borsboom, 2017). Our analysis is strictly limited to DSM-IV symptoms. Such an approach will necessarily miss all other possible posttraumatic manifestations, including symptoms that may be unique or indigenous to the particular cultural contexts under study. Cognitive and emotional symptoms that have been added to the DSM-5

were also missing from our analyses.

Although the wording of the question was identical to the DSM-IV symptom description ("difficulty falling asleep or staying asleep"), the question about sleep problems was set slightly apart from the other questions relating to posttraumatic stress symptoms in the intake assessment, among items related to depression. As items following each other in questionnaires appear to have stronger links between them in network analyses (Skogbrott Birkeland et al., 2020), it is possible that this distance from other items might have conversely resulted in a downward bias in estimates of the centrality and connectivity of the sleeping problems symptom.

Notably, clients from the two sites we studied did not form two homogenous groups. In particular, their national, cultural, and religious backgrounds differed also within the sites. As Benfer et al. (2018) note, mixture models for network analysis that could be used to classify different types of structures in a population are not yet available. The development of better tools to analyze factors moderating and affecting the network structure of symptoms is an important future direction for cross-culturally oriented analyses, too.

Finally, ours was an exploratory, post hoc study. The interpretations and explanations we have provided for our findings must be considered with this in mind.

4.3. Conclusions

Are there multiple possible network structures of PTSD or one universal one? We found some evidence that the network structures and strongest links between different symptoms identified in varied populations of trauma survivors in Europe do reproduce among African refugees dealing with severe effects of multiple traumatic events. However, we also identified significant differences in structures even between two samples of African refugees differing in cultural and religious background and living conditions, and especially between these samples and structures reported in European samples. This highlights the role factors such as type of trauma, living conditions and circumstances, as well as culture may play in PTSD symptomatology, as captured by the network approach.

The differences relate especially to the symptoms that appear to be most central to PTSS networks. We found emotional numbing and concentration problems to be most central in an urban and a refugee camp sample in Kenya, respectively. Meanwhile, the low centrality of amnesia seen in most previous network analyses of PTSS was not reproduced here. Notwithstanding the considerable debate about the nature and interpretability of node strength centrality estimates (Bringmann et al., 2019; Dablande & Hinne, 2019), these differences are informative and may be relevant for assessment of PTSS and interventions among refugees dealing with severe PTSS, in particular in Central and Eastern Africa.

The roles of numbing and dissociative-type symptoms in the network structure of PTSS among refugees calls for further attention. They may hint at the significance of different subtypes of PTSD in this population, as well. At the same time, the extent to which key symptoms and links we identified represent depression driving or keeping up PTSS symptomatology among help-seeking refugees merits further study. Acknowledging the limitations of what we may infer about possible causal influences from cross-sectional network analyses, our results suggest interventions targeting concentration problems as well as emotional overmodulation and numbing may hold promise.

Funding

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.janxdis.2021.102358.

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