

Mindfulness networks: Analyzing associations with self-compassion, other-compassion, need fulfillment, and satisfaction in midlife married Canadians

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Abstract

Interest in mindfulness in the field of romantic relationships is growing. Drawing from a Self-Determination Theory (SDT) perspective—which proposes that the basic psychological needs for autonomy, competence, and relatedness are foundational for well-being—we attempted to map out the complex associations between mindfulness, self-compassion, other-compassion, basic need fulfillment in relationships, and increased relationship and sexual satisfaction. A sample of 640 midlife (40–59-year-old) married Canadians was recruited from a national panel. To test the associations at a systems-level, we utilized psychological network analysis based on the premise that the relational and sexual effects of mindfulness are understood as part of a dynamic and multivariate network

Statement of relevance: This study examines how mindfulness, self-and-other-compassion, and need fulfillment relate to relationship and sexual satisfaction in midlife married couples (age 40–59). By using psychological network analysis, the study offers new insights into the complex interplay between these factors. The findings highlight the importance of need fulfillment, especially relatedness needs, in connecting mindfulness and self-compassion to satisfaction, and provide a unique systems-level perspective on mindfulness in relationships.

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of associations with other variables. Need fulfillment in relationships (particularly relatedness needs) occupied a central position in the model, connecting mindfulness and self-compassion with relationship satisfaction and sexual satisfaction. The findings underscored the major importance of SDT in relationships, and the overall structure of the network was consistent with growing theories of mindfulness in relationships. Future research employing longitudinal network models will aid in elucidating this system's operation over time.

KEYWORDS

midlife marriage, mindfulness, networks, quantitative methods, relationship satisfaction, sexual satisfaction

1 | INTRODUCTION

The notion that “loving one's self” or “knowing one's self” predicates the ability to love or know others is engrained in the empirical literature (Branden, 1994; Campbell & Baumeister, 2003) and more recently is part of the premise of Mindfulness-Based Stress Reduction and Acceptance and Commitment Therapy (Baer, 2015). There has been a strong and growing interest in the individual-level application of constructs with roots in Buddhist philosophy, like mindfulness (i.e., nonjudgmental attention and awareness to the present moment experiences) and self-compassion (a kind disposition toward one's self; Allen & Knight, 2005). The relational applications of mindfulness and self-compassion have also recently begun to garner attention (Karremans et al., 2017; Neff & Beretvas, 2013). Recent theorizing in this area suggests that mindfulness is situated within a complex and dynamic system containing numerous intra-and-inter-personal variables that contribute to relational and sexual well-being (Karremans et al., 2017). However, a read of the existing literature suggests that individual studies have been focused on a small number of specific mechanisms/associations (i.e., associations between mindfulness and attachment orientations; Gazder & Stanton, 2023). The literature has also primarily recruited younger adults who are in shorter-duration relationships, leaving the effects of mindfulness largely unexplored among midlife individuals in longer relationships. If the goal is to learn how mindfulness might help relationships, then an important part of theory testing efforts should be devoted to the study of relationships that are longer in duration. This study utilizes psychological network modeling, a newer methodology well-suited to understanding the system of complex interrelationships between many constructs/variables in a group of married Canadians between the ages of 40 and 59. We used this methodology to map out the complex system of associations between mindfulness, self-compassion, other-compassion, relationship satisfaction, and sexual satisfaction. We also integrated Self-Determination Theory (SDT) to identify how basic need fulfillment in relationships may intersect with these associations.

1.1 | Relationship and sexual satisfaction

Romantic relationships are vital for health and longevity (Biswas-Diener & Diener, 2001; Waite & Gallagher, 2000), and sexuality is key to happy partnerships (Butzer & Campbell, 2008; Sprecher & Cate, 2004). A small number of studies suggest that mindfulness is associated with higher relationship satisfaction directly (Quinn-Nilas, 2020), and indirectly because of associations with increased empathy (Wiggins, 2012) and less intense emotional stress responses to conflict (Barnes et al., 2007). Recent theorizing centers the indirect role of mindfulness for relational satisfaction (Karremans et al., 2017), and recent research has supported specific variables as pathways for indirect effects, like perceived stress (Morin et al., 2023). For sexuality, studies on mindfulness and sexuality show that mindfulness interventions can improve low arousal and sexual response in people who have had endometrial or cervical cancer (Brotto et al., 2012; Brotto & Basson, 2014), and qualities of mindfulness (i.e., paying attention) are associated with positive sexual outcomes (Khaddouma et al., 2015; Leavitt et al., 2021). However, researchers have only begun to explore the mechanisms through which these effects may occur, and if the links hold true for midlife people in their 40s and 50s. This group is at the confluence of changes in relationship satisfaction (tending to decrease in satisfaction) over time (Christopher & Sprecher, 2000; Karney & Bradbury, 1995) and social commitments (e.g., caretaking for children and aging parents; Grundy & Henretta, 2006), therefore, constructs like mindfulness and self-compassion may be of particular relevance for the relationship and sexual satisfaction of this demographic. This generation is sometimes referred to as the “sandwich generation” because they are at the intersection of caretaking responsibilities for both aging parents and often for their own children simultaneously (Parker & Patten, 2013), motivating deliberate study of this group. Research in the area of relationships shows that mindfulness is likely connected to relationship and sexual outcomes in a complex and largely indirect way (Karremans et al., 2017; Khaddouma et al., 2015). To gain a richer understanding of the role of mindfulness in terms of relational and sexual outcomes it is important to adopt a broader, systems-level statistical perspective as an alternative to piecemeal testing of specific effects.

1.2 | Mindfulness in relationships as a multivariate system

Karremans et al. (2017) postulate that dispositional mindfulness contributes directly to basic mechanisms/processes (including awareness of implicit processes, emotional regulation, executive control, and self-other connectedness), and these basic mechanisms support relationship processes (relationship specific responses that could be positive or negative behavioral, affective, and cognitive; Karremans et al., 2017). It is these relationship processes that are hypothesized to directly contribute to relationship outcomes. A multivariate systems-level analytic approach maps well onto Karremans et al.'s (2017) theoretical model, which is predicated on a complex array of direct and indirect (both individual and dyadic) associations between intraindividual and relational variables. It is important to clarify that we do not directly refer to Systems Theory (Cox & Paley, 1997) per se when we evoke the word “system” in this context, rather, we are referring to an analytic approach focused on understanding and exploring the complex interrelationships between a larger number of variables—a *multivariate* system. Rather than focusing on isolated statistical relationships and hypotheticals, a systems-level approach recognizes the fundamental interconnectedness of these variables and aims to understand how they connect (and how they do not) in terms of their statistical associations with relationship and sexual

outcomes simultaneously (rather than piecemeal testing of a small number of direct and indirect effects at a time). Ultimately, this approach allows a bird's-eye view of how a large number of variables relate to one another, to seed research which may help researchers and practitioners develop a more comprehensive understanding of the role of mindfulness in relationships, and to eventually design interventions that target multiple variables within the broader system. A broader, systems-level approach also allows researchers to explore new avenues of research and generate novel hypotheses by simultaneously testing a very large number of effects (rather than a small number of focal effects, which may inadvertently miss important dynamics or preemptively hypothesize mechanisms absent adequate foundational empirical work). By aligning the ostensibly complex system of mindfulness in relationships with methodology designed to explore such systems, future researchers may ultimately be better equipped to study specific mechanisms/pathways as those pursuits will be built upon a strong tapestry of exploratory evidence. This perspective is consistent with approaches that highlight the need for confirmatory research to be first built upon a strong foundation based on meaningful input from exploratory work (Scheel et al., 2021). In this study, we seek to contribute to this exploratory foundation by aiming to understand the interrelationships between mindfulness, self-compassion, compassion, basic need fulfillment in relationships, and relationship/sexual satisfaction. Specifically, we sought to understand how a SDT framework, as expressed by the inclusion of basic psychological need fulfillment in relationships, would factor into the mindfulness system in terms of its associations with relationship and sexual satisfaction.

1.2.1 | SDT in relationships

SDT is a broad theory that focuses on the fulfillment of a set of proposed psychological needs foundational for individual functioning: autonomy (the need to be in charge of one's actions and to be able to control them on one's own), relatedness (how connected and cared for someone feels by other people in their lives, as well as how important they feel to other people and how much they feel they contribute to them), and competence (need to feel effective and competent in the important areas of their life; Ryan & Deci, 2000). Fulfillment of these basic needs has been related to a rich array of well-being outcomes, including for older individuals (Tang et al., 2020). There is reason to believe that the core principles of SDT, namely, fulfillment of the three basic needs in relationships, are enmeshed with relationship/sexual outcomes, and with mindfulness. La Guardia et al. (2000) were among the first to examine basic needs in relationships, finding that secure attachment was predicated on need fulfillment. Other research has supported that overall need fulfillment was linked to personal happiness, secure attachment, increased commitment, less perceived conflict, and more adaptable approaches to conflict (Patrick et al., 2007). Although some research has connected need fulfillment to sexual satisfaction (Wood et al., 2021), this is a research area that has not been thoroughly investigated. In conclusion, a range of relationship (and sexual) indicators may be connected to the fulfillment of the needs for autonomy, competence, and relatedness in relationships, although research into need fulfillment in romantic relationships continues to be preliminary.

Mindful awareness is hypothesized to be supportive of the three basic needs because awareness of one's own values, ideas, actions, and opportunities is hypothesized to be a precursor to enacting the types of behaviors (and having necessary internal awareness) that support need fulfillment (Ryan & Deci, 2000). There have been theoretical musings (i.e., that mindfulness is particularly associated with autonomy need fulfillment; Brown & Ryan, 2003; Brown et al.,

2007), however, no research to date has directly studied the supportive role of mindfulness for basic need fulfillment in relationships, and alongside central indices of relationship/sexual well-being, like relationship and sexual satisfaction. For the relationship context, considering SDT alongside Karremans et al.'s (2017) theoretical model is advantageous, as together they generate interesting new research avenues. Karremans et al.'s (2017) model points to mindfulness being indirectly related to couples' satisfaction outcomes through basic (e.g., awareness of implicit processes) and relationship processes (e.g., partner acceptance, forgiveness, coping)—highlighting that the effects of mindfulness are primarily indirect through more proximal mechanisms. The fulfillment of the basic needs for autonomy, competence, and relatedness in relationships may represent one of these more proximal mechanisms. However, this proposition has not directly been tested, perhaps because researchers have not yet explicitly connected theoretical propositions of SDT to Karremans et al.'s (2017) model. Karremans et al.'s (2017) mindfulness model and SDT are complex theories with robust empirical backing on their own. However, given that they have not been investigated together in romantic relationships, it is prudent to explore the interrelationships among their focal variables, with an approach allowing for maximal complexity.

1.2.2 | Self-compassion

Self-and-other-compassion warrant consideration within this system, particularly, their potential intersections with mindfulness, need fulfillment, and relationship/sexual outcomes. Growing evidence supports that participation in mindfulness training programs such as MBSR and MBCT increases self-compassion (Birnie et al., 2010; Kuyken et al., 2010; Shapiro et al., 2005, 2007). Furthermore, self-compassion is associated with relationship outcomes, such as positive relationship styles. Even above and beyond attachment and self-esteem—couples in one study who were high in self-compassion were also high in relationship satisfaction and relationship well-being (Neff & Beretvas, 2013). Other research supports effects of self-compassion on relationship behaviors such as increased motivation to correct for interpersonal mistakes, increased accommodation, and increased marital satisfaction (Baker & McNulty, 2011). Crucially, Neff and Beretvas (2013) theorize that self-compassion may be related to positive romantic relationship outcomes because self-compassionate individuals are better at balancing their own basic needs (for autonomy and relatedness), and, thus, would be better able to balance these needs in their relationships. They theorized that self-compassionate people have a higher capacity to meet their own personal needs, and thus would be less defensive and more accepting in relationships (Neff & Beretvas, 2013). To date, few empirical studies support the connection between trait self-compassion and sexual satisfaction (Ferreira et al., 2020) and sexual distress (Michael et al., 2021), yet this is a rich area worth exploring. Tendencies toward being harshly self-critical and to being distracted by negative self-oriented thoughts during a sexual encounter have been strongly linked to poor sexual functioning outcomes, for example, through poor body image (Carvalho et al., 2017). These issues may be especially important for midlife persons due to the prevalence of physiological health conditions and sexual disorders (Quinn-Nilas et al., 2018). While the existing studies have shown that mindfulness and self-compassion are associated with relational outcomes in various ways, existing studies have been limited in that they focus on a small number of specific effects. Researchers have so far focused specifically on the effects of mindfulness and self-compassion separately in relationships (and related to sexuality) and have not considered the larger picture of how these constructs themselves are

interrelated (and how they relate dynamically with relationship/sexual variables). By conducting exploratory research using methodologies capable of providing an assessment of the complex interrelations between many variables, we can better model how mindfulness and self-compassion can be utilized to study positive relationship/sexual outcomes.

1.2.3 | Compassion

Self-compassion may manifest interpersonally through other-oriented compassion. Pommier et al.'s (2020) conceptualization of compassion was based on the same theoretical and methodological underpinnings as Neff's Self-Compassion. In this conceptualization, compassion is a nonjudgmental attitude toward others and a natural extension of self-compassion (i.e., self-compassion is a precondition for exhibiting compassion to others; Strauss et al., 2016). Understanding whether "self-love" in the form of self-compassion is enough to enhance relationships with or without "other-love" in the form of other-compassion is vital for understanding *how* intraindividual psychological phenomena translate into interpersonal effects. Although it is widely speculated that mindfulness contributes to compassion, these associations in relationships have only been observed between ostensibly compassionate behaviors like forgiveness (Karremans et al., 2020) but rarely through studying the construct of trait compassion *itself*, mirroring the theoretical structure of self-compassion (kindness, common humanity, and mindfulness). Likewise, studies considering the role of compassion in relationships are limited (and recent), generally finding compassion to be associated with relationship outcomes like marital quality (McDonald et al., 2020). In terms of sexuality, results from prior research have suggested links between higher compassionate relational attitudes and increased sexual satisfaction and orgasm consistency (Fraser et al., 2023). However, Fraser et al. (2023) conceptualized and measured compassion as attitudes and behaviors (separately), like forgiveness. Although these are strong proxies for compassionate attitudes and behaviors respectively, this conceptualization of compassionate behaviors is distinct from compassion as a psychological trait. For instance, higher scores on trait compassion (as measured by Pommier et al., 2020) reflect a higher degree of kindness, beliefs regarding the inherent connectedness of humankind, and a balanced identification with the suffering of others. This psychological conceptualization of compassion (Pommier et al., 2020) is quite different than conceptualizations found in prior investigations focusing on forgiveness, and should not be mistaken as overlapping simply due to the similarities in variable names. In all, investigations into the relational and sexual aspects of compassion have been limited, and the limited extant literature has not focused on trait compassion (as conceptualized by Pommier et al., 2020), but instead has focused on specific behaviors which may be indicators of the broader construct of compassion. It is also unclear exactly how compassion is embedded within the broader mindfulness system (factoring in SDT variables, as well) as has been discussed so far.

1.2.4 | Summary

Despite separately theorized relational paths of mindfulness from Karremans et al. (2017) and from Ryan and Deci's (2000) need fulfillment constructs, empirical data supporting the dynamic interconnections between these variables is scarce. Existing studies have focused on answering proximal questions and have focused on testing specific direct/indirect pathways/effects,

leaving out empirical identification of the broader system (e.g., the model proposed by Karremans et al., 2017). Traditional techniques for assessing these kinds of questions, such as mediation modeling, are prone to Questionable Research Practices (QRPs; Götz et al., 2020) and rely on unrealistic directionality assumptions that are often difficult or impossible to meet in nonexperimental and cross-sectional data. These limitations can result in “seemingly sophisticated conclusions that are ultimately unwarranted” (Rohrer et al., 2022, p. 1). Beyond the testing of specific pathways, an exploration of the system itself has been neglected—we do not yet understand the forest, only the trees.

1.2.5 | Purpose

The purpose of this exploratory study was to generate a map of the system of relationships between mindfulness, self-compassion, other-compassion, fulfillment of three basic needs in relationships (autonomy, competence, relatedness), relationship satisfaction, and sexual satisfaction using psychological network analysis. As part of this, we aim to identify variables with a high level of interconnectedness within the system (i.e., high centrality), and thus, high relative importance. This study was broadly guided by theorizing from Karremans et al. (2017) which proposed that the effects of mindfulness on relationships (and sexuality) would be primarily indirect through other personal and interpersonal mechanisms. We were also guided by SDT, which suggested that fulfillment of fundamental needs in partnerships would be a crucial and central variable within this system.

2 | METHODS

2.1 | Procedure

After receiving REB approval, participants were recruited through Qualtrics analytics panels. Participants qualified if they were between the ages of 40–59, residing in Canada, and were married (no restrictions based on age at marriage or length of marriage). They were sent a basic invitation to the survey and, from there, could click a link to proceed to the online survey. The goal was to recruit only married individuals so as not to introduce additional heterogeneity that might be related to complex decisions regarding cohabitating or common-law couples. The survey was accessed by approximately 1917 people in 2019—the survey was made inaccessible once complete data from 700 participants were collected (to protect participant privacy, data from non-completes were withdrawn and not recorded).

2.2 | Participants

The sample was mostly “White” ($n = 524$; 83%), with the second and third largest groups being “Southeast Asian” ($n = 42$; 7%) and “Black” ($n = 19$; 3%) and with an average age of 49.80 years. The sample was mostly heterosexual ($n = 589$; 93%) with smaller numbers of bisexual ($n = 26$; 4%), gay ($n = 3$; <1%), lesbian ($n = 3$; <1%), queer ($n = 2$; <1%), and pansexual ($n = 2$; <1%). The remainder were uncertain or did not respond. The sample was roughly evenly split between women (including cisgender and transgender; $n = 324$; 52%) and men

(cisgender and transgender; $n = 275$; 44%) and included 25 (4%) gender nonbinary individuals who were included in the full sample network model but were excluded from the gender-separated models. Sixteen individuals did not provide gender information. In terms of geographical location in Canada, most participants were from Ontario ($n = 286$; 45%), Alberta ($n = 82$; 13%), and British Columbia ($n = 74$; 12%), whereas Prince Edward Island ($n = 4$; 1%) and the Northwest Territories ($n = 1$; <1%) were the least represented. Participants were predominantly college/university graduates ($n = 275$; 43%), but a substantial minority of participants reported their highest education level to be high school ($n = 102$; 16%) or trade/technical/vocational training ($n = 52$; 8%). Most participants had children ($n = 514$; 81%), with the average number of children being 2.13. About one-quarter (27%; $n = 139$) of parents reported having one child, 45% ($n = 229$) of parents reported having two children, 19% ($n = 99$) reported having three children, and about 9% reporting four or more ($n = 44$; 9%). All participants were currently married, and the average duration of these marriages was 18.37 years ($SD = 9.74$).

2.3 | Measures

2.3.1 | Mindfulness

The Five-Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2008) contains 39 items (e.g., I think some of my emotions are bad or inappropriate and I shouldn't feel them.) rated on a 5-point Likert-type scale (1 = *never or very rarely true*, to 5 = *very often or always true*). Five facets were assessed: observation, description, awareness, nonjudging of inner experience, and non-reactivity. A mean score of overall mindfulness was used in this study. McDonald's Omega in the current study was .89. Higher scores indicate higher mindfulness.

2.3.2 | Self-compassion

The Self-Compassion Scale (SCS; Neff, 2003) assesses one's tendency to be kind and understanding to themselves, rather than being self-critical and judgmental. It is a 26-item scale consisting of both positive (e.g., "I'm tolerant of my own flaws and inadequacies") and negative items (e.g., "When I see aspects of myself that I don't like, I get down on myself"). Scores were calculated by first reverse coding the responses to the negative items and taking a grand mean to create an average Self-Compassion Scale score (see Neff, 2003 for evidence of reliability and validity). McDonald's Omega in the current study was .92. Higher scores indicate higher self-compassion.

2.3.3 | Compassion

Compassion was measured with the 16-item Compassion Scale (Pommier et al., 2020). Items are rated on a five-point scale (1–5) that measures agreement. An example item is: "When others feel sadness, I try to comfort them." An overall mean score was calculated and used in this study by first reverse coding the negatively worded items and then calculating an average

score. Internal consistency was excellent ($\omega = .89$) in this study. Higher scores represent higher other-oriented compassion.

2.3.4 | Basic need fulfillment in relationships

Need fulfillment in relationships was measured using the Basic Psychological Need Satisfaction in Relationships scale (La Guardia et al., 2000). This is a nine-item scale designed to be used and is worded in relation to a particular person (i.e., romantic partner, father/daughter). Participants were directed to consider “When I am with my partner...” as the question stem. Response options were on a seven-point scale ranging from “not at all true” to “very true.” The scale measures the three basic needs, autonomy, competence, and relatedness. Scores are averaged for each subscale after reverse scoring negatively worded items. An example of an autonomy item is “When I am with *my partner*, I feel free to be who I am.” In the current study, internal consistency was high for the total scale ($\omega = .92$) and the autonomy ($\omega = .75$), competence ($\omega = .80$), and relatedness ($\omega = .87$) subscales. Higher scores represent higher need fulfillment in their relationship.

2.3.5 | Relationship satisfaction

Relationship satisfaction was assessed using the Couple's Satisfaction Index—4 item version (CSI; Funk & Rogge, 2007). An example item from the CSI is “In general, how often do you think that things between you and your partner are going well?” The scale had excellent internal consistency ($\omega = .96$). Higher scores denote higher relationship satisfaction.

2.3.6 | Sexual satisfaction

The Global Measure of Sexual Satisfaction (Lawrance & Byers, 1995) was used to assess sexual satisfaction. The scale asks participants to describe their sexual relationship with their partner across five dimensions on a seven-point scale: *Good–Bad*, *Pleasant–Unpleasant*, *Positive–Negative*, *Satisfying–Unsatisfying*, and *Valuable–Worthless*. Higher scores on this scale indicate higher sexual satisfaction. Internal consistency has been consistently high ($\alpha > .90$; Byers, 2005; Lawrance & Byers, 1995). Internal consistency in the present study was excellent ($\omega = .97$).

2.4 | Data analysis

2.4.1 | Data cleaning and missing data

The dataset underwent cleaning and removal of participants to ensure only quality data were retained. Six participants were removed due to incorrect answers on any of the four attention check questions, three were removed due to showing a consistently uniform response pattern, 20 were removed due to responses that were too quick (quicker than half the median speed), and 31 were removed for choosing “choose not to respond” for 5% or more of the items. After these exclusions, the final dataset consisted of 640 cases with minimal missing data (less than

5%), which were handled pairwise for the network models using the “pairwise” option in the *bootnet* package.

2.4.2 | Network analyses

To adequately address the complexity inherent in our research question, it is necessary to utilize a methodology capable of mapping out a dynamic multivariate space. One such methodology is psychological network modeling, which is a type of data-driven, covariance-based modeling approach that seeks to generate a model which maximizes fit to the data. The outcome of network analysis is a matrix of conditional pairwise associations represented by a graph. Network models offer a powerful tool for examining the overall structure of the interrelationships within a dynamic system of many psychological concepts and are well-suited for research aimed at exploring complex models with many variables (and their associations).

A network model contains nodes (visually represented by circles), which represent variables (in our case, aggregate scores) in the dataset, and the relationships (in our case, partial correlation coefficients represented by nondirectional lines which denote nondirectional associations) between nodes—called edges. Thickness of the edges in the network graph corresponds to strength of the association, and color of the edges corresponds to direction of association (blue denotes positive relationship; red denotes negative relationship).

We conducted network analysis using the *bootnet* package in R (Epskamp & Fried, 2018). Specifically, we estimated a Pairwise Markov Random Field (PMRF) using the Gaussian Graphical Model (GGM) to model pairwise partial correlations between the variables (i.e., pairwise correlations controlling for each other variable in the model). We used Extended Bayesian Information Criterion (EBIC) for model selection and Graphical Least Absolute Shrinkage and Selection Operator (GLASSO) for regularization (the “*EBICglasso*” option). As the number of variables increases, so does the number of statistical parameters (i.e., edges) being estimated. With a large number of edges being estimated, the risk of overfit and encountering unstable estimates also increases. Statistical regularization helps to minimize the number of spurious edges to counterbalance the risk of overfit while factoring in model complexity. Specifically, GLASSO estimates edge weights using penalized maximum likelihood estimation, constraining some weak edges to exactly zero, and resulting in a “sparse” model that eliminates potentially spurious edges. A best-fitting model is selected based on which model has the smallest EBIC (i.e., better comparative model fit to the data). We used default settings for the EBIC hyper-tuning parameter (.5; preference toward simple structure models), and we visualized our network models using the “spring” layout method, which positions strongly connected nodes closer together, and weaker nodes farther apart to aid visual interpretation. Lastly, we handled ordinal response options using the *corMethod* “auto cor” function to estimate polychoric correlations.

After estimating the network model, we evaluated the stability and replicability of our model considering Isvoranu et al.'s (2022) suggestions for current best practices. First, we estimated bootstrapped confidence intervals for the edge weights to estimate the stability and precision of our estimates. Second, the *netSimulator* function was used to run a post hoc simulation to test sensitivity of the network to fluctuations in sample size. Lastly, we examined the stability of our centrality estimates by using case-dropped bootstrapping via the *boot_casedrop* function to test if the centrality estimates are stable as cases were systematically dropped from the model.

In network models, there are some emerging rules of thumb for sample size. We adhered to two criteria established by Isvoranu et al. (2022). First, we did not include more than 30 nodes in the network (there were just eight), and there are “at least several hundred cases” (Isvoranu et al., 2022, p. 128). To maximize the balance between sensitivity and specificity, we utilized the appropriate estimation method (EBIC + GLASSO) for our sample size. In addition, we present a transparent assessment of the model’s veracity in terms of the uncertainty surrounding the estimates of edge weights, the stability of the centrality indices, and simulation-based estimations of the model’s reproducibility. In doing so, we provide transparent information regarding the stability and anticipated replicability of our findings. Syntax and output are provided on the authors’ OSF: https://osf.io/48wes/?view_only=586fc40fe14a4fefba167b7634f2fa3b.

3 | RESULTS

3.1 | Network topography

3.1.1 | Full sample model

Descriptive statistics for study variables are shown in Table 1. The model has eight nodes, meaning there are a potential 28 edges. For the overall model, 22 nonzero edges were present in the estimated network (shown in Figure 1), with a mean weight of .12. Individual edge weights—representing pairwise partial correlation coefficients—are shown in Table 2 (alongside bivariate correlations).

3.1.2 | Gender comparisons

Before interpreting a specific network model, we first wanted to determine if there was evidence to warrant separate consideration of men’s and women’s networks. To test this, we estimated the network separately by splitting the sample by binary gender group (inclusive of both cisgender and transgender individuals, but excluding gender nonbinary individuals). To aid cross-group visual interpretation, we: (1) estimated the models separately by group (including the full sample model), (2) averaged the layouts across the groups, and (3) displayed the models using this averaged layout (Isvoranu et al., 2022). By keeping the locations of the nodes the

TABLE 1 Descriptive statistics of study variables.

	SC	M	RS	SS	NSr	NSa	NSc	C
<i>N</i>	627	600	637	637	636	634	636	627
Missing	13	40	3	3	4	6	4	13
Mean	3.08	3.77	4.44	5.10	5.17	5.32	5.21	3.88
Standard deviation	0.65	0.48	1.35	1.66	1.54	1.40	1.37	0.60
Minimum	1.15	2.13	1.00	1.00	1.00	1.00	1.00	2.00
Maximum	5.00	5.15	6.25	7.00	7.00	7.00	7.00	5.00

Abbreviations: C, compassion; M, mindfulness; NSa, autonomy need fulfillment; NSc, competence need fulfillment; NSr, relatedness need fulfillment; RS, relationship satisfaction; SC, self-compassion; SS, sexual satisfaction.

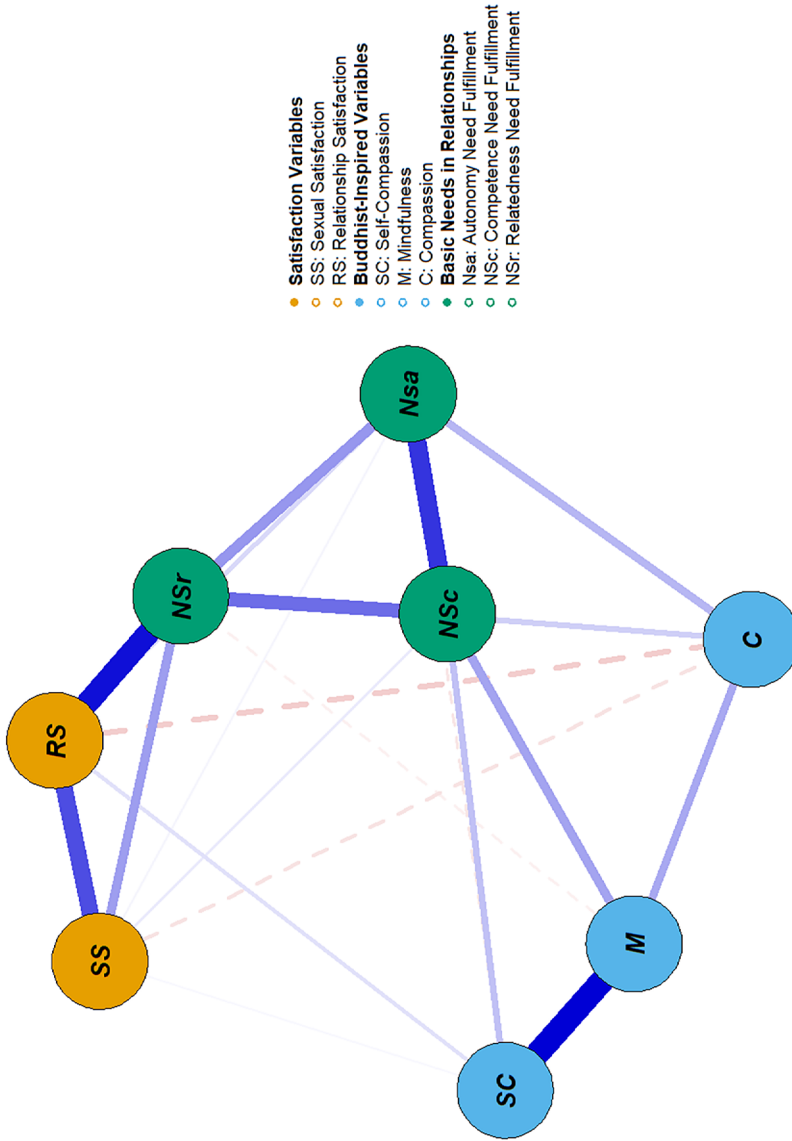


FIGURE 1 Full sample network model. Nodes of like-colors were manually specified to denote conceptually similar concepts but these colors do not represent any statistical indices.

TABLE 2 Edge weights of the network for the whole sample on the bottom diagonal; bivariate correlations on the top diagonal.

	SS	RS	SC	M	Nsa	NSc	NSr	C
SS	-	.74***	.30***	.28***	.54***	.56***	.70***	.10*
RS	.37	-	.35***	.29***	.63***	.61***	.82***	.13*
SC	.02	.06	-	.65***	.30***	.46***	.35***	.20***
M	0	0	.53	-	.36***	.50***	.33***	.33***
Nsa	.02	.08	-.05	0	-	.76***	.73***	.33***
NSc	.04	0	.13	.19	.42	-	.75***	.31***
NSr	.20	.49	0	-.03	.22	.30	-	.27***
C	-.06	-.10	0	.18	.15	.02	.10	-

Note: These edge weights correspond to the full sample model in Figure 1.

Abbreviations: C, compassion; M, mindfulness; NSa, autonomy need fulfillment; NSc, competence need fulfillment; NSr, relatedness need fulfillment; RS, relationship satisfaction; SC, self-compassion; SS, sexual satisfaction.

* $p < .05$. ** $p < .01$. *** $p < .001$, for bivariate correlations only. Edge weights are not tested for conventional statistical significance.

same, it is easier to visually compare the models. All graphs are shown using the averaged layout across groups (Figures 1, S1, and S2).

Network comparison test

Further considerations of gender separated networks are partly predicated on the results of a series of network comparison tests that provide evidence for overarching differences between the networks when separated by gender. This is an important first step, because without screening via such omnibus testing one risks overinterpreting idiosyncratic network-to-network differences. First, we tested for empirical evidence of overall differences between the gender group models. We compared the gender models using the Network Comparison Test (NCT; van Borkulo et al., 2023) which uses nonparametric permutation methods to assess if data from two groups could reasonably be drawn from the same population network (Isvoranu et al., 2022). The NCT generates several statistical tests. The first is an omnibus test of if there is at least one edge that differs across the networks; interpretation of this test is most appropriate when the researcher does not necessarily have a prior hypothesis about if and which edges might differ (as is the case in this study). The p -value of this test indicated it was not statistically significant, $p = .29$, suggesting no differences between men's and women's network models in aggregate. The second test is of global strength, the absolute sum of all edge weights, to examine if one group has a stronger and/or a denser network than another. The results of this test were not statistically significant, suggesting that men and women are not statistically different based on global strength ($p = .46$). Because the results of the NCT suggested that the two groups were similar in terms of network topography and strength, we did not probe further for differences as there was no empirical basis to do so. We correlated the edge weights between the two gender networks and found that the overall edge weights were very strongly correlated, $r = .93$. We therefore focus our inferences on the full sample network; but the separate gender models are shown in supplementary material for transparency and for interested readers (S1 and S2).

3.1.3 | Network structure

The full sample network is shown in Figure 1 and numerical edge weights (representing the partial correlation coefficients as shown in the figure) are shown in Table 2. We added color to the nodes to aid in visual interpretation of the three groupings of variables (satisfaction variables; mindfulness and compassion variables; need fulfillment variables), these node colorings do not represent anything statistical and reflect arbitrary groupings. The first grouping is the mindfulness (M), self-compassion (SC), and compassion grouping (M-SC-C). The conditional association between mindfulness and self-compassion was the strongest association in the network (see Table 2 for edge weights matrix). However, mindfulness and self-compassion had largely weak relationships with other variables in the system and particularly negligible direct associations with relationship and sexual satisfaction. Compassion was an intermediary and somewhat peripheral variable, displaying relatively minor correlations with other variables (primarily with mindfulness and autonomy need fulfillment).

The second grouping included the basic need fulfillment nodes, which appeared to cluster closely together, and share strong, positive relationships to each other. Higher need fulfillment in one domain was positively associated with higher need fulfillment in the other domains, but competence need fulfillment was the bridge that connected mindfulness and self-compassion associations to the three basic needs grouping. People higher in M and SC were also higher in competence, which itself was associated with higher need fulfillment of the autonomy and relatedness needs. Interestingly, relatedness fulfillment (NSr) was less strongly related to competence (NSc) and autonomy (NSa) and was more strongly related to relationship satisfaction (positively). Relatedness appears to form a bridge of strong associations connecting the need fulfillment variables (and in turn mindfulness and self-compassion) to the romantic relationships/sexuality grouping: relationship (RS) and sexual satisfaction (SS). Relatedness need fulfillment and its association with relationship satisfaction was the second strongest association in the entire network. For the satisfaction grouping, there was a strong positive edge between relationship satisfaction and sexual satisfaction.

Although there are some weaker edges in the model, these edges do not warrant significant consideration. Results of networks estimated via EBIC GLASSO are most accurate in detecting prominent edges in a sparse network (Isvoranu et al., 2022). Very weak edges may represent false positives. Furthermore, in a subsequent section, our examination of edge-weight stability suggests that the very weak edges have wide variability meaning they are difficult to interpret with any certainty—focus should be placed on the interpretation of stronger, and more stable edges, as we have done.

Node centrality

In network modeling, it is frequently advantageous to draw conclusions about nodes that are vital to the system via the inspection of centrality indices. Nodes high on such centrality indices may be crucial factors for future research since they are well integrated into the way the system functions. There are many ways to quantify how and why nodes are influential, and we focus on four of them. Firstly, node “Strength” is the total of the absolute partial correlation coefficients of directly attached edges—how strongly a node relates to other adjacent and directly attached nodes (via edges). Relatedness need fulfillment had the highest strength and is highest on “Expected Influence”—which is the same as node strength however it does not use the absolute values (Figure 2). Competence fulfillment was the highest on “Closeness”—meaning it has the *largest number* of relationships with other variables; and it shared the highest

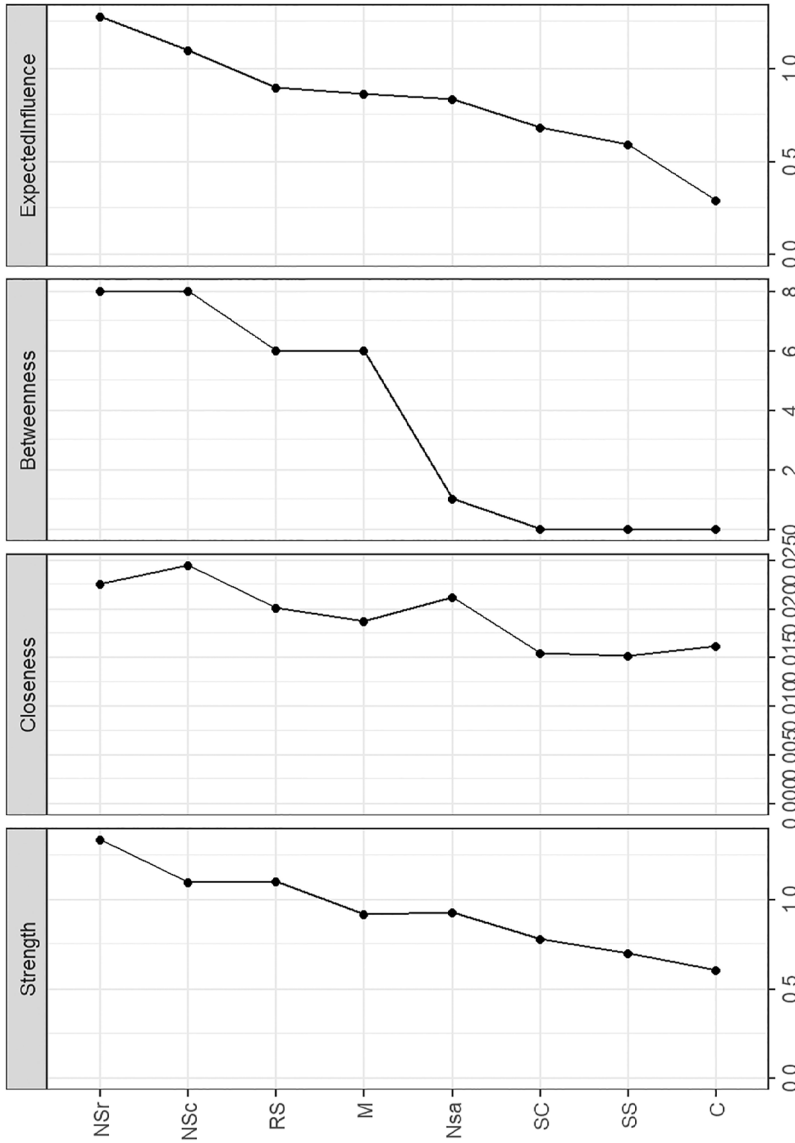


FIGURE 2 Plot of node centrality indices. Nodes are in descending order with the highest centrality at the top.

“Betweenness” with relatedness fulfillment—meaning that competence and relatedness bridge associations between the most nodes. Overall, the centrality indices highlight the importance of relatedness fulfillment in terms of having the highest direct impact (in terms of magnitude of conditional associations) on proximal nodes, whereas competence fulfillment can be seen to have an intermediary role in bridging associations between different elements of the system (mindfulness, self-compassion, other-compassion, and need fulfillment).

3.2 | Stability of model and parameters

3.2.1 | Stability of edge-weights

Bootstrapping is used to ascertain the stability of edge-weight estimates within network models. With many parameters being estimated in a network model, some weak estimates will be unstable across bootstrapped samples (and should be interpreted with caution) and some will be stable, and thus interpretable. The results of the bootstrapped confidence intervals for the edge weights are displayed in Figure 3. Due to the use of regularization in the model, they cannot be taken as a proxy for significance tests; rather, they represent a crucial measure of the stability of the parameter estimates. The edges with the greatest magnitude also tended to have the smallest confidence bands, indicating that only the strongest edges are stable enough to lend themselves to substantive interpretation. In our study, the confidence intervals for the edges of interest, such as the edges connecting the three basic needs, the links between mindfulness and

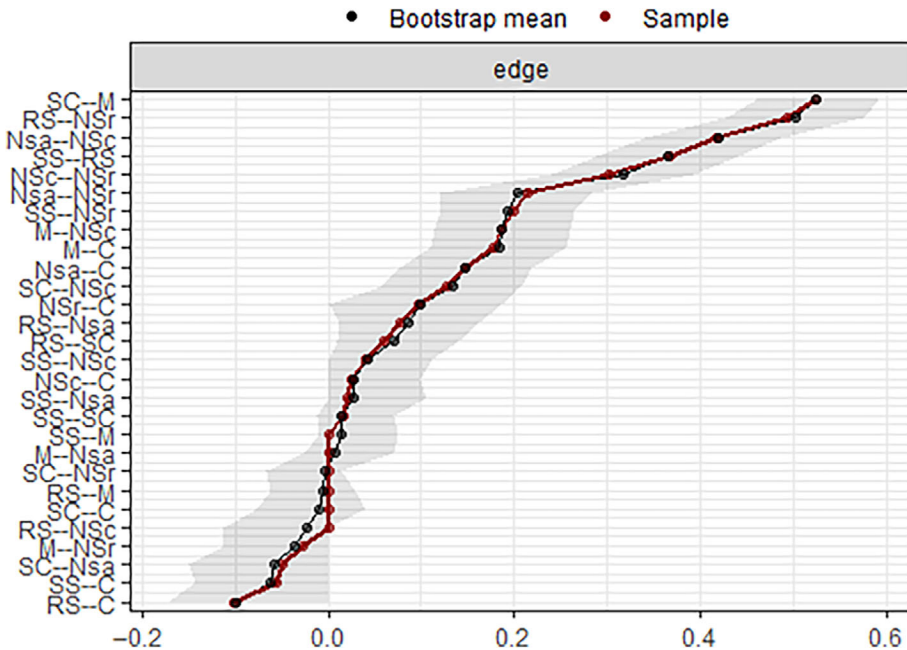


FIGURE 3 Edge weight stability using nonparametric bootstrapping. The gray area is the 95% confidence interval of the bootstrapped samples. Many edges cutoff at 0 (as expected) and this is due to the use of regularization.

self-compassion, and the direct connections between SS and RS, are narrower suggesting a greater degree of accuracy/estimated long-run stability of those specific estimates. All of the negative edge weights had confidence intervals that included 0, meaning that these should not be interpreted substantively because in some of the bootstrapped samples those edges were weak enough to be estimated at exactly 0 via regularization. For example, this means that the negative edge between compassion and relationship satisfaction should be interpreted with extreme caution because the confidence interval is wide and included 0.

3.2.2 | Stability of centrality indices

We also used case-drop bootstrapping to estimate the stability of the centrality indices. In this procedure, cases are dropped from the sample systematically and changes in the centrality indices are plotted (see Figure 4) to identify if any centrality inferences are particularly sensitive and unstable to sample fluctuations. According to Epskamp and Fried's (2018) simulation study, correlations between case-dropped samples and the original sample should ideally be above .50 and at least above .25 to safely interpret centrality indices. As can be seen in our plot, our centrality index estimates were quite stable and consistently above .50, however, it should be noted that betweenness did appear to have considerable variability although still above acceptable thresholds (except at the most extreme levels of case-drop). Overall, our centrality indices appear stable and interpretable.

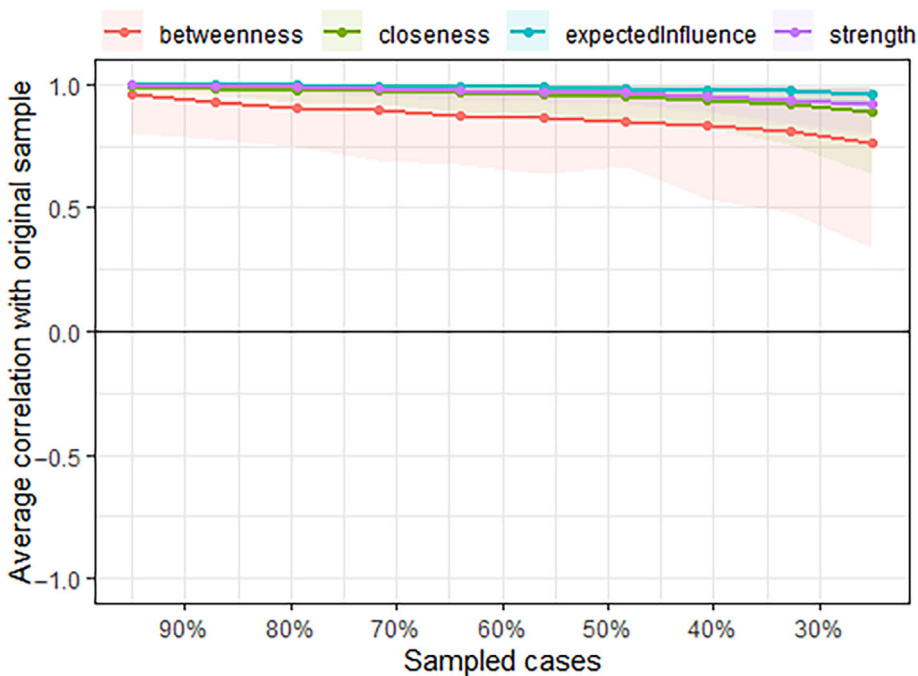


FIGURE 4 Results of case-drop bootstrapping on centrality indices.

3.2.3 | Simulation

Isvoranu et al. (2022) recommend a simulation study be conducted to understand the network’s anticipated replicability—we perform a simulation here as a sensitivity analysis of sample size and to inform future research in this area. Our simulation (Figure 5) showed that the correlations between the simulated networks and the “true” network (i.e., the network with parameters as estimated in our study) remain very high regardless of simulated sample size (from our specified array of samples). High and consistent sensitivity across varying sample sizes suggests that our model at our sample size (and across most sizes) retained strong sensitivity to correctly detect true edges (assuming the current model is true). Median sensitivity drops slightly below .80 (i.e., a commonly accepted cutoff for statistical power estimates) with samples below 600, suggesting that future researchers seeking to use network modeling to replicate this network should aim for samples at least above that but ideally in the range of 600–1000. Note that the specificity does not improve even as sample size increases significantly and stays highly variable in all sample sizes. This is partly a feature of the estimation method—networks estimated via regularization techniques prioritize sensitivity and sacrifice specificity. Even with large-sample simulations, there were minimal appreciable increases in specificity—specificity was stable. In sum, the stability of these characteristics across a wide array of sample sizes (both smaller and larger than ours) suggests we have a reasonably stable model.

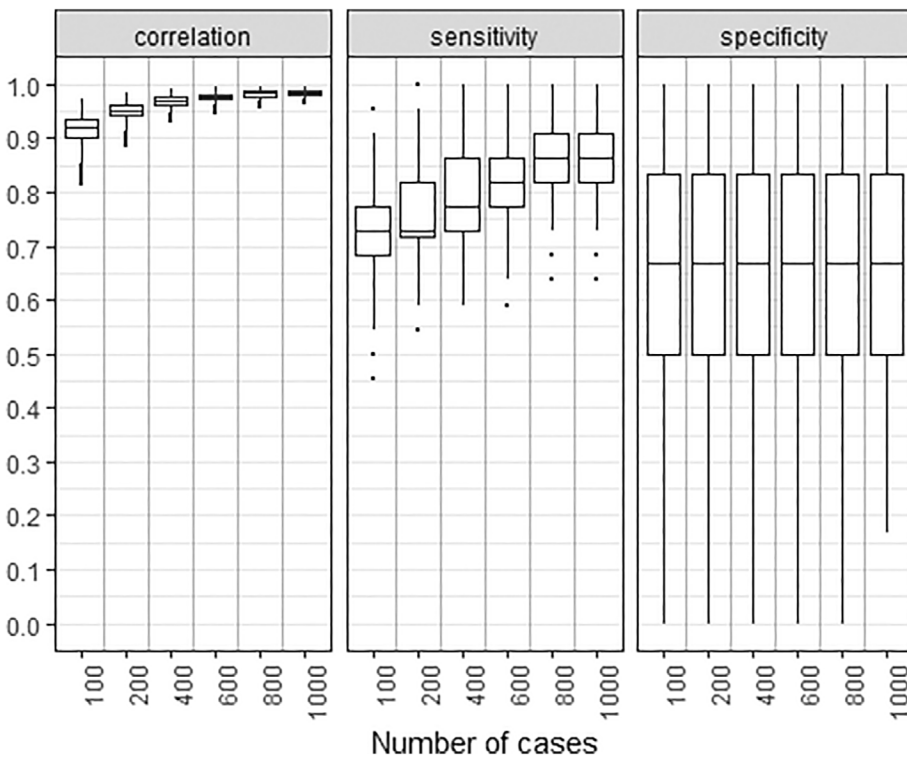


FIGURE 5 Results of simulation study with 1000 samples. The y-axis shows correlation coefficient values in the farthest-left panel, but represents probabilities for the sensitivity and specificity panels.

3.3 | General summary

In general, this network demonstrates a topography showing that individual variables like mindfulness, self-compassion, and other-compassion have associations with relationship and sexual satisfaction outcomes primarily indirectly through more proximal relational variables (i.e., basic need fulfillment in relationships). Our findings showed strong interrelationships between the three types of basic need fulfillment in relationships (suggesting that fulfillment in one domain was strongly related to fulfillment in each other domain), which bridged the associations between the ostensibly intraindividual elements of the system (mindfulness, self-and-other-compassion) with relational and sexual satisfaction outcomes. The most central—and therefore most important variables for the system—were relatedness need fulfillment, paralleled closely by competence fulfillment.

4 | DISCUSSION

This study explored the system of associations between mindfulness, self-compassion, other-compassion, basic need fulfillment in relationships, and relationship and sexual satisfaction in a sample of married, midlife adults. By focusing on studying the system itself (rather than testing specific effects and their statistical significance), our findings present a complex picture of the associations connecting these variables. Results are generally compatible with the growing theory of the relational aspects of mindfulness, especially the relational mindfulness model of Karremans et al. (2017). Findings underscore that being mindful and self-compassionate are interpersonally relevant but through associations with other, more proximal variables. Our findings provide hints about the central, and close interconnection between the three types of basic need fulfillment (particularly relatedness and competence). Our results also extend prior theorizing by incorporating SDT, demonstrating need fulfillment to be a part of a dynamic system of variables similar to what is proposed by Karremans et al. (2017), and highlighting that SDT variables may tie together mindfulness and relationship and/or sexual variables with statistical associations.

4.1 | Pathways of SDT

Relatedness captures the experience of being valued and cared for by others (Ryan & Deci, 2000). In the context of romantic relationships, relatedness is a crucial concept and should theoretically be a strong predictor of relationship satisfaction (Deci & Ryan, 2014). Our finding that relatedness need fulfillment was the most central node—and thus the most important variable in the system (containing both intraindividual and interindividual variables)—was in line with this supposition. This finding is somewhat tautological—suggesting that fulfillment of one's relatedness needs in one's relationship is associated with relationship satisfaction. However, it should be noted that at the item level, the relatedness need fulfillment items ask specifically about how “loved and cared about” one feels when they are with their partner, how distant they feel when they are with their partner, and how close/intimate they feel when they are with their partner. These are distinct (but of course closely related) to global evaluations of relational satisfaction. Additionally, it is crucially important in the SDT context to study the interrelations between all three aspects of need fulfillment. In SDT, competence and autonomy are also

critical for relationships, and research indicates that they contribute to relationship outcomes independently (La Guardia et al., 2000). Our approach was unique, as we sought to explore the system of associations that connect relational outcome variables with the entire suite of need fulfillment variables simultaneously, which allowed us to present evidence about how various forms of need fulfillment intersect with other variables in the system (in addition to each other). In our study, competence fulfillment in relationships was relatively high on both strength and betweenness centrality. This finding suggests that having a partner who fulfills one's competence needs (or evaluating that to be the case) is influential within the system, particularly as it relates to mindfulness and self-compassion. Relationally, competence needs are associated with secure attachment (La Guardia et al., 2000) and with relationship satisfaction (Patrick et al., 2007). Although of the three needs, competence had the weakest association with relational well-being variables in our study, in other literature, competence has had the strongest association with individual well-being variables like positive affect and self-esteem (Patrick et al., 2007). Just because competence does not strongly relate to relational/sexual well-being variables does not mean that it is not influential in the context of the system as-a-whole as demonstrated by our study, because it is associated with other variables which are proximal to the relational elements of the system. Because our study took a systems-level approach, our findings can point to competence as a potentially important bridge variable, relating strongly to our intraindividual variables, but also relating strongly to relatedness need fulfillment, which itself was strongly associated with relationship/sexual satisfaction. Of course, these findings do not represent causal relationships—our study design does not allow for any causal nor directional inference to be made.

Other-compassion had few and generally weak associations with other variables and it was the variable lowest on the centrality indices, suggesting it has relatively low importance within the system. The inclusion of compassion was based on the premise that other-oriented compassion may be part of how the intrapersonal variable of self-compassion exerts an interpersonal effect, but this was not strongly supported by our results. Self-compassion was more central (i.e., higher in centrality indices) than other-compassion and shared a very strong pathway with mindfulness. These findings may be due to the non-dyadic nature of this study (i.e., we cannot estimate partner effects). One's other-compassion may be more strongly connected to one's partner's results than one's own and should be explored in future dyadic studies.

Our findings must be interpreted in light of the sample, which consists of middle-aged, married Canadians between the ages of 40 and 59. Individuals within this age range experience increased stress due to their dual roles as caregivers for their parents and their own children (Grundy & Henretta, 2006), and relationship habituation alongside changes in relationship satisfaction over time (Christopher & Sprecher, 2000; Karney & Bradbury, 1995). Important age-based aspects should also be considered when assessing mindfulness and self-compassion; older (vs. younger) persons meditate more, are more attentive (Baer et al., 2008), and have higher self-compassion (Homan, 2016). This further complicates comparisons across the literature, which tend to draw from younger samples.

Lastly, currently as written there is no mention of need fulfillment in relationships within Karremans et al.'s (2017) model. We sought to integrate the well-researched SDT (Ryan & Deci, 2000) into Karremans et al.'s (2017) relational mindfulness model. We believe there are compatibilities between SDT and Karremans et al.'s (2017) model—and our results point to the central role of specific facets of SDT as an indirect factor. Yet, it is not immediately clear where need fulfillment in relationships would fall in Karremans et al.'s (2017) conceptual groupings. Because Ryan and Deci (2000) propose that need fulfillment is highly fundamental, one might

be tempted to consider it as one of Karremans et al.'s (2017) basic mechanisms, except in this study we assessed need fulfillment in the *relationship*—which has some of the flair of Karremans et al.'s (2017)'s relationship processes. Regardless, replication will be needed to support our findings, and future studies that simultaneously examine need fulfillment alongside some of the well-established *basic mechanisms* and *relationship processes* (as established by Karremans et al., 2017) would serve to provide empirical data to further elaborate on the compatibilities. Indeed, network analysis would be well suited for such a task, because researchers could identify the pathways and relative positions of each of these variable clusters. This would not only help to expand empirical evidence for Karremans et al.'s (2017) model, but also to understand how SDT and other variables/frameworks situate within this broader system.

4.2 | Limitations

The cross-sectional and individual level, nonexperimental, between-subjects design utilized in the current study prevents conclusions on temporal precedence, causal effects, partner effects, and within-subjects effects. As network modeling is a young and developing field/method, there are currently no comparative studies that employ this methodology for this topic. This sample included only Canadians in midlife who were married; participants were largely heterosexual, and mostly cisgender. Therefore, the generalizability of the conclusions is limited to this population and future work should secure more diverse samples. Mindfulness was measured by the FFMQ, however, we want to note that a part of the self-compassion scale is similarly titled “mindfulness versus overidentification.” This is an important dimension to Neff's conceptualization of the construct and it is different from the 5-facets measured by the FFMQ, at least on the surface level. The lines between self-compassion and mindfulness are blurry to begin with and this has been a source of considerable debate (Neff & Dahm, 2015). It is beyond the scope of this study to fully interrogate the differences and similarities between the measures/conceptualizations of each construct. To the extent that these questions remain unanswered, it will remain uncertain if and to what degree we as researchers should account for this conceptual haziness (Lawson & Robins, 2021) in our research. Although it is possible that the same participants took the survey multiple times, Qualtrics Panels uses sophisticated duplication protection to prevent this and thus the risks of multiple participation are no more elevated in this study compared to other online studies. It is important to review some of the pros and cons of a relatively new and less-familiar methodology like network modeling. The final model is quite dependent on the inputs—meaning that if we had conducted our study in a different way and included a different set of candidate variables, the results could be quite different. In a similar way to Structural Equation Modeling, it is incumbent upon the researchers to justify variable selection, because variable choice can alter the results. Replication, as always, must be emphasized. Our study can and should be understood to be an exploration of a system of theoretically meaningful variables, not as a confirmatory test of specific hypotheses.

4.3 | Conclusion

Mindfulness has become an increasingly popular variable in relationships research with promising findings. We constructed a psychological network model with a sample of midlife married Canadians to explore the complex systems-level interrelationships between mindfulness,

self-and-other-compassion, basic need fulfillment in relationships, and relationship and sexual satisfaction. Our findings suggest a complex system, with relatedness need fulfillment and competence need fulfillment being the most central and impactful variables within the system.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

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

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