

Symptom Network Analysis of Insomnia, Depression, and Anxiety Among Incarcerated Men in China: Implications for Correctional Mental Health Assessment

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Abstract

Background:

The comorbidity of insomnia, depression, and anxiety is prevalent among incarcerated populations. From a correctional mental health perspective, this study aimed to identify core and bridge symptoms in the symptom networks of insomnia, depression, and anxiety among incarcerated men, providing a basis for mental health screening and psychological service interventions.

Methods:

This study included 584 incarcerated men in China ($M = 36.50$, $SD = 9.57$). Insomnia, depressive, and anxiety symptoms were assessed using the Athens Insomnia Scale (AIS), Patient Health Questionnaire-9 (PHQ-9), and Generalized Anxiety Disorder-7 (GAD-7), respectively. Network analysis was used to construct an insomnia symptom network and a comorbidity network of insomnia, depression, and anxiety. Network centrality and bridge centrality were used to identify core and bridge symptoms.

Results:

The prevalence of insomnia was 66.1%. Study 1 identified “Awakenings during night” (AIS 2) and “Daytime functioning capacity” (AIS 7) as core hubs within the insomnia network. Study 2 showed that “Restlessness” (GAD 5) had the highest expected influence, suggesting its high centrality in the cross-sectional symptom network. “Sleep” (PHQ 3) and “Sad mood” (PHQ 2) emerged as key bridge symptoms.

Conclusions:

Core and bridge symptoms may represent important intervention targets for the comorbidity of insomnia, depression, and anxiety among incarcerated populations. These findings may inform symptom screening and psychological service prioritization in correctional settings. Future longitudinal and intervention studies are needed to further clarify the causal and clinical implications of these symptoms.

Introduction

Insomnia refers to frequent and persistent difficulty falling asleep or maintaining sleep [1, 2]. According to a meta-analysis [3], the global prevalence of insomnia was 16.2%, indicating that it is one of the most common sleep disorders among adults worldwide [4–7]. Studies have consistently demonstrated that insomnia is closely associated with depressive and anxiety symptoms, which in turn compromise physical health [9–10]. Taylor et al. [10] reported that individuals with insomnia faced a 9.8-fold increase in clinically significant depression and a 17.3-fold increase in anxiety relative to non-insomniacs. Chronic

insomnia is a well-established risk factor for the onset of both conditions [11], a risk which is further amplified in incarcerated populations. A review covering 11 countries [12] indicated that the prevalence of insomnia in incarcerated populations ranged from 26.2% to 72.5%. Similarly, Geng et al. [13] found that 26.2% (95% CIs: 24.0%-28.5%) of Chinese male prisoners had insomnia, underscoring a pervasive vulnerability across correctional settings. Key identified causes for this discrepancy include prison-specific stressors: improper temperature, poor lighting, constant noise [14], lack of personal autonomy [15], and rigid institutionalized schedules [16], all of which increase the risk of insomnia. These findings suggest that sleep problems among incarcerated individuals should be considered not only as isolated sleep complaints but also as clinically relevant symptoms within broader correctional mental health assessment. Beyond sleep pathology, insomnia is frequently intertwined with depression and anxiety symptoms in incarcerated populations [13–14, 17] and has also been associated with elevated suicidal ideation [14]. Therefore, exploring the relationships between insomnia, depression, and anxiety symptoms in incarcerated men may help clarify symptom-level patterns relevant to correctional mental health screening and psychological service prioritization.

Identifying the core symptoms of insomnia, as well as the bridge symptoms connecting insomnia, depression, and anxiety, is crucial for improving mental health assessment in incarcerated populations. Prior research has documented the high prevalence of insomnia in correctional settings [18] and its strong associations with anxiety and depression [10]. However, the symptom-level associations among these symptoms remain poorly understood. As Borsboom and Cramer revealed [19], core symptoms act as pivotal hubs within symptom networks. Identifying these symptoms can help clarify which symptoms are most strongly embedded in a network and therefore most relevant for assessment [20]. Identifying bridge symptoms allows for the detection of symptoms that connect different symptom communities and may indicate broader cross-domain psychological distress. Understanding whether the “nighttime maintenance” or the “daytime dysfunction” is acting as the more central component of the insomnia network in incarcerated men is essential for improving symptom screening and correctional mental health assessment. Network analysis provides a useful framework to address this gap by estimating partial correlation networks [21], allowing researchers to identify both central core nodes [22] and bridge structures connecting different symptom clusters [23]. Therefore, network analysis is well-suited for analyzing the associations among insomnia, depression, and anxiety symptoms in incarcerated men.

Network analysis is widely used in clinical psychology [24–25], and its robust theoretical foundations are valuable for studying psychopathological networks [19, 26]. For instance, in insomnia research, network studies have revealed population-specific central symptoms: impaired daytime functioning in mental health professionals during COVID-19 [27], sleep maintenance difficulties in workers [20], and sleep pattern concerns in the general population [28]. However, these findings are restricted to particular community or occupational samples, and incarcerated populations remain critically understudied despite their unique environmental risk factors. This gap is important because symptom networks may vary across contexts, and correctional environments involve distinctive constraints that may shape both nighttime sleep problems and daytime functioning.

Feinstein [29] first proposed the concept of comorbidity, which refers to the co-occurrence of distinct disorders and provides a theoretical basis for understanding the interactions among insomnia, depression, and anxiety. Empirical evidence has confirmed both substantial symptom overlap [10, 30] and strong bivariate correlations among these conditions [31]. Network analyses have further clarified these dynamics. Studies among Macao residents have pinpointed sleep maintenance as a core symptom [32], while research among community adults in Western contexts has identified “trouble relaxing” as a key bridge symptom [23]. Other studies have demonstrated that sleep problems act as a critical link between the core symptoms of major depressive disorder and generalized anxiety disorder [33]. While previous literature has identified sleep as an important symptom linking affective and anxiety-related problems, the role of affective symptoms (e.g. sad mood) as additional bridge symptoms in high-stress settings remains insufficiently understood, and evidence from incarcerated populations remains limited.

Given the unique vulnerabilities and compromised psychological profiles of incarcerated individuals [18, 34], investigating these three conditions as a comorbid cluster is essential for identifying clinically salient symptoms and improving correctional mental health assessment. By determining core and bridge symptoms specific to the prison context, network analysis can inform symptom screening and psychological service prioritization in correctional settings. Thus, the current study was developed, and we sought to examine the symptom-level structure of insomnia, depression, and anxiety among incarcerated men in China. To address these aims, the present research comprises two sequential sub-studies. Study 1 examined the insomnia symptom network in incarcerated men to identify core insomnia symptoms. Study 2 expanded the scope to an insomnia–depression–anxiety symptom network, analyzing interactions among insomnia, depression, and anxiety symptoms, with the aim of identifying bridge nodes and core symptoms across all three domains using advanced centrality indices such as strength and bridge-expected-influence. This research aimed to provide empirical evidence for symptom screening and psychological service prioritization in correctional settings.

Methods

Participants and Ethical Considerations

Participants were recruited from a male prison in Guangdong Province, China. A total of 584 incarcerated men completed the survey, all aged between 18 and 64 years ($M = 36.50$, $SD = 9.57$). Regarding their marital status at the time of arrest, 45.9% were married, 23.3% were single, 22.4% were cohabiting, and 8.4% were divorced.

Prison dormitories were equipped with 12 bunks (six double-tier beds), with each room typically accommodating 10 to 12 individuals. Surveys were conducted in small-group sessions (i.e., 30 to 50 participants) using paper-and-pencil measures. The sessions were supervised by prison guards and postgraduate psychology students, with the guards assisting only with administrative order and

institutional safety, and the postgraduate students providing standardized clarifications following a predefined script to ensure consistency.

Participation was entirely voluntary, all participants provided written informed consent. Participants were informed that refusal or withdrawal would not affect their prison management, routine care, or access to services. In accordance with ethical guidelines for correctional research, no material or financial incentives were provided. However, as a psychological benefit, participants were informed they would receive a summary report of their individual sleep quality assessment afterward.

The dataset collected in this study was also utilized for a psychometric evaluation of the Athens Insomnia Scale (AIS) in a separate study. Whereas Lu et al. [35] focused exclusively on the instrument's structural validation, the current study addresses a distinct research question by using network analysis to examine symptom-level associations among insomnia, depression, and anxiety from a correctional mental health assessment perspective.

Measures

The Athens Insomnia Scale (AIS)

The AIS [36] was used to measure insomnia symptom severity. It is a self-report measure consisting of eight items, each rated using a four-point scale ranging from 0 to 3, with anchors ranging from “No problem” to “Very severe problem.” The scale covers two sub-domains: nighttime sleep problems and daytime dysfunction. Higher total scores indicate more severe insomnia. The AIS was translated into Chinese by Chung et al. [37] and had since been validated in adolescent samples. The Chinese version of the AIS has been shown to have good reliability and validity [38–40]. The Cronbach's α of the AIS in the current study was .91.

The Patient Health Questionnaire-9 (PHQ-9)

The PHQ-9 [41] is a nine-item self-report questionnaire used to assess the severity of depressive symptoms respondents have experienced over the previous two weeks. Each item corresponds to one diagnostic criterion for major depressive disorder, as defined in the DSM-IV, including references to specific somatic symptoms such as sleep disturbances. All items are rated using a four-point Likert scale ranging from 0 (“Not at all”) to 3 (“Nearly every day”). The total score is calculated by summing all item scores, with higher scores indicating more severe depressive symptoms. In the current study, we adopted the Chinese revised version of the PHQ-9 [42] which has demonstrated good psychometric properties and has been widely validated among Chinese populations [43]. The internal consistency of the PHQ-9 in the present research sample was good, with a Cronbach's α coefficient of .89.

The Generalized Anxiety Disorder-7 (GAD-7)

The GAD-7 [44] was used to measure anxiety symptoms in respondents. It is a seven-item self-report scale which measures anxiety symptom severity over the previous two weeks. This scale evaluates symptoms such as restlessness and irritability. Items are rated on a four-point scale ranging from 0 (“Not at all”) to 3 (“Nearly every day”). Total scores are summed and generally range from 0 to 21, with higher scores indicating greater anxiety severity. The Chinese version [46] was used, and had demonstrated good validity and comprehensibility. The Cronbach’s α of the GAD-7 in the current study is .94.

Data Analysis Strategy

Network Estimation and Visualization

All analyses were conducted in R [46], primarily using the *bootnet*, *qgraph*, and *networktools* packages. Initially, descriptive information of the AIS, PHQ-9, and GAD-7 was estimated via the *describe* function in R [47]. The *estimateNetwork* function in the R package *bootnet* was used to estimate the internal network of insomnia (Study 1) and the insomnia–depression–anxiety symptom network (Study 2). In the network model, the insomnia, depression, and anxiety symptoms are represented as nodes, and the associations between them as edges [48]. The least absolute shrinkage and selection operator (LASSO) and extended Bayesian information criteria (EBIC) can be used to shrink edges in the network and choose related tuning parameters. This allows the symptom network to be sparser and easier to interpret [48]. Due to skewed mean score distributions, nonparametric correlations were calculated using nonparanormal transformations[49]. The network was visualized using R packages *qgraph* [48] and *bootnet* [21], with thicker edges indicating stronger associations, green edges representing positive connections, and red edges denoting negative ones.

Centrality and Stability Analysis

To quantify node importance, strength, expected influence, and closeness centrality were calculated via the *qgraph* package [48]. Strength centrality, defined as the sum of absolute edge weights for a specific node, reflects how strongly the node is connected to others. Expected influence measures the overall impact of a node and is more suitable than traditional centrality indices for networks with both positive and negative edges [50]. Higher expected influence values indicate greater overall connectivity in the symptom network. Although closeness centrality was estimated to assess the indirect connectedness of a node to all other nodes in the network, its interpretation was contingent upon stability results. Additionally, 1-step bridge expected influence was calculated to identify bridge symptoms within the insomnia, anxiety, and depression network. Nodes were assigned to three distinct communities (i.e., Insomnia, Depression, Anxiety) based on the theoretical constructs of the scales (AIS, PHQ-9, GAD-7). Higher values of bridge-expected-influence indicate stronger cross-community connectivity among symptom clusters, thus the 80th percentile was used as a cutoff for identifying bridge symptoms.

The network stability was evaluated by the correlation stability coefficient (CS coefficient) through a case-drop bootstrapping procedure. A CS larger than 0.25 indicated that the nodes had moderate stability, while values greater than 0.5 indicated strong stability [51]. The network accuracy was assessed using bootstrapped 95% confidence intervals (CIs) through a non-parametric bootstrapping procedure, with narrower CIs having a more accurate network. Finally, a bootstrapped difference test was conducted between centrality indices and edge weights to identify whether the nodes and edges differ from each other [52]. The stability and accuracy were examined using the R package *bootnet* [21].

This research comprised two sub-studies: Study 1 examined the individual insomnia network (8 nodes) to identify core symptoms, while Study 2 analyzed the insomnia-depression-anxiety symptom network (24 nodes, including 8 AIS items, 9 PHQ items, and 7 GAD items) to identify both central symptoms across domains and corresponding bridge symptoms.

Results

Descriptive and Correlational Statistics

Item-level descriptive statistics and corrected item-total correlations are presented in Table 1, and scale-level correlations are in Table 2. Although total scores were significantly positively correlated, the network analysis was constructed based on a partial correlation matrix to control for multicollinearity by conditioning on all other variables [53]. Based on the AIS cut-off score of > 6 [54], prevalence of insomnia in this sample was 66.1%, with a mean AIS score of 9.35. These results indicate that insomnia symptoms were highly prevalent among incarcerated men in this sample, underscoring the relevance of sleep assessment in correctional mental health contexts.

Table 1: Descriptive Statistics and Corrected Item-Total Correlation of Scale Items

Item	Mean	SD	CITC
AIS 1	1.36	0.82	0.67 ^{**}
AIS 2	1.29	0.82	0.73 ^{**}
AIS 3	1.15	0.86	0.67 ^{**}
AIS 4	1.47	0.84	0.72 ^{**}
AIS 5	1.28	0.85	0.77 ^{**}
AIS 6	0.79	0.89	0.72 ^{**}
AIS 7	1.00	0.94	0.77 ^{**}
AIS 8	1.01	0.83	0.67 ^{**}
PHQ 1	1.09	0.87	0.68 ^{**}
PHQ 2	0.76	0.88	0.74 ^{**}
PHQ 3	1.35	1.01	0.65 ^{**}
PHQ 4	1.20	0.95	0.74 ^{**}
PHQ 5	0.82	0.90	0.61 ^{**}
PHQ 6	0.90	0.93	0.60 ^{**}
PHQ 7	0.75	0.90	0.67 ^{**}
PHQ 8	0.54	0.79	0.66 ^{**}
PHQ 9	0.18	0.54	0.50 ^{**}
GAD 1	0.62	0.81	0.80 ^{**}
GAD 2	0.66	0.87	0.82 ^{**}
GAD 3	0.91	0.91	0.81 ^{**}
GAD 4	0.87	0.93	0.80 ^{**}
GAD 5	0.61	0.81	0.85 ^{**}
GAD 6	0.78	0.89	0.82 ^{**}
GAD 7	0.42	0.77	0.74 ^{**}

Note. CITC = Corrected Item-Total Correlation. ** $p < .01$.

Table 2: Descriptive Statistics and Correlations Between the Measures

Measure	Mean	SD	AIS	PHQ-9	GAD-7
AIS	9.35	5.40	-		
PHQ-9	7.59	5.72	0.76**	-	
GAD-7	4.87	5.16	0.62**	0.81**	-

Note. AIS = Athens Insomnia Scale; PHQ-9 = Patient Health Questionnaire-9; GAD-7 = Generalized Anxiety Disorder-7. ** $p < .01$.

Study 1: Network Analysis of Insomnia Symptoms

The estimated network of insomnia is presented in Figure 1, comprising eight nodes divided into nighttime sleep problems (AIS – NSP: AIS 1 – AIS 5) and daytime dysfunction (AIS – DD: AIS 6 – AIS 8). Based on recommendations and standards from existing literature (Epskamp et al., 2018), stability was assessed using the CS coefficient, with values above 0.50 indicating high reliability. In Study 1, the CS coefficient for strength centrality was 0.594, exceeding the preferred threshold. The results of the node strength difference test (Figure 2) identified “Awakenings during night (AIS 2)” and “Daytime functioning capacity (AIS 7)” as core hubs in this insomnia network, indicating that these symptoms had relatively high connectivity within the cross-sectional insomnia symptom network. In addition, bootstrapped 95% confidence intervals (CIs) further confirmed the magnitude of weighted edges within the insomnia structure. As shown in Figure 3, the strongest edge in the network was “Daytime wellbeing (AIS 6) – Daytime functioning capacity (AIS 7)” ($r = 0.45$, 95% CIs [0.36, 0.52]). Other prominent associations included “Total sleep duration (AIS 4) – Sleep quality (AIS 5)” ($r = 0.42$, 95% CIs [0.33, 0.50]) and “Awakenings during night (AIS 2) – Earlier final awakening (AIS 3)” ($r = 0.40$, 95% CIs [0.32, 0.48]).

[insert Figure 1 about here]

Study 2: Insomnia–Depression–Anxiety Symptom Network

Network Structure and Central Symptoms

The network of insomnia, depression, and anxiety symptoms is presented in Figure 4 (above), where 136 (49.28%) of 276 possible edges were non-zero. The expected influences were utilized as the primary centrality index. As illustrated in Figure 4 (below), “Restlessness (GAD 5)” displayed the strongest expected influence, followed by “Fatigue (PHQ 4),” “Daytime functioning capacity (AIS 7),” “Irritability (GAD 6),” and “Sad mood (PHQ 2).” This suggests that these individual symptoms were the most

centrally connected symptoms in the cross-sectional insomnia–depression–anxiety symptom network. In contrast, other symptoms such as “Daytime sleepiness (AIS 8),” “Guilt (PHQ 6),” and “Appetite (PHQ 5)” showed comparatively lower expected influence values.

[insert Figure 4 about here]

Identification of Bridge Symptoms

Bridge expected influence analysis revealed that sleep-related depressive symptoms showed strong cross-community connectivity among the insomnia, depression, and anxiety symptom clusters. As Figure 5 shows, the symptoms with the strongest bridge expected influence were “Sleep (PHQ 3)” and “Sad mood (PHQ 2).” The strongest edges within the network were primarily observed within specific symptom clusters, notably between “Total sleep duration (AIS 4)” and “Sleep quality (AIS 5),” as well as between “Awakenings during night (AIS 2)” and “Earlier final awakening (AIS 3).” However, a notable cross-community association was identified between “Sleep induction (AIS 1)” and “Sleep (PHQ 3).” This interaction, along with the high bridge expected influence of “Sad mood” (PHQ 2), suggests that both sleep-related and affective symptoms may be relevant to cross-domain symptom associations in this incarcerated sample.

[insert Figure 5 about here]

Network Stability and Accuracy

Bootstrap procedures indicated generally good stability of the main centrality indices and acceptable accuracy of the estimated edge weights. Specifically, the correlation stability (CS) coefficients for closeness, strength centrality, and expected influence were above 0.5 (0.59, 0.75, and 0.67, respectively), indicating that these centrality metrics were stable. However, acknowledging the inherent instability often associated with closeness in psychopathological networks, the current study prioritized strength centrality (Study 1) and expected influence (Study 2) when identifying core symptoms to support a more cautious interpretation of node centrality. The widths of the bootstrap CIs indicated that the accuracy of edge-weight estimates between insomnia symptoms and depression/anxiety symptoms was generally acceptable (Figures 6).

[insert Figure 6 about here]

Discussion

The present study yielded several findings across two sub-studies. Study 1 identified “Awakenings during night (AIS 2)” and “Daytime functioning capacity (AIS 7)” as the core symptoms of the insomnia network in incarcerated men. In this network structure, the correlation between daytime states (“Daytime wellbeing (AIS 6) – Daytime functioning capacity (AIS 7)”) was the strongest. Strong correlations were also observed between sleep related symptoms, specifically “Awakenings during night (AIS 2) – Earlier final awakening (AIS 3)” and “Total sleep duration (AIS 4) – Sleep quality (AIS 5).” Study 2 revealed that in

the insomnia–depression–anxiety symptom network among incarcerated men, “Restlessness (GAD 5)” was the most central node, exhibiting the strongest expected influence, while “Sleep (PHQ 3)” and “Sad mood (PHQ 2)” demonstrated the strongest bridge expected influence, suggesting their important roles in linking insomnia, depression, and anxiety symptom communities. The strongest edges within the network and between symptom clusters were “Daytime wellbeing (AIS 6) – Daytime functioning capacity (AIS 7)” and “Sleep (PHQ 3) – Sleep induction (AIS 1).” These two edges were found to be important associations within the symptom network, highlighting the relevance of daytime impairment and sleep-related depressive complaints for correctional mental health assessment.

Core Symptoms of the Insomnia Network

Previous studies have identified awakenings during night and daytime functional capacity as the core symptoms of insomnia. In fact, the diagnostic criteria for insomnia research as proposed by the American Academy of Sleep Medicine (AASM) Work Group (2004) require that insomnia needs to meet both nighttime sleep disorders (e.g., difficulty falling asleep and maintaining sleep) and daytime functional impairment (e.g., fatigue and lack of concentration), providing an authoritative basis for defining core symptoms. Multiple empirical studies have also validated the clinical applicability of this standard. A survey conducted on Chinese prisoners [13] showed that 24.6% of the insomnia population had difficulty maintaining sleep, and 38.8% had daytime functional impairment, both of which were symptoms with higher incidence rates in this group. A network analysis targeting mental health professionals[27] also found that interference with daytime functioning was the strongest core node in the insomnia symptom network. Morin et al. [7] further confirmed that insomnia symptoms with both nighttime sleep problems and daytime dysfunction were more persistent than those with only one of these issues, highlighting the clinical significance of both as core symptoms. Collectively, these research results support the conclusion that “Awakenings during night (AIS 2)” and “Daytime functioning capacity (AIS 7)” are core symptoms of the insomnia network.

Practically, Blanken et al. [55] found that cognitive therapy had symptom-specific effects on insomnia-related daytime functioning. This finding suggests that daytime functioning may be a clinically meaningful symptom to monitor when considering sleep-related psychological services in correctional settings. Notably, the consistently high centrality of “Daytime functioning capacity (AIS 7)” across both the individual insomnia network (Study 1) and the insomnia–depression–anxiety symptom network (Study 2) reinforces its role as a clinically relevant symptom marker in correctional settings.

Bridge Symptoms in the Insomnia–Depression–Anxiety Symptom Network

In the insomnia–depression–anxiety symptom network among incarcerated men, the strongest bridge expected influence [56] was “Sleep (PHQ 3)” and “Sad mood (PHQ 2).” While “Sleep (PHQ 3)” may represent a sleep-related bridge symptom, consistent with the cross-diagnostic stability identified by Tao et al. [54]. “Sad mood (PHQ 2)” may represent an affective bridge symptom within the emotionally

isolating prison environment. This dual-bridge structure suggests that connections among insomnia, depression, and anxiety symptoms may involve both sleep-related complaints and affective distress [30]. “Sleep (PHQ 3)” specifically refers to difficulty falling asleep or maintaining a state of sleep, or excessive sleep difficulty [41]. As a core bridge node connecting the three major communities of insomnia, depression, and anxiety, its high bridge expected influence suggests that sleep-related depressive complaints are closely linked with both insomnia and anxiety symptoms.

The finding that “Restlessness (GAD 5)” emerged as the most central node in the overall network is noteworthy. This symptom may reflect psychological tension, agitation, or hyperarousal that is closely embedded in the insomnia–depression–anxiety symptom network. In the high-stress, confined environment of a prison, restlessness often reflects a state of chronic psychological and physiological hyperarousal. This underscores that anxiety management, specifically addressing psychomotor agitation, is highly relevant to correctional mental health assessment and psychological service prioritization.

Regarding the sleep-related bridge symptom, “Sleep (PHQ 3)” emerged as a prominent bridge node in our network. This finding is consistent with network studies in college students [57] and Macau residents [32], suggesting that sleep disruption may be a cross-diagnostic symptom across different populations and settings [58]. Difficulty in sleep (such as awakenings during night) is both a core symptom of insomnia (see Study 1) and an important correlate of anxiety [59–60]. Therefore, symptoms with high bridge expected influence may be useful for identifying individuals whose sleep complaints are accompanied by broader affective distress. Timely clinical attention for incarcerated men experiencing sleep-induced depressive symptoms can support early recognition of co-occurring insomnia, depression, and anxiety symptoms in correctional settings.

Environmental Specificity of Network Structure

In the network structure of insomnia–depression–anxiety in incarcerated men, the strongest edges are generally located within specific mental disorder communities, consistent with previous network research [30, 32, 61–62]. In the network structure of insomnia among incarcerated men, the strongest association was identified between “Daytime well-being (AIS 6)” and “Daytime functioning capacity (AIS 7),” highlighting that subjective daytime distress is intrinsically coupled with functional impairment in this population, and suggesting that daytime consequences are a central feature of chronic insomnia. Another prominent edge within the community was observed between “Total sleep duration (AIS 4)” and “Sleep quality (AIS 5).” This differs from findings in other community samples. For example, among day workers, Dekker et al. [63] found that the strongest edge was between “Early morning awakening” and “Difficulty maintaining sleep.” Similarly, Bai et al. [32] reported that the strongest edge was between “Severity of sleep onset” and “Sleep maintenance.”

We conceptualize this difference as potentially reflecting the influence of the unique prison environment. Prison-specific factors, such as environmental noise, sentence length, and violent charges, substantially affect sleep duration and quality[12]. In resource-depleted contexts where control over one’s sleep

environment (e.g., lighting, noise) is stripped, individuals may place greater emphasis on sleep duration as a salient indicator of sleep quality. Thus, the observed strong association between “Total sleep duration (AIS 4)” and “Sleep quality (AIS 5)” may reflect the close linkage between sleep quantity and perceived sleep quality in correctional environments where external sleep conditions are difficult to control.

The strongest cross-community edge that appears in the network structure is “Sleep induction (AIS 1) – Sleep (PHQ 3).” Sleep induction difficulties involve physiological abnormalities during the initial stage of sleep and are characterized by neurophysiological hyperarousal. This hyperarousal is reflected in an increased proportion of electroencephalogram beta waves, which indicate cortical activation [64]. It is also associated with a significant decrease in P2 amplitude, an event-related potential component related to sleep-protective gating mechanisms [65]. In the prison context, this induction phase may be especially relevant because difficulty initiating sleep can be closely tied to both insomnia severity and depression-related sleep complaints [66–67]. Consequently, routine assessment of sleep induction problems may provide useful information for identifying incarcerated individuals with co-occurring sleep and affective difficulties.

Clinical Implications and Intervention Pathways

In summary, this study constructed both an insomnia network and a symptom network of insomnia, depression, and anxiety among incarcerated men, identifying central insomnia symptoms, bridge symptoms across insomnia, depression, and anxiety, and prominent within- and cross-community edges. “Restlessness (GAD 5)” emerged as the most central symptom of the entire network, and as such, anxiety-related agitation should be considered during psychological screening and follow-up assessment in correctional settings.

Based on these findings, a symptom-informed assessment framework may be useful for correctional mental health practice. First, screening for core insomnia symptoms, particularly “Awakenings during night (AIS 2)” and “Daytime functioning capacity (AIS 7),” may help identify individuals with prominent sleep-maintenance problems and daytime impairment. Moreover, attention to bridge symptoms, particularly “Sleep (PHQ 3)” and “Sad mood (PHQ 2),” may help identify individuals with broader cross-domain sleep and affective distress. Finally, correctional environmental factors, including noise, lighting, shared rooms, and institutional schedules, should also be considered because they may shape sleep complaints and daytime functioning. For instance, measures such as white noise masking or optimized lighting control may be considered in future correctional sleep-health initiatives, although their effectiveness should be evaluated empirically.

Implementing such a symptom-informed approach may help correctional mental health staff move beyond total-score screening and attend to clinically salient symptoms within and across diagnostic domains. Given the relatively high expected influence of “Fatigue” (PHQ 4), daytime activity planning may also be considered when addressing fatigue-related functional impairment in correctional mental health services. Taken together, these findings support the value of symptom-level network analysis for

identifying clinically salient sleep and affective symptoms that may inform screening, follow-up assessment, and psychological service prioritization in correctional settings.

Limitations and Future Directions

This study has several limitations. First, due to the cross-sectional study design, it is not possible to fully determine the causal relationships nor the temporal dynamics of symptom change. Although insomnia symptoms were closely connected with depressive and anxiety symptoms in the network, the present data cannot determine how these associations unfold over time. Future investigations are recommended to employ longitudinal network models to track the dynamic interactions of symptoms over time, which would help verify the directional influence between core and peripheral nodes and clarify the temporal precedence of symptom activation.

Second, although the correlation stability (CS) coefficients for all metrics reached acceptable thresholds, this study prioritized strength centrality and expected influence for our primary interpretations. This ensured that the identified central symptoms reflected the most reliable degree of connectivity. Because the ranking of node scores in the strength centrality index is not completely consistent with the rankings in closeness and betweenness, the central symptoms in this study only reflect the degree of connectivity between other variables within the network. Future research should increase sample sizes and replicate the present findings in independent correctional samples to improve the estimation stability of closeness and betweenness indices, thereby enabling a more comprehensive and multi-dimensional interpretation of symptom centrality.

Third, although correctional environmental factors and environmental stressors were discussed, our data relied on self-report measures, which may be subject to recall bias or social desirability, particularly within a correctional setting. Future studies should integrate objective measures such as actigraphy or physiological markers of hyperarousal to provide a more granular validation of the sleep-related processes discussed in this study.

Finally, this study examined only incarcerated men; whether similar insomnia–depression–anxiety symptom networks would be observed among incarcerated women remains unclear. Future investigations should extend to female populations to explore gender differences in network structures and refine gender-specific assessment approaches for correctional settings.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Review Committee (IRB) of the School of Education, Guangzhou University (approval number: GZHU202312). All procedures were performed in accordance with the ethical standards of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to their involvement in the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analyzed in this study are not publicly available due to the confidential nature of the prison setting but are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare that they have no competing interests.

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Author Contributions

TC and SW contributed equally to this work and share co-first authorship. They conceptualized the study, developed the methodology, conducted the formal analysis and investigation, and drafted the original manuscript. QX and YL contributed to the methodology and formal analysis. MW conceptualized the study, provided resources, supervised the research process, administered the project, and critically reviewed and edited the manuscript. MW is the corresponding author. All authors read and approved the final manuscript.

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Figures

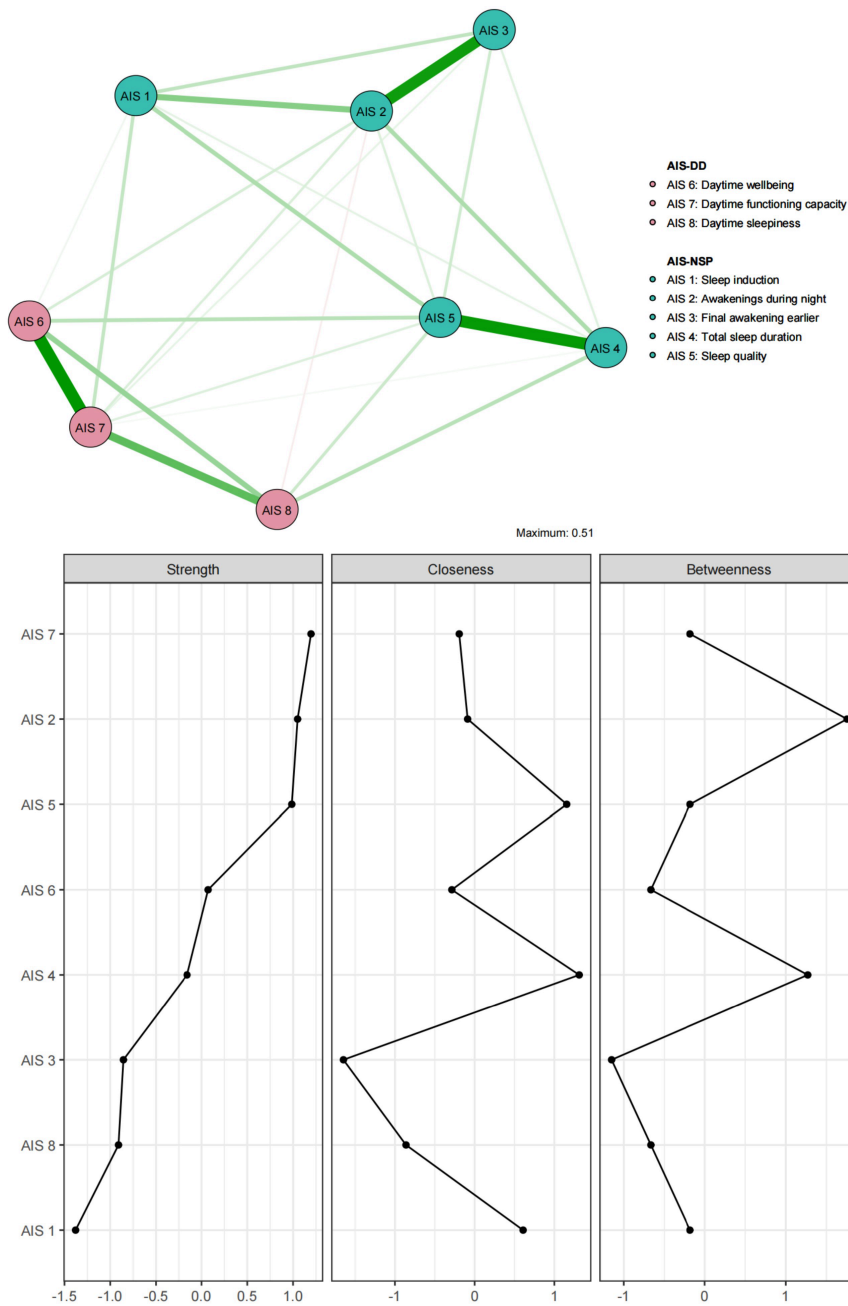


Figure 1

Network of Insomnia

Note. The above panel shows the network diagram. Green edges indicate positive associations; red edges indicate negative associations. The below panel displays the resulting centrality indices sorted by strength.

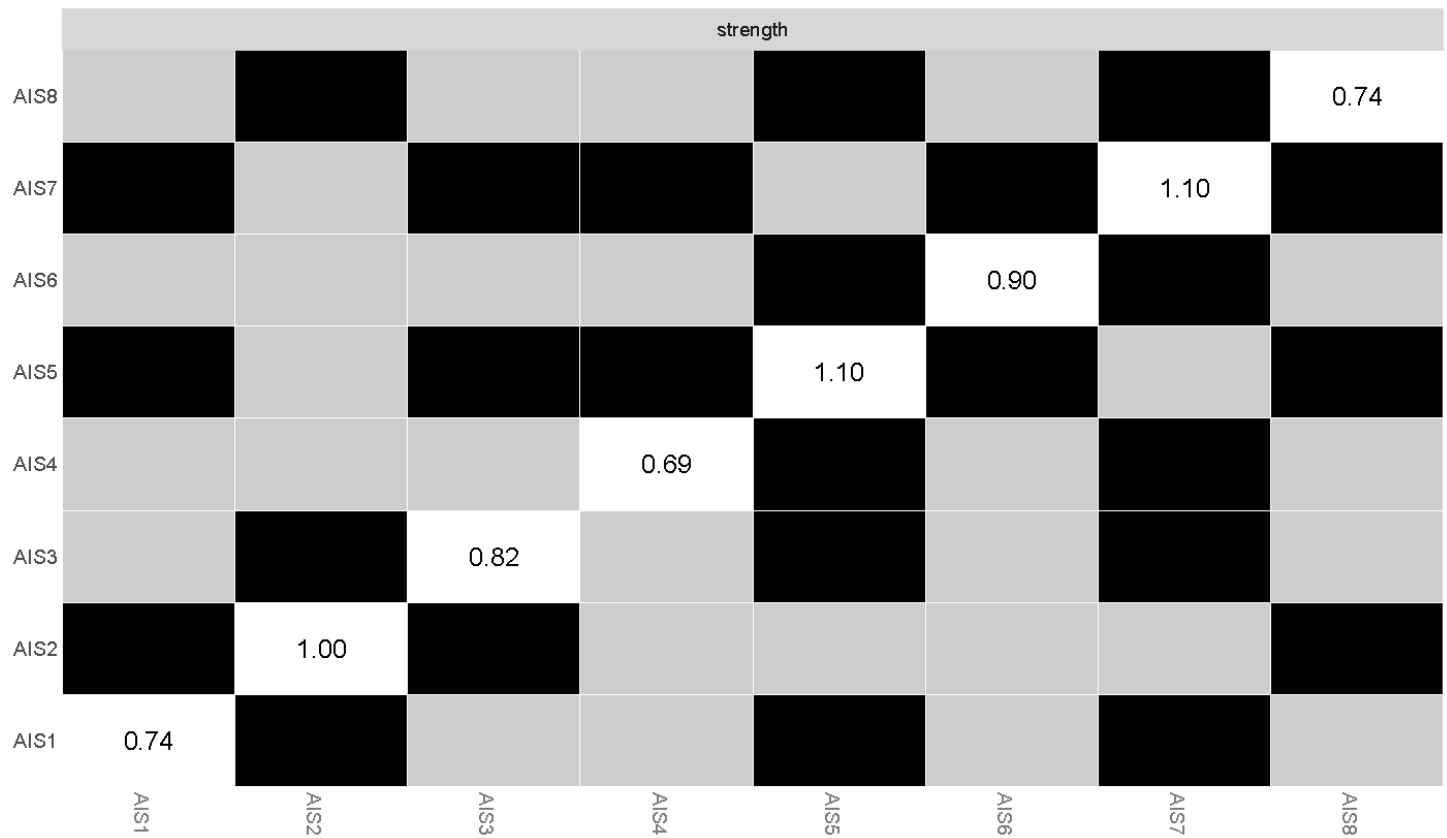


Figure 2

Bootstrap Difference Test Results ($\alpha = .05$) Between the Strengths of Variable Nodes in the Network of Insomnia

Note. Black boxes indicate significant differences between nodes, while gray boxes indicate no significant differences between nodes.

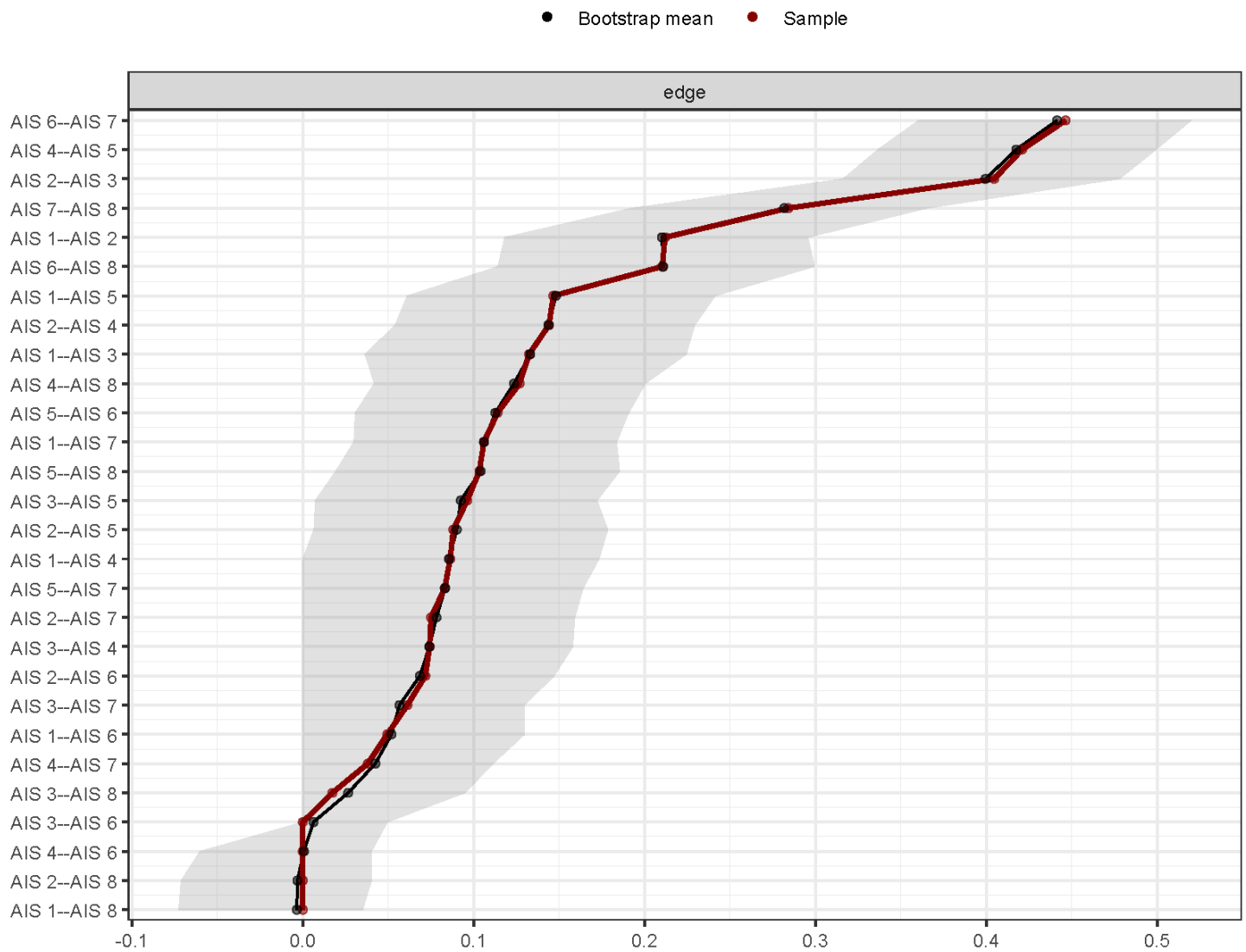


Figure 3

Bootstrapped Confidence Intervals for Edge Weights in the Insomnia Network

Note. Gray areas indicate bootstrapped confidence intervals.

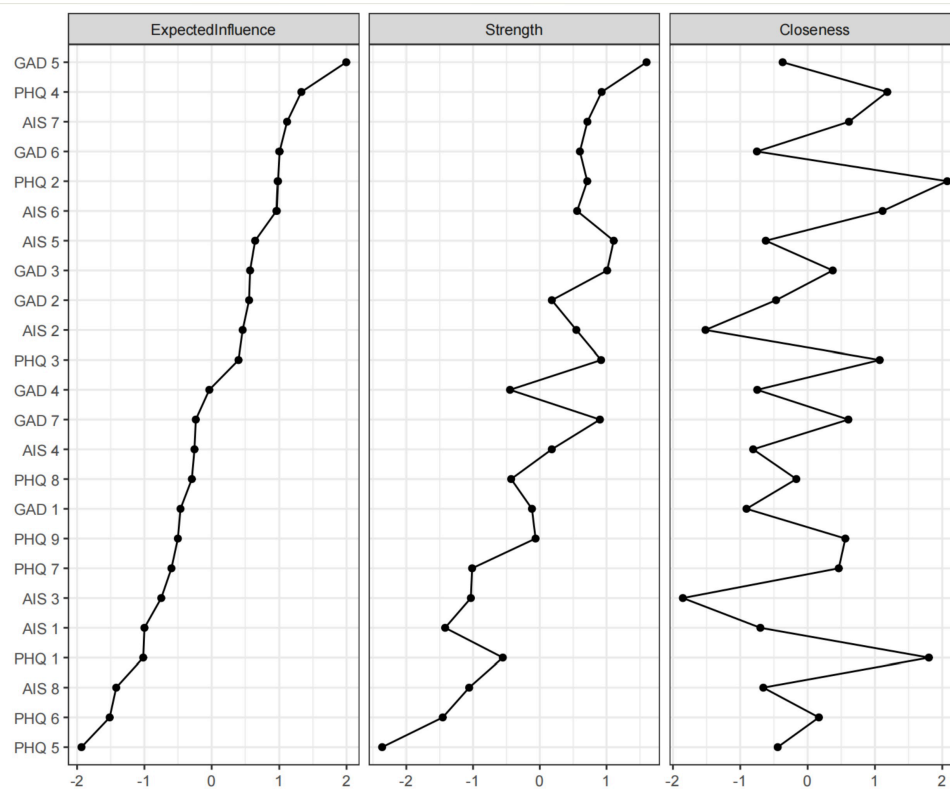
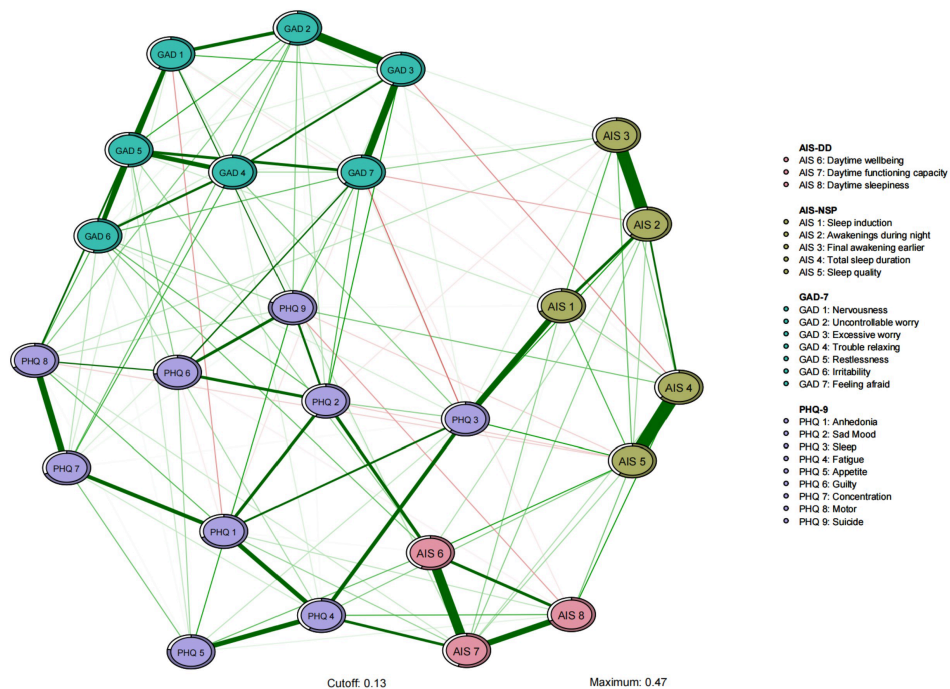


Figure 4

Insomnia-Depression-Anxiety Symptom Network

Note. The above panel shows the network diagram. Green edges indicate positive associations; red edges indicate negative associations. The below panel displays the resulting centrality indices sorted by expected influence.

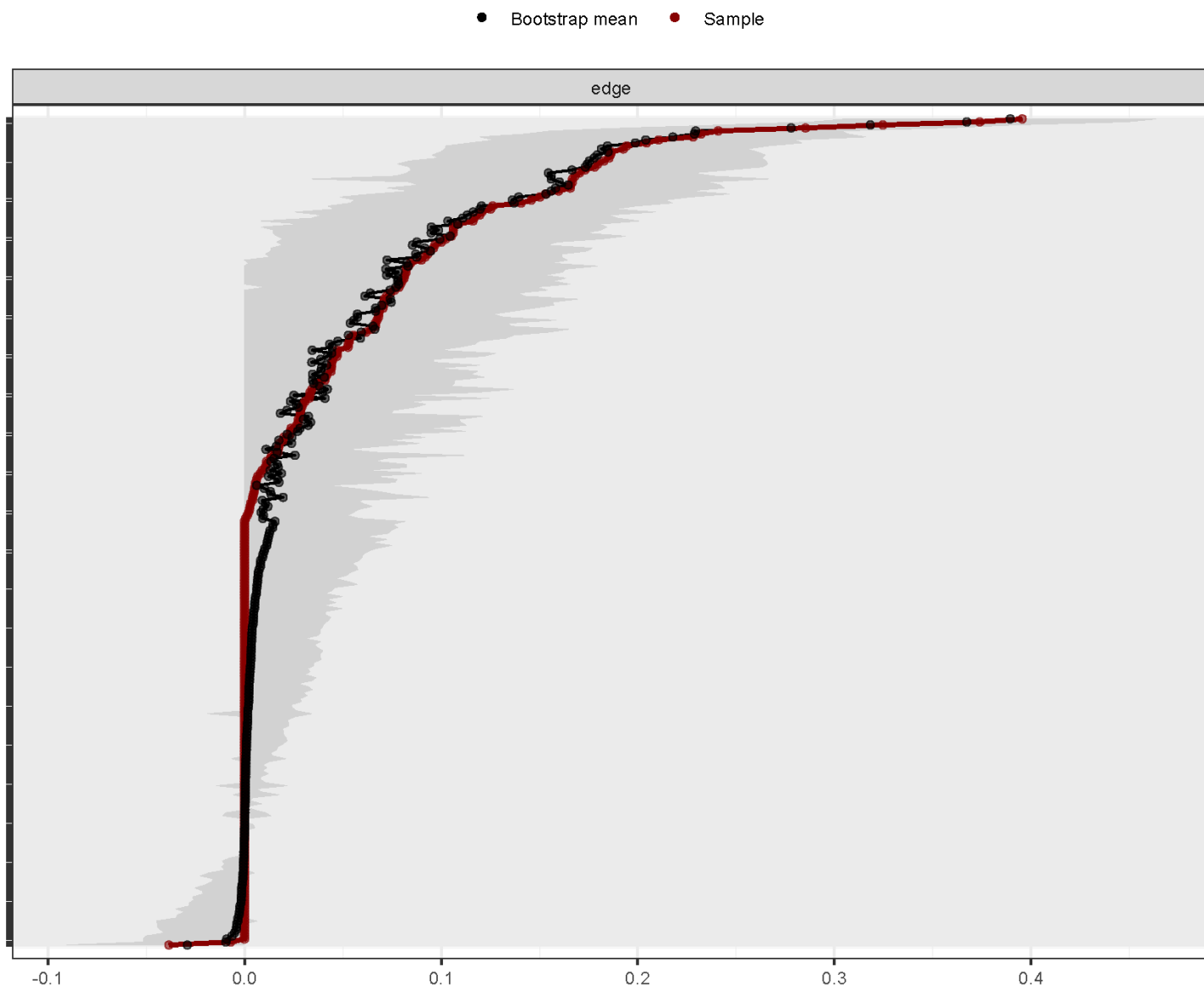


Figure 6

Bootstrapped Confidence Intervals for Edge Weights in the Insomnia–Depression–Anxiety Symptom Network

Note. Gray areas indicate bootstrapped confidence intervals.