Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

A Network Analysis of Loneliness in Intimate Relationships and AI Attachment Among Married Saudi Couples

Fatma Khalifa Elsayed
fkkhalifa1@kau.edu.sa
King Abdulaziz University
Jwanaa Abdullah Aljohani
King Abdulaziz University
Khawla farid Obaidullah
King Abdulaziz University
Dalia Khalid Kaki
King Abdulaziz University
Randa Adham Jumah
King Abdulaziz University
Roa Talal Sagga
King Abdulaziz University

Research Article

Keywords: AI attachment, marital loneliness, network analysis, exploratory graph analysis, emotional hurt, social substitution, Saudi Arabia

Posted Date: July 7th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10026296/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

AI systems are increasingly used as emotional companions, yet their intersection with loneliness experienced within marriage remains largely unexamined. Marital loneliness is associated with relational conflict, declining satisfaction, and psychological distress, and individuals may turn to AI to compensate for unmet emotional needs within the marriage. Despite growing interest in both phenomena, no study has modelled their interplay using network-based methods, nor validated the relevant instruments in Arabic-speaking samples. This study addresses both gaps among married Saudi adults.

Methods

A cross-sectional correlational design was applied. 306 married individuals in Saudi Arabia completed the AI Attachment Scale (emotional closeness, social substitution, moral appreciation) and the Loneliness in Intimate Relationships Scale (detachment, emotional hurt, guilt). Confirmatory factor analysis evaluated instrument validity. Exploratory Graph Analysis (EGA) with graphical LASSO estimated network structure, and eight centrality indices identified the most influential nodes. All analyses were conducted in R version 4.5.0.

Results

CFA supported acceptable fit for both scales. EGA identified two communities corresponding precisely to the two constructs (density = 0.67; all edges positive). Emotional hurt was the most central node across all indices (Strength = 0.97, Eigenvector = 1.00). Cross-community edges were weak, though AI social substitution showed the strongest links to marital guilt (0.099) and emotional hurt (0.077). AI moral appreciation was notably peripheral across the network.

Conclusions

Emotional hurt appears to organise the marital loneliness network, suggesting that addressing it may reduce broader relational distress and AI-compensatory behaviour. Social substitution with AI seems to reinforce rather than relieve marital pain. Clinically, couple therapy may benefit from prioritising emotional repair over directly targeting AI use.

Introduction

Recent years have witnessed a fundamental shift in human–technology interaction. Artificial intelligence (AI) tools have transcended their original function as instruments of productivity and task completion to assume a social and emotional presence in individuals' daily lives. According to data from the Organisation for Economic Co-operation and Development [1], more than one-third of individuals across OECD member states used generative AI tools during 2025. In a similar vein, the Communications, Space and Technology Commission [2] reported that 21.5% of Saudi Arabia's population use such tools, with the 20–29 age group accounting for 27.3% of total users. AI can be defined as a system that employs hardware and data to perform tasks requiring comprehension, reasoning, problem-solving and decision-making, thereby simulating aspects of human intelligence [3, 4].

Within this technological landscape, generative AI has emerged as a technology capable of real-time interactive conversation, user input analysis and the simulation of human-like emotional and social exchanges. Systems such as Replika, Character.AI and XiaoIce are designed to function as emotional companions, guides or friends, and users have reported forming affective bonds that, in some cases, extend beyond instrumental use and may rise to the level of attachment to the AI itself [5]. [6] define AI attachment as a growing tendency among individuals to become attached to AI agents and to relate to them as psychologically, socially and morally meaningful entities, encompassing a sense of emotional closeness to these systems and engaging with them as a substitute for or supplement to human social interaction.

Attachment theory provides a valuable framework for understanding this phenomenon. Bowlby (1969) posited that human beings possess an innate propensity to bond with others—attachment figures to whom they turn in times of threat or vulnerability and from whom they derive practical support and emotional comfort, provided those figures are perceived as stronger and wiser [7]. Individual differences in attachment are commonly described along two principal dimensions: attachment anxiety, which reflects fear of abandonment and the use of hyperactivating strategies in response to perceived threats; and attachment avoidance, which reflects a tendency to eschew intimate relationships and maintain psychological distance through deactivating strategies [7]. Because AI systems offer immediate responsiveness, continuous emotional support and the absence of any risk of abandonment or rejection, [6] propose that such systems may activate the same functional patterns that characterise human attachment relationships. Highly anxious individuals may thus turn to AI as a safer alternative that satisfies their need for emotional closeness without exposing them to the vulnerability inherent in human relationships. Indeed, research has shown that attachment anxiety directly influences problematic use of conversational AI systems and indirectly influences such use through emotional attachment to these systems, a relationship that is moderated and deepened by the tendency to anthropomorphise AI [8]. These systems satisfy psychological needs including a sense of fulfilment, emotional presence and affirming feedback [6].

Crucially, the loneliness that propels individuals toward AI is often not general social loneliness but rather a form of loneliness experienced specifically within the marital relationship. Marital loneliness is a psychologically distinct phenomenon of growing importance in contemporary literature. It is not a condition of external isolation but a state of inner isolation that arises within the marital relationship itself, when there is a perceived discrepancy between the closeness, support and affection one desires from one's partner and what is actually experienced [9]. Research has identified multiple contributing factors, most notably ongoing marital conflict, frequent criticism and the absence of warmth, understanding and emotional support [10, 11]. According to Gottman's theory, marital loneliness emerges when spouses reach a state of emotional flooding from negative reactions and begin to manage their difficulties in isolation, thereby avoiding further conflict. This results in parallel marital roles in which each partner experiences estrangement and loneliness [10]. Weiss's theory of loneliness [12] complements this perspective by distinguishing between objective loneliness (the quantity of social interactions) and subjective loneliness (satisfaction with the quality of those interactions), thereby explaining how an individual may feel lonely despite the presence of a partner when the relationship lacks depth and genuine connection [13].

Marital loneliness carries severe negative consequences that extend beyond the individual and profoundly affect relational dynamics [14], psychological stability [15] and physical health [16]. It predicts lower levels of relationship satisfaction and accelerates the decline of that satisfaction over time; it is also associated with heightened relational tension, increased reported conflict, and diminished trust between partners [9].

The phenomena of AI attachment and marital loneliness converge at a central juncture. The literature indicates that marital loneliness, as a state of inner isolation arising despite the presence of a partner—is negatively associated with the quality of emotional interaction and intimacy between spouses [17] and drives individuals to seek companionship and emotional connection from sources outside the relationship. In this context, recent advances in AI have given rise to social companion systems that have become an increasingly prominent focus of emotional attachment. This relationship may evolve into strong affective bonds that, in some instances, extend beyond the bounds of instrumental use [18]. Interaction with these systems progresses gradually from initial surface-level engagement to deeper involvement characterised by emotional investment and trust-building, supported by features such as empathy and a non-judgmental presence [19]. Thus, attachment to AI does not form randomly; it arises as a direct response to unmet emotional needs, most notably loneliness [18].

However, the relationship is not unidirectional. Growing attachment to AI systems may, in turn, contribute to weakened human bonds and a decline in motivation for genuine communication within the marital relationship [20, 5]. This finding is consistent with Arabic-language studies showing that weakened emotional interaction between spouses is associated with recourse to interaction patterns outside the relationship, such as the use of social media as a substitute for direct communication, which in turn negatively affects marital quality [21]. A potentially circular relationship thus takes shape between marital loneliness and AI attachment, each feeding and deepening the other.

Despite growing scholarly interest in both loneliness and interaction with AI systems, the literature remains limited in its treatment of these phenomena within an integrated framework situated in the marital context. Prior studies have examined marital loneliness within the domain of human relationships without incorporating AI systems as a factor [17], whereas studies of AI attachment have

focused on general loneliness and social anxiety without distinguishing marital loneliness as a distinct experience that occurs within an existing relationship [6, 8]. Arabic-language studies, to the best of our knowledge, have been confined to traditional interactive alternatives such as social media platforms and have not addressed AI systems in the emotional context of marital relationship [21]. Moreover, the mechanisms through which AI attachment forms and intertwines with the components of marital loneliness have not yet been examined using analytical methods capable of uncovering the nature of the mutual relationships among these variables.

Addressing this research gap, the present study examines the relationship between marital loneliness and AI attachment through the lens of network analysis, drawing on two psychometric instruments: the AI Attachment Scale (AIAS) [6] and the Loneliness in Intimate Relationships Scale (LIRS) [13]. The study is timely, as the rate of generative AI system use for emotional interaction is rising at an unprecedented pace, whilst evidence suggests that marital loneliness has become one of the most prevalent yet least documented sources of psychological distress in the prior literature. Furthermore, neither of the two instruments employed has yet been validated on Arabic-speaking samples, rendering this research a contribution that is simultaneously psychometric and theoretical. Both variables are conceptualised as multidimensional psychological constructs that call for a network analytic examination capable of revealing the patterns of interrelationship among their components. This approach aligns with contemporary theoretical directions that conceptualise psychological phenomena as interconnected systems, thereby contributing to a more nuanced and integrated understanding of this phenomenon in its contemporary context. At the applied level, the findings of this study shed light on the impact of AI use on the quality of emotional marital interaction and contribute to raising awareness of the importance of emotional fulfilment and genuine communication in reducing the experience of loneliness within the relationship.

The Problem

Despite accelerating scholarly interest in both marital loneliness and human–AI interaction, the literature remains strikingly fragmented, treating these phenomena as parallel but disconnected domains. Studies of marital loneliness have largely confined themselves to intra-dyadic dynamics, neglecting the potential role of AI systems as alternative sources of emotional connection [17]. Conversely, investigations into AI attachment have predominantly focused on general social loneliness or trait anxiety, failing to isolate the distinct experience of loneliness that arises *within* an existing marital relationship [6, 8]. Arabic-language research, where it exists, has examined only traditional digital substitutes such as social media, leaving entirely unaddressed the emergence of emotionally intelligent generative AI as a relational companion [21]. More critically, no study to date has employed analytical methods capable of uncovering the mutual, reciprocal interplay between the multidimensional components of marital loneliness (detachment, emotional hurt, guilt) and those of AI attachment (emotional closeness, social substitution, moral appreciation). Such a gap is not merely academic: as generative AI use for emotional interaction surges globally, with more than one-third of individuals in OECD countries now engaging with these systems [1] and as marital loneliness emerges as a prevalent yet under-documented source of psychological distress [9], the absence of an integrated, network-based understanding leaves researchers and clinicians without a coherent map of how these two phenomena shape one another. The present study therefore addresses this lacuna by applying exploratory graph analysis to model the relational architecture between AI attachment and marital loneliness for the first time, situating the inquiry within a culturally specific married Saudi sample.

Methodology

Design

A cross-sectional, correlational design was employed to examine the network structure of AI attachment and marital loneliness.

Participants:

A total of 306 married participants were recruited for this study. The sample comprised 231 females (75.5%) and 75 males (24.5%), reflecting a predominantly female respondent base. The age distribution of participants was as follows: the largest proportion fell within the 35 years and older category (n = 156, 51.0%), followed by those aged 30–34 years (n = 47, 15.4%), 25–29 years (n = 36, 11.8%), 20–24 years (n = 37, 12.1%), and under 20 years (n = 30, 9.8%). Thus, the sample was skewed toward middle-aged and older adults, with over half of the participants aged 35 years or above.

Regarding marital duration, the majority of participants reported being married for more than 12 years (n = 115, 37.6%), followed by 4–7 years (n = 70, 22.9%), 8–12 years (n = 69, 22.5%), 1–3 years (n = 39, 12.7%), and less than one year (n = 13, 4.2%). This distribution indicates that the sample predominantly consisted of individuals in long-established marriages, with nearly two-thirds having been married for over eight years.

In terms of daily AI application usage, the majority of participants reported using AI for less than two hours per day (n = 165, 53.9%). Smaller proportions reported usage of 2–4 hours (n = 73, 23.9%), 5–7 hours (n = 41, 13.4%), or more than 7 hours (n = 27, 8.8%). When asked whether they believed AI could compensate for aspects of human relationships, participant responses were diverse: the largest group disagreed with this notion (n = 91, 29.7%), followed by those who strongly disagreed (n = 75, 24.5%), those who agreed (n = 64, 20.9%), those who were neutral (n = 52, 17.0%), and those who strongly agreed (n = 24, 7.8%). Thus, while a substantial minority endorsed some compensatory potential of AI, the prevailing sentiment was scepticism regarding AI's capacity to replace or meaningfully substitute for human relational connection.

Regarding spousal AI usage as estimated by participants, the majority believed their partners used AI for less than two hours per day (n = 157, 51.3%), followed by 2–4 hours (n = 65, 21.2%), 5–7 hours (n = 39, 12.7%), and more than 7 hours (n = 45, 14.7%). This pattern broadly mirrored participants' own usage reports, suggesting general concordance in AI engagement within couples.

All participants were currently married, and the sample was drawn from individuals residing in Kingdom of Saudi Arabia, reflecting a culturally specific context in which marital relationships are traditionally highly valued. The demographic composition, predominantly female, middle-aged or older, and in long-term marriages, provides a distinctive lens through which to examine the intersection of AI attachment and marital loneliness, though it also limits the generalisability of findings to younger, male, or more recently married populations.

Measures:

1. Demographic Data Questionnaire:

To determine the basic characteristics of the study sample, a demographic questionnaire was developed that included key variables such as gender, age group, educational level, average daily social media usage, and the participant's perception of whether artificial intelligence can contribute to fulfilling some of the human need for communication. An additional section addressed the duration of marriage, the average social media use of the spouse, the frequency of marital disputes related to this use, and the overall level of satisfaction with the marital relationship.

2. AI Attachment Scale [6]:

To measure the nature of participants' attachment to AI systems, the study adopted the AI Attachment Scale developed by Kasturiratna and Hartanto [6]. This scale defines attachment as an increasing tendency among individuals to connect with AI agents and treat them as entities with psychological, social, and moral significance. The final version of the scale consists of 15 statements distributed across three dimensions: emotional closeness, social substitution, and moral appreciation, with five statements per dimension. The statements are evaluated using a five-point Likert scale from (1 strongly disagree) to (5 strongly agree), with higher scores reflecting a higher level of attachment. The scale has demonstrated high psychometric properties, with Cronbach's alpha values ranging between 0.95 and 0.97, and a time reliability coefficient (ICC = 0.89), with verification of convergent and differential validity and achievement of standard equivalence across genders and cultures.

Factorial validity:

The three-factor correlated model demonstrated acceptable-to-good fit: $\chi^2(87) = 174.78$, $p = .011$ (scaled); CFI = .96; TLI = .95; RMSEA = .057 (90% CI [.045, .070]); SRMR = .043. All standardised factor loadings were significant ($p < .001$) and ranged from .54 to .79 (median = .74; Table 1). No items fell below the conventional .50 threshold for retention, though EC5 (.54) and MA3 (.59) exhibited relatively lower loadings. The one-factor unidimensional model showed substantially poorer fit: $\chi^2(90) = 584.17$, CFI = .76, RMSEA = .134, SRMR = .093. A scaled chi-square difference test confirmed that the three-factor model was superior ($\Delta\chi^2(3) = 171.2$, $p < .001$). Modification indices suggested correlated residuals between SS2 and SS4 (MI = 21.68, EPC = − .25) and cross-

loading of EC5 onto social substitution (MI = 22.00). However, given the absence of a strong theoretical justification, no post hoc modifications were applied.

A bifactor model specifying a general attachment factor (G) alongside three orthogonal specific factors (EC, SS, MA) converged successfully and demonstrated excellent fit: CFI = .97, TLI = .95, RMSEA = .054, SRMR = .033. General factor loadings ranged from .29 to .74 (mean = .57). Specific factor loadings were notably lower (EC mean = .14; SS mean = .47; MA mean = .55), indicating that most common variance was captured by the general factor. Table 1 presentss the descriptive indices and loadings of structural models.

Table 1
Item Descriptive Statistics and Standardised Factor Loadings

Item	Mean (SD)	Skew	CFA Loading	Bifactor G-Loading
EC1	2.76 (1.14)	-0.10	.68	.61
EC2	2.83 (1.17)	-0.06	.78	.65
EC3	3.20 (1.18)	-0.36	.68	.74
EC4	2.76 (1.21)	0.08	.74	.71
EC5	3.01 (1.17)	-0.14	.54	.53
SS1	2.68 (1.36)	0.18	.79	.65
SS2	3.05 (1.28)	-0.19	.72	.67
SS3	2.84 (1.25)	-0.06	.77	.67
SS4	2.68 (1.34)	0.13	.78	.62
SS5	2.72 (1.30)	0.11	.78	.63
MA1	3.25 (1.15)	-0.50	.71	.63
MA2	3.23 (1.11)	-0.32	.65	.45
MA3	3.28 (1.19)	-0.49	.59	.29
MA4	3.19 (1.16)	-0.32	.76	.58
MA5	2.99 (1.16)	-0.24	.75	.58

Note. EC = Emotional Closeness; SS = Social Substitution; MA = Moral Appreciation. All loadings standardised and significant at $p < .001$ unless otherwise noted.

Cronbach's α for the total scale was .90 (Guttman's λ6 = .92). Subscale α coefficients were .81 (emotional closeness), .88 (social substitution), and .82 (moral appreciation). McDonald's ω total was .92, indicating excellent composite reliability.

3. Loneliness in Intimate Relationships Scale [13]:

To measure feelings of loneliness within marital relationships, the Loneliness in Marital Relationships Scale [13] was applied. This scale differs from traditional loneliness tools in that it is specifically designed to detect the unique loneliness that may arise within marital relationships, a subjective state that manifests when the vitality of the marital bond declines and emotional detachment creeps in between partners despite their physical presence. The scale consists of 14 items distributed across three dimensions: detachment (6 items), emotional hurt (4 items), and guilt (4 items). The items are scored on a six-point Likert scale from (1 does not describe my situation at all) to (6 describes my situation perfectly), with higher scores associated with greater levels of marital distress and overall loneliness. Cronbach's alpha values for the dimensions ranged between 0.64 and 0.87, and factor structure analyses confirmed the validity of the three-dimensional model.

Validity and reliability:

Internal consistency of the Loneliness in Intimate Relationships Scale [13] was evaluated using Cronbach's α, Guttman's λ6, and McDonald's ω. The total scale demonstrated excellent internal consistency (α = .92, λ6 = .93, ω = .94), substantially exceeding the recommended threshold for research applications [22]. Subscale reliabilities ranged from acceptable to good: Detachment (6 items; α = .84, λ6 = .83), Emotional Hurt (4 items; α = .76, λ6 = .72), and Guilt (4 items; α = .81, λ6 = .78). The lower bound of these values aligns with the original development study's reported range (α = .64–.87), though the present sample yielded more robust estimates for the Emotional Hurt subscale.

Item-level analysis revealed corrected item-total correlations ranging from .40 to .72 across all 14 items, with all values exceeding the conventional .30 retention criterion [23]. No item deletion would have substantively improved total scale reliability (α_if_deleted range = .91–.92). The Guilt subscale demonstrated the highest internal consistency, while Emotional Hurt, despite containing only four items, exhibited acceptable reliability, consistent with the properties of shorter scales [24].

The hypothesised three-factor correlated model (Detachment, Emotional Hurt, Guilt) was tested using confirmatory factor analysis with maximum likelihood estimation (ML). The model fit indices revealed a somewhat complex pattern: while the chi-square test was statistically significant ($\chi^2(74) = 307.83$, $p < .001$), reflecting sensitivity to sample size, other fit indices indicated marginal to adequate fit. The CFI was .91, falling within the acceptable range (≥ .90; [25]), though the TLI (.89) marginally missed conventional thresholds. The RMSEA was .077 (90% CI [.067, .088]), which meets the criterion for acceptable fit (≤ .08; [26]), and the SRMR (.064) was below the .08 threshold. Collectively, these indices suggest that the three-factor structure is tenable though not optimal.

Standardised factor loadings ranged from .48 to .85 (Table 2). All items loaded significantly on their respective factors ($p < .001$). One item, G4 ("I feel guilty about my role in the relationship's difficulties"), exhibited a loading (.48) slightly below the preferred .50 threshold, suggesting potential item refinement. The remaining 13 items demonstrated adequate to strong loadings (M = .71), supporting the convergent validity of each subscale.

Table 2
Standardised Factor Loadings from CFA

Subscale/Item	λ	SE	P
Detachment			
DET1	.73	.06	< .001
DET2	.73	.06	< .001
DET3	.74	.07	< .001
DET4	.73	.06	< .001
DET5	.66	.07	< .001
DET6	.55	.07	< .001
Emotional Hurt			
EH1	.59	.07	< .001
EH2	.74	.08	< .001
EH3	.53	.07	< .001
EH4	.79	.08	< .001
Guilt			
G1	.85	.05	< .001
G2	.80	.05	< .001
G3	.78	.06	< .001
G4	.48	.06	< .001
Note. All loadings are standardised and significant at p < .001.			

Data Analysis Strategy

All analyses were performed in R version 4.5.0 (R Core Team, 2025). After computing descriptive statistics and Pearson correlations for the six subscale scores, we employed Exploratory Graph Analysis (EGA; [27]) using the graphical LASSO with EBIC model selection (EGAnet package; [28]) to estimate a sparse, undirected network of partial correlations, with community structure identified via the walktrap algorithm. Node-level influence was assessed through eight centrality indices (Degree, Strength, Betweenness, Closeness, Eigenvector, Hub, Authority, and Expected Influence) derived from the igraph package [29]. Global network properties, density, global strength, mean edge weight, clustering coefficient, average path length, and the proportion of positive versus negative edges, were subsequently calculated, along with within- and between-community edge summaries to characterise the cohesion of the identified communities and their cross-connections. A parametric bootstrap with 500 iterations (bootEGA) was conducted to evaluate the stability of the dimensional solution. All visualisations (network plots, edge weight heatmap, centrality barplots, and correlation heatmap) were generated using qgraph, ggplot2, and corrplot.

Results

Descriptive Statistics

The final sample comprised 306 participants. Descriptive statistics for the six subscale sum scores are presented in Table 3. The AI Attachment subscales (Emotional Closeness, Social Substitution, Moral Appreciation) demonstrated mean scores ranging from 13.96 to 15.94 (possible range 5–25), with standard deviations between 4.41 and 5.35. The Loneliness subscales (Detachment,

Emotional Hurt, Guilt) showed mean scores ranging from 9.91 to 16.23 (possible ranges 4–24 for Emotional Hurt and Guilt; 6–36 for Detachment), with standard deviations between 4.82 and 7.11. Skewness and kurtosis values for all variables fell within acceptable ranges for multivariate normality (|skew| < 2, |kurtosis| < 7; Kline, 2016).

Table 3
Descriptive Statistics for AI Attachment and Loneliness Subscales (N = 306).

Subscale	Mean	SD	Min	Max	Skew	Kurtosis
AI Attachment Scale						
AI Emotional Closeness	14.56	4.42	5	25	-0.23	-0.62
AI Social Substitution	13.96	5.35	5	25	-0.05	-0.96
AI Moral Appreciation	15.94	4.41	5	25	-0.44	-0.07
Loneliness Scale						
LON Detachment	16.23	7.11	6	36	0.43	-0.38
LON Emotional Hurt	9.91	4.82	4	24	0.53	-0.46
LON Guilt	10.56	5.29	4	24	0.42	-0.82

Correlation Matrix

Pearson product-moment correlations among the six subscales are displayed in Table 4. Within the AI Attachment Scale, significant positive correlations emerged among all three subscales, with the strongest association observed between Emotional Closeness and Social Substitution ($r = .667$, $p < .001$). Within the Loneliness Scale, all three subscales were strongly and positively intercorrelated, with the strongest relationship between Emotional Hurt and Guilt ($r = .790$, $p < .001$). Cross-scale correlations were uniformly positive but substantially weaker, ranging from $r = .158$ (AI Moral Appreciation with LON Guilt) to $r = .379$ (AI Social Substitution with LON Guilt). This pattern suggests that the two scales measure related yet distinct constructs.

Table 4
Pearson Correlation Matrix Among Subscales.

Variable	1	2	3	4	5	6
1. AI Emotional Closeness	—					
2. AI Social Substitution	.667	—				
3. AI Moral Appreciation	.520	.404	—			
4. LON Detachment	.233	.312	.250	—		
5. LON Emotional Hurt	.287	.375	.188	.760	—	
6. LON Guilt	.251	.379	.158	.724	.790	—
Note. All correlations significant at $p < .001$ (two-tailed).						

Exploratory Graph Analysis (EGA)

Exploratory Graph Analysis using the graphical LASSO (glasso) with EBIC model selection revealed a two-dimensional community structure (see Fig. 1). The first community comprised the three AI Attachment subscales (Emotional Closeness, Social Substitution, Moral Appreciation). The second community comprised the three Loneliness subscales (Detachment, Emotional Hurt, Guilt). This structure aligns precisely with the theoretical distinction between the two measurement instruments, providing strong evidence of construct validity.

Edge Weights and Network Structure

The estimated network contained 10 edges (all positive) among the six nodes, representing 66.7% of all possible connections (network density = .667). Edge weights ranged from 0.015 to 0.504 (*M* = 0.234, *SD* = 0.190). Within the AI Attachment community, the strongest connection was between Emotional Closeness and Social Substitution (weight = 0.504), followed by Emotional Closeness with Moral Appreciation (0.324), and Social Substitution with Moral Appreciation (0.073). Within the Loneliness community, the strongest connection was between Emotional Hurt and Guilt (0.467), followed by Detachment with Emotional Hurt (0.408), and Detachment with Guilt (0.306).

Cross-community connections were notably weaker, with four edges connecting the two communities (weights ranging from 0.015 to 0.099). The strongest cross-community connection was between AI Social Substitution and LON Guilt (0.099), suggesting that individuals who use AI for social substitution may also experience guilt about their marital relationships. The complete edge weight matrix is presented in Fig. 2.

Centrality Indices

Comprehensive centrality analysis was conducted to identify the most influential nodes within the network. Eight distinct centrality indices were computed: Degree, Strength, Betweenness, Closeness, Eigenvector, Hub, Authority, and Expected Influence. Results are presented in Table 6.

Table 6
Complete Centrality Indices (Sorted by Strength)

Node	Comm.	Degree	Strength	Betweenness	Closeness	Eigenvector	Hub	Authority	Expected Influence
LON Emotional Hurt	2	4	0.968	1.333	0.167	1.000	1.000	1.000	0.968
LON Guilt	2	3	0.873	0.333	0.143	0.936	0.936	0.936	0.873
AI Emotional Closeness	1	3	0.843	0.333	0.143	0.416	0.416	0.416	0.843
LON Detachment	2	3	0.778	0.833	0.143	0.857	0.857	0.857	0.778
AI Social Substitution	1	4	0.754	1.333	0.167	0.481	0.481	0.481	0.754
AI Moral Appreciation	1	3	0.461	0.833	0.143	0.271	0.271	0.271	0.461

Note. Comm.= Community; Community 1 = AI Attachment Scale; Community 2 = Loneliness in Intimate Relationships Scale.

Emotional hurt within marital relationships emerged as the undisputed psychological engine of the entire network, saturating every centrality index with near-maximum values (Strength = 0.968, Betweenness = 1.333, Eigenvector = 1.000, Hub = 1.000, Authority = 1.000). This is not a statistical artefact but a psychological reality: emotional hurt is simultaneously the most connected experience (high Degree), the critical bridge through which other painful states, guilt, detachment, even compensatory AI use, must pass (high Betweenness), the topological centre from which distress radiates most efficiently (high Closeness), and preferentially attached to other highly influential nodes, creating a self-amplifying loop of mutual reinforcement (Eigenvector = 1.000). Its perfect Hub and Authority scores reveal a bidirectional, recursive dynamic: emotional hurt both shapes and is deepened by guilt and withdrawal, locking the individual in a closed cycle of relational pain. Psychologically, this means that to feel emotionally hurt is rarely to feel only that; it is to be simultaneously guilty about the state of one's relationship, detached from one's partner, and paradoxically driven toward AI as a compensatory but ultimately futile escape. By contrast, the markedly lower centrality of AI Moral Appreciation (Strength = 0.461, Eigenvector = 0.271) reveals a different psychological truth: ascribing moral standing to AI is experientially peripheral, largely disconnected from both marital distress and other forms of AI engagement, challenging the assumption that moral appreciation is an integral component of human-AI bonding. The remaining nodes occupy psychologically distinct intermediary positions. Guilt (Strength = 0.873, Eigenvector = 0.936) derives its potency not from how many experiences it

touches but from the emotional intensity of its singular tie to emotional hurt, suggesting guilt is a secondary emotional response, a painful awareness of having failed one's partner, that arises only after hurt has taken root. AI Social Substitution (Strength = 0.754, Betweenness = 1.333) serves as the primary bridge between the AI and loneliness communities, revealing a paradoxical clinical dynamic: turning to AI to compensate for social deficits does not soothe distress but instead deepens marital guilt and emotional hurt, transforming technology into an avoidant coping mechanism that exacerbates the very pain it seeks to escape. Detachment (Strength = 0.778, Betweenness = 0.833) occupies a mediating pathway from emotional hurt to guilt, suggesting a three-stage psychological cascade: hurt first triggers emotional withdrawal (detachment), which then generates guilt about having withdrawn. Finally, AI Emotional Closeness (Strength = 0.843, Eigenvector = 0.416) demonstrates moderate but insulated influence, implying that feeling close to AI is a relatively self-contained emotional experience, one that does not strongly implicate other attachment processes. Collectively, these centrality findings crystallise into a single clinical insight: emotional hurt is the linchpin of the network. Interrupting it would not merely reduce one symptom; it would destabilise the entire architecture of distress, loosening guilt, dissolving detachment, and perhaps even reshaping how individuals relate to AI. Figures 3 presents the centrality indices for the study nodes.

Global Network Metrics

The global properties of the estimated network indicated a moderately dense structure, with 10 positive edges identified among the six nodes, representing 66.7% of all possible connections (network density = 0.667). The predominance of positive edges (100%) is theoretically meaningful: it suggests that higher scores on all subscales, whether measuring AI attachment or marital loneliness, covary in a consistent, unidirectional manner. In practical terms, individuals who reported stronger emotional closeness to AI also tended to report higher social substitution and moral appreciation, while those who experienced greater detachment, emotional hurt, or guilt in their marital relationships similarly showed elevations across all loneliness dimensions. This pattern of uniform positive connectivity implies an absence of trade-offs or compensatory mechanisms within the network; rather, the constructs appear to operate as coherent, internally aligned systems.

The global strength of the network—the sum of absolute edge weights, was 2.338, with a mean edge weight of 0.234. These values reflect a network where connections are neither trivial nor overwhelmingly strong, suggesting a balanced structure in which nodes exert meaningful but not excessive influence upon one another. The clustering coefficient of 0.500 indicates moderate local connectivity, meaning that nodes within the same community tend to form tightly interconnected triads, yet there remains room for cross-community information flow. Critically, the average path length was 0.140, a notably low value that signifies highly efficient communication across the network. In network psychometric terms, this implies that activation or change in any one node can rapidly propagate to other nodes, potentially reflecting the spreading nature of psychological states such as attachment insecurity or relational distress.

Turning to within-community connectivity, both identified communities demonstrated robust internal coherence, though with meaningful differences. The AI Attachment community comprised three internal edges with a mean weight of 0.300 (SD = 0.217), indicating moderate consistency among its constituent subscales. The Loneliness community, by contrast, exhibited stronger internal cohesion, with a mean internal edge weight of 0.394 (SD = 0.081). This suggests that the three dimensions of marital loneliness—detachment, emotional hurt, and guilt, are more tightly coupled with one another than the three dimensions of AI attachment are among themselves. Substantively, this may reflect the more established and socially embedded nature of marital relationships, wherein emotional experiences are closely intertwined, compared with the comparatively nascent and perhaps more differentiated nature of human-AI bonds.

Between-community connectivity was notably weaker, comprising four edges with a mean weight of 0.064 (SD = 0.034). This disparity between within- and between-community edge weights provides empirical support for the discriminant validity of the two scales: the AI Attachment Scale and the Loneliness in Intimate Relationships Scale measure related yet separable constructs. However, the presence of cross-community connections indicates that the two constructs are not entirely independent. The strongest of these bridging connections involved AI Social Substitution linking to both Loneliness Guilt (0.099) and Loneliness Emotional Hurt (0.077). This pattern is compelling: individuals who turn to AI to compensate for perceived deficits in human social interaction may simultaneously experience guilt about the state of their marital relationships and heightened emotional hurt arising from those relationships. In other words, social substitution with AI does not occur in a relational vacuum; it appears to be

associated with, and perhaps partially driven by, distress within intimate partnerships. Weaker cross-community connections also emerged between AI Moral Appreciation and Loneliness Detachment (0.064), and between AI Emotional Closeness and Loneliness Emotional Hurt (0.015), suggesting that even the more emotionally engaged and morally reflective dimensions of AI attachment bear some, albeit limited, relation to marital loneliness.

Discussion

The present study provides the first network analysis of AI attachment and marital loneliness. Emotional hurt within the marriage emerged as the most influential node across all eight centrality indices (strength = 0.97, eigenvector = 1.00), indicating that it simultaneously co-occurs with guilt, detachment, and compensatory AI use. Its high hub and authority values suggest a recursive dynamic: emotional hurt both shapes and is deepened by guilt and withdrawal, locking individuals into a self-amplifying cycle of relational distress. This finding extends Gottman's theory of marital loneliness by specifying a network pathway from emotional flooding to avoidant coping, and aligns with Weiss's distinction between objective and subjective loneliness in that subjective hurt —not contact quantity—organises the network. The two-community structure supports the discriminant validity of both scales. Cross-community edges were weak, but AI social substitution formed the strongest bridge to marital guilt (0.099) and emotional hurt (0.077), revealing a clinically paradoxical mechanism: turning to AI for social compensation does not alleviate distress but deepens marital pain, transforming technology into an avoidant strategy that exacerbates the very suffering it seeks to escape. This pattern is consistent with prior work on social media and AI companions, suggesting a general principle that digital substitutes for human connection, when deployed in the context of marital distress, may reinforce rather than reduce relational suffering. AI moral appreciation was markedly peripheral, challenging assumptions that moral standing is integral to human–AI bonding. Global network properties (density = 0.667, all positive edges; average path length = 0.140) indicate that activation or change in any node, particularly emotional hurt, may propagate rapidly across the network. Stronger internal cohesion within the loneliness community (mean edge weight = 0.394) than within the AI attachment community (0.300) suggests that the emotional dimensions of marital relationships are more tightly coupled than those of nascent human–AI bonds.

Limitations

Several limitations should be noted. The cross-sectional design precludes causal or temporal inferences; longitudinal network analyses are required to establish directionality. The sample was predominantly female (75.5%), aged 35 years or older (51%), and in long-term marriages (over eight years for 60%). Findings may not generalise to younger, male, or more recently married populations. The sample was drawn exclusively from Saudi Arabia, a context in which marital relationships are traditionally highly valued; cross-cultural replication is needed. Reliance on self-report measures introduces potential shared method variance, and spousal AI use was assessed via participant perception rather than objective measurement. The absence of negative edges may reflect construct operationalisation rather than a genuine absence of trade-offs. Finally, the marginally acceptable fit of the loneliness scale (TLI = 0.89) and the low loading of item G4 (0.48) suggest that further refinement of this instrument for Arabic-speaking samples is warranted.

Implications for Mental Health, Practice, and Policy

Clinically, the centrality of emotional hurt suggests that therapeutic efforts should prioritise repairing emotional hurt within the marital relationship rather than directly discouraging AI use, as addressing this core node may reduce guilt, detachment, and compensatory AI engagement. The validated Arabic versions of both scales can assist in identifying individuals experiencing this hurt–guilt–detachment cascade, with elevated AI social substitution scores signalling a potentially maladaptive coping pattern that paradoxically deepens distress. Public health and couple education programmes should normalise the experience of feeling ‘together yet alone’ as an outcome of a self-amplifying network, equipping couples with communication tools to address emotional hurt before compensatory digital behaviours become entrenched, and distinguishing in premarital programmes between AI as a tool and AI as a relational substitute. For companion AI systems marketed for loneliness relief, warning disclosures or design features that encourage human connection—such as periodic prompts inviting users to reflect on whether AI use supplements or supplants authentic relationships—may be warranted. Finally, funding agencies should prioritise longitudinal, dyadic, and cross-cultural studies to examine how AI engagement and marital processes interact dynamically over time.

Conclusion

As generative AI use for emotional interaction increases globally, this study demonstrates that feeling ‘together yet alone’ is not a paradox but a predictable outcome of a self-amplifying network in which emotional hurt, guilt, detachment, and AI social substitution mutually reinforce one another. Emotional hurt emerged as the most influential node; AI social substitution was associated with deeper, not reduced, marital pain; and AI moral appreciation was peripheral. Clinically, couples therapy should prioritise emotional repair over directly targeting AI use. Interrupting this cycle begins with naming and addressing the hurt. The validated Arabic versions of both scales provide new tools for cross-cultural research. Policymakers and developers may need to reconsider marketing claims for companion AI systems, as they may inadvertently reinforce the distress they aim to alleviate. The key question is not whether humans can form attachments to machines—they can—but whether such attachments support human flourishing or undermine it. In the context of marital loneliness, the evidence leans towards the latter. Restoration of genuine human connection remains the priority.

Declarations

Ethics approval and consent to participate

The research protocol received ethical approval from the Research Ethics Committee of the Faculty of Arts and Humanities, King Abdulaziz University (Approval No. REC-FAH-KAU-2026-019; approved on 20 May 2026). All procedures involving human participants were conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all participants prior to their participation in the study. Participation was voluntary, and participants were informed about the purpose of the study, the confidentiality of their responses, and their right to withdraw at any time without penalty.

Consent for publication

Not applicable. This manuscript does not contain any individual person’s data in any form (e.g., photographs, names, or other identifying information).

Competing interests

The authors declare that they have no competing interests.

Author Contribution

All authors have read and agreed to the published version of the manuscript. Conceptualization, F.K.E. and J.A.A.; Methodology, F.K.E., K.F.O., and D.K.K.; Formal Analysis, R.A.J.; Investigation, F.K.E. and R.T.s.; Data Curation,F.K.E.; Writing—Original Draft Preparation, F.K.E.; Writing—Review and Editing, F.K.E. and J.A.A.; Supervision, F.K.E.; Project Administration, F.K.E.; Funding Acquisition, F.K.E. All authors have read and agreed to the published version of the manuscript.

Acknowledgement

This project was funded by KAU Endowment (WAQF) at King Abdulaziz University, Jeddah, Saudi Arabia. The authors, therefore, acknowledge with thanks WAQF and the Deanship of Scientific Research (DSR) for financial support.

Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy or ethical restrictions related to participant confidentiality.

References

1. Organisation for Economic Co-operation and Development. AI use by individuals surges across the OECD as adoption by firms continues to expand [Internet]. OECD; 2026 https://www.oecd.org/en/about/news/announcements/2026/01/ai-use-by-individuals-surges-across-the-oecd-as-adoption-by-firms-continues-to-expand.html
2. Communications, Space and Technology Commission. Saudi Internet Report 2024 [Internet]. Riyadh: CST; 2025. https://www.cst.gov.sa/ar/media-center/news/N2025051200.
3. Hertlein KM, Springer P. Artificial intelligence in couple and family therapy: Introduction of the AI competencies. J Marital Fam Ther. 2026;52. https://doi.org/10.1111/jmft.70121.
4. Lee JY, Ahn E, Xu A, Yang Y, Chang Y, Cha H, et al. Artificial intelligence in applied family research involving families with young children: A scoping review. Fam Relat. 2025;74(3):1121–45. https://doi.org/10.1111/fare.13090.
5. Ho JQH, Hu M, Chen TX, Hartanto A. Potential and pitfalls of romantic Artificial Intelligence (AI) companions: A systematic review. Comput Hum Behav Rep. 2025;19:100715. https://doi.org/10.1016/j.chbr.2025.100715.
6. Kasturiratna KS, Hartanto A. Attachment to artificial intelligence: Development of the AI attachment scale, construct validation, and the psychological mechanisms of human–AI attachment. Comput Hum Behav Rep. 2026;21:100912. https://doi.org/10.1016/j.chbr.2025.100912.
7. Yang F, Oshio A. Using attachment theory to conceptualize and measure the experiences in human-AI relationships. Curr Psychol. 2025;44(11):10658–69. https://doi.org/10.1007/s12144-025-07917-6.
8. Heng S, Zhang Z. Attachment anxiety and problematic use of conversational artificial intelligence: Mediation of emotional attachment and moderation of anthropomorphic tendencies. Psychol Res Behav Manag. 2024;18:1775–85. https://doi.org/10.2147/PRBM.S531805.
9. Mund M, Johnson MD. Lonely me, lonely you: Loneliness and the longitudinal course of relationship satisfaction. J Happiness Stud. 2021;22(2):575–97. https://doi.org/10.1007/s10902-020-00241-9.
10. Gottman JM. The Marriage Clinic: A scientifically based marital therapy. New York: WW Norton & Company; 1999.
11. Marini CM, Ermer AE, Fiori KL, Rauer AJ, Proulx CM. Marital quality, loneliness, and depressive symptoms later in life: The moderating role of own and spousal functional limitations. Res Hum Dev. 2020;17(4):211–34. https://doi.org/10.1080/15427609.2020.1837598.
12. Weiss SF. Learning to disambiguate. Inf Storage Retr. 1973;9(1):33–41. https://doi.org/10.1016/0020-0271(73)90005-3.
13. Rokach A, Sha'ked A, Ben-Artzi E. Loneliness in Intimate Relationships Scale (LIRS): Development and validation. Int J Environ Res Public Health. 2022;19(19):12970. https://doi.org/10.3390/ijerph191912970.
14. Sease TB, Sandoz EK, Yoke L, Swets JA, Cox CR. Loneliness and relationship well-being: Investigating the mediating roles of relationship awareness and distraction among romantic partners. Behav Sci (Basel). 2024;14(6):439. https://doi.org/10.3390/bs14060439.
15. Lee SL, Pearce E, Ajnakina O, Johnson S, Lewis G, Mann F, et al. The association between loneliness and depressive symptoms among adults aged 50 years and older: a 12-year population-based cohort study. Lancet Psychiatry. 2021;8(1):48–57. https://doi.org/10.1016/S2215-0366(20)30383-7.
16. Holt-Lunstad J. Social connection as a critical factor for mental and physical health: evidence, trends, challenges, and future implications. World Psychiatry. 2024;23(3):312–32. https://doi.org/10.1002/wps.21224.
17. Leavitt CE, Price AA, Inman NF, Lee M, Sandridge A, Harrison Z, et al. Loneliness within a romantic relationship: Do gratitude and forgiveness moderate between loneliness and relational and sexual well-being? J Sex Marital Ther. 2025;51(3):309–22. https://doi.org/10.1080/0092623X.2025.2467416.
18. Hu D, Lan Y, Yan H, Chen CW. What makes you attached to social companion AI? A two-stage exploratory mixed-method study. Int J Inf Manag. 2025;83:102890. https://doi.org/10.1016/j.ijinfomgt.2025.102890.
19. Skjuve M, Følstad A, Fostervold KI, Brandtzaeg PB. My chatbot companion: A study of human-chatbot relationships. Int J Hum Comput Stud. 2021;149:102601. https://doi.org/10.1016/j.ijhcs.2021.102601.
20. Kim M, Lee S, Kim S, Heo J, Lee S, Shin YB et al. Therapeutic potential of social chatbots in alleviating loneliness and social anxiety: Quasi-experimental mixed methods study. J Med Internet Res. 2025;27:e65589. Available from: https://www.jmir.org/2025/1/e65589

21. Al-Momani FA, Al-Khaza'leh HA, Al-Shaqran H. Emotional divorce and its relationship with social media use among married individuals. J Soc Sci. 2022;50(1):152–70.
22. Nunnally JC, Bernstein IH. Psychometric theory. 3rd ed. New York: McGraw-Hill; 1994.
23. Hair JF, Risher JJ, Sarstedt M, Ringle CM. When to use and how to report the results of PLS-SEM. Eur Bus Rev. 2019;31(1):2–24. https://doi.org/10.1108/EBR-11-2018-0203.
24. Eisinga R, Grotenhuis MT, Pelzer B. The reliability of a two-item scale: Pearson, Cronbach, or Spearman-Brown? Int J Public Health. 2013;58(4):637–42. https://doi.org/10.1007/s00038-012-0416-3.
25. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct Equ Model. 1999;6(1):1–55. https://doi.org/10.1080/10705519909540118.
26. Browne MW, Cudeck R, Bollen KA, Long JS. Alternative ways of assessing model fit. In: Bollen KA, Long JS, editors. Testing Structural Equation Models. Newbury Park: Sage; 1993. pp. 136–62.
27. Golino HF, Epskamp S. Exploratory graph analysis: A new approach for estimating the number of dimensions in psychological research. PLoS ONE. 2017;12(6):e0174035. https://doi.org/10.1371/journal.pone.0174035.
28. Golino H, Jimenez M, Garrido LE, Christensen AP. Generalized total entropy fit index: A new fit index to compare bifactor and correlated factor structures in SEM and network psychometrics. PsyArXiv. 2024.
29. Csardi G, Nepusz T. The igraph software. Complex Syst. 2006;1695:1–9.

Figures

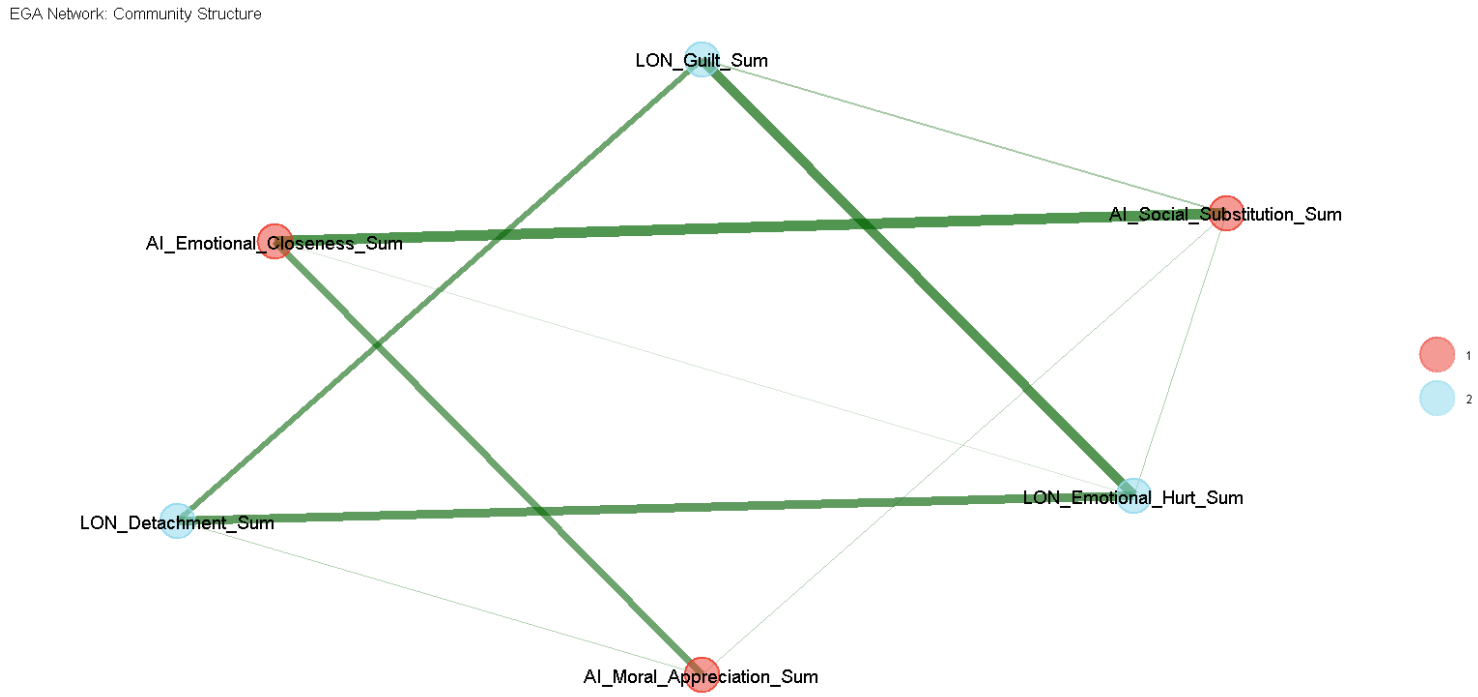


Figure 1

EGA Network Visualisation with Community Structure

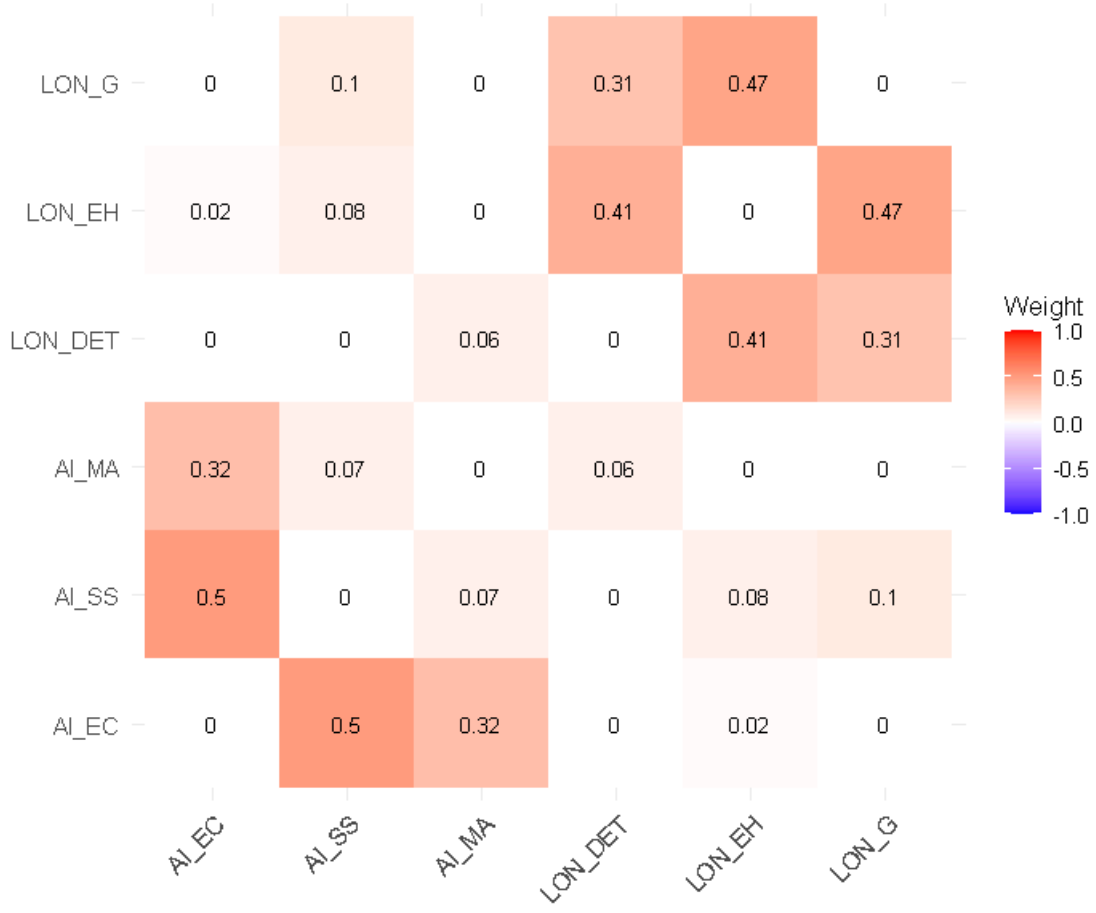


Figure 2

Edge Weights Between All Nodes (Partial Correlations)

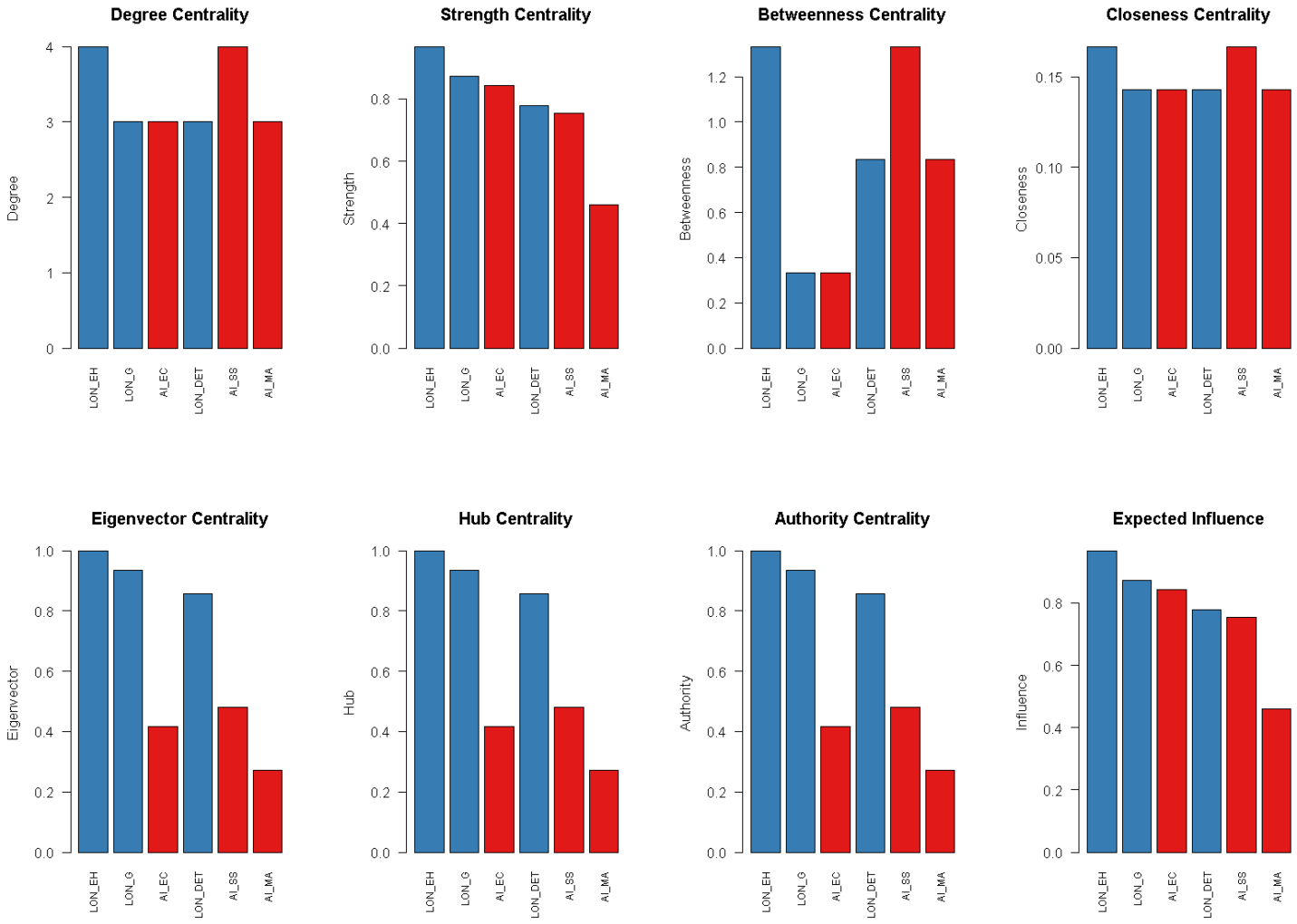


Figure 3

Centrality indices of Nodes pivotals.