

Research Article

# Linking Marital Support to Aging-Related Biomarkers: Both Age and Marital Quality Matter

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## Abstract

**Objectives:** Marital support is central to couples' relationships, yet support's health implications can vary widely. Guided by attribution bias and aging theories, the current study examined whether age and marital satisfaction moderate the links of perceived and received spousal support to aging-related biomarkers.

**Methods:** Couples ( $N = 93$ , ages 22–77) rated marital satisfaction, overall perceived spousal support, and the quality of support received from their spouse in a lab-based discussion. Blood samples collected at baseline, immediately post-discussion, 3 hr post-discussion, and end-of-visit were assayed for proinflammatory cytokines tumor necrosis factor (TNF)- $\alpha$  and interleukin (IL)-6, as well as insulin-like growth factor (IGF)-1.

**Results:** Consistent with predictions, less satisfied older couples who received lower-quality spousal support during their discussion had greater increases in TNF- $\alpha$  than those who received higher-quality support; highly satisfied couples of all ages and less satisfied younger couples did not show these inflammatory changes. Highly satisfied older couples with greater perceived spousal support had lower TNF- $\alpha$  across the day and higher IGF-1.

**Discussion:** Marital satisfaction and age may shape spousal support's significance for healthy aging. Rose-colored lenses worn only in the most satisfying marriages may protect couples from the possible health risks of low-quality received support and enhance potential benefits of perceived support. For better or worse, these health implications may grow with older age.

**Keywords:** Biomarkers, Health, Marriage, Marital support, Life course and developmental change

The marital relationship impacts physical health and longevity, with effect sizes similar to those of healthy diets and regular exercise (Robles, Slatcher, Trombello, & McGinn, 2014). Spousal support likely plays a central role in marriage's health consequences. According to theoretical models, satisfaction with the partner's support is a key component of marital quality (Kiecolt-Glaser & Newton, 2001; Robles et al., 2014). At the same time, according to the broader social support literature, support's consequences can vary widely. The current

study sought to extend our understanding of how spousal support relates to health.

## Perceived and Received Support: Separate Interpersonal Processes

As two separate dimensions of support, perceived and received support have distinct health sequelae (Uchino, 2009). On the one hand, perceived support—the feeling that help

will be available when needed—consistently predicts better health outcomes. According to a 73-study meta-analysis, greater self-rated perceived support was associated with delayed mortality (Holt-Lunstad, Smith, & Layton, 2010). The same meta-analysis found a null association between self-rated received support—appraisals of help delivered at a particular time—and mortality, perhaps because some epidemiological studies have linked it to *higher* mortality rates, even after accounting for initial health status (Krause, 1997; Uchino, Bowen, Kent de Grey, Mikel, & Fisher, 2018). (Like the studies in the meta-analysis, most prior work has captured received support via self-report. Nevertheless, the literature is also rich with parallel laboratory-based observation and experimental designs that have linked discrete acts of support with physiological reactivity; see a synthetic review by Uchino (2009) for further detail.) Indeed, there are many ways in which received support can go awry—by being delivered in an insensitive way, making the recipient feel incompetent, or being marred by the tension of an ambivalent relationship (Uchino, 2009). Marital satisfaction and age are two key factors that may augment the health effects of perceived and received spousal support.

### The Lens of Marital Satisfaction

A person's general attitude about their marriage serves as a filter through which they view spousal support, thus shaping its health relevance. According to attribution bias theory, happier couples tend to make dispositional attributions for positive aspects of their partner and situational attributions for negative aspects, whereas less satisfied couples do the opposite (Bradbury & Fincham, 1990). For example, a woman sparks a discussion with her partner about her goal of leading a healthier lifestyle. If the partner compliments her efforts, a more satisfied wife might feel grateful for having a supportive mate, whereas a less happy wife may reject the comment as disingenuous or question the partner's intent. If, during the same conversation, the partner makes an insensitive remark, a less happy wife would see it as confirmation that her partner is hypercritical and shallow; in contrast, a happier wife may dismiss the comment, attributing it to stress or poor mood. Indeed, less happy partners are more likely to suffer health consequences of low-quality received support, and highly satisfied spouses are more likely to benefit from greater perceived support.

### Aging: Social-Emotional and Biological Changes

Received and perceived spousal support may have larger effects on health with older age. As middle-aged and older adults prune distant social ties (Carstensen, 1995), the marital relationship assumes an increasingly central role in couples' lives. With the advancement of biological aging, physiological responsiveness to stressors becomes dysregulated (Charles, 2010), further magnifying the health consequences of marital stress and support. Prior studies of marital conflict corroborate our working hypothesis that health implications

are greater among older people. In two separate marital disagreement studies, the effect sizes of healthy older couples' immune reactivity to conflict were medium to large (Kiecolt-Glaser et al., 1997), whereas effects in healthy younger couples were small to medium (Kiecolt-Glaser et al., 1993). Likewise, associations between post-conflict appraisals and wound healing emerged only in middle-aged and older partners, not younger couples (Wilson et al., 2017).

As people seek to maximize emotional well-being and meaningful experiences with loved ones in older age (Carstensen, 1995), they increasingly shift away from overt confrontation to avoiding and reframing potential stressors (Charles, 2010). Consistent with theory, in a 13-year study of marital disagreement, discussions grew less belligerent and more conflict-avoidant (Verstaen, Haase, Lwi, & Levenson, 2018). Further, older couples' positive affect was less disrupted by marital disagreement compared to younger counterparts' (Wilson et al., 2017). Older adults rated their spouses' behavior more positively than did independent coders, although this perceptual bias was fully explained by the older couples' higher marital satisfaction (Story et al., 2007). The bias also arose more consistently during disagreement than in a collaborative problem-solving task (Story et al., 2007), which raises questions of whether potential age-related biases extend beyond marital conflict. Further, many of the age-related behavioral changes that emerge in marital disagreement—for example, decreases in belligerence and increases in conflict avoidance—are specific to aggression and overt confrontation, which support-related discussions may not elicit.

### The Joint Consideration of Marital Satisfaction and Age

Although older adults may take greater care to avoid social tensions (Carstensen, 1995; Charles, 2010), older age and higher marital satisfaction do not necessarily correspond (Wilson et al., 2017). Older people do still experience relationship strain (Birditt, Newton, Cranford, & Ryan, 2016) and can find spousal support unsatisfying, thus underscoring the need to understand the interplay of age and marital satisfaction. Carstensen, Gottman, and Levenson (1995) found that older, less happy couples were by far the most likely to avoid initiating negative exchanges. In the Americans' Changing Lives study, the oldest couples saw the largest improvements in self-rated health over 8 years linked to high marital satisfaction, and the steepest declines in association with high marital strain (Umberson, Williams, Powers, Liu, & Needham, 2006).

### Aging-Related Biomarkers: Inflammation and IGF-1

Three well-characterized aging-related biomarkers were of interest in the current study: tumor necrosis factor (TNF)- $\alpha$  and interleukin (IL)-6—two proinflammatory cytokines—and insulin-like growth factor-1 (IGF-1). Proinflammatory

cytokines signal the presence of inflammation, and chronic, systemic inflammation is a hallmark of chronic conditions such as cardiovascular disease, Alzheimer's disease, and diabetes (Franceschi et al., 2000). According to the "inflammaging" hypothesis, increasing chronic inflammation with age heightens the likelihood of inflammation-based diseases in older adulthood (Franceschi et al., 2000). In adults, the hormone IGF-1 has primary functions of promoting bone health and maintaining skeletal muscle (Arvat, Broglio, & Ghigo, 2000) and, thus, lower levels are linked to greater frailty and functional limitations in older adults (Cappola et al., 2003). Together, heightened inflammation and low IGF-1 foreshadow even greater functional limitations and earlier mortality (Beberashvili et al., 2013; Cappola et al., 2003).

Not only do proinflammatory cytokines and IGF-1 index processes relevant to biological aging, but they also react to psychological stress. Chronic psychological stress is associated with heightened inflammation (Kiecolt-Glaser et al., 2003), and acute stressors (e.g., stressful speech tasks) trigger inflammatory responses (Marsland, Walsh, Lockwood, & John-Henderson, 2017). Cankaya, Chapman, Talbot, Moynihan, and Duberstein (2009) found that unexpected bereavement was associated with higher inflammation and lower IGF-1.

### Current Study: Research Questions and Hypotheses

To disentangle the context-dependent health correlates of marital support, the current study examined the moderating effects of marital satisfaction and age on the links between received and perceived support and aging-related biomarkers in an age-diverse sample of married couples. We first assessed whether marital satisfaction and age moderate in a three-way interaction the associations between the quality of support received from the spouse during a lab discussion and inflammatory changes following that discussion. Consistent with attribution bias theory and empirical evidence, we hypothesized that less satisfied older couples would have greater inflammatory increases following lower-quality support and, in contrast, more satisfied older couples would be buffered from inflammatory increases associated with lower-quality support. We expected younger couples to exhibit similar, but smaller patterns.

Given the more global nature of perceived spousal support (Uchino, 2009), we assessed the moderating effects of marital satisfaction and age on perceived support in its links to overall inflammation and baseline IGF-1, due to its within-day stability. We predicted that older age and higher marital satisfaction would enhance the links between greater perceived spousal support and lower inflammation as well as higher IGF-1. On the other hand, we expected less satisfied older couples to experience significantly smaller benefit from greater perceived spousal support in terms of lower inflammation and higher IGF-1. Younger couples were predicted to demonstrate parallel, but weaker patterns.

## Method

### Participants

Heterosexual couples ( $N = 186$  individuals) married at least 2 years were recruited from the local community for a larger study on marital stress and wound healing (Kiecolt-Glaser et al., 2005). We excluded couples if either spouse took blood pressure medication, smoked, or had immune- or endocrine-related health problems. The Ohio State Research Review Committee approved the project; all subjects gave written informed consent before participation. To calculate the current study's sensitivity to detect hypothesized three-way interactions, we adjusted the sample size to account for the highest intraclass correlation coefficient (ICC) across all outcomes. IGF-1 had the strongest correlation between partners ( $ICC = .5$ ), which resulted in an effective sample size of  $N = 124$ , providing an even more conservative estimate for the other models. Assuming  $\alpha = .05$ , one focal predictor for each model, and up to 13 total predictors, our study had 80% power to detect an increase in  $R^2$  with small-to-medium effect sizes and greater (Cohen's  $f^2 \geq .06$ ).

The sample ranged 22–77 years old ( $M = 38.2$ ) and had been married for 2–52 years ( $M = 11.9$ ). More than half graduated college (60.7%); most were white (90.9%). Most were in their first marriage (81.5%) and had children (71.4%).

### Data Collection Procedure

At 7 a.m., couples arrived at the hospital research unit and completed a baseline blood draw. At 7:45 a.m., small 8-mm blisters were raised by a vacuum with gentle suction on the forearm over the course of 1–1.5 hr. This methodology provided a controlled, safe, and standardized way for the parent study to investigate how marital behaviors were associated with wound healing rates. The wounding procedure was not designed to serve as a stressor and did not drive changes in the systemic inflammation values that the current study examined. See [Supplementary Material](#) for details. At 10:45 a.m., couples engaged in two social support discussions randomized by gender. According to a well-established protocol (Pasch & Bradbury, 1998), spouses were each given 10 min to discuss something they would like to change about themselves. The topic could be any personal difficulty or goal (e.g., striving for a job promotion, maintaining a healthier diet), but could not be a source of marital tension. Couples were asked to converse about the topic as they normally would, as if they were at home. After the first discussion, both spouses privately rated the discussion. They took the next 10 min to discuss the second spouse's topic and, again, provided ratings. Couples were then given 30 min to complete an oral history exercise, where they jointly told the story of their relationship (Kiecolt-Glaser et al., 2005). Couples provided blood samples and completed questionnaires throughout the admission, and were discharged the following morning.

## Measures

Established measures are described in brief; see [Supplementary Material](#) for details.

### Marital satisfaction

The 15-item Marital Adjustment Test (MAT) was used because of its ability to discriminate between satisfied and dissatisfied couples ([Locke & Wallace, 1959](#)).

### Perceived support

Perceived availability of spousal support was captured with the Social Support Questionnaire-Short Form, Revised (SSQSR) ([I. G. Sarason, B. R. Sarason, Shearin, & Pierce, 1987](#)). The SSQSR asks globally about network members who perform support functions in six different domains. An example is “Whom can you really count on to distract you from your worries when you feel under stress?” Participants listed up to nine individuals. The areas in which the person listed the spouse as a source of support were summed, with scores ranging 0–6.

### Received support

Participants rated each support discussion on a 1–9 scale. Items assessed how satisfied the person was with the discussion’s outcome, how productively they worked together, the emotional tone, how well the partner had understood them, and how much the partner had supported them. Items were averaged to index the quality of support received from their spouse during the 10-minute lab discussion (Cronbach’s  $\alpha = .89$ ).

### Stressful life events

The Psychiatric Epidemiological Research Inventory (PERI) Life Events Scale ([Dohrenwend, 1978](#)) provided the number and types of major life changes within the last year; subjects judged whether each event was negative or positive. The summed negative events served as a covariate due to associations with poorer health and immune function ([Shields & Slavich, 2017](#)).

### Proinflammatory cytokines

Plasma IL-6 and TNF- $\alpha$  levels were assayed from four blood samples throughout the admission—morning baseline, immediately after the discussions, 3 hr after the interaction tasks, and at the end of the study visit. Cytokine levels were assayed using Quantikine High Sensitivity Immunoassay kits (R&D Systems, Minneapolis, MN), per kit instructions. Samples were run undiluted in duplicate, and all samples for a couple were run simultaneously. The intra-assay coefficient of variation (CV) for IL-6 was 4.4%, and the inter-assay CV was 3.7%; corresponding values for TNF- $\alpha$  were 3.0% and 8.4%.

### Insulin-like growth factor-1

Serum IGF-1 was assayed using enzyme-linked immunosorbent assay (R&D Systems) per kit instructions. This

marker was only analyzed at baseline because of its stability. The intra-assay CV was 4.3% and inter-assay CV, 8.3%.

## Analytic Plan

### Model sequence and interaction interpretation

Hypotheses were evaluated in SAS v9.4 (Cary, NC) PROC MIXED using linear mixed models that accounted for within-couple correlation. The Kenward-Roger degrees of freedom controlled type I error ([Kenward & Roger, 1997](#)). For all analyses, we began by modeling the predicted three-way interaction (i.e., Model A) among age, marital satisfaction, and received or perceived support, with all treated as continuous variables. For significant interactions, simple slopes were plotted using ESTIMATE commands at ages 30, 50, and 70, to illustrate effects among young adult, middle-aged, and older couples, respectively. We also plotted marital satisfaction effects at the sample mean and 1 *SD* above. Although 36 people in the sample (19.9%) met the cutoff for clinically significant marital distress (MAT < 100), people older than age 60 were not among them. Among people aged 50 and older, 16% met the clinical cutoff and none scored below 75. Because hypotheses concerned the intersection of age and marital satisfaction, we did not probe interaction effects at the lowest levels of satisfaction to stay within the lower limits for older couples. Thus, references to “less satisfied” couples are made in comparison to their highly satisfied counterparts, and do not denote clinically significant marital distress. We also report follow-up analyses that excluded participants with MAT scores < 75; findings did not change ([Supplemental Material](#)). Nonsignificant three-way interactions were removed to examine the two-way interactions of received or perceived support with age and marital satisfaction (i.e., Model B). Nonsignificant two-way interactions were trimmed in final main-effects-only models (i.e., Model C).

### Received support quality and inflammatory changes

First, to capture the moderating effects of age and marital satisfaction on links between received support quality and subsequent inflammatory changes, we modeled area under the curve (AUC) relative to baseline ([Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003](#)), to account for pre-support differences in TNF- $\alpha$  and IL-6. These AUC-change values were natural-log-transformed to better approximate normality of residuals. Models controlled for confounds relevant to inflammatory changes within the day, including gender and body mass index (BMI) ([O’Connor et al., 2009](#)), discussion order, and the person’s rating of the support-giving conversation. See details about all covariates in [Supplementary Material](#).

### Perceived support and inflammation across the day

Second, we examined the moderating effects of age and marital satisfaction on links between perceived support

and inflammation across the day. Because we expected perceived spousal support to predict overall TNF- $\alpha$  and IL-6 production, including baseline levels, we modeled natural-log-transformed AUC relative to ground (Pruessner et al., 2003). Models controlled for confounds relevant to baseline inflammation as well as the levels across the day—gender, BMI, and education (O'Connor et al., 2009), stressful life events (Shields & Slavich, 2017), and the support discussion appraisals, averaged due to their correlation ( $r = .52$ ).

**Perceived support and IGF-1**

Finally, we examined the moderating effects of age and marital satisfaction on the links between perceived spousal support and IGF-1, controlling for factors that could affect baseline levels—gender, BMI, education, and stressful life events.

**Results**

**Descriptive Statistics and Preliminary Analyses**

Our sample's marital satisfaction ( $M = 114.3, SD = 23.0$ ) was comparable to that of another large community sample of married couples ( $M = 114.7, SD = 20.8; t(370) = 0.16, p = .87$ ) (Crane, Allgood, Larson, & Griffin, 1990). According to a paired-samples  $t$ -test of couples in our sample, wives' marital satisfaction ( $M = 112.7, SD = 24.5$ ) did not statistically differ from husbands' satisfaction ( $M = 116.0, SD = 21.6; t(87) = -1.84, p = .07$ ). Consistent with prior marital studies (e.g., Carstensen et al., 1995), older individuals in our sample had also been married longer. Correlations between age and marital satisfaction were nonsignificant (Table 1). Among women, marital satisfaction, received support, and perceived support were positively interrelated; among men, the same was true for marital satisfaction and its links between received and perceived support. The weak-to-moderate strength of these correlations provided evidence that they are related, yet distinct constructs (Table 1).

**Received Support Quality and Inflammatory Changes**

**Tumor necrosis factor- $\alpha$**

As predicted, both age and marital satisfaction moderated the association between received support and changes in TNF- $\alpha$  from baseline in a three-way interaction (Model A,  $B = 0.001, SE = 0.0002, p = .014$ , Cohen's  $f^2 = 0.20$ ). Depicted in Figure 1, among middle-aged and older partners of average marital satisfaction, lower-quality received support was associated with greater increases in TNF- $\alpha$  across the admission period (e.g., Estimate<sub>age50</sub> =  $-0.23, SE = 0.07, p = .002$ ; Estimate<sub>age70</sub> =  $-0.35, SE = 0.10, p = .001$ ). By contrast, younger partners with average marital satisfaction, as well as partners of all ages with high marital satisfaction, did not show these significant associations ( $ps > .250$ ).

**Interleukin-6**

Neither age nor marital satisfaction moderated the link between received support and changes in IL-6, in three-way or two-way interactions (Models A and B,  $ps > .250$ ). However, in Model C, partners who received lower-quality support had greater increases in IL-6 throughout the day ( $B = -0.14, SE = 0.07, p = .049$ ). Older individuals also had larger increases in IL-6 across the admission ( $B = 0.01, SE = 0.01, p = .037$ ).

**Perceived Support and Inflammation Across the Day**

**Tumor necrosis factor- $\alpha$**

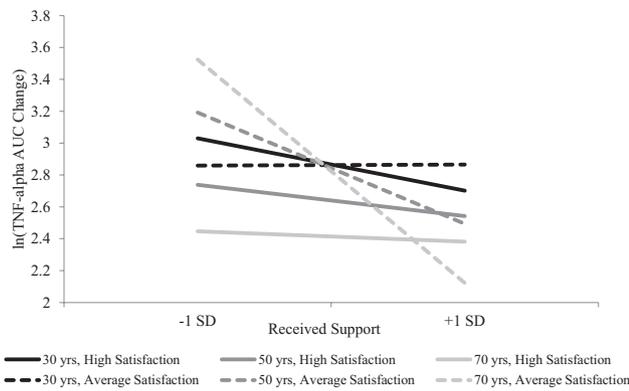
Age and marital satisfaction moderated the association between perceived support and TNF- $\alpha$  in a three-way interaction (Model A,  $B = -0.0003, SE = 0.0001, p = .036$ , Cohen's  $f^2 = 0.11$ ). As shown in Figure 2, only among middle-aged and older partners with high marital satisfaction was greater perceived spousal support associated with lower TNF- $\alpha$  across the day (Estimate<sub>age50</sub> =  $-0.18, SE = 0.07, p = .014$ ; Estimate<sub>age70</sub> =  $-0.43, SE = 0.14, p = .003$ ). However, neither highly satisfied middle-aged and older partners ( $p > .250$ ) nor individuals with average marital satisfaction at any age ( $ps > .095$ ) showed this link.

**Table 1.** Description of Couples in the Sample

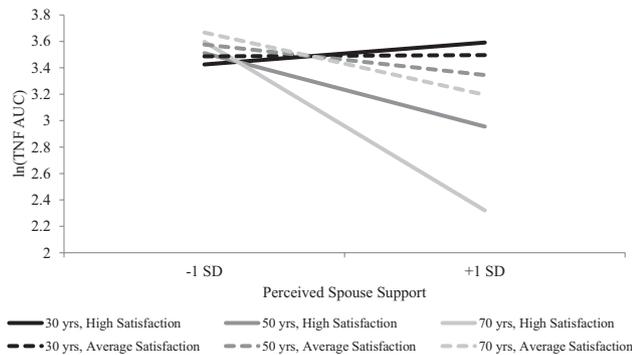
Variable	1	2	3	4	5	Men	Women
						<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )
1. Age	.95*	.81*	.14	.15	-.24*	39.2 (13.3)	37.2 (12.0)
2. Years married	.84*	1.00*	.16	.14	-.02	11.9 (11.0)	
3. Marital satisfaction	.10	.09	.70*	.32*	.18	116.0 (21.6)	112.7 (24.5)
4. Received support	.07	.06	.36*	.30*	.27*	7.1 (1.4)	6.9 (1.6)
5. Perceived support	-.13	-.08	.45*	.30*	.47*	5.5 (1.1)	5.2 (1.5)

Note: Intercorrelations for women fall below the diagonal and, for men, above the diagonal. Correlations between partners are reported along the diagonal and are italicized. M = mean; SD = standard deviation.

\* $p < 0.05$ .



**Figure 1.** Associations between received support quality and changes in TNF- $\alpha$  across the day as a function of marital satisfaction and age. Both age and marital satisfaction moderated the association between received support and changes in TNF- $\alpha$  from baseline in a three-way interaction (Model A,  $B = 0.001$ ,  $SE = 0.0002$ ,  $p = .014$ ). Effects are depicted at 1 SD above (+1 SD) and below (-1 SD) the average of received support quality. Among middle-aged and older partners of average marital satisfaction, lower-quality received support was associated with greater increases in TNF- $\alpha$  across the admission period (gray, dotted line, Estimate<sub>age50</sub> = -0.23,  $SE = 0.07$ ,  $p = .002$ ; light gray, dotted line, Estimate<sub>age70</sub> = -0.35,  $SE = 0.10$ ,  $p = .001$ ).



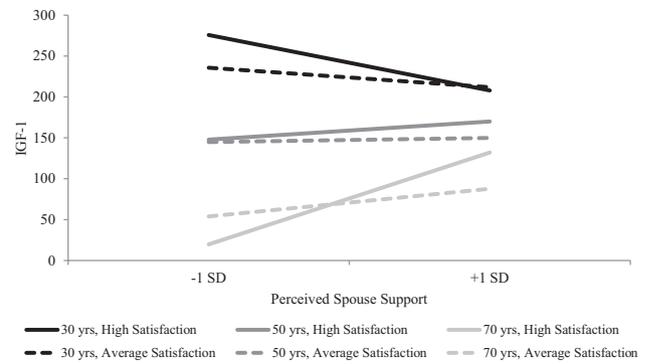
**Figure 2.** Associations between perceived spouse support and TNF- $\alpha$  levels across the day as a function of marital satisfaction and age. The three-way interaction among marital satisfaction, age, and perceived support was significant (Model A,  $B = -0.0003$ ,  $SE = 0.0001$ ,  $p = .036$ ). Effects are depicted at 1 SD above (+1 SD) and below (-1 SD) the average of perceived spouse support. Only among middle-aged and older partners with high marital satisfaction was greater perceived spousal support associated with lower TNF- $\alpha$  across the day (gray, solid line, Estimate<sub>age50</sub> = -0.18,  $SE = 0.07$ ,  $p = .014$ ; light gray, solid line, Estimate<sub>age70</sub> = -0.43,  $SE = 0.14$ ,  $p = .003$ ).

### Interleukin-6

Neither age nor marital satisfaction moderated the association between perceived support and IL-6 (Models A and B,  $ps > .250$ ). In Model C, older age was linked to higher IL-6 across the day ( $B = 0.01$ ,  $SE = 0.01$ ,  $p = .014$ ), but perceived support did not predict IL-6 ( $p > .250$ ).

### Perceived Support and IGF-1

Age and marital satisfaction moderated the link between perceived spousal support and IGF-1 in a three-way



**Figure 3.** Associations between perceived spouse support and IGF-1 as a function of marital satisfaction and age. The interaction among marital satisfaction, age, and perceived support was statistically significant (Model A,  $B = .041$ ,  $SE = 0.014$ ,  $p = .005$ ). Effects are depicted at 1 SD above (+1 SD) and below (-1 SD) the average of perceived spouse support. Highly satisfied, older partners showed a positive association between greater perceived support and higher IGF-1 (light gray, solid line, Estimate<sub>age70</sub> = 37.43,  $SE = 16.64$ ,  $p = .026$ ). Contrary to prediction, lower perceived spousal support was associated with higher IGF-1 among younger, highly satisfied partners (black, solid line, Estimate<sub>age30</sub> = -22.61,  $SE = 10.16$ ,  $p = .027$ ). Excluding partners aged 30 and younger, the interaction among age, marital satisfaction, and perceived support on IGF-1 remained significant ( $B = .046$ ,  $SE = 0.022$ ,  $p = .043$ ).

interaction (Model A,  $B = 0.041$ ,  $SE = 0.014$ ,  $p = .005$ , Cohen's  $f^2 = 0.12$ ). Highly satisfied older partners showed a significant association between greater perceived support and higher IGF-1 (Figure 3, Estimate<sub>age70</sub> = 37.43,  $SE = 16.64$ ,  $p = .026$ ). Among those with average marital satisfaction, there was no link between perceived support and IGF-1 ( $ps > .207$ ). Contrary to prediction, lower perceived spousal support was associated with higher IGF-1 among younger, highly satisfied partners (Estimate<sub>age30</sub> = -22.61,  $SE = 10.16$ ,  $p = .027$ ). Follow-up tests probed whether this three-way interaction was driven by the unexpected effect among younger, happier couples. Excluding partners aged 30 and younger, the interaction among age, marital satisfaction, and perceived support on IGF-1 remained significant (Model A,  $B = 0.046$ ,  $SE = 0.022$ ,  $p = .043$ ). In this model, the link between perceived support and IGF-1 remained significant among highly satisfied older partners (Estimate<sub>age70</sub> = 38.11,  $SE = 18.53$ ,  $p = .043$ ). These associations remained nonsignificant among partners with average levels of satisfaction ( $ps > .250$ ).

### Discussion

Following a spousal support discussion, less satisfied middle-aged and older couples who received lower-quality support had greater increases in inflammatory marker TNF- $\alpha$  than those who received higher-quality support; partners who received lower-quality support also had greater increases in IL-6. Furthermore, highly satisfied middle-aged and older couples with greater perceived spousal support had lower TNF- $\alpha$  across the day; highly satisfied older couples also had higher IGF-1 with greater perceived

spousal support. Findings reveal the importance of marital satisfaction and age in shaping the relevance of spousal support for healthy aging: marital satisfaction serves as a critical lens, and older age magnifies the associations.

### Received Support and Inflammatory Changes

The current results extend our understanding of spousal support's health relevance by identifying the joint importance of marital satisfaction and age for the links between received support and inflammatory changes. Forty years of theorizing and empirical work have sought to explain why received support sometimes leads to negative health outcomes, beyond confounds such as initial health status. First, received support is thought to neutralize the negative effects of stress by helping a person to cope, rather than providing direct benefits (Cohen & Wills, 1985). Second, received support can easily fail to meet the recipient's needs, or make the recipient feel incompetent or dependent (Baltes & Wahl, 1996; Cutrona, Shaffer, Wesner, & Gardner, 2007). Thus, when received support is ineffective, it may leave stress unchecked or, worse, fuel its negative consequences. Our findings suggest that less satisfied middle-aged and older couples were most susceptible to inflammatory associations with low-quality support. Few studies have examined immune changes following a spousal support discussion; therefore, this work also highlights the immune relevance of received spousal support.

According to attribution bias theory, less satisfied couples would have made more personal attributions for lower-quality received support (e.g., "my partner is not being helpful because he does not care about me or my problem"). As a result, they may have thought about it for longer, and it may have polluted subsequent interactions. In contrast, happier couples would have dismissed lower-quality received support as situational, an exception to the rule. Future work must explore whether the cascade that propagates among less satisfied couples involves individual processes (e.g., rumination), dyadic ones (e.g., later interaction dynamics), or both.

Notably, less satisfied couples in this sample were defined relative to comparatively *happier* counterparts, but had moderate satisfaction levels in absolute terms. As a sample drawn from the community, clinically significant marital distress was low, and although age and marital satisfaction were not correlated, the oldest participants were not among the most significantly distressed couples. These patterns are consistent with past work (e.g., Carstensen et al., 1995), and may reflect systematic selection out of chronically discordant marriages. Thus, to ensure that our comparisons fell within the scope of the data, we interpreted interaction terms at a conservative lower threshold, that is, the sample mean. In follow-up analyses, the findings remained significant after excluding those with the most extreme marital distress, who were all younger than

age 50. Indeed, only the most highly satisfied middle-aged and older couples were protected from associations between lower-quality received support and greater subsequent inflammation.

To our knowledge, this study provides the first evidence that middle-aged and older couples, not younger couples, show larger inflammatory elevations after lower-quality received support. This age association parallels age-related inflammatory dysregulation seen in other contexts. For example, older adults' inflammation increases more dramatically and recovers more slowly in response to infection compared to that of younger people (Bruunsgaard, Skinhøj, Qvist, & Pedersen, 1999). Older people also have stronger inflammatory responses to physical insults (e.g., burns) than younger counterparts (Stanojic, Chen, Xiu, & Jeschke, 2016).

This age association also extends prior findings that older people exhibit larger immune responses after marital conflict (Kiecolt-Glaser et al., 1993, 1997; Wilson et al., 2017) to the marital support context, which may be uniquely important for older couples' health. Indeed, according to social-emotional aging theories, older couples are less likely to engage in overt conflict, whereas the need for assistance persists or grows with increasing age. Additionally, though links between support and health were nonsignificant among younger couples, we do not conclude that marriage is irrelevant to younger adults' health—rather, it may take a more discordant relationship or larger sample to see the inflammatory correlates of lower-quality support in younger people. Further, toxic patterns repeated over time may accumulate to manifest in greater immune dysregulation years later.

### Perceived Support, Inflammation, and IGF-1

Consistent with a 73-study meta-analysis linking perceived support to lower mortality rates (Holt-Lunstad et al., 2010), we found that greater perceived spousal support was associated with outcomes characteristic of healthy aging—lower TNF- $\alpha$  and higher IGF-1. Extending this literature, these links differed by age and were only significant among older, happier couples, mirroring the moderating effects found for received support and inflammatory changes.

Indeed, only the most satisfied partners reaped the benefits of more available spousal support. Consistent with theory, these highly satisfied partners would be more likely to view more involved spousal support as positive and attribute the involvement to the spouse's supportive nature. On the other hand, less satisfied partners may have dismissed more extensive spousal support as obligatory or overinvolved. Of note, our perceived support measure indexed the number of support domains that the spouse would provide if needed, such that higher scores reflected greater availability of support, not greater satisfaction with support. Some measures combine the number of domains with support satisfaction (e.g., Walen & Lachman, 2000),

which is likely to be colored by marital satisfaction itself and, thus, may eliminate marital satisfaction as a moderator.

Similar to the age differences in inflammatory responses to received support, the significant links between perceived spousal support and lower inflammation emerged among middle-aged and older couples, not their younger counterparts. Although the meta-analysis of perceived support and mortality may have included an overrepresentation of middle-aged and older adults, the idea that associations between perceived support and health may be pronounced among older people has not been explicitly tested in prior work. Our finding also contributes biological evidence to a central principle in life span theories of human development: that environmental influences, including social relationships, assume an increasingly stronger role in health and well-being as we age (Baltes, Lindenberger, & Staudinger, 2006).

Consistent with the TNF- $\alpha$  findings, associations between perceived support and IGF-1 emerged among older adults, building on the small literature linking psychosocial processes to this important aging-related hormone (Cankaya et al., 2009). We found the opposite association in younger couples and hesitate to overinterpret this unexpected pattern, as the age-graded effect remained significant when we excluded younger people. The parallel results between TNF- $\alpha$  and IGF-1 bolster confidence in the findings; they also reflect the mechanistic, bidirectional relationships between proinflammatory cytokines and IGF-1 found in both basic and clinical studies. For example, applying TNF- $\alpha$  to rats' blood vessel tissue reduced IGF-1 production by 85% (Anwar, Zahid, Scheidegger, Brink, & Delafontaine, 2002). Likewise, people with IGF-1 deficiencies showed elevated inflammation, and hormone replacement therapy reduced circulating inflammation (Sesmi et al., 2000; Sesmi, Miller, Hayden, & Klibanski, 2001).

Furthermore, the prognostic value of low IGF-1 for poor aging-related outcomes is clearest when considered jointly with inflammation. In a community sample of older women, the synergistic effects of low IGF-1 and high IL-6 predicted more mobility problems (Cappola et al., 2003). In the same study, women with low IGF-1 and high IL-6 were twice as likely to die within 5 years compared to the lowest-risk group, with high IGF-1 and low IL-6. The effects were similar in a sample of dialysis patients: 82% with low IGF-1 and high IL-6 had died 4 years later, compared to 48% who died in the high IGF-1/high IL-6 group (Beberashvili et al., 2013).

### Comparing Results for IL-6 and TNF- $\alpha$

We did not find evidence for hypothesized moderation with IL-6, either in overall levels or changes from baseline. Indeed, IL-6 is particularly responsive to indwelling venous catheters (Kiecolt-Glaser et al., 2015), which may have obscured the signal with unrelated variability. Instead, we detected main effects, wherein those who received

lower-quality support in the lab discussion had larger subsequent IL-6 increases, which dovetails with prior work showing that support quality can modulate health consequences (Cohen & Wills, 1985; Uchino, 2009). Further, older people had larger IL-6 increases and higher overall levels compared to younger participants. This is consistent with the "inflamm-aging" hypothesis and prior work suggesting that chronic inflammation generally rises with age, perhaps by increasingly dysregulated inflammatory responsiveness (Franceschi et al., 2000).

### Limitations and Future Directions

Due to the cross-sectional design, we could not draw causal conclusions about the associations or tease apart age differences from cohort effects. A cross-sequential longitudinal design would be needed to distinguish age and cohort patterns, and to examine how the dynamics of marital support and healthy aging accumulate over time. The study sample lacked representation of same-sex and unmarried couples, and had few racially diverse participants. Couples were selected based on strict health criteria, so the study's older couples were particularly healthy compared to their peers. Thus, it is possible that our observed associations underestimate the effects that would be seen in the general population—an important topic for future research. Future work should also examine whether observers' ratings of support discussions predict changes in inflammation beyond couples' own perceptions, and whether these associations differ by age.

### Conclusions

In conclusion, age and marital satisfaction jointly governed the links between marital support and biomarkers of healthy aging. Consistent with marital theory, only the rose-colored lenses worn in the most satisfying marriages may protect couples from the possible health risks of low-quality received support and enhance potential health benefits of perceived support. Findings extend growing evidence that, for better or worse, marital processes may be particularly important for health in older ages (Umberson et al., 2006; Wilson et al., 2017). This work helps to illuminate the ways in which marriage may evolve across adulthood and thus shape the implications of marital support for healthy biological aging.

### Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

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## Conflict of Interest

None reported.

## References

- Anwar, A., Zahid, A. A., Scheidegger, K. J., Brink, M., & Delafontaine, P. (2002). Tumor necrosis factor-alpha regulates insulin-like growth factor-1 and insulin-like growth factor binding protein-3 expression in vascular smooth muscle. *Circulation*, *105*, 1220–1225. doi:10.1161/hc1002.105187
- Arvat, E., Broglio, F., & Ghigo, E. (2000). Insulin-like growth factor I: Implications in aging. *Drugs & Aging*, *16*, 29–40. doi:10.2165/00002512-200016010-00003
- Baltes, P. B., Lindenberger, U., & Staudinger, U. M. (2006). Life span theory in developmental psychology. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology: Vol. I. Theoretical models of human development* (pp. 569–664). New York: Wiley.
- Baltes, M. M., & Wahl, H.-W. (1996). Patterns of communication in old age: The dependence-support and independence-ignore script. *Health Communication*, *8*, 217–231. doi:10.1207/s15327027hc0803\_3
- Beberashvili, I., Sinuani, I., Azar, A., Kadoshi, H., Shapiro, G., Feldman, L., ... Averbukh, Z. (2013). Decreased IGF-1 levels potentiate association of inflammation with all-cause and cardiovascular mortality in prevalent hemodialysis patients. *Growth Hormone & IGF Research*, *23*, 209–214. doi:10.1016/j.ghir.2013.07.005
- Birditt, K. S., Newton, N. J., Cranford, J. A., & Ryan, L. H. (2016). Stress and negative relationship quality among older couples: Implications for blood pressure. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, *71*, 775–785. doi:10.1093/geronb/gbv023
- Bradbury, T. N., & Fincham, F. D. (1990). Attributions in marriage: Review and critique. *Psychological Bulletin*, *107*, 3–33. doi:10.1037//0033-2909.107.1.3
- Bruunsgaard, H., Skinhøj, P., Qvist, J., & Pedersen, B. K. (1999). Elderly humans show prolonged in vivo inflammatory activity during pneumococcal infections. *The Journal of Infectious Diseases*, *180*, 551–554. doi:10.1086/314873
- Cankaya, B., Chapman, B. P., Talbot, N. L., Moynihan, J., & Duberstein, P. R. (2009). History of sudden unexpected loss is associated with elevated interleukin-6 and decreased insulin-like growth factor-1 in women in an urban primary care setting. *Psychosomatic Medicine*, *71*, 914–919. doi:10.1097/PSY.0b013e3181be7aa8
- Cappola, A. R., Xue, Q. L., Ferrucci, L., Guralnik, J. M., Volpato, S., & Fried, L. P. (2003). Insulin-like growth factor I and interleukin-6 contribute synergistically to disability and mortality in older women. *The Journal of Clinical Endocrinology and Metabolism*, *88*, 2019–2025. doi:10.1210/jc.2002-021694
- Carstensen, L. L. (1995). Evidence for a life-span theory of socioemotional selectivity. *Current Directions in Psychological Science*, *4*, 151–156. doi:10.2307/20182356
- Carstensen, L. L., Gottman, J. M., & Levenson, R. W. (1995). Emotional behavior in long-term marriage. *Psychology and Aging*, *10*, 140–149. doi:10.1037//0882-7974.10.1.140
- Charles, S. T. (2010). Strength and vulnerability integration: A model of emotional well-being across adulthood. *Psychological Bulletin*, *136*, 1068–1091. doi:10.1037/a0021232
- Cohen, S., & Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. *Psychological Bulletin*, *98*, 310–357. doi:10.1037//0033-2909.98.2.310
- Crane, D. R., Allgood, S. M., Larson, J. H., & Griffin, W. (1990). Assessing marital quality with distressed and nondistressed couples: A comparison and equivalency table for three frequently used measures. *Journal of Marriage and the Family*, *52*, 87–93. doi:10.2307/352841
- Cutrona, C. E., Shaffer, P. A., Wesner, K. A., & Gardner, K. A. (2007). Optimally matching support and perceived spousal sensitivity. *Journal of Family Psychology*, *21*, 754–758. doi:10.1037/0893-3200.21.4.754
- Dohrenwend, B. S. (1978). Social stress and community psychology. *American Journal of Community Psychology*, *6*, 1–14. doi:10.1007/BF00890095
- Franceschi, C., Bonafè, M., Valensin, S., Olivieri, F., De Luca, M., Ottaviani, E., & De Benedictis, G. (2000). Inflamm-aging. An evolutionary perspective on immunosenescence. *Annals of the New York Academy of Sciences*, *908*, 244–254. doi:10.1111/j.1749-6632.2000.tb06651.x
- Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2010). Social relationships and mortality risk: A meta-analytic review. *PLOS Medicine*, *7*, e1000316. doi:10.1371/journal.pmed.1000316
- Kenward, M. G., & Roger, J. H. (1997). Small sample inference for fixed effects from restricted maximum likelihood. *Biometrics*, *53*, 983–997. doi:10.2307/2533558
- Kiecolt-Glaser, J. K., Glaser, R., Cacioppo, J. T., MacCallum, R. C., Snydersmith, M., Kim, C., & Malarkey, W. B. (1997). Marital conflict in older adults: Endocrinological and immunological correlates. *Psychosomatic Medicine*, *59*, 339–349. doi:10.1097/00006842-199707000-00001
- Kiecolt-Glaser, J. K., Jaremka, L., Andridge, R., Peng, J., Habash, D., Fagundes, C. P., ... Belury, M. A. (2015). Marital discord, past depression, and metabolic responses to high-fat meals: Interpersonal pathways to obesity. *Psychoneuroendocrinology*, *52*, 239–250. doi:10.1016/j.psyneuen.2014.11.018
- Kiecolt-Glaser, J. K., Loving, T. J., Stowell, J. R., Malarkey, W. B., Lemeshow, S., Dickinson, S. L., & Glaser, R. (2005). Hostile marital interactions, proinflammatory cytokine production, and wound healing. *Archives of General Psychiatry*, *62*, 1377–1384. doi:10.1001/archpsyc.62.12.1377
- Kiecolt-Glaser, J. K., Malarkey, W. B., Chee, M., Newton, T., Cacioppo, J. T., Mao, H. Y., & Glaser, R. (1993). Negative behavior during marital conflict is associated with immunological down-regulation. *Psychosomatic Medicine*, *55*, 395–409. doi:10.1097/00006842-199309000-00001

- Kiecolt-Glaser, J. K., & Newton, T. L. (2001). Marriage and health: His and hers. *Psychological Bulletin*, *127*, 472–503. doi:10.1037//0033-2909.127.4.472
- Kiecolt-Glaser, J. K., Preacher, K. J., MacCallum, R. C., Atkinson, C., Malarkey, W. B., & Glaser, R. (2003). Chronic stress and age-related increases in the proinflammatory cytokine IL-6. *Proceedings of the National Academy of Sciences*, *100*, 9090–9095. doi:10.1073/pnas.1531903100
- Krause, N. (1997). Received support, anticipated support, social class, and mortality. *Research on Aging*, *19*, 387–422. doi:10.1177/0164027597194001
- Locke, H. J., & Wallace, K. M. (1959). Short marital adjustment and prediction tests: Their reliability and validity. *Marriage and Family Living*, *21*, 251–255. doi:10.2307/348022
- Marsland, A. L., Walsh, C., Lockwood, K., & John-Henderson, N. A. (2017). The effects of acute psychological stress on circulating and stimulated inflammatory markers: A systematic review and meta-analysis. *Brain, Behavior, and Immunity*, *64*, 208–219. doi:10.1016/j.bbi.2017.01.011
- O'Connor, M. F., Bower, J. E., Cho, H. J., Creswell, J. D., Dimitrov, S., Hamby, M. E., ... Irwin, M. R. (2009). To assess, to control, to exclude: Effects of biobehavioral factors on circulating inflammatory markers. *Brain, Behavior, and Immunity*, *23*, 887–897. doi:10.1016/j.bbi.2009.04.005
- Pasch, L. A., & Bradbury, T. N. (1998). Social support, conflict, and the development of marital dysfunction. *Journal of Consulting and Clinical Psychology*, *66*, 219–230. doi:10.1037/0022-006X.66.2.219
- Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*, *28*, 916–931. doi:10.1016/s0306-4530(02)00108-7
- Robles, T. F., Slatcher, R. B., Trombello, J. M., & McGinn, M. M. (2014). Marital quality and health: A meta-analytic review. *Psychological Bulletin*, *140*, 140–187. doi:10.1037/a0031859
- Sarason, I. G., Sarason, B. R., Shearin, E. N., & Pierce, G. R. (1987). A brief measure of social support: Practical and theoretical implications. *Journal of Social and Personal Relationships*, *4*, 497–510. doi:10.1177/0265407587044007
- Sesnilo, G., Biller, B. M., Llevadot, J., Hayden, D., Hanson, G., Rifai, N., & Klibanski, A. (2000). Effects of growth hormone administration on inflammatory and other cardiovascular risk markers in men with growth hormone deficiency. A randomized, controlled clinical trial. *Annals of Internal Medicine*, *133*, 111–122. doi:10.7326/0003-4819-133-2-200007180-00010
- Sesnilo, G., Miller, K. K., Hayden, D., & Klibanski, A. (2001). Inflammatory cardiovascular risk markers in women with hypopituitarism. *The Journal of Clinical Endocrinology and Metabolism*, *86*, 5774–5781. doi:10.1210/jcem.86.12.8087
- Shields, G. S., & Slavich, G. M. (2017). Lifetime stress exposure and health: A review of contemporary assessment methods and biological mechanisms. *Social and Personality Psychology Compass*, *11*, e12335. doi:10.1111/spc3.12335
- Stanojic, M., Chen, P., Xiu, F., & Jeschke, M. G. (2016). Impaired immune response in elderly burn patients: New insights into the immune-senescence phenotype. *Annals of Surgery*, *264*, 195–202. doi:10.1097/SLA.0000000000001408
- Story, T. N., Berg, C. A., Smith, T. W., Beveridge, R., Henry, N. J., & Pearce, G. (2007). Age, marital satisfaction, and optimism as predictors of positive sentiment override in middle-aged and older married couples. *Psychology and Aging*, *22*, 719–727. doi:10.1037/0882-7974.22.4.719
- Uchino, B. N. (2009). Understanding the links between social support and physical health: A life-span perspective with emphasis on the separability of perceived and received support. *Perspectives on Psychological Science*, *4*, 236–255. doi:10.1111/j.1745-6924.2009.01122.x
- Uchino, B. N., Bowen, K., Kent de Grey, R., Mikel, J., & Fisher, E. B. (2018). Social support and physical health: Models, mechanisms, and opportunities. In E. B. Fisher, L. D. Cameron, A. J. Christensen, U. Ehlert, Y. Guo, B. Oldenburg, & F. J. Snoek (Eds.), *Principles and concepts of behavioral medicine: A global handbook* (pp. 341–372). New York: Springer New York.
- Umberson, D., Williams, K., Powers, D. A., Liu, H., & Needham, B. (2006). You make me sick: marital quality and health over the life course. *Journal of Health and Social Behavior*, *47*, 1–16. doi:10.1177/002214650604700101
- Verstaen, A., Haase, C. M., Lwi, S. J., & Levenson, R. W. (2018). Age-related changes in emotional behavior: Evidence from a 13-year longitudinal study of long-term married couples. *Emotion*. Advance online publication. doi:10.1037/emo0000551
- Walen, H. R., & Lachman, M. E. (2000). Social support and strain from partner, family, and friends: Costs and benefits for men and women in adulthood. *Journal of Social and Personal Relationships*, *17*, 5–30. doi:10.1177/0265407500171001
- Wilson, S. J., Andridge, R., Peng, J., Bailey, B. E., Malarkey, W. B., & Kiecolt-Glaser, J. K. (2017). Thoughts after marital conflict and punch biopsy wounds: Age-graded pathways to healing. *Psychoneuroendocrinology*, *85*, 6–13. doi:10.1016/j.psyneuen.2017.07.489