RESEARCH ARTICLE

The psychometric network structure of mental health in eating disorder patients

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Abstract

Objective: Psychometric network analysis has led to new possibilities to assess the structure and dynamics of psychiatric disorders. The current study focuses on mental health networks in patients with anorexia nervosa, bulimia nervosa, binge eating disorder and other specified eating disorders (EDs).

Method: Network analyses were applied with five mental health domains (emotional, psychological and social well-being, and general and specific psychopathology) among 905 ED patients. Also, networks of 36 underlying symptoms related to the domains were estimated. The network stability, structure and (bridge) centrality of the nodes were assessed for the total group and each ED type. Network differences between the ED types were also examined.

Results: ED psychopathology was only weakly connected with the well-being domains. Psychological well-being was the most central node in the domain network. The most central nodes in the symptom network were *feeling depressed*, *feeling worthless*, *purpose in life* and *self-acceptance*. Bridge symptoms between well-being and psychopathology were *self-acceptance*, *environmental mastery*, *interested in life* and *feeling depressed*. There were no network differences between the ED types in both the domain and symptom networks.

Conclusions: This study shows novel associations between well-being and psychopathology in ED patients. Central domains and their underlying symptoms may be especially important to consider in treatment for promoting mental health in ED patients.

1 | INTRODUCTION

Psychiatric diseases, such as eating disorders (EDs), are traditionally explained with the medical disease model (Engel, 1977). In statistical terms, the medical disease model is considered a latent variable model (Borsboom, 2016). This means that the symptoms are understood to be caused by an underlying (biological) disorder. However, for many psychiatric diseases, there is no identifiable underlying disorder with a known common cause (Zachar & Kendler, 2007). EDs are currently understood as the result of a complex interaction between biological, psychological and environmental factors (Himmerich et al., 2019).

While clear (biological) causes may be discovered in the future, an alternative approach is to understand psychiatric disorders as networks of symptoms, caused and maintained by biological, psychological and environmental mechanisms (Borsboom, 2016). Borsboom (2016) states that if these causal relationships are sufficiently strong, the symptoms may generate a level of feedback that makes them self-sustaining, leading to a network being stuck in a disorder state. Psychometric network theory proposes that this is a primary feature of mental disorders, which can be understood as strongly connected symptom networks (Borsboom, 2016). Developments in psychometric network analysis have led to new possibilities to examine and understand the structure and dynamics of psychiatric disorders. In these analyses, symptoms are specified as nodes, which can be associated with each other in a network. In a psychometric network, the centrality of nodes (e.g. the relative importance in a network compared to each other) can be estimated, as well as the strength of the association between nodes, that is edge-weights (Epskamp, 2020; Epskamp & Fried, 2017).

1.1 | ED pathology networks

There is an emerging body of literature examining the network structure of ED pathology (Christian et al., 2019; DuBois et al., 2017; Elliott et al., 2020; Forbush et al., 2016; Forrest, Jones, et al., 2018; Levinson et al., 2017; Perko et al., 2019; Wang et al., 2019). These studies show that specific symptoms are more central in ED pathology networks than others. For instance,

Highlights

- Psychometric network analysis shows novel associations between well-being and psychopathology in eating disorder (ED) patients.
- The most central mental health domain and underlying symptoms were psychological well-being, feeling depressed feeling worthless, purpose in life and self-acceptance.
- A transdiagnostic approach to ED treatment, focusing on central mental health symptoms may be warranted.

weight-related concerns and *shape and weight over-evaluation* have been found to be the most central symptoms in several studies (DuBois et al., 2017; Elliott et al., 2020; Forbush et al., 2016; Forrest, Jones, et al., 2018; Levinson et al., 2017; Smith et al., 2019). *Shape and weight over-evaluation* are considered a primary maintaining factor for ED symptoms in enhanced cognitive behavioural therapy (CBT-E), the first choice of treatment for EDs (Fairburn et al., 2015; Forrest et al., 2018). In a longitudinal study, it was found that *feeling fat* and *fear of weight gain* were among the most central symptoms, and baseline symptom centrality predicted posttreatment recovery status in patients with anorexia nervosa (AN) (Elliott et al., 2020).

1.2 | ED pathology/co-morbidity networks

Associations between ED pathology and co-morbidity have also been examined recently (Elliott et al., 2020; Forrest et al., 2019; Levinson, et al., 2018, 2017; Monteleone et al., 2019; Smith et al., 2020; Solmi, Koyanagi, et al., 2019; Vanzhula et al., 2019). Networks with both ED pathology and general psychopathology (i.e. general distress, anxiety and mood symptoms) showed several high centrality symptoms in addition to the ED symptoms, such as *depression*, *anxiety*, *interpersonal sensitivity*, *ineffectiveness* (Monteleone et al., 2019; Solmi, Collantoni, et al., 2019), and *nervousness*, *feeling overwhelmed*, *concentration difficulties*, and *low self-esteem* (Smith et al., 2019). In addition, several studies

examined the centrality of bridge symptoms linking two communities of nodes, for instance, ED pathology and general psychopathology, with the bridge function from the R networktools package (Jones, 2020). Central bridge symptoms play a primary role in connecting two or more communities (Jones et al., 2019). Specific bridge symptoms were found, relating ED pathology to general psychopathology, such as *sensitivity to physical sensations* (i.e. changes in appetite, feeling wobbly or dizzy) among patients with BN (Levinson et al., 2017) and *feelings of worthlessness*, *not wanting to eat in social situations* and *negative reactions to weighing oneself* among patients with AN (Elliott et al., 2020). Network analyses have also been applied to ED pathology and other specific psychopathology such as social anxiety or post-traumatic stress disorder (PTSD) (Levinson et al., 2018; Vanzhula et al., 2019). Levinson et al. (2018) found that *difficulty with drinking beverages* and *eating in public* were central bridge symptoms between ED pathology and social anxiety. Vanzhula et al. (2019) identified *binge eating*, *irritability* (PTSD), *desire for a flat stomach* and *concentration problems* (PTSD) as the strongest bridge symptoms connecting ED pathology with PTSD. In a study examining ED pathology and both general and specific psychopathology (anxiety, depression, obsessive-compulsive and post-traumatic stress problems) in patients with AN, it was found that *depression*, *personal alienation*, *low self-esteem* and *interoceptive deficits* showed the highest bridge centrality (Monteleone et al., 2019, pp. 1263–1273).

1.3 | Well-being and mental health

Patients with EDs do not only report high levels of co-morbidity, but also lower levels of well-being, compared to the general population (de Vos et al., 2018; Tomba et al., 2014). Well-being consists of three core dimensions, emotional, psychological and social (Bohlmeijer et al., 2012; Keyes, 2006, 2012; Westerhof & Keyes, 2008). Emotional well-being is about subjective happiness, comprising positive affect and being satisfied with one's life (Keyes, 2002). Psychological well-being is defined as positive individual mental functioning, indicated by six facets: self-acceptance, personal growth, autonomy, environmental mastery, positive relationships and purpose in life (Ryff, 2014; Ryff & Singer, 1996). Social well-being concerns adequate societal functioning and comprises five dimensions: social actualization, contribution, integration, acceptance and interest (Keyes, 1998).

Adequate levels of well-being are considered as necessary as low levels of psychopathology for mental health (Fava & Guidi, 2020; Keyes, 2005; Radstaak et al., 2020; Westerhof & Keyes, 2010). The complete mental health or dual continua model describes that well-being and psychopathology are two related but distinct domains of mental health (Keyes, 2005; Westerhof & Keyes, 2010). This suggests that optimal levels in one domain do not necessarily lead to optimal levels in the other domain (Trompetter et al., 2017). Factor analysis shows further support for the dual continua model, compared to alternatives (Keyes et al., 2008; Lamers et al., 2011; Magalhães & Calheiros, 2017; Perugini et al., 2017). Correlational studies report low or negligible (Magalhães & Calheiros, 2017; Perugini et al., 2017) to moderate correlations between well-being and general psychopathology (Peter et al., 2011). In clinical populations, such as patients with anxiety, mood, ED and personality disorders, moderate to high correlations between well-being and general psychopathology were found (de Vos et al., 2018; Franken et al., 2018). Correlations between well-being and specific ED psychopathology were however low and not even statistically significant for patients with BN and BED (de Vos et al., 2018). The strength of the correlations between well-being and ED-pathology were dependent on the type of pathology (i.e. general or specific), as well as the ED type (de Vos et al., 2018).

Until date, these associations have only been tested in separate bivariate analyses. Psychometric network analysis will provide additional knowledge on how the mental health dimensions are connected by controlling for each other's influence. In addition, the underlying symptoms of the mental health dimensions can be examined on centrality and how they are connected. Examining both well-being and psychopathology in a psychometric network is further substantiated by the perspective of people with lived experience. People who have recovered from an ED consider several aspects of well-being as fundamental criteria for recovery in addition to the absence of ED symptoms, such as self-acceptance, positive relationships, personal growth and autonomy (de Vos et al., 2017). In addition, people who consider themselves recovered use other transdiagnostic criteria for recovery, besides ED pathology such as general psychopathology, quality of life and social participation (Slof-Op't Landt et al., 2019).

1.4 | This study

Psychometric network studies among ED patients have primarily focused on ED pathology or co-morbidity networks. Mental health is, however, not only about symptoms of psychopathology but also about the presence of well-being. The network structure of overall mental health has not been examined among ED patients.

The first aim was to examine the network structure of the mental health domains. Five domains were distinguished: emotional, psychological and social well-being, and general and specific (ED) psychopathology. The overall network structure and centrality of the domains were examined for each ED type. Also, differences in networks between ED types were examined. Research question (RQ)1 was: 'which nodes are most central in the domain mental health network?' and RQ2: 'are there differences in the network structures and node strength centralities between the ED types?'.

The second aim was to examine networks of underlying symptoms that make up the mental health domains among ED patients. RQ3 was: 'which nodes are most central and which nodes serve as a bridge symptom between well-being and psychopathology in the symptom mental health network of ED patients?', and RQ4: 'are there differences in the network structure and node strength centrality between the ED types?'

2 | METHOD

2.1 | Participants and procedure

Participants were ED patients with AN, bulimia nervosa (BN), binge eating disorder (BED) and other specificied feeding and eating disorders (OSFED) receiving treatment at Stichting Human Concern, a specialized centre for the treatment of EDs with five outpatient treatment centres located in the Netherlands. The inclusion criteria were: (1) a primary DSM five ED diagnosis at intake, (2) a minimum age of 17, since this is the minimum age for treatment at the centre, (3) being able to understand and fill in the questionnaires and (4) consent to participate in the research. Exclusion criteria for treatment were (1) not being able to write and understand the Dutch language, (2) severe and active auto-mutilation, (3) active psychosis, (4) severe depression, (5) active suicidal ideation and (6) acute somatic complications. A total of 1066 patients who started treatment between March 2015 and September 2018 were screened for inclusion. Eleven patients did not have an ED diagnosis, 121 patients did not fill in the questionnaires, and 29 patients did not consent to have their data used for research purposes.

The diagnosis was set by a psychiatrist in collaboration with an intake team, consisting of a dietician, family therapist and a psychologist. Patients followed outpatient treatment with sessions once or twice a week with a psychologist. A combination of the following methods was used in treatment: insight giving therapy, cognitive behavioural change, emotion-regulation and food/weight management. Patients filled in questionnaires every three months as part of their treatment to monitor recovery. These results were discussed with the patient and within the multidisciplinary treatment team to evaluate treatment. This study used these anonymized questionnaires, meaning that the study did not lead to any additional workload for patients. Patients were informed about the aims of the study and signed an informed consent stating that they could withdraw the possibility to include their data for scientific research. The Behavioral, Management and Social Sciences Ethics committee of the University of Twente approved the study protocol.

2.2 | Instruments

2.2.1 | Eating disorder psychopathology

The 36 item Eating Disorder Examination Questionnaire (EDE-Q) was used to measure ED psychopathology (EDP domain) with the global score (Fairburn & Beglin, 1994). A seven-point Likert scale (0 = not 1 day; 6 = every day) was used to measure the frequency of symptoms in the last 28 days. An example item is: 'has your weight influenced how you think about (judge) yourself as a person?' Lower scores are indicative for lower EDP. The internal consistency of the global scale was 0.92.

2.2.2 | General psychopathology

The symptomatic distress (SD) scale of the Outcome Questionnaire (OQ-45) (Jong et al., 2008) was used for the measurement for general psychopathology (GPP domain) (Warmerdam et al., 2017). The symptomatic distress scale has 25 items and shows good psychometric properties (Jong et al., 2008). Items are scored on a five-point Likert scale, ranging from 0 'never' to 4 'always'. An example item is: 'I feel irritated.' The internal consistency of the SD scale was 0.91.

2.2.3 | Well-being

The Mental Health Continuum Short Form (MHC-SF) was used to measure well-being (Keyes, 2002; Lamers et al., 2011). The MHC-SF measures overall, emotional, psychological and social well-being with 14 items, rated on a six-point Likert scale ranging from 0 'never' to 5 'always'. Emotional well-being (EWB domain) consists of three items measuring *happiness*, *avowed life satisfaction* and *interested in life*. Psychological well-being (PWB domain) consists of six items measuring self-acceptance, positive relationships, autonomy, personal growth,

environmental mastery and purpose in life. Social well-being (SWB domain) consists of five items measuring social actualization, contribution, integration, acceptance and interest. The internal consistency of the scales was 0.86, 0.83 and 0.73 for emotional, psychological and social well-being, respectively.

2.3 | Analysis

One-way analysis of variance (ANOVA) with Games-Howell post hoc analyses and chi-square tests with post-hoc analyses were used to examine differences in background characteristics between the ED types.

2.3.1 | Symptom network item selection

To estimate stable networks, the number of nodes in the symptom network had to be limited. Also, nodes should not represent the same underlying symptom (topological overlap) (Levinson, et al., 2018). Two strategies were used to limit the number of nodes and prevent topological overlap, based on the procedure used by Levinson et al. (2020).

First, the authors assessed all items on relevance for the domain and topological overlap. For the measurement of EDP, we focused only on the core symptoms to limit the number of nodes. Seven of the 22 attitudinal EDE-Q items were selected, based on a comparison study of short forms of the questionnaire (Machado et al., 2020). The EDE-Q7 short-form items efficiently screen and measure core EDP (Grilo et al., 2015; Machado et al., 2020). For the measurement of GPP, 16 of the 25 OQ-45 SD items were used. The following items were excluded. 'After heavy drinking, I need a drink the next morning to get going' showed a near-zero variance and was therefore not eligible for network estimation. Four items asking about physical symptoms (example question: 'I have sore muscles') were excluded because we were primarily interested in psychopathology. Four items showed substantial topological overlap with a well-being item and were therefore removed. 'I feel no interest in things', was considered similar to the well-being question 'how often did you feel interested in life' (EWB). 'I am satisfied with my life, was considered similar to the question 'how often did you feel satisfied with life' (EWB). 'I like myself', was considered similar to the item 'how often did you feel that you liked most parts of your personality' (PWB). 'I am a happy person', was considered similar to the item 'how often did you feel happy' (EWB). For the measurement of well-being, all 14 items of the MHC-SF were included.

In the second part, the correlations between the items were examined with the goldbricker function of the R networktools package (Jones, 2020). The goldbricker function compares dependent overlapping correlations in a network and is best implemented when overlapping items have already been removed theoretically by trained professionals (Levinson, et al., 2018). Goldbricker function measures the proportion of correlations between items. Based on earlier research, 0.25 was used as a cut-off for a significant proportion and 0.01 as the p-value for determining statistical significance (Levinson, et al., 2018). Two EDE-Q items were significantly correlated ((1) 'deliberately trying to limit the amount of food' and (2) 'trying to exclude foods from diets'). The second item was removed upon discussion, leading to 36 included items for the symptom network analyses. See also Table 1 for an overview of the included symptoms and their description.

The original scales of the EDE-Q (global) and MHC-SF (emotional, psychological, social) were used for the domain networks. However, because of the topological overlap and items not strictly measuring GPP, a revised scale with the selected 16 items of the OQ-45 SD scale was used. The internal consistency of this scale was 0.89.

2.3.2 | Network estimation and centrality measures

Regularized networks were estimated in the R package qgraph using the Gaussian graphical model (Epskamp et al., 2016; Epskamp et al., 2012). For the first and second research question, partial correlations were estimated (interval scales).For the third and fourth research question, polychoric correlations were estimated (ordinal scales). For all networks, the Graphical LASSO (GLASSO) with the Extended Bayesian Information Criterion (EBIC) was used to regularize the networks (Epskamp et al., 2016). Each line (edge-weights) between two nodes (symptoms) reflects the partial or polychoric correlations, and the GLASSO shrinks low correlations to 0 in order to reduce false-positive errors (Epskamp et al., 2018, Borsboom, & Fried, 2018).

Node centrality was examined for all networks with the strength measure. Strength centrality (S) is a measure of a node's overall involvement in the network and is calculated as the sum of all absolute connections to other nodes (McNally, 2016). Although there are other centrality measures, such as betweenness or closeness, recent work shows that these may not be considered valid and meaningful for centrality in psychometric networks (Bringmann et al., 2019). Bridge symptoms (Jones et al., 2019) are symptoms that connect two communities

TABLE 1 Node descriptions and strength centrality of the symptom mental health networks

Node	Symptom	Short Description	S		
			EDs	AN	OSFED
Emotional well-being (EWB)					
WB1	Happiness	Feeling happy, joy, enjoyment	0.53	0.95	0.46
WB2	Interested in life	Being interested in life	1.49	1.25	1.29
WB3	Life satisfaction	Feeling satisfied with life	0.12	0.92	−0.16
Social well-being (SWB)					
WB4	Contribution	Feeling that one's life is useful to society	0.33	−0.48	0.57
WB5	Integration	Having a sense of belonging to, and support from a community	−0.84	−0.93	−0.65
WB6	Actualization	Believing that people, social groups and society can evolve positively	−0.33	−0.42	−0.90
WB7	Acceptance	Having a positive attitude towards others while accepting and acknowledging people's differences and their complexity	−0.27	−0.42	−0.12
WB8	Coherence	Being interested in society or social life	−1.23	−0.91	−1.49
Psychological well-being (PWB)					
WB9	Self-acceptance	Holding warm and positive attitudes towards oneself and past life	1.53[a]	1.86[a]	1.04
WB10	Environmental mastery	The ability to manage responsibilities and mould environments to one's needs	−0.13	−0.40	−0.08
WB11	Positive relationships	Having warm, satisfying, trusting personal relationships and being capable of empathy and intimacy and being open and personal to others.	−0.04	−0.52	0.03
WB12	Personal growth	Showing insight into one's own self and potential, having a sense of development	−0.57	−0.06	−1.10
WB13	Autonomy	Exhibiting a self-direction that is often guided by one's own socially accepted and conventional internal standards	−0.61	−0.13	−0.99
WB14	Purpose in life	Holding goals and beliefs that affirm one's sense of direction in life and feeling that life had a purpose and meaning	1.79[a]	1.96[a]	1.61[a]
Eating disorder psychopathology (EDP)					
ED1	Limit food	Deliberately trying to limit the amount of food to influence shape or weight	−0.91	−0.91	−0.80
ED2	Food rules	Trying to follow definite rules regarding eating to influence shape or weight	−0.38	−0.24	−0.48
ED3	Influence weight	Has weight influenced thinking (judging) about self as a person	0.29	0.11	0.41
ED4	Influence shape	Has shape influenced thinking (judging) about self as a person	0.86	1.06	0.59
ED5	Dissatisfied weight	Being dissatisfied with weight	−0.49	−0.75	−0.26
ED6	Dissatisfied shape	Being dissatisfied with shape	0.70	0.72	1.11
General psychopathology (GPP)					
GP1	Fatigue	Feeling tired quickly	−0.56	−0.79	−0.06
GP2	Self-blame	Blaming self for things happening	−0.12	0.02	−.53
GP3	Irritated	Feeling angry or irritated	−1.35	−1.23	−.82
GP4	Suicidal thoughts	Having thoughts of ending one's own life	−0.86	−1.36	−0.68
GP5	Feeling weak	Feeling fragile or weak	1.01	0.69	1.52[a]

TABLE 1 (Continued)

Node	Symptom	Short Description	S		
			EDs	AN	OSFED
GP6	Anxiety	Feeling fearful or anxious	0.36	0.55	0.22
GP7	Feeling worthless	Feeling worthless	1.88a	1.58[a]	1.62[a]
GP8	Concentration issues	Having difficulty to concentrate on tasks	−0.81	−0.34	−0.76
GP9	Feeling hopeless	Feeling hopeless or desperate	1.04	1.04	1.43
GP10	Disturbing thoughts	Disturbing thoughts which come to the mind and a person cannot get rid of	−0.02	−0.21	0.09
GP11	Feeling worrisome	Feeling that something bad is going to happen	−0.28	−0.63	−0.10
GP12	Afraid of open spaces	Feeling afraid of open spaces, of driving, or being on buses, subways and so forth	−1.47	−1.72	−0.68
GP13	Nervousness	Feeling nervous or jumpy	0.16	0.84	−0.40
GP14	Mind wrong	Feeling that something is wrong with one's own mind	−0.86	−0.62	−1.15
GP15	Sleep problems	Having trouble falling or staying asleep	−2.11	−1.88	−2.23
GP16	Feeling depressed	Feeling sad, blue, or down	2.11[a]	1.42	2.21[a]

Note: S = strength centrality reported in standardized scores.
[a]Strength centrality ≥1.5 *SD* from the mean score.

of nodes and can be quantified with bridge centrality (Jones et al., 2019). Bridge strength centrality (*BS*) was used to quantify the connectivity, measured as the sum of all absolute connections of a symptom with symptoms in another community and was estimated with the bridge function of the networktools R package (Jones, 2020). The three domains of well-being were clustered into one community (well-being), and the two domains of psychopathology in a second community based on the assumptions of the dual-continua model. This allowed for testing which 'symptoms' connect well-being with psychopathology.

2.3.3 | Network stability

The stability of all networks was assessed with the R package bootnet (Epskamp et al., 2016). First, the accuracy of the edge-weights was estimated by drawing non-parametric bootstrapped 95% confidence intervals (CIs) with 2000 bootstraps. Second, the stability of the strength centrality was estimated using the correlation-stability (CS) coefficient with 2000 bootstraps. The CS-coefficient gives an indication of the maximum proportion of cases that can be dropped from the dataset such that with 95% probability the correlation between original centrality indices and centrality indices based on the subsets remains above (by default) 0.7 (Epskamp et al., 2016). The CS-coefficient should not be below 0.25 and preferably above 0.5 (Epskamp et al., 2016).

2.3.4 | Network comparisons

The network comparison test (NCT) package in R (van Borkulo et al., 2017, p. 34) was used to identify network differences between the ED types (research questions 2 and 4). The NCT is a two-tailed permutation test and can be used for examining differences in both cross-sectional groups and repeated measures (van Borkulo et al., 2017, p. 34). The overall network structure and global strength centrality were examined, and *p*-values < 0.05 indicate a significant difference. We tested only for differences in specific edge-weights or strength centrality when the overall tests were statistically significant in order to minimize the likelihood of type I error (Van Borkulo et al., 2017).

3 | RESULTS

3.1 | Patient characteristics

The average age of the patients was 26.9 years (*SD* = 8.9), and the age of onset and duration of the ED was 16.2 years (*SD* = 5.5) and 10.1 years (*SD* = 9.2). One hundred and twenty-eight patients (14.1%) had a personality disorder and 562 patients (62.1%) a co-morbid psychiatric disorder. There were no differences between the ED types in the start age of the ED (Welch's *F* [3, 294.41] = 1.79, *p* = 0.073) and in the proportions of patients having an personality disorder (χ^2 [3] = 3.46, *p* = 0.326) or other psychiatric disorder (χ^2 [3] = 1.69, *p* = 0.640). However, statistically

TABLE 2 Patient characteristics

N	ED 905	AN 318	BN 195	BED 80	OSFED 312	Statistics	
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	F	Post-hoc analysis
Age	26.9 (8.9)	24.6 (7.9)	27.1 (7.5)	31.2 (10.4)	28.0 (9.6)	14.81*	BED > AN, BN; AN < BN, OSFED
Startage ED	16.2 (5.5)	16.4 (4.8)	16.6 (5.3)	14.8 (6.5)	16.2 (6.0)	2.33	
ED duration	10.1 (9.2)	7.6 (7.7)	9.5 (7.2)	15.9 (11.0)	11.6 (10.3)	19.33*	BED > AN, BN, OSFED; BN < OSFED; AN < BN, OSFED;
BMI kg/m^2	21.7 (7.2)	16.5 (1.7)	22.5 (3.9)	32.2 (8.4)	23.9 (7.4)	302.94*	AN < BN, BED, OSFED; BED > BN, OSFED; BN < OSFED
	N (%)	n (%)	n (%)	n (%)	n (%)	χ^2	Post-hoc analysis
Personality disorder	128 (14.1%)	54 (17%)	24 (12.3%)	9 (11.3%)	41 (13.1%)	3.46	
Co-morbid disorder**	562 (62.1%)	200 (62.9%)	127 (65.1%)	49 (61.3%)	186 (59.6%)	1.69	

Note: *p-value < 0.001, **Co-morbid disorders include mood and anxiety, developmental, trauma-related, neurocognitive and addictive disorders.

significant differences between the ED types were found for age (Welch's F [3,297.41] = 14.81, p < 0.001), duration of the ED (Welch's (F [3,295.59] = 19.33, p < 0.001), and body mass index (BMI kg/m^2) (Welch's F [3, 254.07] = 302.94, p < 0.001). See Table 2 for an overview of the results of the post-hoc analyses with the specific differences between the ED types.

3.2 | Domain mental health networks

Research questions 1 and 2 concerned the network structure and potential differences between the ED types of the domain mental health networks. First the accuracy of the networks was tested. The overall network structure was considered stable for the ED, AN, BN and OSFED networks with relatively small edge-weights CI's (see the supporting information for the figures). The BED network showed somewhat larger CI's compared to the other networks. The strength centrality was excellent for the overall ED (CS(cor = 0.7) = 0.75), AN (CS(cor = 0.7) = 0.75), BN (CS(cor = 0.7) = 0.67) BED (CS(cor = 0.7) = 0.60) and OSFED (CS(cor = 0.7) = 0.75) network.

3.2.1 | Network estimates

Figure 1 represents the domain mental health networks per ED type. All networks show positive associations between the well-being domains and between the psychopathology domains. The associations between well-being and psychopathology were negative, with the strongest edge-weights between EWB, PWB and GPP. EDP was not, or only weakly connected with the well-being domains.

Table 3 shows the strength (*S*) centralities of the nodes and the mean scores of the domains. The results demonstrate that the most central overall mental health domains across all ED types is PWB (*S* = 1.37), followed by GPP (*S* = 0.26) and EWB (*S* = 0.21), and the least central domain is EDP (*S* = −1.33).

3.2.2 | Network comparisons

The bootstrapped difference test (NCT) did not show significant differences in the network structure and global strength between the AN, BN BED and OSFED networks on overall network structure and global strength (see the supporting information).

3.3 | Symptom mental health networks

Research questions 3 and 4 concerned the symptom mental health network structure and potential differences between the ED types. The accuracy of the networks was tested. The bootstrapped CI's of the edge-weights were considered relatively stable in the total ED network, as well as the AN, BN and OSFED network. The BED network was however considered unstable (see the supporting information for the figures). The overall strength centrality for the symptom networks were stable for the ED (CS(cor = 0.7) = 0.75), AN (CS (cor = 0.7) = 0.59) and OSFED network (CS (cor = 0.7) = 0.52). The BN (CS(cor = 0.7) = 0.21) and BED (CS(cor = 0.7) = 0.00) networks were however considered unstable, and therefore not estimated and used for comparisons.
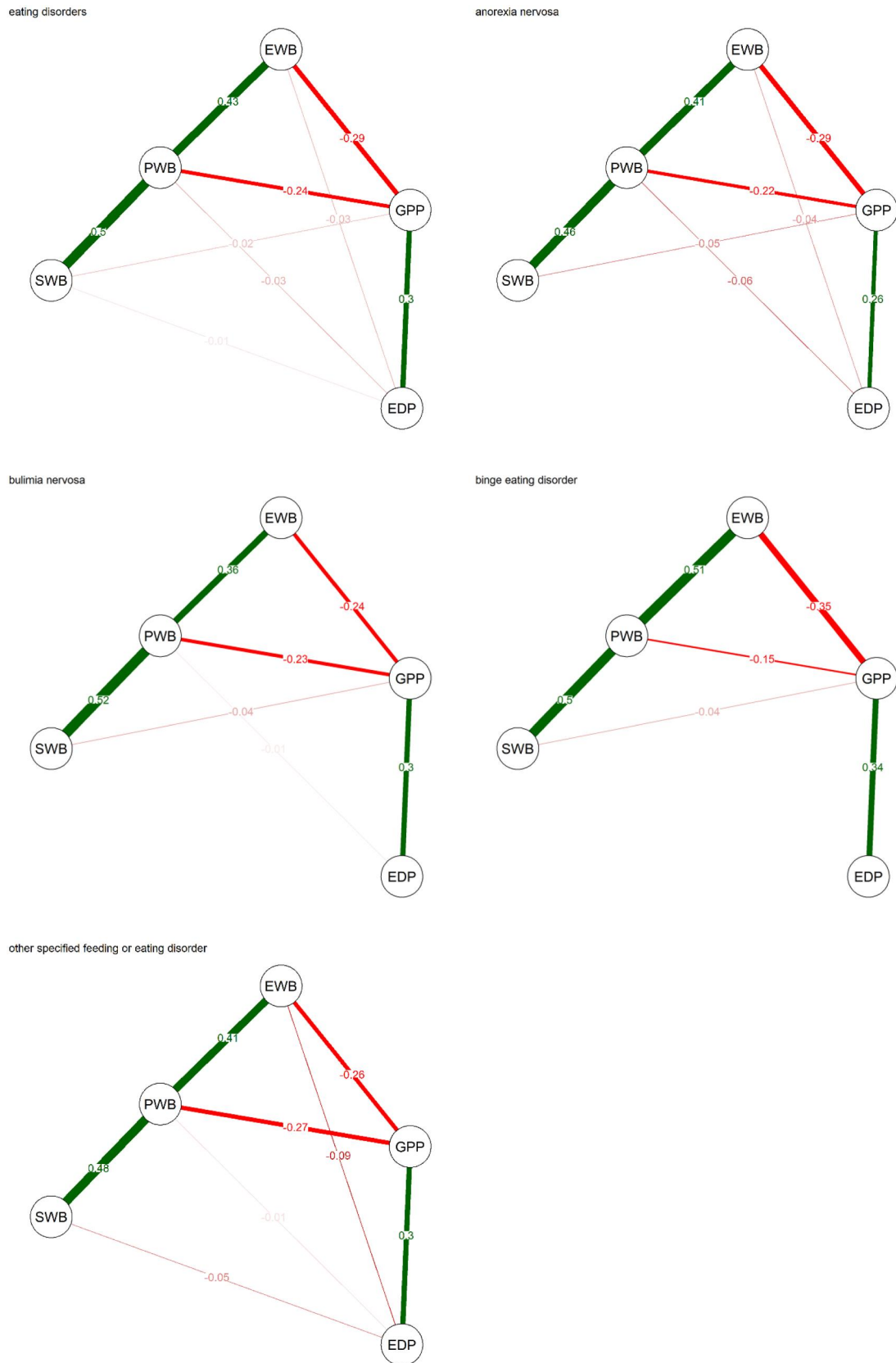
FIGURE 1 Domain mental health networks per ED type. EDP, eating disorder psychopathology; EWB, emotional well-being; GPP, general psychopathology; PWB, psychological well-being; SWB, social well-being [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 3 Mean scores and strength centrality and mean scores of the domain mental health networks for each ED type

Node	Description	ED M (SD)	S	AN M (SD)	S	BN M (SD)	S	BED M (SD)	S	OSFED M (SD)	S
EDP	ED psychopathology	3.84 (1.21)	−1.33	3.77 (1.21)	−1.41	4.11 (1.12)	−1.48	3.46 (1.01)	−1.38	3.79 (1.26)	−1.28
GPP	General psychopathology	34.35 (9.80)	0.26	36.05 (9.43)	0.16	35.08 (9.51)	0.26	29.56 (8.02)	0.18	32.94 (10.13)	0.22
EWB	Emotional well-being	2.44 (1.11)	0.21	2.24 (1.16)	0.37	2.44 (1.07)	0.07	2.72 (1.08)	0.48	2.58 (1.06)	0.27
PWB	Psychological well-being	2.37 (1.01)	1.37	2.23 (1.02)	1.30	2.30 (0.99)	1.30	2.67 (1.04)	1.25	2.50 (0.99)	1.37
SWB	Social well-being	2.13 (1.00)	−0.49	2.11 (0.95)	−0.42	1.98 (1.01)	−0.15	2.27 (1.14)	−0.53	2.22 (1.00)	−0.58

Note: S = strength centrality reported in standardized scores.
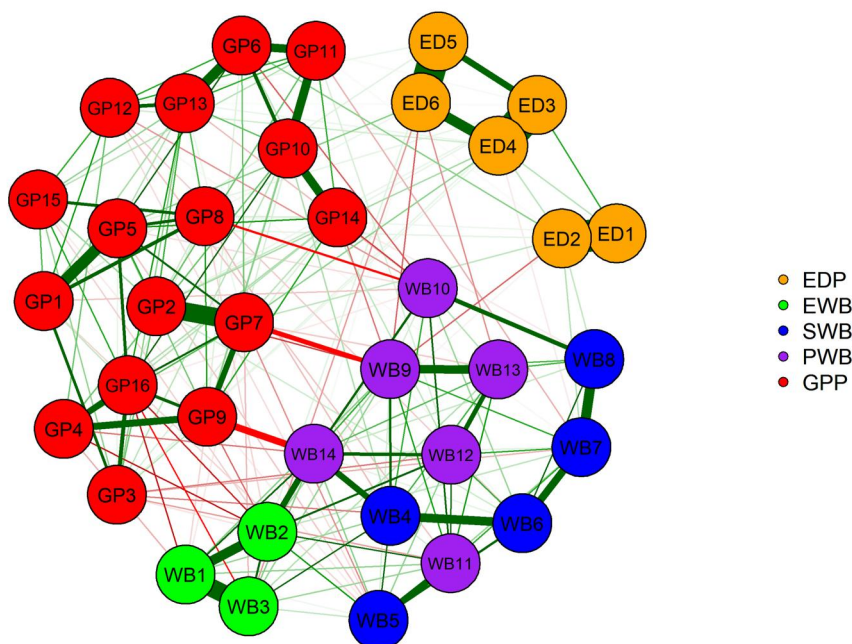

FIGURE 2 Symptom mental health networks. Descriptions of the nodes can be found in Table 1 [Colour figure can be viewed at wileyonlinelibrary.com]

3.4 | Network estimates

Figure 2 shows the symptom mental health network for the total ED group. The network shows overall positive associations between the well-being symptoms, positive associations between the psychopathology symptoms and negative associations between both. The strongest bridge symptoms (≥1.5 *SD* from the *BS* mean) for the ED network were; *self-acceptance* (WB9, *BS* = 0.40), *environmental mastery* (WB10, *BS* = 0.35), *interested in life* (WB2, *BS* = 0.28) and *feeling depressed* (GP16, *BS* = 0.28). For the AN and OSFED network respectively the following bridge symptoms were found, *self-acceptance* (WB9, *BS* = 0.35), *feeling depressed* (GP16, *BS* = 0.32), *interested in life* (WB2, *BS* = 0.32), and; *environmental mastery* (WB10, *BS* = 0.41), *feeling hopeless* (GP9,

BS = 0.35), *self-acceptance* (WB9, *BS* = 0.34) and *feeling depressed* (GP16, *BS* = 0.33). The AN and OSFED networks can be found in the supporting information, as well as the *BS* centrality of all symptoms.

The node strength centrality of the networks can be found in Figure 3 and Table 1. The most central nodes (≥1.5 SD from the mean *S* centrality): were *feeling depressed* (GP16, *S* = 2.11), *feeling worthless* (GP7, *S* = 1.88), *purpose in life* (WB14, *S* = 1.79) and *self-acceptance* (WB9, *S* = 1.53) for the ED network, *purpose in life* (WB14, *S* = 1.96), *self-acceptance* (WB9, *S* = 1.86) and *feeling worthless* (GP7, *S* = 1.58) for the AN network and *feeling depressed* (GP16, *S* = 2.21), *feeling worthless* (GP7, *S* = 1.62), *purpose in life* (WB14, *S* = 1.61) and *feeling weak* (GP5, *S* = 1.52) for the OSFED network.
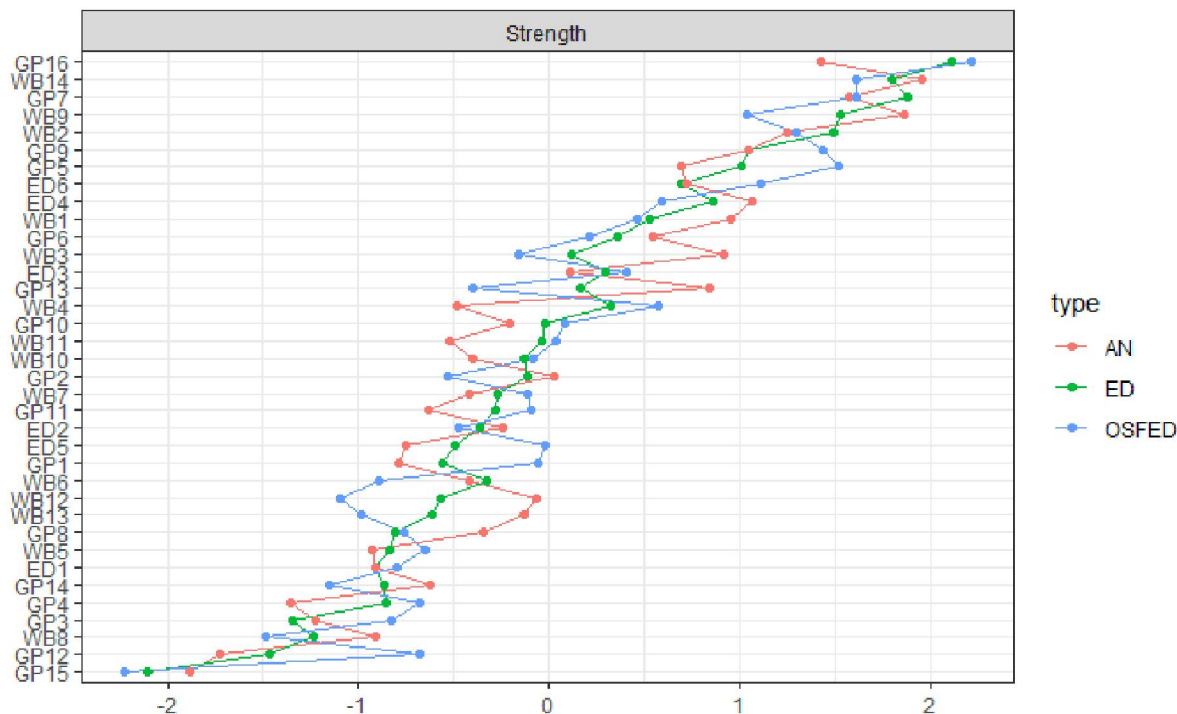
FIGURE 3 Strength centrality of the symptom mental health networks. Standardized scores in descending order [Colour figure can be viewed at wileyonlinelibrary.com]

3.4.1 | Comparisons

The AN and OSFED networks were compared on overall network structure and strength centrality. No differences were found in the overall network structure ($M = 0.20$, $p > 0.05$) and global network strength ($S = 0.18$, $p > 0.05$).

4 | DISCUSSION

Well-being and psychopathology are two distinct but related dimensions of mental health according to the dual continua model (Keyes, 2012). From a psychometric perspective, it is unclear which mental health domains (i.e. emotional, psychological and social well-being, general and ED specific psychopathology) and their underlying symptoms are central and related to each other. This study aimed to examine psychometric networks of mental health in ED patients on a domain and symptom level.

4.1 | Domain mental health networks

The strongest negative associations between well-being and psychopathology were between EWB, PWB and GPP, while the associations of well-being with EDP were negligible. These results are in accordance with earlier

research (de Vos et al., 2018) and imply that improvements in specific ED psychopathology, may not necessarily lead to changes in well-being and vice versa. Several pathways may explain the absence of significant associations between well-being and EDP. For instance, a low insight in, or denial of the disease's severity may contribute to inaccuracy in self-reporting among ED patients (Vitousek et al., 1998). This may also apply to other aspects of mental health, such as well-being. Based on clinical experience, some patients may still function well in society, have an academic career, and therefore report adequate (social) well-being despite the illness. Lastly, binge eating and other ED behaviours may serve as a mechanism to cope with daily stressors and anxiety, making it possible to function relatively adequately in society, as long as the disadvantages, such as shame, low self-worth, inter-personal problems and physical consequences do not overweigh the advantages of being able to cope with daily stressors (Goss & Gilbert, 2002).

The most central node (RQ1) in the domain network was PWB, followed by EWB and GPP. Theories on mental health have emphasized PWB as essential for living a good and fulfilling life (Ryff & Singer, 1996, 2008, 2008). ED patients report lower PWB than controls (de Vos et al., 2018; Tomba et al., 2014), while its presence is considered essential for personal recovery (de Vos et al., 2017). In a qualitative meta-analysis, it was found that recovered individuals consider several aspects of

PWB, such as self-acceptance, positive relationships, personal growth and autonomy as fundamental criteria for ED recovery (de Vos et al., 2017).

No differences between the ED types were found (RQ2) in the overall network structure and strength centrality. This study is in accordance with earlier research examining bivariate correlations between the mental health domains, where low correlations (edge-weights) between well-being and EDP were found for AN and OSFED and no relevant correlations (edge-weights) for BN and BED (de Vos et al.,2018). However, it is important to note that an unknown but substantial number of the same patients were present in this study and the earlier study from de Vos et al. (2018). The results suggest that the overall structure of mental health may be independent of the ED type. This is consistent with the idea that well-being and GPP are transdiagnostic constructs. Fava and Guidi (2020) note that the pursuit of mental health cannot be conceived as a therapeutic intervention for specific mental disorders, but as a transdiagnostic strategy incorporated in individualized therapeutic plans.

4.2 | Symptom mental health networks

The most central symptoms (RQ3) in the overall mental health network were *feeling depressed*, *feeling worthless*, *purpose in life* and *self-acceptance*, and the most influential bridge symptoms *self-acceptance*, *environmental mastery*, *interested in life*, and *feeling depressed*. This is largely in line with earlier co-morbidity network studies. Earlier studies considered *feeling depressed* and *feeling worthless* also as highly central symptoms in co-morbidity networks among ED patients (Elliott et al., 2020; Smith et al., 2019; Solmi, Collantoni, et al., 2019). A general conclusion of the co-morbidity network studies was that these central transdiagnostic symptoms should be addressed in treatment in addition to the ED symptoms in order to improve overall psychopathology. This study adds to the knowledge that several influential well-being symptoms should also be considered in a transdiagnostic approach for treatment addressing mental health.

Several influential ED symptoms were found in network pathology studies (DuBois et al., 2017; Elliott et al., 2020; Forbush et al., 2016; Levinson et al., 2017; Wang et al., 2019), such as *weight-related concerns* and *shape and weight over-evaluation*. However, ED symptoms were not influential in the mental health networks. While relationships between happiness, depression and perceived body image have been substantiated in an earlier study (Stokes & Frederick-Recascino, 2003), this study showed relatively small edge-weights between ED pathology and well-being.

Based on the results, we conclude that in order to improve overall mental health, a focus in treatment may be warranted on influential symptoms, such as *feeling depressed*, *feeling worthless*, *purpose in life* and *self-acceptance*. Although the role and importance of centrality in network analysis are still under debate (Bringmann et al., 2019), network theory suggests that changes or improvements on these central (bridge) symptoms, may lead to improvements of the overall mental health network, while changes in peripheral symptoms may less likely lead to changes in other symptoms (Borsboom, 2016; McNally, 2016). A recent network study among patients with AN showed that central symptoms predict posttreatment outcomes and clinical impairment, which supports the validity of network theory in that central symptoms may have a strong influence on clinical impairment and recovery (Elliott et al., 2020).

This study found no differences in the symptom networks between AN and OSFED (RQ4). These results may support a transdiagnostic approach in clinical treatment to promote mental health in ED patients, as suggested by Fava and Guidi (2020). However, the network stability for patients with BN and BED was insufficient in this exploratory study. Also, differences between BN, BED and the other ED types were found on several background characteristics. The insufficient stability of the networks and potentially confounding background characteristics make it difficult to draw firm conclusions across all ED types. New research is needed to further examine the transdiagnostic approach in clinical treatment for ED patients.

Several psychological treatments have been developed specifically targeting some of these mental health symptoms or aspects. These treatments may be effective by addressing influential mental health symptoms. Enhanced cognitive-behavioural therapy (CBT-E) for EDs was developed to target feelings of worthlessness, hopelessness and low self-esteem (Cooper & Fairburn, 2011). Acceptance and commitment therapy (ACT) helps patients choose life directions in various domains (i.e. meaning and purpose in life) with committed action (Hayes et al., 2016). Compassion focused therapy (CFT) strongly emphasizes the importance of alleviating self-criticism and shame by fostering self-acceptance or compassion (Gilbert, 2009). Well-being therapy addresses all six aspects of PWB (Fava et al., 1998; Fava et al., 2005; Radstaak et al., 2020). Outcome studies show that these so-called third-wave behavioural treatments effectively alleviate symptoms in ED patients (Linardon et al., 2017). However, little is known about whether these treatments help to improve patients overall mental health. Gains in positive functioning are frequently not considered in

outcome studies, despite the impaired PWB in clinical populations (Tomba & Tecuta, 2016). Studies should focus on the effectiveness of interventions on both ED pathology and transdiagnostic criteria.

4.3 | Limitations

A limitation is that the network analyses were performed on a cross-sectional level. This means that no causal inferences or prognostic consideration can be drawn and longitudinal study designs with multiple measurements, using a random intercept cross-lagged panel model (Hamaker et al., 2015) or panel data network analysis (Epskamp, 2020) may provide more definite knowledge on the associations between the domains and potential causal determinants. We excluded several items from the general psychopathology domain showing topological overlap with well-being items. However, excluding them from the psychopathological domain instead of the well-being domain was arbitrary and may have led to different results if they were excluded from the well-being domain. However, the pathological items were positively worded, for instance, 'interested in life', which seems to be more about well-being or positive mental health. We considered nodes with an S SD $\geq$ 1.5 as the most central nodes, which is arbitrary. There are currently no specific rules of thumb as we are aware of how many nodes should be classified as central. It is possible that not all relevant symptoms for mental health were included. For instance it was found that resilience was considered important for mental health and recovery among ED patients (Calvete et al., 2017; de Vos et al., 2017). We were not able to obtain data of psychotropic drug use among the patients, while the use of psychotropic drugs may alter feelings of well-being and psychopathological symptoms. Another limitation is that the BN and BED networks were not considered stable and therefore not tested. This also means that the overall ED network results and conclusions should be interpreted with caution and may not apply to BN and BED patients. It is recommended to test the symptom networks in larger groups of patients with BN and BED. At last, self-report measures were used, which are subject to measurement biases (Anglim et al., 2020).

5 | CONCLUSION

This study shows novel associations between well-being and psychopathology in eating disorder patients. Psychological well-being was the most central mental health domain, and the most central underlying symptoms were

feeling depressed, *feeling worthless*, *purpose in life* and *self-acceptance*. Primary bridge symptoms between well-being and psychopathology were *self-acceptance*, *environmental mastery*, *interested in life* and *feeling depressed*. A transdiagnostic approach to ED treatment, focusing on central psychopathological and well-being symptoms may be warranted in order to improve overall mental health in patients with EDs.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available upon reasonable request by contacting the corresponding author.

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REFERENCES
Anglim, J., Horwood, S., Smillie, L. D., Marrero, R. J., & Wood, J. K. (2020). Predicting psychological and subjective well-being from personality: A meta-analysis. *Psychological Bulletin*, *146*(4), 279–323.

Bohlmeijer, E. T., Bolier, L., Westerhof, G. J., & Walburg, J. A. (2012). *Handboek Positieve psychologie [Handbook positive Psychology]*. Amsterdam: Uitgeverij Boom.

Borsboom, D. (2016). A network theory of mental disorders. *World Psychiatry*, *16*(1), 5–13. https://doi.org/10.1002/wps.20375

Bringmann, L. F., Elmer, T., & Epskamp, S. (2019). What do centrality measures measure in psychological networks? *Journal of Abnormal Psychology*, *136*(1), 1–34. https://doi.org/10.13140/RG.2.2.25024.58884

Calvete, E., Las Hayas, C., & Gómez Del Barrio, A. (2017). Longitudinal associations between resilience and quality of life in eating disorders. *Psychiatry Research*, *259*, 470–475. https://doi.org/10.1016/j.psychres.2017.11.031

Christian, C., Perko, V. L., Vanzhula, I. A., Tregarthen, J. P., Forbush, K. T., & Levinson, C. A. (2019). Eating disorder core symptoms and symptom pathways across developmental stages: A network analysis. *Journal of Abnormal Psychology*, *129*(2), 177–190. https://doi.org/10.1037/abn0000477

Cooper, Z., & Fairburn, C. G. (2011). The evolution of 'enhanced' cognitive behavior therapy for eating disorders: Learning from treatment nonresponse. *The Cognitive and Behavioral Practice*, *18*(3), 394–402. https://doi.org/10.1016/j.cbpra.2010.07.007

De Jong, K., Nugter, M., Lambert, M., & Burlingame, G. (2008). *Handleiding voor afname en scoring van de Outcome Questionnaire (OQ− 45.2) [Manual for administering and scoring of the Outcome Questionnaire].*

De Vos, J. A., Lamarre, A., Radstaak, M., Bijkerk, C. A., Bohlmeijer, E. T., & Westerhof, G. J. (2017). Identifying fundamental criteria for eating disorder recovery: A systematic review and qualitative meta-analysis. *Journal of Eating Disorders*, *5*(34), 1–14. https://doi.org/10.1186/s40337-017-0164-0

De Vos, J. A., Radstaak, M., Bohlmeijer, E. T., & Westerhof, G. J. (2018). Having an eating disorder and still being able to

flourish? Examination of pathological symptoms and well-being as two continua of mental health in a clinical sample. *Frontiers in Psychology*, 9(October), 2145. https://doi.org/10.3389/FPSYG.2018.02145

DuBois, R. H., Rodgers, R. F., Franko, D. L., Eddy, K. T., & Thomas, J. J. (2017). A network analysis investigation of the cognitive-behavioral theory of eating disorders. *Behaviour Research and Therapy*, 97, 213–221. https://doi.org/10.1016/j.brat.2017.08.004

Elliott, H., Jones, P. J., & Schmidt, U. (2020). Central symptoms predict posttreatment outcomes and clinical impairment in anorexia nervosa: A network analysis. *Clinical Psychological Science*, 8(1), 139–154. https://doi.org/10.1177/2167702619865958

Engel, G. (1977). The need for a new medical model: A challenge for biomedicine. *Science*, 196(4286), 129–136. https://doi.org/10.1126/science.847460

Epskamp, S. (2020). Psychometric network models from time-series and panel data. *Psychometrika*, 85, 206–231. https://doi.org/10.1007/s11336-020-09697-3

Epskamp, S., Borsboom, D., & Fried, E. I. (2016). Estimating psychological networks and their accuracy: A tutorial paper. https://doi.org/10.3758/s13428-017-0862-1

Epskamp, S., Borsboom, D., & Fried, E. I. (2018). Estimating psychological networks and their accuracy: A tutorial paper. *Behavior Research*, 50(1), 195–212. https://doi.org/10.3758/s13428-017-0862-1

Epskamp, S., Cramer, A. O. J., Waldorp, L. J., Schmittmann, V. D., & Borsboom, D. (2012). qgraph: Network visualizations of relationships in psychometric data. *Journal of Statistical Software*, 48(4). https://doi.org/10.18637/jss.v048.i04

Epskamp, S., & Fried, E. I. (2017). A tutorial on regularized partial correlation networks. *Psychological Methods*, 23(4), 617–634. https://doi.org/10.1037/met0000167

Fairburn, C. G., Bailey-Straebler, S., Basden, S., Doll, H. A., Jones, R., Murphy, R., Cooper, M. E., Cooper, Z. (2015). A trans-diagnostic comparison of enhanced cognitive behaviour therapy (CBT-E) and interpersonal psychotherapy in the treatment of eating disorders. *Behaviour Research and Therapy*, 70, 64–71. https://doi.org/10.1016/j.brat.2015.04.010

Fava, G. A., & Guidi, J. (2020). The pursuit of euthymia. *World Psychiatry*, 19(1), 40–50. https://doi.org/10.1002/wps.20698

Fava, G. A., Rafanelli, C., Cazzaro, M., Conti, S., & Grandi, S. (1998). Well-being therapy. A novel psychotherapeutic approach for residual symptoms of affective disorders. *Psychological Medicine*, 28(2), 475–480. https://doi.org/10.1017/S0033291797006363

Fava, G. A., Ruini, C., Rafanelli, C., Finos, L., Salmaso, L., Mangelli, L., & Sirigatti, S. (2005). Well-being therapy of generalized anxiety disorder. *Psychotherapy and Psychosomatics*, 74(1), 26–30. https://doi.org/10.1159/000082023

Forbush, K. T., Siew, C. S. Q., & Vitevitch, M. S. (2016). Application of network analysis to identify interactive systems of eating disorder psychopathology. *Psychological Medicine*, 1–11.2016. https://doi.org/10.1017/S003329171600012X

Forrest, L. N., Jones, P. J., Ortiz, S. N., & Smith, A. R. (2018). Core psychopathology in anorexia nervosa and bulimia nervosa: A network analysis. *International Journal of Eating Disorders*, 51(7), 668–679. https://doi.org/10.1002/eat.22871

Forrest, L. N., Sarfan, L. D., Ortiz, S. N., Brown, T. A., Smith, A. R., & Diego, S. (2019). Bridging eating disorder symptoms and trait anxiety in patients with eating disorders: A network approach. *International Journal of Eating Disorders*, 52(6), 701–711.

Franken, K., Lamers, S. M. A., Ten Klooster, P. M., Bohlmeijer, E. T., & Westerhof, G. J. (2018). Validation of the mental health continuum-short form and the dual continua model of well-being and psychopathology in an adult mental health setting. *Journal of Clinical Psychology*, 1–16.2017. https://doi.org/10.1002/jclp.22659

Gilbert, P. (2009). Introducing compassion-focused therapy. *Advances in Psychiatric Treatment*, 15(3), 199–208. https://doi.org/10.1192/apt.bp.107.005264

Goss, K., & Gilbert, P. (2002). Eating disorders, shame and pride. In P. Gilbert, & J. Miles (Eds.), *Body shame, Conceptualisation, research and treatment* (1st ed.). Routledge.

Grilo, C. M., Reas, D. L., Hopwood, C. J., & Crosby, R. D. (2015). Factor structure and construct validity of the eating disorder examination-questionnaire in college students: Further support for a modified brief version. *International Journal of Eating Disorders*, 48(3), 284–289. https://doi.org/10.1002/eat.22358.Factor

Hamaker, E. L., Kuiper, R. M., Grasman, R. P. P. P., Sciences, B., & Sciences, B. (2015). A critique of the cross-lagged panel model. *Psychological Methods*, 20(1), 102–116. https://doi.org/10.1037/a0038889

Hayes, S. C., Luoma, J., Bond, F. W., Masuda, A., & Lillis, J. (2016). Acceptance and commitment therapy: Model, processes, and outcomes. *The Act in Context: The Canonical Papers of Steven C. Hayes*, 249–279. https://doi.org/10.4324/9781315745138

Himmerich, H., Bentley, J., Kan, C., & Treasure, J. (2019). Genetic risk factors for eating disorders: An update and insights into pathophysiology. *Therapeutic Advances in Psychopharmacology*, 9, 1–20. https://doi.org/10.1177/https

Jones, P. J. (2020). *Networktools: Assorted tools for identifying important nodes in networks.* R package version 1.2.3.

Jones, P. J., Ma, R., & McNally, R. J. (2019). Bridge centrality: A network approach to understanding comorbidity. *Multivariate Behavioral Research*, 0(0), 1–15. https://doi.org/10.1080/00273171.2019.1614898

Keyes, C. L. M. (1998). Social well-being. *Social Psychology Quarterly*, 61(2), 121–140.

Keyes, C. L. M. (2002). The mental health continuum: From languishing to flourishing in life. *Journal of Health and Social Behavior*, 43(2), 207–222. https://doi.org/10.2307/3090197

Keyes, C. L. M. (2005). Mental illness and/or mental health? Investigating axioms of the complete state model of health. *Journal of Consulting and Clinical Psychology*, 73(3), 539–548. https://doi.org/10.1037/0022-006X.73.3.539

Keyes, C. L. M. (2006). Subjective well-being in mental health and human development research worldwide: An introduction. *Social Indicators Research*, 77(1), 1–10. https://doi.org/10.1007/s11205-005-5550-3

Keyes, C. L. M. (2012). Toward a science of mental health. *The Oxford handbook of positive psychology* (2 Ed.). https://doi.org/10.1093/oxfordhb/9780195187243.013.0009

Keyes, C. L. M., Wissing, M., Potgieter, J. P., Temane, M., Kruger, A., & van Rooy, S. (2008). Evaluation of the mental health

continuum-short form (MHC-SF) in setswana-speaking South Africans. *Clinical Psychology & Psychotherapy*, 15(3), 181–192. https://doi.org/10.1002/cpp.572

Lamers, S. M. A., Westerhof, G. J., Bohlmeijer, E. T., Ten Klooster, P. M., & Keyes, C. L. M. (2011). Evaluating the psychometric properties of the mental health Continuum-Short Form (MHC-SF). *Journal of Clinical Psychology*, 67(1), 99–110. https://doi.org/10.1002/jclp.20741

Langer, C. A., Zerwas, S., Calebs, B., Forbush, K., Kordy, H., Watson, H., Bulik, S., Levine, M., Crosby, R. D., Peat, C., Runfola, C. D., Zimmer, B., Moesner, M., Marcus, M. D., Bulik, C. M. (2017). .The core symptoms of bulimia nervosa, anxiety, and depression: A network analysis, *Journal of Abnormal Psychology*. 126, 340–354. https://doi.org/10.1037/abn0000254

Levinson, C. A., Brosof, L. C., Vanzhula, I., Christian, C., Jones, P., Rodebaugh, T. L., Fernandez, J. K., White, E. K., Warren, C., Weeks, J. W., Menatti, A., Lim, M. H., Fernandez, K. C. (2018). Social anxiety and eating disorder comorbidity and underlying vulnerabilities: Using network analysis to conceptualize comorbidity. *International Journal of Eating Disorders*, 51(7), 693–709. https://doi.org/10.1002/eat.22890

Linardon, J., Fairburn, C. G., Fitzsimmons-Craft, E. E., Wilfley, D. E., & Brennan, L. (2017). The empirical status of the third-wave behaviour therapies for the treatment of eating disorders: A systematic review. *Clinical Psychology Review*, (October). https://doi.org/10.1016/j.cpr.2017.10.005

Machado, P. P. P., Grilo, C. M., Rodrigues, T. F., Vaz, A. R., & Crosby, R. D. (2020). Eating disorder examination – questionnaire short forms: A comparison. *International Journal of Eating Disorders*, 53(6), 937–944. https://doi.org/10.1002/eat.23275

Magalhães, E., & Calheiros, M. M. (2017). A dual-factor model of mental health and social support: Evidence with adolescents in residential care. *Children and Youth Services Review*, 79, 442–449. https://doi.org/10.1016/j.childyouth.2017.06.041

McNally, R. J. (2016). Can network analysis transform psychopathology? *Behaviour Research and Therapy*, 86, 95–104. https://doi.org/10.1016/j.brat.2016.06.006

Monteleone, A. M., Mereu, A., Cascino, G., Criscuolo, M., Maria, P. S. Y., Castiglioni, C., Zanna, V. (2019). Re-conceptualization of anorexia nervosa psychopathology: A network analysis study in adolescents with short duration of the illness (pp. 1263–1273). https://doi.org/10.1002/eat.23137

O'Connor, C. G., & Beglin, S. (1994). Assessment of eating disorders: Interview or self-report questionnaire? *International Journal of Eating Disorders*, 16(4), 363–370.

Perko, V. L., Forbush, K. T., Siew, C. S. Q., & Tregarthen, J. P. (2019). Application of network analysis to investigate sex differences in interactive systems of eating-disorder psychopathology. *International Journal of Eating Disorders*, 20(February), 1343–1352. https://doi.org/10.1002/eat.23170

Perugini, M. L. L., de la Iglesia, G., Castro Solano, A., & Keyes, C. L. M. (2017). The mental health continuum–short form (MHC–SF) in the Argentinean context: Confirmatory factor analysis and measurement invariance. *Europe's Journal of Psychology*, 13(1), 93–108. https://doi.org/10.5964/ejop.v13i1.1163

Peter, T., Roberts, L. W., & Dengate, J. (2011). Flourishing in life: An empirical test of the dual continua model of mental health

and mental illness among Canadian university students. *International Journal of Mental Health Promotion*, 13(1), 13–22. https://doi.org/10.1080/14623730.2011.9715646

Radstaak, M., Hüning, L., & Bohlmeijer, E. T. (2020). Well-being therapy as rehabilitation therapy for posttraumatic stress disorder symptoms: A randomized controlled trial. *Journal of Traumatic Stress*, 1–11. https://doi.org/10.1002/jts.22500

Ryff, C. D. (2014). Psychological well-being revisited: Advances in the science and practice of Eudaimonia. *Psychotherapy and Psychosomatics*, 83, 10–28.

Ryff, C. D., & Singer, B. (1996). Psychological weil-being: Meaning, measurement, and implications for psychotherapy research. *Psychotherapy and Psychosomatics*, 65(1), 14–23. https://doi.org/10.1159/000353263

Slof-Op't Landt, M. C. T., Dingemans, A. E., de la Torre Y Rivas, J., & van Furth, E. F. (2019). Self-assessment of eating disorder recovery: Absence of eating disorder psychopathology is not essential. *International Journal of Eating Disorders*(April), 1–6. https://doi.org/10.1002/eat.23091

Smith, K. E., Mason, T. B., Crosby, R. D., Cao, L., Leonard, R. C., Wetterneck, C. T., & Hospital, M. (2020). A comparative network analysis of eating disorder psychopathology and co-occurring depression and anxiety symptoms before and after treatment. *Psychological Medicine*, 49(2), 314–324. https://doi.org/10.1017/S0033291718000867.A

Smith, K. E., Mason, T. B., Crosby, R. D., Cao, L., Leonard, R. C., Wetterneck, C. T., Moessner, B. E. R., Farrell, N. R., Riemann, B. C., Wonderlich, S. A., Moessner, M. (2019). A comparative network analysis of eating disorder psychopathology and co-occurring depression and anxiety symptoms before and after treatment. *Psychological Medicine*, 49(2), 314–324. https://doi.org/10.1017/S0033291718000867

Solmi, M., Collantoni, E., Meneguzzo, P., Tenconi, E., & Favaro, A. (2019). Network analysis of specific psychopathology and psychiatric symptoms in patients with anorexia nervosa. *European Eating Disorders Review*, 27(1), 24–33. https://doi.org/10.1002/erv.2633

Solmi, M., Koyanagi, A., Thompson, T., Fornaro, M., Correll, C. U., & Veronese, N. (2019). Corrigendum: Network analysis of the relationship between depressive symptoms, demographics, nutrition, quality of life and medical condition factors in the osteoarthritis initiative database cohort of elderly North-American adults with or at risk for ost. *Epidemiology and Psychiatric Sciences*, 29, e22. https://doi.org/10.1017/S2045796019000064

Stokes, R., & Frederick-Recascino, C. (2003). Women's perceived body image: Relations with personal happiness. *Journal of Women & Aging*, 15(1), 17–29.

Tomba, E., Offidani, E., Tecuta, L., Schumann, R., & Ballardini, D. (2014). Psychological well-being in out-patients with eating disorders: A controlled study. *International Journal of Eating Disorders*, 47(3), 252–258. https://doi.org/10.1002/eat.22197

Tomba, E., & Tecuta, L. (2016). Well-being therapy in a patient with anorexia nervosa. *Psychotherapy and Psychosomatics*, 85, 369–370.

Trompetter, H. R., Lamers, S. M. A., Westerhof, G. J., Fledderus, M., & Bohlmeijer, E. T. (2017). Both positive mental health and psychopathology should be monitored in psychotherapy:

Confirmation for the dual-factor model in acceptance and commitment therapy. *Behaviour Research and Therapy*, *91*, 58–63. https://doi.org/10.1016/j.brat.2017.01.008

van Borkulo, C. D., Boschloo, L., Kossakowski, J. J., Tio, P., Schoevers, R. A., Borsboom, D., & Waldorp, L. J. (2017). Comparing network structures on three aspects: A permutation test. *Manuscript Submitted*, 34. (March) https://doi.org/10.13140/RG.2.2.29455.38569

Vanzhula, I. A., Calebs, B., Fewell, L., & Levinson, C. A. (2019). Illness pathways between eating disorder and post-traumatic stress disorder symptoms: Understanding comorbidity with network analysis. *European Eating Disorders Review*, *27*(2), 147–160. https://doi.org/10.1002/erv.2634

Vitousek, K., Watson, S., & Wilson, G. T. (1998). Enhancing motivation for change in treatment-resistant eating disorders. *Clinical Psychology Review*, *18*(4), 391–420.

Wang, S. B., Jones, P. J., Dreier, M., Elliott, H., & Grilo, C. M. (2019). Core psychopathology of treatment-seeking patients with binge-eating disorder: A network analysis investigation. *Psychological Medicine*, *49*(11), 1923–1928. https://doi.org/10.1017/S0033291718002702

Warmerdam, L., Barendregt, M., & de Beurs, E. (2017). Risk adjustment of self-reported clinical outcomes in Dutch mental health care. *Journal of Public Health*, *25*(3), 311–319. https://doi.org/10.1007/s10389-017-0785-4

Westerhof, G. J., & Keyes, C. L. M. (2008). Geestelijke gezondheid is meer dan de afwezigheid van geestelijke ziekte. *MGV*, *10*(63), 808–820.

Westerhof, G. J., & Keyes, C. L. M. (2010). Mental illness and mental health: The two continua model across the lifespan. *Journal of Adult Development*, *17*(2), 110–119. https://doi.org/10.1007/s10804-009-9082-y

Zachar, P., & Kendler, K. S. (2007). Psychiatric disorders: A conceptual taxonomy. *AJP*, *164*(4), 557. https://doi.org/10.1176/appi.ajp.164.4.557

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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