

ON THE DIMENSIONAL APPROACH TO ADOLESCENT PSYCHOPATHOLOGY: A SYSTEMATIC REVIEW

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SUMMARY

In child and adolescent psychiatry, the clinical presentation of disorders in adolescents is complex, and categorical approaches have limitations by focusing on individual disorders. The intricate system of psychopathology during adolescence can be effectively modeled using network science, which integrates statistical and computational techniques through artificial intelligence tools. Network analysis of psychometric data from psychiatric disorder assessment tests has been extensively studied in both general psychiatry and child psychiatry. However, a comprehensive evaluation of existing network approaches that model multiple psychiatric or neurodevelopmental disorders encountered in adolescents remains necessary. We conducted a systematic literature review across two different databases - PubMed and Scopus - using the keywords “network analysis”, “adolescent” and “psychiatry” to address this question. The selection of articles was based on age criteria and the number of pathological entities studied. Out of 406 articles, 69 were selected and analyzed. The results from some of these studies are described in this article. Notably, we observe significant heterogeneity in the findings, highlighting both the richness and complexity of adolescent psychopathology. Further research is needed to validate the already proposed results and standardize the models studied.

Key words: child and adolescent psychiatry – complexity - psychometrics

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INTRODUCTION

Mental illness ranks among the leading causes of disability worldwide, according to the World Health Organization (WHO) (Murray & Lopez 2002). Most studies, both prospective and retrospective, highlight that most psychiatric disorders begin in childhood (Merikangas et al. 2009). Recent epidemiological studies emphasize the need to improve diagnostic methods for psychiatric disorders in children and adolescents (Merikangas et al. 2009).

In child and adolescent psychiatry, the clinical presentation of disorders in adolescents is complex, and the categorical approach has limitations that hinder proper patient care by focusing on a single disorder. Symptoms in children and adolescents, influenced by family and school systems on which they heavily rely, evolve parallel to intellectual and emotional maturity throughout brain development. It would be misleading to consider symptoms as static entities at any given time.

Indeed, the categorical approach is no longer sufficient, as current research indicates that mental pathology is more accurately represented as a spectrum (Merikangas et al. 2009), a complex system where symptoms interact with each other (Borsboom 2017). This complex system can be modeled using network science, which integrates statistical and computational techniques through artificial intelligence tools (Borsboom 2017).

Network theory has gained prominence in the past decade as it enables the exploration of the complexity of psychopathological constructs. In these approaches, disorders are viewed as interconnected systems of symptoms rather than manifestations of a single latent disorder.

Network analysis techniques allow for the comprehensive representation, analysis, and study of these complex systems. Moreover, network modeling offers the philosophical advantage of rejecting the unrealistic notion that all symptoms of a disorder share a single causal context, while also avoiding the relativistic view that disorders are mere labels for an arbitrary set of symptoms. Instead, it proposes a framework where disorders are conceptualized as systems rather than distinct entities (Borsboom 2017, Borsboom & Cramer 2013).

Network analysis of psychometric data from psychiatric disorder assessment tests has been extensively studied in psychiatry and child psychiatry. Studies utilizing network analysis have been conducted on disorders such as anorexia (Delaquis et al. 2023), autism spectrum disorder (ASD) (Suen et al. 2024), attention deficit and hyperactivity disorder (ADHD) (Farhat et al. 2022), depression (Manfro et al. 2023), and numerous others. Network analysis enables data aggregation, highlighting the interconnectivity of items, symptoms, or manifestations of a disorder, modeling these interactions, and determining their mutual influences (Borsboom 2017). Beyond addressing the dimensional view of psychopathological disorders, it statistically identifies stable links between symptoms by considering the entire system.

A network consists of nodes and edges between these nodes. Nodes represent symptoms, items from psychometric scales, or characteristics such as age or sex. Edges denote connections between these nodes established across the entire network. Depending on the type of network studied, these edges can be directed (as

in directed acyclic graphs) or undirected (as in BGGM), and can be positive or negative, and with a strength (Borsboom & Cramer 2013, Epskamp et al. 2018).

Are there existing network approaches modeling multiple psychiatric or neurodevelopmental disorders encountered in adolescents? In this article, we first present our analysis method and then discuss our findings. In the discussion, we will explore the relevance of network analysis in child psychiatry for adolescents.

METHOD

A comprehensive search was conducted by one author in PubMed and Scopus using the following keywords: “network analysis,” “adolescent,” and “psychiatry”.

The initial selection was based on the titles of the articles, ensuring alignment with the research question outlined in the introduction. If the title was ambiguous, the abstract was reviewed for clarity.

Exclusion criteria were as follows: studies not using network analysis, studies including only patients over 18 years of age, and studies including only patients under 12 years of age.

A secondary selection was performed based on two primary inclusion criteria. The first inclusion criterion

was age: studies had to focus on the adolescent period (12 to 17 years), with a tolerance for ages 10 to 25 years if more than 50% of the patients were between 12 and 17 years old. The second inclusion criterion required articles to analyze more than two psychopathological disorders, with a minimum of two different psychometric scales for the disorders or a set of symptoms for a diagnosis from classifications such as the DSM-5.

RESULTS

A total of 406 articles were identified in this search, with 366 from PubMed and 40 from Scopus. After removing 26 duplicates, 380 articles remained. Following the initial screening, 158 articles were excluded because they were research protocols, genetic studies, or neuroradiological studies rather than network analysis studies.

A second screening was conducted on the remaining 222 articles. After applying the two inclusion criteria, 2 articles were not accessible, and 151 articles were excluded. Thus, 69 articles met the inclusion criteria.

We selected a portion of the results based on the diagnostic terms listed below. The selection process is represented in Figure 1.

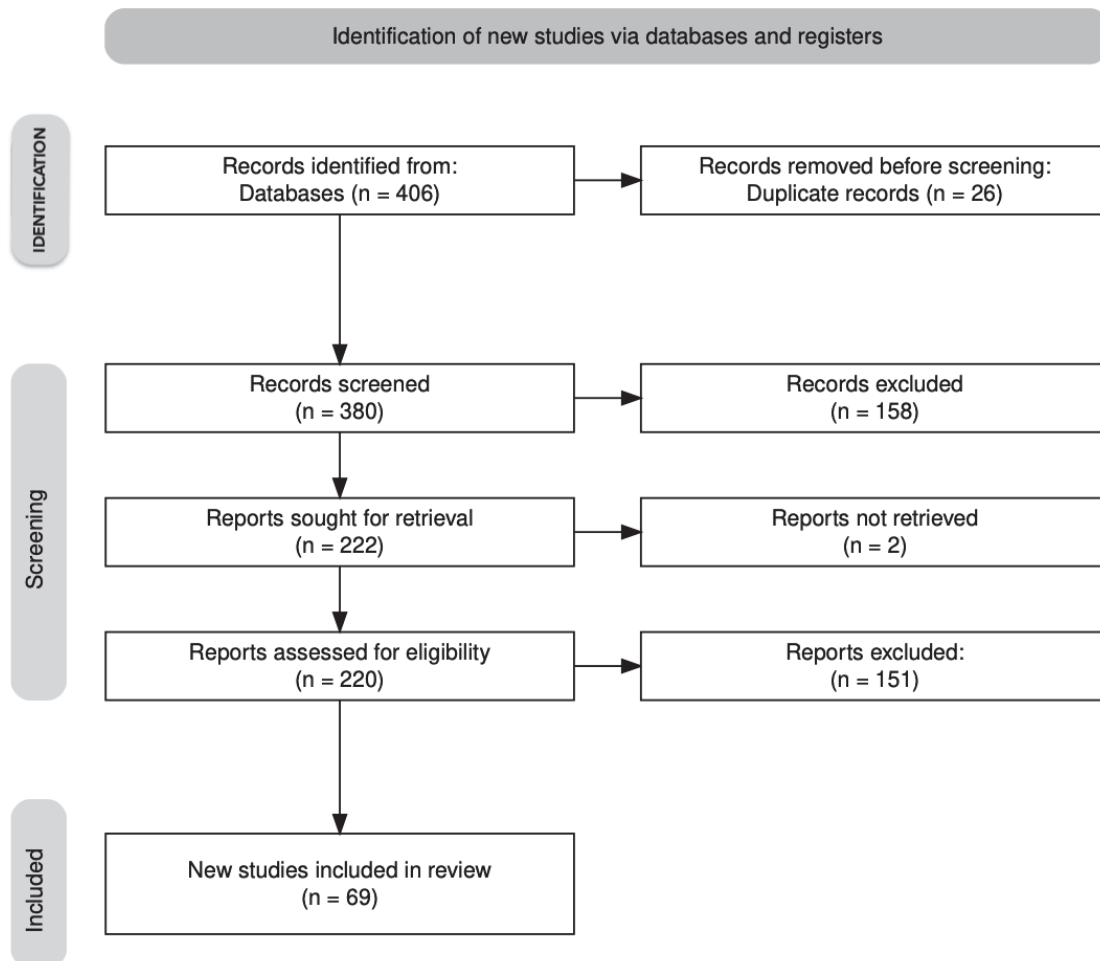


Figure 1. PRISMA Flow Diagram for Article Selection (Haddaway et al. 2022)

Depression and anxiety symptoms

Out of the 66 articles reviewed, 59 focused on depression or depressive symptoms. 46 articles explored the relationship between depression and anxiety, either addressing these two disorders alone or in specific contexts such as associations with suicidal risk, internet addiction, emotional dysregulation, and other factors.

Anhedonia, sadness, and significant worry were consistently identified as central symptoms across multiple studies.

He et al. found that the most central symptom in the comorbidity network throughout all three developmental stages was "loss of control" (He et al. 2023). "Excessive worry" and "anhedonia" emerged as core symptoms in early adolescence, with "restlessness" becoming the core symptom in late adolescence. They also identified three bridge symptoms linking anxiety and depression: "anhedonia," "sad mood," and "fatigue" (He et al. 2023).

Network analysis further revealed that the nodes PHQ2 ("sad mood"), GAD6 ("irritability"), GAD3 ("worry too much"), and PHQ6 ("guilt") were central symptoms in the adolescent network model (Wang et al. 2023).

Suicidality

Ten percent of the selected articles focused on suicidality and suicidal risk behaviors.

The most central node in terms of strength and expected influence was "Consider taking your own life" (Fonseca-Pedrero et al. 2024). The nodes with the greatest influence were those related to emotional intelligence abilities. Suicidal behavior showed a positive correlation with depression symptoms and negative affect, while it was negatively correlated with self-esteem and positive affect (Fonseca-Pedrero et al. 2024).

In line with previous studies on anxiety and depression, it appears that significant worry, guilt, irritability, and sadness are central symptoms associated with suicidal risk (Cai et al. 2023).

Neurodevelopmental disorder

Autism Spectrum Disorder & Attention Deficit and Hyperactivity Disorder

Only 4 out of the 66 selected articles considered Autism Spectrum Disorder (ASD), while 17 articles included symptoms from Attention Deficit Hyperactivity Disorder (ADHD). In one study analyzing the association between ADHD and ASD, ADHD symptoms were strongly interconnected, as were ASD symptoms, with few and weak connections between the two constructs (Farhat et al. 2022). The few non-redundant connections were between traits such as "waiting for one's turn to speak," "bad at taking turns in conversations," or "shifting the conversation to preferred topics," and certain motor hyperactivity symptoms (Farhat et al. 2022).

Additionally, depressive mood and oppositional behavior showed a relatively high linkage, suggesting that these symptoms mediate the association between otherwise unrelated symptoms. Irritability symptoms had stronger and more direct associations with other nodes compared to aggressiveness symptoms (Hirota et al. 2020).

According to another study, socio-environmental stressors and emotional dysregulation may explain the associations between childhood neurodevelopmental traits and depressive symptoms during development (Farhat et al. 2023). The link between depressive symptoms and ADHD-ASD was indirect and mediated by relational difficulties with peers (Farhat et al. 2023).

Eating Disorders

Seven articles included items and symptoms related to eating disorders. Concern over Mistakes, Eating Preoccupation, Social Fear, and Overvaluation of Weight and Shape showed the highest strength centrality in the network (Delaquis et al. 2023). Nodes with the highest bridge strength included Concern over Mistakes, Doubt about Actions, Overvaluation of Weight and Shape, and Depression (Delaquis et al. 2023).

Central nodes related to self-esteem and depression included feelings of worthlessness and self-dislike, respectively (Eadeh et al. 2021). Feeling like a failure was the most frequent bridging symptom between disordered eating and depression symptoms (Eadeh et al. 2021).

Depression symptoms and personal alienation exhibited the highest centrality in the network, followed by asceticism, post-traumatic stress problems, drive for thinness, low self-esteem, and physical symptoms of anxiety (Monteleone et al. 2019). Three symptom clusters related to eating disorder psychopathology, self-esteem issues, and internalizing difficulties were identified. Depression symptoms, personal alienation, low self-esteem, and interoceptive deficits showed the highest bridge centrality. In addition to core symptoms of eating disorders, negative affect and internalizing symptoms appear to contribute independently to the psychopathology of anorexia nervosa, regardless of illness duration (Monteleone et al. 2019).

Results were heterogeneous, yet consistently indicated that low self-esteem and depression symptoms play significant roles. Central nodes in most models of disordered eating were a desire to lose weight and discomfort when seeing one's own body.

Psychotic symptoms and experiences

Nine articles focusing on psychotic episodes, symptoms, or psychotic experiences were reviewed. The findings varied significantly. According to Lo Buglio's results, positive symptoms were not connected to the rest of the network, and there was no association

between psychotic symptoms and anxiety or depression (Lo Buglio et al. 2022). Conversely, other authors such as Qiao highlighted that depression, anxiety, and negative affects were central symptoms (Qiao et al. 2024). Mood and low self-esteem exhibited the highest strength-centrality among all variables. While psychotic-like experiences (PLE) and depressive symptoms showed strong overall correlation, unique associations between symptoms from these two constructs were infrequent.

Multiple disorders network

Two studies by Imperiale focused on various disorders: anxiety disorders, mood disorders, and neurodevelopmental disorders (ADHD and oppositional defiant disorder) (Imperiale et al. 2021, 2023). These studies allow for the visualization of central symptoms and their distribution according to four severity thresholds (high scores on the scales). Interrelationships between domains of anxiety, behavioral disorders, anxiety/mood/eating disorders, and mood/eating disorders were identified, suggesting that specific patterns of multimorbidity emerge as the severity levels of psychopathology increase (Imperiale et al. 2021). The second study aimed to evaluate whether psychopathology symptom networks differ between individuals with and without life treatment: seeking treatment, undergoing treatment, and receiving prolonged treatment.

Anxiety, depression, mania, behavioral disorders, and ADHD were compared across groups with a history of childhood violence (Russell et al. 2022). The clustering or distribution into domains remained relatively consistent with other studies, including those by Imperiale.

Network analysis revealed that anxious/depressed mood and attention problems were the most central and interconnected nodes. For individuals with underweight or overweight, anxiety, depression, and social withdrawal were central and associated with thought problems and self-perception issues (Zeiler et al. 2021).

One of the most recent studies analyzed ASD, ADHD, depression, anxiety, and psychotic-like symptoms (functioning and quality of life) (Suen et al. 2024). This study demonstrated higher comorbidity in younger and depressed patients. In the group of older patients without associated psychopathological disorders, they were more likely to have ASD or ADHD. A link was determined between ASD, ADHD, and well-being, but no causality was established (Suen et al. 2024). Certain symptoms were more associated with the risk of developing comorbidities: increased sensitivity to sensory input, ability to shift attention, difficulties maintaining attention and completing tasks, forgetfulness, and working memory issues, as well as constant activity and restlessness. Forgetfulness and working memory issues emerged as the main symptoms, with anxiety symptoms predicted after one year (Suen et al.

2024). Organizational and planning problems, the ability to shift attention, a preference for routine, and difficulties with change predicted depressive symptoms (Suen et al. 2024).

DISCUSSION

To our knowledge, this is the first systematic literature review focused on modeling adolescent psychopathology using network analysis. Previous studies have also been conducted but often included adult populations, which fall outside the scope of our investigation for this article. Notably, Borsboom and Cramer explored symptom networks across all symptoms listed in the DSM-IV, depicting all symptoms in a comprehensive network (Borsboom & Cramer 2013).

As stated in the introduction, the network approach allows for a dimensional perspective on psychiatric disorders, avoiding the pitfalls of categorical approaches that may overlook certain symptoms or patients with few representative symptoms. This network approach is particularly valuable because it identifies key symptoms and important connections, which can help predict comorbidities and inform interventions.

Some variations between results have been observed. For instance, the association between ASD and ADHD showed weaker connections between the two domains. This can be explained by the statistical method of network analysis used, such as the eLASSO technique (Farhat et al. 2022) (or in other cases, bootstrapping), which retains only certain connections. Additionally, these discrepancies can be attributed to small sample sizes or unstable results that do not hold up under rigorous stability testing methods. Our review of these articles reveals significant heterogeneity in the results. Definitions of disorders varied between articles, and the psychometric scales used differed as well. While some symptoms were similar across studies, it is challenging to overlay the networks identified by different authors.

Nonetheless, network analysis provides a holistic approach to understanding adolescent psychopathology. A comprehensive perspective should also integrate risk factors, adverse childhood events, and neurobiological and neurological imaging data, as examined in certain studies. Genetic factors were investigated in a highly specific manner, focusing on individual genes rather than broader constructs.

However, there are several limitations to this article. First, we were lenient regarding the age range. If we had strictly adhered to the 12-17 year age range, the number of relevant articles would have been minimal. To account for various cultural and developmental dimensions, we included younger children and transition-age youth from 18 to 25 years. A limitation is the scarcity of temporal networks in our review, which could provide a more accurate reflection of the development and

evolution of symptom relationships over time. An inherent limitation of the network approach is the selection of items, leading to heterogeneity in results.

Furthermore, these studies established networks at a specific point in time, often not replicated by other authors or in different populations. Some very stable models have not been applied in clinical settings to determine risk factors and comorbidities. Validation of these scales would require recalculating these networks in other populations.

Another limitation observed in some studies is the use of psychometric scale scores rather than distinct symptoms. Using scale scores can obscure and lose the specificity of certain symptoms and items. Interpreting links based on network connections between items can be problematic, as networks are simplified models of reality, and symptoms may not always be fully represented, leading to potential overinterpretation and errors.

CONCLUSION

Network analysis is an effective method for modeling symptoms, disorders, and factors influencing psychopathology in child and adolescent psychiatry. These studies yield interesting results for specific disorders; however, significant heterogeneity remains, and we are still in the early stages of modeling childhood and adolescent disorders. Further research is needed to validate, expand, and refine these findings.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the first author utilized ChatGPT to check the spelling and grammar of the manuscript. Following the use of this tool, the first author reviewed and edited the content as necessary and assumes full responsibility for the publication's content.

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All Authors contributed to the literature search and the drafting of the text.

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