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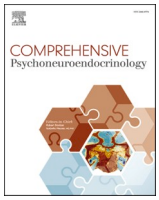

Couples in breast cancer survivorship: Daily associations in relationship satisfaction, stress, and health

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ABSTRACT

Romantic relationships are a key health determinant underlying both morbidity and mortality. Dr. Janice Kiecolt-Glaser's prolific research revealed cardiovascular, metabolic, endocrine, and immune pathways connecting marriage to health and longevity. In addition to her empirical work, she developed conceptual models on marriage, the gut microbiome, stress reactivity, and spousal health concordance; these models guide and inspire mechanistic research, serve as essential readings for graduate students and mentees, and provide inspiration for researchers across career stages. This paper highlights Dr. Kiecolt-Glaser's influential work, includes personal reflections and professional growth as past mentees, and provides Dr. Kiecolt-Glaser-inspired evidence linking relationships to health among couples in breast cancer survivorship. Using baseline questionnaires and daily dairies, breast cancer survivors (stage I-IIIB) and their cohabiting partners (60 individuals, 30 couples) rated their relationship satisfaction, stress, and physical health symptoms every day for 7 days. Results suggest that breast cancer survivors and their partners who felt more satisfied with their relationships also felt less stressed, both typically and on a daily basis. Survivors' and partners' lower stress was also associated with fewer physical health problems on average and in daily life. These findings demonstrate the daily stress and health advantages of satisfying relationships for both breast cancer survivors and their partners. We discuss the study's implications and several avenues for Dr. Kiecolt-Glaser-inspired research addressing a relationship's long-term health impact among couples in survivorship.

1. Introduction

1.1. Our[1] work with Dr. Janice Kiecolt-Glaser

Epidemiological studies have identified romantic relationships as a key health determinant underlying both morbidity and mortality [1,2]. Throughout her prolific career, Dr. Janice (Jan) Kiecolt-Glaser revealed cardiovascular, metabolic, endocrine, and immune pathways connecting marriage to health and longevity [3]. Applying her cross-disciplinary innovation and rigorous methods, she published groundbreaking and highly cited studies inspiring researchers and clinicians across career stages.

Dr. Kiecolt-Glaser's work shaped my career long before I applied to work with her as a postdoctoral fellow. Though there were many, two papers in particular ignited my interest in psychoneuroimmunology (PNI) and relationship science as a graduate student: her 2001 Psychological Bulletin review illustrating marital negativity's harsher health effects on women than men [4], and her 2005 Archives in General Psychiatry paper showing hostile marital interactions predicted slower wound healing over time [4]. In this 2005 seminal wound healing study, Kiecolt-Glaser and colleagues found that couples who were more hostile during marital discussions had wounds that healed more slowly than

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[1] The first and second authors, Drs. Shrout and Renna, respectively, worked together as postdoctoral mentees of Dr. Kiecolt-Glaser. First-person singular references regard the first author's experiences. First-personal plural references regard the first and second authors' experiences.

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couples whose interactions were less hostile. In fact, the wounds in high-hostile couples healed at only 60 % of the rate of low-hostile couples. This was a groundbreaking study because it showed that the quality of relationships and couples' interactions can influence immune functioning in ways that enhance risks for both acute and chronic illness. Little did I know that these papers would set the stage for my own work with Dr. Kiecolt-Glaser.

Several years after reading these papers for the first time, I led secondary analyses on Dr. Kiecolt-Glaser's wound healing data (in collaboration with the current paper's second author, Dr. Renna). We showed that couples' typical negative communication patterns colored spouses' reactions to the marital discussions, amplifying their emotional, relational, and immunological impact [5]. The combination of their self-reported negative communication patterns and their discussion-based behaviors predicted lower positive emotions after the discussions, more negative evaluations of the discussions, and slower wound healing in the weeks after the discussions. Incorporating a gender perspective, we also found that emotional and immune responses were particularly strong for women compared to men. These findings demonstrate how distressed marriages pose long-term relational and health risks, most notably in women.

Dr. Kiecolt-Glaser and colleagues' models connecting marital interactions to the gut microbiome [6] and couples' health concordance [7] also guide and inspire mechanistic marriage and health research. These models illustrate how relationship dynamics influence healthy aging through changes in the gut environment, such as intestinal permeability and gut dysbiosis, and its associated inflammation, as well as through partners' increasingly shared and more similar emotions and health behaviors. Applying her marital quality and gut microbiome model, our longitudinal research with Dr. Kiecolt-Glaser showed that women with and without breast cancer had lower intestinal permeability and inflammation when they were more satisfied with their relationships compared to when they were less satisfied [8]. These findings identified the gut environment as a mechanistic pathway from women's strong relationships to lower inflammation and better health. When applying Dr. Kiecolt-Glaser's dyadic health concordance model, our research showed that couples' emotions and physiology tracked together across positive, supportive, and conflictual discussions [9]. Couples who were less enthusiastic and understanding showed stronger emotional and physiological linkage in markers reflecting shared stress (negative emotion, electrodermal activity, systolic blood pressure). Couples' more enthusiastic and understanding behaviors, however, strengthened physiological linkage at healthier levels of physiological adaptation (heart rate variability). This research suggests that couples' positive dynamics may shield partners from emotional and physiological stress, while lacking such behaviors may enhance their emotional and physiological vulnerability.

While we were postdocs with Dr. Kiecolt-Glaser, she led a review paper and developed a model illustrating the individual and dyadic factors that influence the duration and magnitude of the body's stress response. That is, we identified factors that either help alleviate stress or make stress worse and last longer. We discussed how a stressor can influence the body across time, ranging from seconds to minutes and hours, such as through cortisol release and proinflammatory signaling, to years via metabolic dysregulation, chronic disease development, inflammaging, and early mortality. For dyadic factors, we discussed how stress contagion and poor relationship quality worsen and prolong the stress response, while supportive and positive relationship dynamics reduce stress and its health consequences. Continuing Dr. Kiecolt-Glaser's conceptual contributions and linking them to our own programs of research, Dr. Renna and I each developed conceptual PNI models—my model related to couple dynamics, and her model incorporated negative emotionality. In my model and review paper, I developed the dyadic biobehavioral stress model to provide a comprehensive roadmap addressing how partners influence their own and each other's morbidity and mortality risks through emotional, psychological, behavioral, and biological pathways [10]. The goal of this model is to inspire interdisciplinary research on relationships, stress, and health to help explain how, and under what conditions, partners influence each other's health. Dr. Renna's model and review paper unveiled the biobehavioral model of negative emotionality. She discussed how negative emotions and maladaptive emotion regulation promote immune system activation/dysfunction, increasing morbidity and mortality risks [11].

We applied these models and continued our work inspired by and conducted with Dr. Kiecolt-Glaser to reveal key pathways connecting couple dynamics to each partner's health. Across our work, we demonstrated that couples' negative conflict and communication predicted each partner's poorer self-rated health, greater negative emotion, lower heart rate variability, delayed wound healing, and heightened inflammation, heart rate, blood pressure, and cortisol [5,9,12,13]; in contrast, couples' positive communication patterns were associated with each partner's better health across these self-report and biological markers. In our breast cancer work (see Renna & Shrout, this issue [14]), survivors' satisfying relationships were linked to improved psychological and physical functioning, as well as lower stress, gut leakiness, and inflammation across treatment [8,15,16]. These findings showed that the quality of survivors' marriages, rather than the marriage itself, was associated with better emotional and physical health in survivorship. This work builds on Dr. Kiecolt-Glaser's legacy, providing mechanistic evidence across psychological, behavioral, and biological pathways that foster each partner's health and longevity or fuel their disease risk and early mortality.

Connecting these lines of work on the health effects in couples and breast cancer survivors, I am leading a project addressing a relationship's stress and health impact among breast cancer survivors and their partners. As I learned first-hand from Dr. Kiecolt-Glaser, I formed a team of multidisciplinary scientists with expertise across clinical health psychology, social relationships and psychoneuroimmunology, and breast cancer therapies, and actively involve my own mentees in studying relationships and health. This project, informed by our work with Dr. Kiecolt-Glaser, examines daily associations in relationship, stress, and health perceptions among breast cancer survivors and their partners. The overarching goal is to identify the day-to-day health benefits of survivors' satisfying relationships as potential pathways to better long-term health.

1.2. The present study

Breast cancer survivors who experience heightened stress and physical symptoms after treatment ends have an increased risk for comorbid disease development, reduced quality of life, and premature mortality [17,18]. Epidemiological research shows that, compared to women without a cancer history, breast cancer survivors have higher rates of cardiovascular disease, diabetes, and all-cause mortality, particularly as they age [17,18]. Likewise, given the heightened stress from cancer, partners of survivors are also vulnerable to poor health and have greater health risks relative to partners of those without a cancer history [19,20]. Partners are often referred to as "secondary survivors" because of the emotional and physical stress from the potential loss of their partners and the fear of cancer recurrence [21,22]. This stress enhances disease risks and threatens long-term health [19].

Despite these health consequences, couples' strong and satisfying relationships offer broad health benefits and protect health during stress [10,23,24]. When compared to those in unhappy marriages, happily married individuals showed greater heart rate variability [25] and were less likely to develop cardiovascular disease over time [26,27]. Among breast cancer survivors, our longitudinal research showed that, compared to dissatisfied and unpartnered survivors, satisfied survivors had greater psychological and physical health improvements from diagnosis to nearly two years after treatment ended [15]. Our longitudinal work also parsed out effects between and within survivors, showing that when partnered survivors were more satisfied with their

relationships, they also had lower perceived stress, intestinal permeability, and inflammation than when they were less satisfied [8,16]. Likewise, survivors who were more satisfied on average across treatment also had lower stress, intestinal permeability, and inflammation than less satisfied survivors. These findings highlight the importance of taking a within-person approach to capture how changes in a survivor's relationship satisfaction are associated with changes in their own stress and health across survivorship.

Research on couples in survivorship has also shown that their relationship dynamics change from day to day [28,29]. Compared to couples with more negative interactions, more positive couples reported lower negative emotions the same day and the following day. Couples with more positive interactions also reported lower distress, feeling more understood and cared for, and greater intimacy [30,31], each of which underly and helps maintain satisfying relationships [32,33]. These findings show survivors' and partners' relationship perceptions contribute to better emotional and relational health. However, research has yet to address a relationship's day-to-day physical health impact on survivors and partners despite the notable health effects in physically healthy couples. Research is needed to examine how breast cancer survivors' and partners' relationship satisfaction predict changes in emotional and physical health, particularly given their heightened risks for long-term health problems. Including both survivors and their partners' perspectives can identify key pathways connecting relationships to better health.

The current study examined daily relationship, stress, and health perceptions in breast cancer survivors and their partners. Couples completed baseline assessments and then a daily diary to investigate how survivors' and partners' relationships contribute to their stress and health in daily life. These methods help identify everyday mechanisms connecting survivors' satisfying relationships to their long-term health. To capture physical ailments that both breast cancer survivors and their partners might experience on a day-to-day basis, we assessed a wide range of physical symptoms relevant to the general population (e.g., congestion, dizziness, constipation/diarrhea), along with specific symptoms that may be especially elevated among survivors (e.g., hot or cold flashes, nausea, muscle soreness); this approach is consistent with past research examining transient experiences of physical symptoms, as well as interpersonal interactions, tensions, and stressors, in daily life [34–36]. Extending the within-person approach of our longitudinal work, we also parsed out within- and between-person effects to address how changes in survivors' and partners' relationship satisfaction were associated with changes in their own stress and health each day. Capturing these fluctuations will help illuminate how daily relationship experiences contribute to their stress and health risks in real-time and naturalistic settings. These methods offer a vital window into couples' homes and daily interactions to demonstrate the health benefits and costs of couples' relationships and stress in everyday life.

Accordingly, this study assessed associations in typical and daily relationship satisfaction, perceived stress, and physical health problems. It was expected that feeling more relationally satisfied at baseline would be associated with lower stress and fewer physical health problems at baseline and in daily life; it was also expected that lower stress at baseline would be associated with fewer physical health problems at baseline and in daily life. For daily associations at the within-person level, it was expected that on days survivors and partners felt more satisfied than usual, they would also feel less stressed and report fewer physical health problems; likewise, on days they felt less stressed than usual, it was expected that they would also report fewer physical health problems. At the between-person level, we hypothesized that survivors and partners who felt more satisfied, on average, throughout the diary would also report lower stress and fewer physical health problems than those with lower average satisfaction.

2. Methods

2.1. Participants and procedure

Breast cancer survivors (stage I-IIIB) and their cohabiting partners (n = 60 individuals, 30 couples) were recruited to participate in a longitudinal study on couples' daily health in survivorship. Survivors completed cancer treatment (surgery, radiation, or chemotherapy, whichever came last), except for longer-term hormonal therapies, at least 3 months prior to allow treatment-related side effects to decline [37,38]. Exclusion criteria included a history of any other cancer for the survivor, and any history of cancer for the partner, except basal or squamous cell skin carcinoma, significant sensory impairments that would interfere with study completion, nightshift work that would interfere with the diary protocol, and couples not living together full time (7 days per week); couples also needed to not travel during the daily diary. Interested couples completed an online questionnaire and virtual Zoom call to determine eligibility. Although the sample was small, hypotheses were adequately powered given the repeated measures and daily diary design. Power analyses accounted for missing data and correlated data within person and couple. By including 60 participants over 7 days, 420 assessments of data were collected. Using a conservative response rate of 80 % (336 assessments) and a design effect of 1.556 from prior ecological-based daily research [39], the effective sample size was 215 assessments. We therefore have 0.80 power to detect small to medium effects of 0.10–0.20 ($\alpha = .05$). Table 1 provides sample characteristics. Most couples were different-sex and married, with an average relationship duration of 29.85 years (SD = 16.80, range = 2–55 years), and had been living together for 30.03 years (SD = 16.29, range = 2–55 years). Survivors' average age was 58.07 years (SD = 12.71, 31–77 years), and their partners' average age was 60.63 years (SD = 14.56, range = 32–87 years). Table 1 provides additional sample characteristics.

Participants first completed a baseline online survey followed by a 7-day experience sampling diary study. The diary study used ExpiWell for assessments, a widely used experience sampling smartphone application. Participants received smartphone notifications to complete assessments via ExpiWell three times each day, along with reminders for each uncompleted assessment; the current study used the evening assessment data from 8 to 11:59 p.m. to address associations in daily satisfaction, stress, and physical health [40,41]. Assessments expired and became inactive outside this window [42]. Participants were asked to avoid discussing their responses with their partners. Following established protocols to increase compliance and data quality, study personnel met virtually with each couple to review study procedures and ensure ExpiWell notifications worked properly; provided user handouts for each portion of the study; monitored the assessments and contacted participants who missed a full day; and provided contact information in case of technical difficulties [40,41]. Response rates were high: on average, participants completed 92.25 % (SD = 8.30) of the evening assessments. Study procedures were approved by the university Institutional Review Board; participants provided written informed consent before participating.

2.2. Baseline survey measures

2.2.1. Relationship satisfaction

The 4-item Couples Satisfaction Index (CSI-4) assessed relationship satisfaction [43]. Developed using item response theory, the short version of the CSI-14 distinguishes between satisfied and dissatisfied partners with greater precision than most commonly used relationship satisfaction scales, and has a cut-score of 13.5 to identify notable marital dissatisfaction [43]. Cronbach's α for the CSI-4 was 0.92.

2.2.2. Perceived stress

The 4-item Perceived Stress Scale (PSS-4) measured perceived stress

Table 1
Baseline sociodemographic data of survivors and partners (N = 60 individuals, 30 couples).

	Survivors		Partners	
	M (*SD*)	%	*M* (*SD*)	%
Age	58.07 (12.71)		60.63 (14.56)	
Cancer stage				
I		60.0		
II		23.3		
IIIA		10.0		
IIIB		6.7		
Cancer treatment				
Chemotherapy treatment (% yes)		50.0		
Radiation treatment (% yes)		60.0		
Time since treatment (years)	5.83 (6.80)			
Postmenopausal (% yes)		83.3		3.3
Gender				
Women		100		3.3
Men		0.0		96.7
Race				
White		86.7		93.3
Black or African American		6.7		6.7
Hispanic/Latinx		6.7		3.3
Multiethnic/Multiracial		3.3		0.0
Sexual orientation				
Straight/heterosexual		93.3		93.3
Bisexual		3.3		3.3
Lesbian		3.3		3.3
Years of education				
< College		20.0		26.7
≥ College		80.0		73.3
Employment status				
Part-time		20.7		10.0
Full-time		44.8		40.0
Retired		24.1		50.0
Unemployed		6.9		0.0
Stay at home parent		3.4		0.0
Household income (survivor and partner average)				
$25,000 to $49,999		9.4		
$50,000 to $74,999		4.8		
$75,000 to $99,999		20.3		
$100,000 to $124,999		34.8		
$125,000 to $149,999		8.9		
$150,000 or more		21.8		
Relationship length (years; survivor rated)	29.85 (16.80)			
Cohabitation length (years; survivor rated)	30.03 (16.29)			
Married		100.0		

over the past month [44]. The 4-item version provides researchers the opportunity to assess perceived stress more easily where short questionnaires are required, such as in longitudinal research [44]. Response options ranged from 1 (*never*) to 5 (*very often*) and averaged so that higher scores indicate greater perceived stress. Cronbach's α for the PSS-4 was 0.78.

2.2.3. Physical health problems

The Physical Health Questionnaire was used to assess physical health problems over the past 2 weeks [45]. Consistent with past research separating double-barreled items [46], a total of 17 items were used to assess somatic symptoms of physical health over the past 2 weeks (e.g. "How often have you experienced headaches?" and "How often did you get an upset stomach?"). Items were rated on a 7-point scale (1 = *not at all*, 7 = *all of the time*) and averaged so that higher scores indicate more physical health problems (α = .88).

2.3. Daily survey measures

2.3.1. Daily relationship satisfaction

Participants were asked to rate the extent to which they currently felt satisfied with their relationship on a scale from 1 (*not at all satisfied*) to 11 (*extremely satisfied*), with higher scores indicating greater daily relationship satisfaction [47,48].

2.3.2. Daily perceived stress

Participants were asked to rate how stressful their day was overall on a scale from 1 (*not at all*) to 11 (*extremely*), with higher scores indicating greater daily perceived stress [49].

2.3.3. Daily physical health problems

Physical health symptoms were measured with Larsen and Kasimatis' somatic symptoms checklist [34,50]. Participants indicated if they experienced 15 different physical symptoms in the past 24 h (headache, constipation/diarrhea, muscle soreness, shortness of breath, tightness in chest, trembling/shaking, backache, cold/flu symptoms, heart pounding, nausea/upset stomach, hot or cold flashes, congestion, poor appetite, sore throat, dizziness). This measure was selected because it captures a wide range of physical ailments that both breast cancer survivors and their partners might experience on a day-to-day basis, along with specific items that may be especially elevated among survivors (e.g., hot or cold flashes, nausea, muscle soreness) [51]. The items were summed to indicate the number of symptoms a participant reported per day, ranging from 0 (not symptom checked) to 15 (all symptoms checked).

2.4. Analytic strategy

First, correlations were conducted on all baseline and diary study variables. Mixed models were used to test differences in survivor and patient variables and to address the study hypotheses. This modeling strategy accounted for missing data by maximizing the use of existing data and including all participants in the analyses, regardless of missing data points, and allowed for explicit modeling of the non-independence in couples' data [52,53]. Models with only baseline variables specified that individuals were nested within couples, and for models with daily variables, individuals were nested within couples and day was a repeated factor across couples [53]. Models included random intercepts using a variance components covariance structure and accounted for the similarity in the residuals of the partners' variables across the time points using an unstructured covariance matrix. Random intercepts and, when possible, random effects for the slopes were estimated. Couples were treated as distinguishable with "role" (breast cancer survivor or partner) as the distinguishing variable. All descriptive analyses were conducted in SPSS Version 29, and multilevel analyses were performed using the MIXED MODELS procedure with restricted maximum likelihood estimation. Daily predictors accounted for both within-person and between-person variability. Thus, variables at the within-person level (level 1) were person-centered so that participants' scores each day reflected how much higher or lower their satisfaction and stress deviated from their own average across the week. At the between-person level (level 2), variables were grand mean-centered to represent a participant's average satisfaction and stress throughout the week. Empty multilevel models were estimated to calculate the intraclass correlation coefficient (ICC) for each daily variable: relationship satisfaction (ICC = 0.68), stress (ICC = 0.31), and physical health symptoms (ICC = 0.52). Normality assumptions were examined (skew was between −2 and +2), including multivariate residuals, which showed two potential multivariate outliers; results did not change when excluding the two data points, and thus all data were used to maximize the use of existing data.

Models 1 and 2 tested hypotheses about baseline associations. Specifically, baseline relationship satisfaction would be associated with lower stress (model 1), and baseline satisfaction and stress (model 2) would be associated with baseline physical health. Models 3a and 4a tested hypotheses that baseline satisfaction (3a) and stress (4a) would predict daily physical health. Models 3b and 4b address hypotheses that baseline and within- and between-person satisfaction (3b) and stress

(4b) would be linked to daily physical health. Age, income, and role (survivor or partner) were included as covariates in the analyses, as was the diary day for models predicting daily variables. Analytic code and data are available upon request from the first author; this study was not preregistered.

3. Results

The sample was more satisfied relative to less satisfied, with 25.9 % scoring below the CSI cut score reflecting notable relationship distress. Participants reported, on average, 2.58 symptoms per day ($SD = 2.00$). The most frequent symptoms across the diary were muscle soreness (70.1 %), backache (33.9 %), and headaches (28.8 %). Table 2 presents correlations among study variables, which are in line with the study hypotheses. At baseline, greater relationship satisfaction was associated with lower stress and fewer physical health problems (*p*s < 0.001); greater stress was correlated with worse physical health ($p < .001$). During the daily diaries, greater daily relationship satisfaction was associated with lower daily stress ($p = .01$) and daily physical symptoms ($p = .04$); greater daily stress was correlated with greater daily physical symptoms ($p < .001$). Older adults reported lower baseline physical health problems ($p = .02$) and greater daily relationship satisfaction ($p = .006$). Individuals with greater household income reported higher baseline satisfaction ($p = .03$) and lower baseline stress ($p < .001$) and physical health problems ($p = .002$). Preliminary mixed models to examine differences in variables by role (Table 3) showed survivors reported greater baseline and daily physical health problems, as well as greater daily stress, than partners.

3.1. Models with baseline predictors of stress and health

All primary model results are shown in Table 4. For baseline predictors and outcomes (models 1 and 2), greater baseline satisfaction predicted lower baseline stress ($p < .001$); greater stress ($p < .001$), but not satisfaction ($p = .96$), predicted poorer baseline physical health. Older adults reported lower stress ($p = .02$) but more physical health problems ($p < .001$) than their younger peers. Those with higher household incomes reported lower stress and fewer physical health problems (*p*s < 0.001) than those with lower household incomes. There were no differences in stress ($p = .90$) or physical health problems ($p = .29$), between survivors and partners.

For baseline predictors of daily outcomes (models 3a and 4a), greater baseline satisfaction predicted lower daily stress ($p = .008$). Greater baseline stress ($p < .001$), but not baseline relationship satisfaction ($p = .34$), was associated with worse daily physical health. Older survivors reported lower daily stress ($p = .046$), but not daily physical health problems ($p = .38$). Survivors reported greater daily stress ($p = .009$) and marginally more physical health symptoms ($p = .07$) than partners.

3.2. Models with baseline and daily predictors of stress and health

Models 3b and 4b with the baseline and the between- and within-person daily predictors showed that greater within-person relationship satisfaction ($p = .003$), but not baseline satisfaction ($p = .06$) or between-person satisfaction ($p = .97$), predicted lower daily stress. Thus, on days survivors and partners felt more satisfied than usual, they also reported lower stress. Age ($p = .06$) and income ($p = .11$) did not predict daily stress levels. Survivors reported greater daily stress than partners ($p = .009$). Greater within-person relationship satisfaction ($p < .001$) predicted fewer daily physical health problems, whereas greater within-person stress ($p = .048$) was associated with more daily physical health problems. Thus, on days survivors and partners felt more satisfied and less stressed than usual, they also reported fewer physical health symptoms. Baseline satisfaction ($p = .56$) and between-person satisfaction ($p = .41$) were not associated with daily physical health problems. Greater baseline stress ($p < .001$), but not between-person stress ($p = .34$), predicted poorer daily physical health. Survivors reported more daily physical health problems than partners ($p = .02$). Age ($p = .60$) and income ($p = .45$) were not related to daily physical health.

Table 3
Estimated marginal means and standard errors of variables.

Variable	*M* (*SE*) by role			
	Survivor	Partner	*p*	Range
Baseline relationship satisfaction	16.50 (0.79)	15.87 (0.79)	0.36	0–21
Baseline stress	2.46 (0.13)	2.43 (0.13)	0.87	1–5
Baseline physical health problems	2.63 (0.19)	2.28 (0.19)	**0.04**	1–7
Daily relationship satisfaction	9.43 (0.29)	9.44 (0.29)	0.96	1–11
Daily stress	4.17 (0.32)	3.53 (0.32)	**.004**	1–11
Daily physical health problems	2.60 (0.30)	2.01 (0.30)	**.005**	0–15

Note. Means and standard errors (SEs) for daily variables represent daily averages during the diary. Significant effects are bolded.

4. Discussion

4.1. The present study findings and implications

Consistent with dyadic stress theories [10,24,54], these findings demonstrated the daily health advantage of satisfying relationships for both breast cancer survivors and their partners. As expected, breast cancer survivors and their partners who felt more satisfied with their relationships also felt less stressed, both typically and on a daily basis. Survivors' and partners' lower stress was also associated with fewer physical health problems on average and in daily life. Prior work has shown the stress and health benefits of a survivor's satisfying relationship over the course of treatment and in early survivorship [15,16]. The current study builds on this prior work by providing evidence that a satisfying relationship is also associated with lower stress and better health in both survivors and partners. Importantly, a daily diary methodology provided a window into couples' daily lives in survivorship. This approach captured connections in couples' everyday relationship, stress, and health perceptions and provided mechanistic insight into the

Table 2
Correlations of primary continuous variables.

Variable	2	3	4	5	6	7	8
1. Baseline relationship satisfaction	−0.49***	−0.51***	0.75	−0.38**	−0.32*	0.17	0.29*
2. Baseline stress	–	0.58***	−0.47	0.31*	0.52***	−0.26^{+}	−0.51***
3. Baseline physical health problems		–	−0.52***	0.58***	0.68***	−0.29*	−0.40**
4. Daily relationship satisfaction			–	−0.40*	−0.29*	0.36**	0.13
5. Daily stress				–	0.52***	−0.19	−0.25+
6. Daily physical health problems					–	−0.23	−0.15
7. Age						–	−0.07
8. Household income							–

Note. Correlations for daily variables represent between-person averages during the diary.
$^{+}p < .10$. *$p < .05$. *$p < .01$. ***$p < .001$.

Table 4
Coefficients (b (SE)) for models predicting baseline and daily stress and physical health problems.

Predictors	Baseline outcomes		Daily outcomes			
	Stress	PH problems	Stress		PH problems	
	1	2	3a	3b	4a	4b
Baseline satisfaction	**−0.04 (0.01)*****	−0.06 (1.25)	**−0.13(0.05)****	−0.13 (0.07)	−0.04 (0.04)	−0.04 (0.06)
Baseline stress	–	**0.62 (0.02)*****	–	–	**1.56 (0.20)*****	**0.97 (0.20)*****
Daily satisfaction (WI)	–	–	–	**−0.45 (0.13)*****	–	**−0.26 (0.06)*****
Daily satisfaction (BW)				−0.01 (0.19)	–	0.20 (0.24)
Daily stress (WI)	–	–	–	–	–	**0.07 (0.03)***
Daily stress (BW)				–	–	0.13 (0.13)
Day			0.10 (0.06)	0.07 (0.06)	**−0.10 (0.03)****	−0.09 (0.03)
Age	**−0.10 (0.004)***	**0.10 (0.01)*****	**−0.04 (0.02)***	−0.04 (0.02)$^{+}$	−0.02 (0.02)	−0.01 (0.02)
Household income	**−0.10 (0.02)*****	**−0.22 (0.03)*****	−0.14 (0.08)	−0.13 (0.08)	−0.11 (0.08)	0.06 (0.08)
Role	−0.01 (0.05)	0.03 (0.03)	**−0.61 (0.23)****	−0.38 (0.27)	−0.39 (0.22)$^{+}$	**−0.52 (0.21)***

Significant effects are bolded. PH = physical health. Role = partner = 0, survivor = 1. WI = within, BW = between. Models 3a and 4a include baseline predictors of daily outcomes. Models 3b and 4b include baseline and daily predictors of daily outcomes. Within-person effects demonstrate fluctuations from day to day. Between-person effects demonstrate average effects across the days.
$^{*}p < .05$. $^{*}p < .01$. $^{***}p < .001$.

day-to-day health benefits of a satisfying relationship.

Greater baseline relationship satisfaction was associated with lower baseline stress and better physical health, but baseline satisfaction did not significantly predict health after accounting for stress. Stress may serve as an important mechanism linking relationship satisfaction to health, consistent with past longitudinal work demonstrating that survivors' higher satisfaction predicted lower stress and inflammation across early survivorship [16]. The daily findings showed that, rather than baseline global perceptions of their relationships or between-person average satisfaction across the week, within-person fluctuations in both daily satisfaction and stress corresponded to changes in physical health. Thus, on days survivors and partners felt more satisfied and less stressed than they typically felt that week, they also reported fewer physical health symptoms. Survivors and partners in satisfying relationships often report open communication about cancer concerns [31] and feeling accepted, validated, and cared for by one another [30]. Though additional work is needed, one possibility in line with this notion is that satisfied survivors and partners may provide and receive the necessary care to reduce their health concerns in daily life. These findings show the importance of capturing links between relationships and health across various timescales and parsing out effects within- and between-person effects in survivorship.

These findings provide pathways that connect relationship perceptions to daily stress and health, particularly among those at high risk for long-term health problems. Even among those without a cancer history, high stress is associated with adverse autonomic, endocrine, and immunological function [55]. Lasting dysregulation across these physiological systems can contribute to chronic disease development, frailty, and accelerated aging [56,57]. Extending prior work to partners of survivors and couples' daily health, the current study reveals that satisfying relationships can translate to lower stress and better health for both survivors and their partners. This is important because survivors and partners have reported reduced intimacy, closeness, and satisfaction across survivorship [58,59]. Enhancing survivors' and their partners' relationships, connecting them to resources, and encouraging satisfying connections may help reduce their emotional and physical symptoms and promote their long-term health. National guidance from the American College of Surgeons' Commission on Cancer [60] and the American Society of Clinical Oncology [61] have discussed the need to screen for distress, and these findings underscore the importance of also screening for relational distress and referring couples to counseling. These findings have important implications for couple-focused programming and prevention to help couples enhance and maintain strong relationships across survivorship (see Gouin and Dymarski, this issue [62], for an excellent review and next steps in couples-based health behavior change interventions to reduce physiological dysregulation and improve dyadic health).

Strengths of this study include the dyadic approach to addressing a relationship's health impact on survivorship. This dyadic approach allowed for examination of links between satisfaction, stress, and health in both survivors and their partners. Differences between survivors and partners were also addressed, which showed survivors' greater stress and physical health problems on a daily basis. This study also used a daily diary methodology that allowed for assessment of everyday relationship, stress, and health dynamics. Providing a window into couples' daily lives in survivorship, this study considered associations in couples' typical and daily experiences and identified the day-to-day stress and health-enhancing effects of satisfying relationships. Findings suggested that while baseline satisfaction predicted lower baseline stress, daily fluctuations in satisfaction were important for understanding corresponding changes in both daily stress and health. This study also adds to the literature revealing pathways from satisfying relationships to better health, notably among middle-aged and older couples who not only experienced a health adversity but whose relationships are central to health [63,64].

Larger sample sizes are needed to address more complex questions, such as testing mechanisms that connect or alter ties between relationship, stress, and health perceptions. Likewise, a larger sample size is needed to examine cross-partner effects including how survivors' satisfaction predicts partners' stress and health, and vice versa. Though significant effort went into inclusive recruitment and inclusion of underrepresented participants in dyadic health science, the sample consisted of married couples who were primarily white, in mixed-gender relationships, college-educated, and had household incomes of $100,000-$124,999, on average. In the current study, individuals with lower income had greater baseline stress. For couples with low socioeconomic status, reducing financial strain is important for enhancing their relationships [65,66]. Policies and programming that target external stressors, such as reducing financial stress, may be important for improving overall stress perceptions that ultimately correlate with better relationships and health. Future work may also consider examining biomarkers in daily life, such as how heart rate variability, inflammation, or cortisol change with relationship satisfaction and stress on a daily basis. Prior work has shown their cross-sectional and longitudinal links and thus daily associations may underly longer-term connections.

4.2. Implications for Dr. Kiecolt-Glaser inspired PNI and relationship research

The current study also provides several avenues for Dr. Kiecolt-Glaser-inspired research addressing a relationship's long-term health

impact among couples in survivorship. In our stress reactivity review paper led by Kiecolt-Glaser [55], we discussed the importance of examining adverse stress-related changes in multiple regulatory systems, such as cardiovascular, hormonal, and immune reactivity, as well as how individual and relational factors exacerbate or temper stress-related health risks. Extending this model to couples in survivorship, research can address stress reactivity in both survivors and partners, including how each individual influences the magnitude and duration of their bodily stress responses. Identifying how relationship dynamics influence survivors' and partners' heightened and prolonged stress reactivity may reveal relational and biological gateways to chronic disease and early mortality.

Combining data on stress reactivity in laboratory and ecological settings can provide nuanced information about the stress response and its health effects in real time and daily life. Our papers with Dr. Kiecolt-Glaser showed that breast cancer survivors' heightened distress predicted higher-than-usual inflammation before and after cancer treatment [67]. Moreover, survivors with a history of distress disorders had lower and thus less healthy heart rate variability before, during, and after a laboratory stressor compared to those without such a history [68]. Future work may address how survivors' satisfying relationships dampen and protect against such strong physiological responses, particularly among survivors with a history of distress disorders. Incorporating daily diary and ecological momentary assessments can assess how partners may alleviate or worsen stress in daily life. For instance, merging laboratory and daily methods can capture how observed and daily relationship behaviors contribute to or help reduce cancer-related stress, prolonged psychological and physical symptoms, and chronic inflammation. Crosstalk between laboratory, ecological, and longitudinal methods may prove quite useful in addressing short- and long-term mechanisms connecting satisfying relationships to enhanced health.

Stemming from Dr. Kiecolt-Glaser's marital conflict and social support work [3,4], future research can examine how couples' cancer-related conversations—supportive or contentious—predict inflammatory, cardiovascular, and endocrine responses. Couples in survivorship may experience greater reactivity to conflict discussions than those without such a health adversity—an important question for future research to address. In another unique blend of Dr. Kiecolt-Glaser's spousal caregiver work [69,70], researchers may consider assessing the biological health of spousal/partner caregivers to breast cancer survivors with more severe and metastatic diagnoses.

In Dr. Kiecolt-Glaser and colleagues' conceptual model on marital interactions and the gut microbiome [6], they discussed how satisfying relationships are linked to healthy aging through lower intestinal permeability and inflammation. In contrast, distressing relationships can accelerate biological aging through gut dysbiosis and adverse structural and functional changes. Her empirical work demonstrated that lower quality and more hostile marital interactions were associated with greater intestinal permeability and, in turn, heightened inflammation [71]. Likewise, more satisfied partners experienced decreased intestinal permeability over 3 months [72]. Partners with lower depressive symptoms also showed increased gut microbiota diversity and richness over time. In our subsequent work, breast cancer survivors' satisfying relationships also predicted lower intestinal permeability and inflammation across treatment [8]. These findings provide promising evidence that gut environment may underly a relationship's health impact—another notable direction for future research.

Dr. Kiecolt-Glaser's 2018 American Psychologist review accompanying her American Psychological Association Award for Distinguished Scientific Contributions summarizes decades of her noteworthy research, as well as offers key next steps to inspire the next generation of PNI and relationship scientists. Each of her conceptual models and reviews is an essential reading for graduate students and trainees, as well as an invaluable resource to turn to for inspiration at any career stage. She is a pioneer who inspired and mentored clinical, health, social, and developmental psychologists to study the far-reaching health effects of stress. I am honored to continue the Kiecolt-Glaser legacy and mentor the next generation of PNI and relationship scholars.

4.3. Personal reflections and conclusions

In Dr. Kiecolt-Glaser's recent book chapter, "Reflections from Pioneering Women in Psychology," she discussed her professional journey, approach to mentoring, and experience as a woman in science [73]. In our group mentoring meetings, we each brought and discussed data, read and reviewed papers together, and collaborated and provided feedback on manuscripts. Dr. Kiecolt-Glaser valued interdisciplinary training, and by having mentees across clinical, health, social, and developmental psychology work together, we developed novel ideas together and pushed the boundaries of our own research. I gained invaluable expertise and support working alongside other mentees, many of whom are featured in this special issue, including Megan Renna, Annelise Madison, and Stepanie Wilson. Through these collaborations, I not only received training in PNI and relationship science, but I also worked on clinically relevant projects, such as addressing how anxiety, worry, and rumination influence health across self-rated and biological markers [74–76], and how diet and inflammatory reactivity can predict changes in depressive symptoms [77,78]. My program of research accelerated and crossed disciplines, and I gained both lifelong collaborators and friends.

In her book chapter, Dr. Kiecolt-Glaser wrote about using audio recordings when giving feedback to mentees; this tool was indeed quite helpful to hear why she suggested certain changes, help us think through our arguments, and become better writers. She also discussed women's downplaying of their achievements. When I did this or felt discouraged, especially when applying to academic jobs amid the COVID-19 pandemic, she was quick to jump in and help me see my value as a teacher and researcher. I could feel her compassion, even with our meetings on Zoom for months on end during this time. Dr. Kiecolt-Glaser's book chapter and work demonstrate the importance of having strong social connections to mitigate life's stress and protect our health. As a Dr. Kiecolt-Glaser mentee, what I cherish most are the relationships I built and continue to nourish. Dr. Kiecolt-Glaser has an extraordinary list of exceptional mentees that I am honored to be a part of. One of the most impressive aspects of this list is that they are deeply compassionate and supportive people. Dr. Kiecolt-Glaser developed a community and network of supportive and satisfying social connections—the very thing she studied and revealed as a key stress buffer and health protector.

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CRediT authorship contribution statement

M. Rosie Shrout: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Megan E. Renna:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **MiKaila J. Leonard:** Writing – review & editing, Project administration, Methodology, Data curation. **Elliot M. Friedman:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Kathy D. Miller:** Writing – review & editing, Supervision, Resources, Methodology, Investigation, Funding acquisition.

Declaration of competing interest

The author(s) declared that there were no conflicts of interest with

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