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Associations between PTSD and psychotic symptoms: A network analysis of patients with psychotic disorders in Uganda Psychosis-PTSD network analysis

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ABSTRACT

Introduction: Individuals with psychosis often endorse a history of trauma, yet the symptom-level interplay between trauma-related and psychotic symptoms is understudied globally and largely absent in Sub-Saharan Africa. We used network analysis to examine associations within and between these domains.

Methods: We conducted a network analysis of 807 participants with a psychotic disorder and trauma history in the Ugandan cohort of the NeuroGAP-Psychosis program. Psychotic symptoms were assessed using the standard Mini International Neuropsychiatric Interview (MINI) version 7.0.2's module K for psychotic disorders and mood disorder with psychotic features, and trauma-related symptoms were assessed using the Post Traumatic Stress Disorder Checklist for DSM-5 (PCL-5). We estimated a mixed graphical model with Extended Bayesian Information Criterion regularization ($\gamma = 0.25$) and pairwise interactions ($k = 2$) to examine PTSD and psychosis symptom networks, computed two-step bridge expected influence, and bootstrapped ($n = 1000$) to assess network stability and accuracy.

Results: Participants' average PCL-5 score was 28.0 (SD = 23.3). Network analysis revealed clustering in both PTSD and psychosis symptoms; psychotic symptoms clustered more strongly together than PTSD symptoms did. Four cross-domain edges, 1) negative symptoms with trouble recalling; 2) odd or unusual beliefs with difficulty concentrating; 3) disorganized speech with negative feelings; 4) odd or unusual beliefs with flashbacks, were identified. Trouble recalling showed the highest mean 2-step bridge expected influence.

Discussion: Memory-related symptoms such as trouble recalling or flashbacks emerged as potential bridge symptoms between PTSD and psychosis in this population. These symptoms could serve as transdiagnostic intervention targets and warrant longitudinal investigation.

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1. Introduction

Individuals with psychotic disorders report higher rates of trauma history and lifetime victimization compared to the general population, with violent victimization within three years endorsed by approximately one in five individuals and lifetime victimization rates reaching one-third of this population (Vries et al., 2019; Benjet et al., 2016). In Sub-Saharan Africa, elevated trauma exposure rates are documented, which can be attributed to ongoing conflicts, natural disasters, and socioeconomic instability (Ng et al., 2020; Morawej et al., 2024; Mugisha et al., 2015). The bidirectional association between trauma and psychosis is complex: trauma exposure increases vulnerability to psychosis while psychotic conditions may heighten susceptibility to traumatic encounters (Vries et al., 2019; Bloomfield et al., 2021; Stevenson et al., 2025). Individuals with both trauma history and psychosis experience decreased psychosocial functioning, higher rates of substance use, homelessness, and suicidal ideation than those with psychosis alone (Mugisha et al., 2015; Buswell et al., 2021). However, trauma history is frequently overlooked in clinical practice despite being more prevalent among individuals with severe mental health conditions (Seow et al., 2016; Campodonico et al., 2022). Therefore, understanding how trauma-related symptoms, regardless of formal posttraumatic stress disorder (PTSD) diagnosis, interact with psychotic symptoms is crucial for comprehensive treatment approaches (van den Berg et al., 2016; Compean and Hamner, 2019; Astill Wright et al., 2023).

Network analysis offers a valuable framework for understanding PTSD-psychosis symptoms by conceptualizing psychopathology as systems of interconnected symptoms rather than manifestations of latent variables (Isvoranu et al., 2017; Epskamp et al., 2018; Robinaugh et al., 2020). This approach is particularly beneficial for examining complex comorbidities because it can identify which specific symptom, often referred to as a bridge symptom, may serve as a pathway between different diagnostic domains (Castro et al., 2019; Jones et al., 2021). Identifying bridge symptoms through network approaches has refined etiological models by showing that interactions between specific symptoms, rather than an unseen common cause, could potentially influence multiple disorders and explain why certain conditions frequently co-occur (Fried et al., 2017; Chen et al., 2024; Müller et al., 2022). Clinically, targeting these symptoms can interrupt pathological feedback loops and improve outcomes, since addressing the symptom that activates multiple domains may reduce distress across them simultaneously (Chen et al., 2024; Müller et al., 2022).

Several studies employed network analysis mostly in high-income settings to identify bridge symptoms linking PTSD and psychotic symptomatology (Fung et al., 2024; Hardy et al., 2021; Misiak et al., 2025; Panayi et al., 2025). Cross-sectional analyses consistently identified trauma-related beliefs and hypervigilance as key bridge symptoms between PTSD and psychotic symptom networks, with trauma-related beliefs having the largest direct influence and, together with hypervigilance, being implicated in the shortest pathways from flashbacks to delusions and auditory hallucinations (Fung et al., 2024; Hardy et al., 2021; Misiak et al., 2025). Longitudinal studies have shown that paranoia predicts and is predicted by hyperarousal, negative self-concept, and emotional dysregulation (Panayi et al., 2025).

However, existing network analysis studies of PTSD-psychosis comorbidity have been limited in scope and generalizability. Many examined only subsets of psychotic symptoms such as delusions or negative symptoms, focused on participants endorsing psychotic symptoms rather than diagnoses, or incorporated additional symptom domains that may have obscured PTSD-psychosis relationships (Astill Wright et al., 2023; Misiak et al., 2025). Furthermore, published studies have been conducted predominantly in European and North American populations, limiting generalizability to Sub-Saharan African contexts where post-conflict trauma exposure and different cultural frameworks for understanding distress may influence symptom expression patterns (Ng et al., 2020; Fried et al., 2018).

To address these limitations, we conducted a network analysis of PTSD symptoms and psychotic symptoms in 807 adults with diagnosed psychotic disorders and trauma history in Uganda, a region with substantial trauma exposure from regional conflicts and high HIV burden (Amone-P'Olak et al., 2022; Ainembabazi et al., 2024). Participants were a group of psychotic patients from the Neuropsychiatric Genetics of African Populations-Psychosis study (NeuroGAP-Psychosis), a case-control study examining the genetic and environmental underpinnings of psychotic disorders in Sub-Saharan Africa amassing 34, 000 participants across multiple sites in Ethiopia, Kenya, South Africa, and Uganda (Stevenson et al., 2019). This study is the first to examine a broad range of PTSD and psychotic symptom associations in a large African sample. While network theory conceptualizes symptoms as causally interacting components, cross-sectional designs cannot establish temporal precedence between symptoms. Therefore, we interpret network edges as statistical associations rather than causal relationships. This approach allows us to identify symptom co-occurrence patterns that may inform hypotheses for future longitudinal research. We aimed to examine the structure of symptom associations and identify bridge symptoms linking PTSD and psychosis domains.

2. Methods

2.1. Data collection

Data for this analysis were collected as part of the Neuropsychiatric Genetics of African Populations-Psychosis study (NeuroGAP-Psychosis) (Stevenson et al., 2019).

2.2. Eligibility and exclusion criteria

Participants included in this study were: 1) adults aged 18 years or older; 2) with a previous diagnosis of a psychotic disorder by a clinician; 3) with a history of trauma, defined as endorsing one or more items of the LEC-5; 4) with complete data PCL-5 and module K of MINI (Sheehan et al., 1998). Individuals were excluded if severe and intrusive psychiatric symptoms at the time of consent could impair decision-making capacity, if they were under the acute influence of alcohol or drugs, or they were inpatients (Jeste et al., 2007).

As part of the NeuroGAP-Psychosis study, psychotic disorders were defined as schizophrenia, schizoaffective disorder, bipolar disorder, psychotic disorders not otherwise specified, and mania not otherwise specified. This umbrella classification was based on longitudinal studies reporting high diagnostic variability among individuals receiving an initial diagnosis of these conditions and substantial evidence from recent genome-wide association studies indicating shared genetic architecture across traditional diagnostic boundaries (Wood et al., 2021; Cardno and Owen, 2014; Kampe et al., 2024).

Participants were recruited from March to December 2022 at outpatient facilities in Butabika National Referral Hospital, Mbarara Regional Referral Hospital, Arua Regional Referral Hospital, and Gulu Regional Referral Hospital. Research personnel were bachelor-level accredited research assistants. All study staff underwent comprehensive training in administering survey measures, including human subjects training and study-specific protocols. Interviewers received ongoing on-site supervision, support, and refresher training throughout the data collection period.

2.3. Sociodemographic characteristics

Age, biological sex at birth (female, male), marital status (divorced or separated, married or cohabiting, single, widowed), and highest level of education (no formal education, primary, secondary, university) were collected through self-reports.

2.4. PTSD symptoms

PTSD symptoms were assessed using the PCL-5 (Blevins et al., 2015). The PCL-5 is a 20-item self-report measure rated on a 5-point scale: 0 (Not at all), 1 (A little bit), 2 (Moderately), 3 (Quite a bit), and 4 (Extremely), indicating how much each symptom has bothered the respondent. To align the timeframe with the lifetime assessment of psychotic symptoms using the MINI, we modified the standard instructions of the PCL-5 to ask about symptoms "in your lifetime." The PCL-5 captures the four PTSD symptom clusters: intrusion (Intrusive memories, Disturbing dreams, Flashbacks, Emotional distress, and Physical reactions), avoidance (Avoidance of internal reminders and Avoidance of external reminders), negative alterations in cognition and mood (Trouble recalling, Negative self-thoughts, Self-blame, Negative feelings, Loss of interest, Feeling distant, and Trouble recalling positive emotions), and alterations in arousal and reactivity (Irritability, Risky Behavior, Hypervigilance, Exaggerated startle, Difficulty concentrating, and Sleep disturbance) (Geier et al., 2019; Hoeboer et al., 2024). Drawing from previous research, we abbreviated each PCL-5 item to improve clarity in figure legends and to facilitate concise reference throughout the manuscript (Geier et al., 2019; Hoeboer et al., 2024).

2.5. Psychotic symptoms

Psychotic symptoms were assessed using the psychosis module (module K) of the MINI. The MINI psychosis module is a 10-item structured diagnostic interview, with each item rated dichotomously as "yes" (symptom present) or "no" (symptom absent), indicating whether the respondent has ever experienced the symptom in their lifetime. The MINI is aligned with psychiatric disorders in the DSM-5 and the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10) (Chamali et al., 2020/03; Korte et al., 2023; Korte et al., 2025). Adapting the approach of a prior study, we assigned a psychopathological term to each MINI K item (Chamali et al., 2020/03). MINI has been used extensively throughout Africa and has shown good construct validity in the NeuroGAP-Psychosis dataset (Korte et al., 2023; Jaguga et al., 2022). The first seven items are self-reported and the remaining three items are assessed through direct observation by interview or chart review. Items were not merged and were analyzed as originally developed.

2.6. Network estimation

Prior to network estimation, item redundancy was assessed using *goldbricker* function from the *networktools* R package. Node pairs were identified as redundant if less than 25% of their correlations with all other nodes in the network were significantly different (Peel et al., 2021). In network analysis, multivariate data are graphically modeled as interconnected systems where each node corresponds to a measured symptom, and each edge represents a conditional dependency between a variable pair (Borsboom and Cramer, 2013; Borsboom et al., 2021/08). To estimate the network of PTSD symptoms and psychotic symptoms, MINI items were treated as binary variables, and PCL-5 items were treated as continuous variables. The estimation was done with the *mgm* package in R to fit a mixed graphical model (MGM) to accommodate both binary and continuous variables (Haslbeck and Waldorp, 2020).

The decision to treat PCL-5 items as continuous variables in our model may be justified by recent methodological research on network estimation with ordinal data (Isvoranu and Epskamp, 2023). A comprehensive simulation study examining network estimation performance across different data types found that polychoric correlations, the standard approach for ordinal data, often performed worse than treating variables as continuous, and that rank transformations performed comparably to more complex transformations designed for ordinal data (Isvoranu and Epskamp, 2023). Since PCL-5 uses a 5-point scale with greater granularity than their tested 4-point scales, treating these responses as continuous may be reasonable, thereby justifying the network estimation via *mgm*.

The estimation involved LASSO regularization with Extended Bayesian Information Criterion (EBIC) model selection with the hypertuning parameter γ set to 0.25, accounting for the exploratory nature of this analysis in an understudied population. This is aligned with the general practice of network estimation to reduce spurious edges within a network, and to retain only the more reliably detected edges (Hevey, 2018). A more conservative estimation with γ set to 0.50 served as a robustness check to verify whether the identified cross-domain edges would remain despite the penalization (Epskamp et al., 2018). Throughout the estimations, all pairwise interactions ($k = 2$) were included while three-way interactions were not.

2.7. Network visualization

The network was visualized using *qgraph* package (Epskamp et al., 2012). Strength of association between a pair of symptoms was represented with line thickness, where thicker edges indicate stronger associations above zero. Blue edges indicate positive associations whereas red edges indicate negative associations. PTSD symptoms were indicated in blue and psychotic symptoms in orange.

2.8. Bridge expected influence

Bridge expected influence (BEI) quantifies how strongly a symptom within a cluster connects to symptoms in other clusters. Differently from strength centrality, expected influence preserves the signs (+ or -) of regression coefficients and maintains information about whether relationships are positive (tendency to co-occur) or negative (tendency to suppress each other). We calculated two-step BEI, which extends the BEI by including both direct connections and indirect connections through one intermediate node from one domain to another. This captures more comprehensive cross-domain influence by identifying symptoms that may bridge diagnostic boundaries through multi-step pathways (Isvoranu et al., 2022).

2.9. Predictability

Predictability quantifies the proportion of variance in each symptom that can be statistically explained by all other symptoms in the network via regularized regression modeling (Borsboom et al., 2021/08). High predictability indicates strong network embeddedness, while low predictability suggests greater influence from unmeasured variables, measurements error, or external factors. Node predictability was calculated as R-squared values for continuous variables (PCL-5) and classification accuracy for binary variables (MINI).

2.10. Transitivity

Transitivity, also often referred to as *clustering coefficient*, is another measure of how densely interconnected nodes are to one another, or put differently, how well related symptoms cluster together (Spineli et al., 2025). There are two types of transitivity: global and local. Global transitivity of a network indicates the extent of clustering on average throughout the entire network. On the other hand, local transitivity of each node indicates how well a particular node connects to adjacent nodes. We used transitivity() function of *igraph* package in R to compute average local transitivity values within each cluster of PCL-5 items and MINI items (Csardi and Nepusz, 2006). The goal was to quantify how well the network of interest captures PTSD and psychosis symptoms manifest in our sample.

2.11. Network stability

We evaluated network parameter reliability using two bootstrap

procedures implemented through the bootnet package (Epskamp and Fried, 2025). Case-drop bootstrap assessed parameter stability by systematically removing increasing percentages of participants and examining whether centrality statistics remained consistent across different sample sizes. Stability was quantified using the correlation stability coefficient, which indicates the maximum percentage of participants that can be removed while maintaining correlation above 0.7 between original and reduced-sample centrality values. Coefficients 0.5 and above indicate acceptable stability. Non-parametric bootstrap evaluated parameter precision by resampling participants with replacement and calculating 95% confidence intervals around edge weights and centrality measures. We also calculated edge inclusion proportions, which measure the frequency with which each edge remained non-zero across bootstrap samples, providing estimates of edge reliability. Both bootstrap procedures used 1000 iterations. All analyses were conducted in R using the mgm, bootnet, qgraph, and ggplot2 packages (Haslbeck and Waldorp, 2020; Epskamp et al., 2012; Epskamp and Fried, 2025; Wickham, 2011).

3. Results

3.1. Demographic and clinical characteristics of the study population

The final analytical sample consisted of 807 participants. The mean age was 38.7 years (SD = 12.4), with the majority (73.5%) aged between 18 and 44 years. More than 51% of the sample was female (51.3%). Almost 40% of participants were married or cohabiting (39.3%), while a substantial proportion were either single (32.8%) or divorced/separated (21.8%). Most participants had completed at least some secondary education (53.6%). Descriptive statistics can be found in Tables 1, S1, and S2. All MINI items, PCL-5 items, LEC-5, and variables used to construct the main descriptive table had complete data, with no missing values.

In terms of psychiatric diagnoses, bipolar disorder was the most common (37.8%), followed by schizophrenia (30.4%) and psychotic disorder not otherwise specified (25.7%). Participants endorsed an average of 6.7 (SD = 2.8) items out of 10 MINI items and 8.7 (SD = 7.0) items out of 20 PCL-5 items as shown in Table 2. The average PCL-5 score was 28.0 (SD = 23.3). Among psychotic symptoms, the most endorsed were odd or unusual beliefs (77.8%), auditory hallucinations (77.7%), and persecutory delusions (77.1%). In contrast, negative symptoms were less prevalent, with 42.3% endorsing any such symptoms. For PTSD symptoms, intrusive memories (66.7%), emotional distress (54.4%), and avoidance of memories (52%) were the most frequently reported.

Table 1
Demographic and clinical characteristics of the study population, n = 807.

	Count	%
Total	807	100
Sex at birth		
Female	414	51.3
Male	393	48.7
Age (years)		
18–29	274	34.0
30–44	319	39.5
45–59	158	19.6
60+	56	6.9
Marital status		
Divorced or separated	176	21.8
Married or cohabitating	317	39.3
Single	265	32.8
Widowed	49	6.1
Level of education achieved		
No formal education	19	2.4
Primary	356	44.1
Secondary	291	36.1
University	141	17.5
Primary diagnosis		
Bipolar disorder	305	37.8
Mania, not otherwise specified	37	4.6
Psychotic disorder, not otherwise specified	207	25.7
Schizoaffective disorder, NOS	13	1.6
Schizophrenia	245	30.4
Study site		
Kampala	215	26.6
Mbarara	64	7.9
Arua	322	39.9
Gulu	206	25.5

Abbreviation: NOS, not otherwise specified.

3.2. Network structure and cross-domain connections

Item redundancy assessment using goldbricker with a standard threshold of 0.25 identified no redundant node pairs, confirming the conceptual distinctness of the included symptoms (Peel et al., 2021). The network estimation with the hypertuning parameter γ set to 0.25 as in Fig. 1 revealed domain-specific clustering, with psychotic symptoms forming a more densely interconnected cluster than PTSD symptoms did. Four cross-domain connections were noted, including negative symptoms with trauma-related memory disruption (edge weight estimate: 0.14), odd beliefs/delusions with concentration difficulties (0.12), disorganized speech with emotional distress and negative emotions (0.11), and odd or unusual beliefs with dissociative flashbacks (0.06) (Table S3).

Predictability and two-step BEI estimates for each node are presented in Fig. 2 and Tables S4–S5. Among psychotic symptoms, disorganized speech had the highest predictability (Classification accuracy, 0.86 [95% CI, 0.82 to 0.89]), followed by odd or unusual beliefs (0.84 [0.81 to 0.88]), auditory hallucinations (0.83 [0.80 to 0.86]), persecutory delusions (0.82 [0.79 to 0.84]), and passivity phenomena (0.82 [0.79 to 0.84]). These values indicate that over 80% of the variance in these symptoms was explained by other nodes in the network, suggesting strong within-cluster connectivity and regulation. The most predictable PTSD symptoms were avoidance of memories (R^2, 0.69 [0.65 to 0.73]), trouble experiencing positive emotions (0.69 [0.64 to 0.73]), negative feelings (0.69 [0.64 to 0.74]), followed closely by difficulty concentrating (0.66 [0.61 to 0.71]), and intrusive memories (0.65 [0.60 to 0.70]). Risky behavior had the lowest predictability (0.40 [0.33 to 0.46]). Consistent with psychotic symptoms showing higher predictability values than PTSD symptoms do, the average local transitivity of psychotic symptoms was higher (0.57 [0.41 to 0.69]) than that of PTSD symptoms (0.37 [0.29 to 0.45]).

Although none of the nodes reached statistical significance, several nodes demonstrated notably high and predominantly positive mean 2-step BEI values. Trouble recalling had the highest mean value (0.45 [95% CI, 0.00 to 1.09]. In addition, symptoms such as negative feelings (0.24 [–0.03 to 0.91]), flashbacks (0.22 [–0.03 to 0.79]), difficulty concentrating (0.19 [–0.01 to 0.69]), and feeling distant or cut off from others (0.14 [–0.03 to 0.63]) also showed 2-step BEI values inclined towards positive values.

3.3. Statistical evaluation of network properties

Network stability assessments via case-dropping bootstrapping yielded correlation stability coefficients of 0.517 for strength, 0.672 for edge weights, and 0.517 for expected influence (Fig. S1). The same coefficients for BEI and closeness were 0. Node strength difference tests via nonparametric bootstrapping identified unusual beliefs and disorganized speech as having greater strength centrality than most other nodes (Fig. S2). This finding indicates these symptoms are most highly connected within the overall network structure, consistent with their high predictability values. Among PTSD symptoms, no nodes showed significantly different strength centrality from others, suggesting more homogeneous connectivity within the trauma-related domain. Edge-weight difference tests demonstrated that the strongest edges were primarily within-domain connections, particularly among psychotic

Table 2
Item-level endorsements on the MINI and the PCL-5, n = 807.

Psychotic symptom endorsement (MINI)	Count	%
K1. Have you ever believed that people were spying on you, or that someone was plotting against you, or trying to hurt you? [Persecutory delusions][a]	622	77.1
K2. Have you ever believed that someone was reading your mind or could hear your thoughts, or that you could actually read someone's mind or hear what another person was thinking? [Delusion of mind reading and/or thought broadcasting]	548	67.9
K3. Have you ever believed that someone or some force outside of yourself put thoughts in your mind that were not your own, or made you act in a way that was not your usual self? Have you ever felt that you were possessed? [Passivity phenomena (thought insertion, somatic passivity, and delusion of control)]	576	71.4
K4. Have you ever believed that you were being sent special messages through the TV, radio, newspapers, books or magazines or that a person you did not personally know was particularly interested in you? [Ideas/delusions of reference]	419	51.9
K5. Have your relatives or friends ever considered any of your beliefs odd or unusual? [Odd or unusual beliefs]	628	77.8
K6. Have you ever heard things other people couldn't hear, such as voices? [Auditory hallucinations]	627	77.7
K7. Have you ever had visions when you were awake or have you seen things other people couldn't see? [Visual hallucinations]	518	64.2
K8. Did the patient ever exhibit disorganized, incoherent or derailed speech, or marked loosening of associations? [Disorganized speech]	612	75.8
K9. Has the patient ever exhibited disorganized or catatonic behavior? [Disorganized or catatonic behavior]	548	67.9
K10. Has the patient ever had negative symptoms, e.g. significant reduction of emotional expression or affective flattening, poverty of speech (alogia) or an inability to initiate or persist in goal-directed activities (avolition)? [Negative symptoms]	341	42.3
PTSD symptom endorsement (PCL-5)	**Count**	**%**
P1. In your lifetime, how much were you bothered by repeated, disturbing, and unwanted memories of the stressful experience? [Intrusive memories][b]	538	66.7
P2. In your lifetime, how much were you bothered by repeated, disturbing dreams of the stressful experience? [Disturbing dreams]	320	39.7
P3. In your lifetime, how much were you bothered by suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)? [Flashbacks]	386	47.8
P4. In your lifetime, how much were you bothered by feeling very upset when something reminded you of the stressful experience? [Emotional distress]	439	54.4
P5. In your lifetime, how much were you bothered by having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)? [Physical reactions]	421	52.2
P6. In your lifetime, how much were you bothered by avoiding memories, thoughts, or feelings related to the stressful experience? [Avoidance of internal reminders]	420	52
P7. In your lifetime, how much were you bothered by avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)? [Avoidance of external reminders]	397	49.2
P8. In your lifetime, how much were you bothered by trouble remembering important parts of the stressful experience? [Trouble recalling]	255	31.6
P9. In your lifetime, how much were you bothered by having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)? [Negative self-thoughts]	342	42.4
P10. In your lifetime, how much were you bothered by blaming yourself or someone else for the stressful experience or what happened after it? [Self-blame]	314	38.9
P11. In your lifetime, how much were you bothered by having strong negative feelings such as fear, horror, anger, guilt, or shame? [Negative feelings]	409	50.7
P12. In your lifetime, how much were you bothered by loss of interest in activities that you used to enjoy? [Loss of interest]	357	44.2
P13. In your lifetime, how much were you bothered by feeling distant or cut off from other people? [Feeling distant]	337	41.8
P14. In your lifetime, how much were you bothered by trouble experiencing positive feelings (for example, being unable to feel happiness or have loving feelings for people close to you)? [Trouble experiencing positive emotions]	307	38
P15. In your lifetime, how much were you bothered by irritable behavior, angry outbursts, or acting aggressively? [Irritability]	292	36.2
P16. In your lifetime, how much were you bothered by taking too many risks or doing things that could cause you harm? [Risky behavior]	143	17.7
P17. In your lifetime, how much were you bothered by being “superalert” or watchful or on guard? [Hypervigilance]	357	44.2
P18. In your lifetime, how much were you bothered by feeling jumpy or easily startled? [Exaggerated startle]	282	34.9
P19. In your lifetime, how much were you bothered by having difficulty concentrating? [Difficulty concentrating]	315	39
P20. In your lifetime, how much were you bothered by trouble falling or staying asleep? [Sleep disturbance]	417	51.7

Abbreviations: MINI = Mini International Neuropsychiatric Interview, standard 7.0.2; PCL-5 = PTSD Checklist for DSM-5; PTSD, post-traumatic stress disorder; Phrases in brackets refer to the corresponding psychopathological terminology.

[a] Phrases in brackets refer to the corresponding psychopathological terminology.

[b] Phrases in brackets indicate keywords that represent the corresponding items, based on previous studies.

symptoms (Fig. S3). Between-domain edges showed smaller magnitudes and greater variability across bootstrap samples.

Edge inclusion proportions revealed that the four cross-domain connections - negative symptoms with trouble recalling, odd or unusual beliefs with concentration difficulties, disorganized speech with negative feelings, and odd or unusual beliefs with dissociative flashbacks - showed variable but generally good stability across bootstrap samples, with inclusion rates ranging from moderate to high. The predominantly non-significant edge differences and wide confidence intervals for cross-domain connections indicate substantial uncertainty in precise edge strength ranking. When γ was set to 0.5 to apply a more conservative criterion, two connections - negative symptoms with trouble recalling and odd or unusual beliefs with flashbacks remained significant.

4. Discussion

The present study examined the association between PTSD and psychotic symptom structures using network analysis and identified bridge symptoms linking these domains in 807 patients with a psychotic disorder and trauma history recruited in Uganda. We found distinct clustering by symptom type with four cross-domain connections with each being 1) negative symptoms with trouble recalling; 2) odd and unusual beliefs with difficulty concentrating; 3) disorganized speech with negative feelings; 4) odd or unusual beliefs with flashbacks. Trouble recalling had the highest mean 2-step bridge expected influence point estimate, followed by negative feelings, odd or unusual beliefs, and flashbacks.

4.1. Symptom patterns among individuals with both psychosis and trauma exposure

Given that the inclusion criteria did not require PTSD diagnosis, PTSD symptoms endorsement was lower than psychosis symptoms. While the PCL-5 score of our sample (mean = 28.0, SD = 23.3) fell below the commonly recommended diagnostic threshold for PTSD which is typically 31–33, it was higher than in trauma-exposed individuals (e.g., mean = 10.1, SD = 11.1) in other studies and fell within the range reported in other studies of psychotic individuals with trauma history (Geier et al., 2019; Roberts et al., 2021).

These patterns likely reflect subthreshold trauma-related symptomatology that remains clinically meaningful (Marshall et al., 2001; Zlotnick et al., 2002). Research suggests that subthreshold PTSD is associated with functional impairment falling between individuals without PTSD and those with PTSD, including increased suicidality, depression, and alcohol use problems (Marshall et al., 2001). Psychiatric

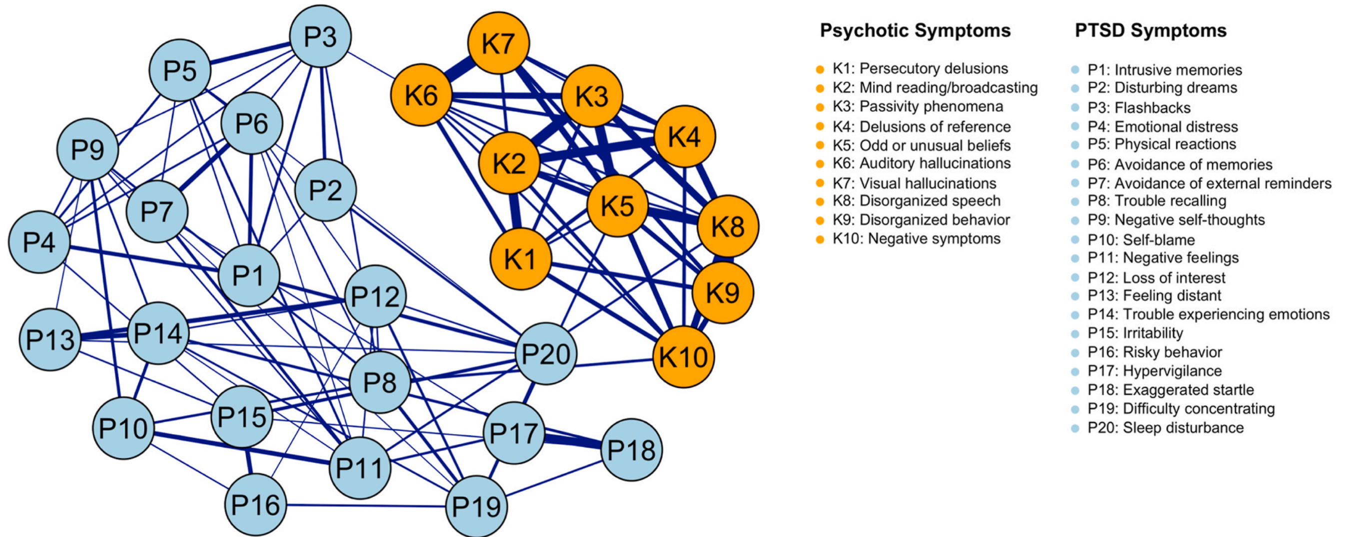

Fig. 1. Network analysis visualization between PTSD and psychotic symptoms, n = 807
The network plot displays psychotic symptoms (orange nodes) and PTSD symptoms (blue nodes) among patients with psychosis and a history of trauma (N = 807). Each node represents a symptom, and edges (lines between nodes) represent regularized partial correlations. Thicker edges indicate stronger associations. All edges are positive.

Fig. 2. 2-step Bridge Expected Influence and Predictability of each node of the network (1000 bootstraps)
Dots denote estimates for bridge expected influence and predictability. Error bars represent 95% CI.
Abbreviations: BEI, bridge expected influence; CI, confidence interval.

outpatients with subthreshold PTSD show social and work morbidity levels comparable to those with full-threshold PTSD (Zlotnick et al., 2002), with longitudinal studies indicating that associated impairment may persist for years (Marshall et al., 2001; Forbes et al., 2012). Future research should explore whether the presence of psychotic symptoms strengthen or exacerbate trauma-related symptom expression, even when total symptom burden remains below standard diagnostic cutoffs.

4.2. Identified edges between PTSD and psychotic symptom domains

Cross-sectional network analyses conducted in the past have identified trauma-related beliefs and hypervigilance as key bridge symptoms between PTSD and psychosis domains. In contrast to prior findings, our results in Uganda suggest that memory-related symptoms, such as trouble recalling, emerge as notable bridge symptoms. While the magnitude of these bridging estimates should be interpreted with caution due to wide confidence intervals, their presence suggests potential cultural or contextual differences. These differences may partly reflect the healthcare context in Uganda, where cognitive impairment in psychosis can be exacerbated by delated treatment access and prolonged use of first-generation antipsychotics, which are associated with cognitive side effects (Mwesiga et al., 2022). The chronicity of illness resulting from delayed care may intensify cognitive disruptions, potentially making memory-related symptoms more prominent bridge features in this population (Mwesiga et al., 2021).

The connection between disorganized speech and emotional distress may reflect shared disruptions in cognitive-linguistic processing under emotional stress. Disorganized speech, characterized by derailment and incoherent expression, could emerge when trauma-related emotional distress overwhelms cognitive resources needed for coherent verbal communication (Schlesselmann et al., 2022; Bentall et al., 2001; Merckelbach and Giesbrecht, 2006). The connection between negative symptoms and trauma-related memory disruption points to potential overlap in motivational and memory systems. Both phenomena involve reduced engagement, as negative symptoms reflect diminished motivation and social withdrawal, while memory disruption represents disengagement from traumatic experiences (Schlesselmann et al., 2022; Ben-Zion et al., 2025). This convergence may involve shared neurobiological pathways, particularly dopaminergic systems that regulate both motivation and memory consolidation (Cabib and Puglisi-Allegra, 2012; Meisenzahl et al., 2007).

The links between unusual beliefs and both concentration difficulties and dissociative flashbacks may reflect culturally informed meaning-making processes rather than pathological belief formation (Asiimwe et al., 2023; Seligman and Kirmayer, 2008). Given the potential limited familiarity with biomedical models of mental illness in these settings, individuals experiencing trauma-related cognitive disruptions may be inclined to draw upon traditional explanatory frameworks to understand their symptoms (Verginer and Juen, 2019). In Uganda's sociocultural context, these beliefs likely represent coherent cultural models for interpreting trauma-related experiences rather than secondary psychopathological phenomena.

4.3. Predictability and cross-domain influence

Psychotic symptoms generally exhibited a more tightly interconnected structure than did PTSD symptoms (Borsboom and Cramer, 2013). This pattern reflects a self-reinforcing cluster, where activation of one symptom is strongly associated with others. Disorganized speech had the highest predictability, suggesting it is particularly shaped by the broader psychotic network and may be responsive to interventions targeting related symptoms (Borsboom and Cramer, 2013). In contrast, PTSD symptoms were less tightly interconnected, with cognitive and affective symptoms showing the highest predictability values within this group. This pattern may reflect the lower prevalence of PTSD symptoms among participants, who had psychosis and trauma exposure but not necessarily meeting criteria for a diagnosis of PTSD. Alternatively, PTSD symptoms in this population may be more influenced by individual-level factors than by network dynamics, compared to psychotic symptoms. Together, these findings suggest that trauma-related symptoms in this context involve both shared network processes and individual variation, warranting a nuanced and personalized approach to intervention.

4.4. Memory disruption as a potential bridge symptom

Two-step BEI analysis provided exploratory evidence for several connectors between PTSD and psychosis. Although bridge symptom rankings showed limited stability with wide CIs, both memory disruption nodes survived stricter parameters ($\gamma = 0.50$): trouble recalling showed the highest edge weight estimate, with flashbacks also showing potential. While these patterns are suggestive, this convergence of memory-related symptoms as potentially influential nodes tentatively suggests that disrupted memory processes may represent a connection worth investigating further for linking PTSD and psychosis in this population (Schlesselmann et al., 2022; Kang et al., 2026).

Memory disruption in PTSD involves both intrusive re-experiencing (flashbacks) and avoidant amnesia (trouble recalling), creating a paradoxical state where traumatic content is concurrently hyper accessible and inaccessible (Pitts et al., 2022). This fragmented memory processing may contribute to psychotic symptoms through several mechanisms. First, when coherent autobiographical memory is compromised, individuals may struggle to distinguish internal mental events and external reality, potentially contributing to hallucinations and delusions (Hardy, 2017). Second, memory gaps may be filled with distorted or confusing content, providing substrate for unusual beliefs (Shakeel and Docherty, 2015; Seabury et al., 2021). Third, the cognitive resources allocated to handle intrusive memories and avoiding recall may be associated with an overwhelmed schema; in our network analysis, the resulting concentration difficulties were statistically linked to unusual beliefs, suggesting a potential connection for further longitudinal investigation (Iyadurai et al., 2019).

The association between trouble recalling and negative symptoms suggests that memory avoidance and motivational withdrawal may represent overlapping disengagement strategies, as both symptoms involve reduced interaction with one's environment (Farina et al., 2022). Research indicates that dopaminergic circuits that regulate both memory consolidation and motivational salience might manifest as avoided memory processing or diminished goal-directed behavior (Rusu and Pennartz, 2020; Duszkiewicz et al., 2019). The combination of high predictability and substantial BEI in negative feelings suggests this symptom is both tightly regulated within the PTSD cluster and positioned to transmit activation to psychotic symptoms, warranting future studies to evaluate it as a particularly strategic intervention target.

4.5. Strengths and limitations

This investigation is, to our knowledge, the first network analysis to employ network analysis between PTSD and psychosis symptomatology among psychotic patients who reported trauma history. By analyzing data from an Ugandan cohort, it also extends PTSD-psychosis network research beyond European and American samples, helping to clarify whether symptom inter-relations generalize across cultural contexts. Furthermore, our methodological approach using MGM preserves the dimensional nature of PTSD symptoms while accommodating the categorical assessment of psychotic experiences, offering advantages over previous studies that required dichotomization of all variables (Haslbeck and Waldorp, 2020). Finally, our sample size and stability analyses enhance the confidence in our findings (Epskamp et al., 2018).

However, several limitations warrant consideration. First, the cross-sectional design precludes causal inferences about the directionality of relationships between symptoms. While we drew on theoretical frameworks to interpret observed associations, these interpretations remain hypothetical and require validation through longitudinal network studies and experimental designs to clarify the temporal dynamics between PTSD and psychotic symptoms. Second, while the MGM model is capable of datasets with continuous (PCL-5) and binary (MINI) items, it may introduce several biases: continuous nodes contribute more variance and may appear artificially more central; binary symptom associations may be underestimated; and regularization may

disproportionately shrink edges connected to binary nodes due to their restricted variance (Haslbeck and Waldorp, 2020). Fewer and comparatively weaker cross-domain edges were detected than anticipated, and BEI showed only moderate stability, indicating that some PTSD–psychosis links may remain undetected with the present sample. The fact that PTSD symptoms endorsed in our sample were largely subthreshold and did not meet diagnostic criteria may have limited our power to detect more frequent or stronger cross-domain connections. Such floor effects tend to yield more conservative centrality and bridge estimates (Isvoranu and Epskamp, 2023). Future studies focusing on a more homogenous population with higher PTSD severity may uncover additional links that were attenuated in the current analysis. Additionally, the directionality of associations between cognitive symptoms (concentration difficulties, memory disruption) and unusual beliefs remain unclear. Without information about trauma timing relative to psychosis onset, we cannot determine whether cognitive disruptions preceded unusual beliefs or vice versa. Future work should employ longitudinal designs, compare network structures across diagnostic subgroups to refine understanding of cross-domain connectors, and investigate the effectiveness of interventions targeting bridge symptoms.

5. Conclusion

This network analysis exploring links between PTSD and psychotic symptoms is the first to investigate these connections specifically among individuals diagnosed with psychosis exposed to forms of trauma rarely represented in previous studies. Our results revealed distinct clustering patterns within each symptom domain, with psychotic symptoms clustering more strongly than do PTSD symptoms. We identified four statistically significant cross-domain symptom connections, including 1) negative symptoms with trouble recalling; 2) odd or unusual beliefs with difficulty concentrating; 3) disorganized speech with negative feelings; 4) odd or unusual beliefs with flashbacks. Trouble recalling emerged as the symptom with the highest two-step BEI estimate, suggesting a critical role in linking these domains. While bridge symptom rankings showed poor stability, the robustness of cross-domain connections across bootstrap sample suggests these represent reliable structural features of PTSD-psychosis networks.

CRediT authorship contribution statement

Hanseul Cho: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Woohyung Lee:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Hyungjun Park:** Writing – review & editing, Visualization, Validation, Methodology, Formal analysis. **Anne Stevenson:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Daniel Bustamante:** Writing – review & editing, Supervision, Methodology. **Rocky Elton Stroud:** Writing – review & editing, Resources, Project administration, Data curation, Conceptualization. **Shaili C. Jha:** Writing – review & editing, Resources, Project administration. **Joseph Kyebuzibwa:** Writing – review & editing, Project administration, Data curation. **Allan Kalungi:** Writing – review & editing, Resources, Project administration, Data curation. **Anita Arinda:** Writing – review & editing, Project administration, Investigation, Data curation. **Emmanuel K. Mwesiga:** Writing – review & editing, Project administration, Data curation. **Raymond Rodokonyero:** Writing – review & editing, Project administration, Investigation, Data curation. **Akena Dickens:** Writing – review & editing, Supervision, Project administration, Investigation. **Manasi Sharma:** Writing – review & editing, Supervision, Resources, Project administration, Investigation. **Kristina J. Korte:** Writing – review & editing, Supervision, Investigation, Funding acquisition, Data curation, Conceptualization.

Code availability

The code for this study is available at Open Science Framework at https://github.com/hanseul0618/neurogap_psychosis_trauma_ssmmh.

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Declaration of competing interest

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmmh.2026.100620.

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