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REGULAR ARTICLE

How Families Make Their Way Into Your Heart: Exploring the Associations Between Daily Experiences Involving Family Members and Cardiovascular Health

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Abstract

Background Cardiovascular disease is a critical public health issue and a growing body of literature on relationships and health point to individuals' interactions and involvement with family members as significant correlates of cardiovascular outcomes. However, less is known about the implications of daily encounters with family members on cardiovascular health outcomes and how the associations vary across adulthood.

Purpose The aims of this study were to examine the associations of positive and negative daily experiences with family members with comprehensive measures of cardiovascular health and to further explore how age moderates these associations.

Methods This study used data from the Midlife in the United States (MIDUS) II and MIDUS Refresher. The sample was composed of respondents who participated in two subprojects of MIDUS, namely the National Study of Daily Experiences (NSDE) and Biomarker Project (N = 1,312). Indices of cardiovascular health included inflammatory markers, autonomic functioning, and Life's Simple 7 scores.

Results Results showed that the associations between daily family experiences and cardiovascular outcomes differed by age. Having more daily negative experiences with family members was associated with better cardiovascular health outcomes among young adults and worse cardiovascular outcomes among older adults. Having more daily positive experiences was also associated with lower heart rate variability for older adults.

Conclusions Results revealed that contrary to the general assumption that negative experiences have health-damaging effects, frequent involvement with family members in daily life, even negative ones, may be indicative of active engagement in life that could be health promoting for younger adults.

Keywords Daily diary study · Cardiovascular health · Age · Family relationships

Introduction

Cardiovascular disease is one of the leading causes of death in the USA, responsible for one in every four deaths each year. It affects almost half of U.S. adults and contributes about $363 billion a year in healthcare costs and lost productivity [1]. One important correlate of cardiovascular outcomes is family relationships [2–4], in that experiences involving family members either promote or harm cardiovascular health. For example, a favorable spousal relationship was associated with lower cardiovascular reactivity and better heart rate variability (HRV) [5, 6], whereas spousal conflicts were related to elevated blood pressure and heart rate [7].

In measuring positive and negative experiences with family members, studies have traditionally used general global measures of support and conflict that assess family relations over long periods of time spanning weeks or months. Though these measures have proven useful and valid, they are prone to recall biases found in retrospective reports and thus do not accurately capture experiences that happen in the course of individuals' day-to-day lives. Therefore, measuring positive and negative familial encounters using microlevel approaches such as daily diary methods could offer a more ecologically valid look at the "slice" of individuals' everyday experiences with their family members [8, 9].

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The daily diary method has long been used in social and behavioral research as a useful tool for capturing individuals' daily experiences in ways that are not possible with traditional survey designs [10]. One major benefit of using the daily diary method is that it allows researchers to examine everyday events and experiences in their natural, spontaneous environment. Furthermore, by collecting reports of daily life closer to when they occur, it substantially reduces memory distortions in the accounts of daily experiences. Using the diary method bears advantage in studying families and family processes as well, by allowing to tap into the dynamic day-to-day experiences and events that contribute to macrolevel, traditional outcomes such as perceived family support or relationship qualities [11]. While issues such as reactance and habituation are often raised as a concern for the daily diary approach, there is a lack of evidence that these issues undermine the diaries' validity [12]. Therefore, the diary method has long been used to measure daily hassles and uplifts, which refer to the relatively minor negative and positive experiences that occur in everyday life [13].

Indeed, these minor events involving family members in daily life are found to have unique effects on health outcomes independent of chronic and major events [14, 15]. Previous studies show that daily marital interactions are significantly associated with cardiovascular outcomes such as carotid artery intima medial thickness [16] and ambulatory blood pressure [17]. However, these studies specifically focused on couple relationships and did not include encounters with other family members. While there are studies that examined health consequences of daily experiences with family members in general, the outcomes were limited to psychological well-being and self-reported physical symptoms [18, 19]. This suggests that the associations between daily experiences with family members and cardiovascular health remain to be explored.

Despite the accumulating evidence on the cardiovascular health consequences of social relationships including those with families, the nuances of the association based on the individual's age received less attention. The strength and vulnerability integration model contends that while older adults utilize various strategies to avoid or mitigate negative experiences and maintain emotional well-being, reduced physiological flexibility that accompanies aging makes their physical health more vulnerable when they are exposed to negative experiences [20]. Conversely, considering the increased potency of the emotional attributes of close relationships in later life [21], positive familial events can be particularly health protective for older adults.

While cardiovascular health indicators are one of the widely examined outcomes of family relationships, many of the studies on social ties and cardiovascular health have focused on either a single marker of cardiovascular functioning (e.g., blood pressure) or an incident of cardiovascular disease [22]. However, using only a single measure of cardiovascular health limits our understanding of how our experiences with family members are related to cardiovascular outcomes because cardiovascular health is reflective of a complex constellation of multiple systems within our body including the regulation of hormones via the hypothalamic–pituitary–adrenal axis, the balance between parasympathetic and sympathetic nervous systems, inflammation, and hemodynamic processes [23]. In order to fully comprehend the role of daily family experiences in cardiovascular health, using comprehensive measures of cardiovascular health is much needed.

Therefore, the aims of this study were to elucidate how day-to-day positive and negative experiences with family collected via a daily diary study are associated with cardiovascular health outcomes. This study also explored whether the associations differed by age. We hypothesized that having fewer positive experiences and more negative experiences would be associated with worse cardiovascular outcomes and that these associations would be stronger for older adults. Also, instead of focusing on a single measure of cardiovascular outcome, this study used comprehensive indicators of cardiovascular health including autonomic, inflammatory, biological, and behavioral measures to gain a more in-depth understanding regarding the link between daily experiences with family and cardiovascular health.

Methods

Sample

Data for this study were drawn from the second wave of the Midlife in the United States (MIDUS II) study and MIDUS Refresher. MIDUS is a national survey on psychological and social well-being in adulthood, and data collection for the second wave took place from 2004 to 2009. MIDUS Refresher was added in 2011–2014 to replenish the MIDUS I baseline cohort. This study selected respondents who participated in the main survey as well as two subprojects of MIDUS, namely the National Study of Daily Experiences (NSDE) and the Biomarker Project. From the MIDUS main survey respondents, the NSDE randomly selected a subsample of 2,804 participants (2,022 from MIDUS II and 782 from MIDUS Refresher) and administered daily telephone interviews across eight consecutive evenings about their daily experiences. A more detailed description of NSDE and its data collection processes can be

found elsewhere [24]. For the Biomarker Project, a subsample of 2,118 participants (1,255 from MIDUS II and 863 from MIDUS Refresher) was recruited to take part in the study. This project provides a wide range of psychophysiological data. Additional information about the project, its protocol, and variables measured are available elsewhere [25].

A total of 1,357 respondents participated in both NSDE and the Biomarker Project. Of these respondents, the final sample for this study included those who provided full data for the study variables (N = 1,191–1,303 depending on the outcome variable).

Measures

Daily experiences with family

This study used data from NSDE to measure daily positive and negative experiences with family members. In NSDE, participants were given stem questions to report their daily stressors and positive events that occurred in the preceding 24 hr in various life domains. With an affirmative response to a stem question, participants were given a series of probing questions that asked who was involved in the experience, perceived intensity, and appraisals (for stressors). Daily stressors were assessed using the Daily Inventory of Stressful Events (DISE) [8], which is a widely used, valid telephone interview instrument designed to capture various daily stressors and stressor characteristics. Daily positive events were examined using an instrument that adapted the DISE questionnaire [26].

In this study, positive experiences were measured using items related to positive events and negative experiences were based on the reports of daily stressors. Not all of the questions on daily stressors and positive events had a follow-up question about who was involved, so this study selected items that had the information available. Three items used for negative experiences were: "*Did you have an argument or disagreement with anyone?*," "*Did anything happen that you could have argued about but you decided to let pass in order to avoid a disagreement?*," and "*Did anything happen to a close friend or relative that turned out to be stressful for you?*." Five items used for positive experiences were: "*Did you have an interaction with someone that most people would consider particularly positive?*," "*Did you have an experience at work/volunteer position that most people would consider particularly positive?*," "*Did you have an experience at home that most people would consider particularly positive?*," "*Did anything happen to a close friend or relative that turned out to be particularly positive for you?*," and "*Did anything else happen to you since yesterday that most people would consider particularly positive?*."

If participants reported having experienced the stressor or positive event, they were asked who was involved. If the experience involved a spouse or partner, child or grandchild, parent, sibling, other relative, or family in general, it was categorized as having a positive/negative familial experience. Each of the eight items used in this study was coded as 1 = *had positive/negative experience with family* and 0 = *did not have positive/negative experience with family*. Scores were then summed across all study days to calculate the total numbers of positive experiences with family and negative experiences with family. The highest possible value was 40 for positive experiences with family (i.e., 5 types of positive events with 8 days of data) and 24 for negative experiences with family (i.e., 3 types of stressors with 8 days of data). As a final step, the summed values were divided by the number of study days that the respondent participated in order to calculate the average number of positive and negative familial experiences during a given day. Higher numbers indicate that the respondent had on average more frequent negative/positive experiences with family members per day.

Age

This study used respondents' age at the time of the Biomarker Project. This was calculated by subtracting respondents' date of birth from their date of visit for the Biomarker Project.

Inflammatory measures

Interleukin 6 (IL-6) and C-reactive protein (CRP) assayed from fasting blood samples were used as markers of inflammation for this study. Serum IL-6 was measured using the Quantikine High-sensitivity enzyme-linked immunosorbent assay kits (ELISA; R&D Systems, Minneapolis, MN). CRP was measured using the BNII nephelometer utilizing a particle enhanced immunonepholometric assay (Dade Behring Inc., Deerfield, IL). The laboratory intra- and interassay coefficients of variance were 3.25% and 12.31% for IL-6 and 4.4% and 5.7% for CRP, all of which fall within acceptable range [27]. Because the distributions of IL-6 and CRP were skewed, natural-logged values were used for analyses.

Heart rate variability

This study used two measurements of HRV—root mean squared successive differences (RMSSD) and high-frequency HRV (0.15–0.40 Hz; HF-HRV)—as indicators of autonomic functioning. Both are frequently used indices of vagal tone [28, 29]. During an 11-min seated resting period, HRV measures were obtained from electrocardiograph (ECG) records. Analog ECG signals were digitized at 500 Hz using a microcomputer. To identify

R waves, ECG waveforms were visually inspected to correct for possible errors [30]. Then, RR interval files were submitted to Fourier-based spectral analysis to compute RMSSD and HF-HRV. HRV was calculated as a mean of two baseline 300-s epochs. The values were natural log-transformed to normalize the distributions.

Life's Simple 7

Life's Simple 7 (hereafter referred to as LS7) is a metric published by the American Heart Association (AHA) which is comprised of comprehensive measures that account for behavioral and biological factors that contribute to cardiovascular health. Measurements include four health behaviors (smoking, physical activity, diet, and body mass index [BMI]) and three biological health factors (blood pressure, total cholesterol, and blood sugar).

Each of the LS7 components was categorized as *poor*, *intermediate*, and *ideal* according to the criteria defined by the American Heart Association [31]. This study adapted definitions of physical activity and healthy diet based on the data available in the MIDUS Biomarker Project. Metrics for LS7 components used in this study—smoking, BMI, physical activity, diet, total cholesterol, blood pressure, and fasting glucose—as well as a more detailed description of measurements for health behaviors are presented in Supplementary Tables 1 and 2. To calculate a composite LS7 score, this study assigned 2 points for *ideal*, 1 point for *intermediate*, and 0 points for *poor* to each of the LS7 metrics and summed across all seven components. Total score ranged from 0 to 14. Respondents with missing information on one or more of LS7's seven components were excluded from the analysis.

Covariates

Covariates included in the analyses were demographic characteristics and health-related variables that are associated with cardiovascular outcomes, which are: gender, marital status, education, race, MIDUS cohort (MIDUS II or Refresher), number of chronic conditions, neuroticism, and self-reported medication use for hypertension and diabetes collected during the Biomarker Project. Gender was 0 = *men* and 1 = *women*. Marital status was coded as 0 = *not married* (i.e., divorced, separated, widowed, never married) and 1 = *married*. Level of education was coded as 0 = *less than a 4-year college degree* and 1 = *4-year college degree or more*. MIDUS cohort was coded as 0 = *MIDUS II* and 1 = *Refresher*. Neuroticism was measured using the Midlife Development Inventory (MIDI) Personality Scales [32]. The average of four adjectives that measure neuroticisms—moody, worrying, nervous, calm (reverse coded)—was used for analyses. Cronbach's alpha coefficient neuroticism was $\alpha = .75$.

For analyses models that used inflammatory and autonomic markers of cardiovascular health as an outcome, this study included BMI and smoking status as additional covariates. BMI was calculated based on the respondent's weight and height. For smoking status, categorization from LS7 measures was used. In other words, the variable was coded as 0 = *currently smoking regularly*, 1 = *smoked regularly in the past year*, and 2 = *never smoked regularly or quit smoking for more than a year*.

Plan of Analyses

For the main analysis model, this study began by testing the associations between daily family experiences and markers of cardiovascular health using stepwise linear regression models. First, the main effects of daily positive and negative experiences with family were examined by simultaneously entering the two variables into a minimally adjusted model that only included demographic characteristics (e.g., age, gender, education, race, marital status, MIDUS membership) as covariates (Model 1). Then, a full model with health-related covariates (e.g., neuroticism, chronic conditions, BMI, smoking status, hypertension medication, high blood sugar medication) added to the analyses was tested (Model 2). As a final step, Models 3 and 4 included interaction terms that tested whether the relation between daily familial experiences and cardiovascular health measures differed by age (Model 3 for positive experiences and Model 4 for negative experiences). Full results from Models 1 to 4 are presented in Supplementary Tables 4–8. All continuous variables were centered at their sample mean for ease of interpretation. Where age moderations were significant, this study further performed regions of significance tests to plot and probe the interaction effects [33, 34]. All analyses for this study were performed using STATA 16.1 [35].

Results

Sample Descriptives

Table 1 presents summary sample descriptive statistics of the study variables. Descriptive statistics were calculated based on individuals who were included in at least one set of regression analyses (N = 1,314). 56.5% of the sample were women, and mean age was 55.87 years (SD = 12.25). The sample primarily identified as white (82.1%) and 46.9% reported having a 4-year college degree or more. In terms of daily experiences with family, participants reported having on average 4 positive experiences and 1.6 negative experiences involving family members across the 8-day period (i.e., 0.49 positive experiences and 0.20 negative experiences on a given day).

Table 1. Sample descriptives of study variables (N = 1,314[a])

	Range	*M* (*SD*)
Age	27 to 86	55.87 (12.25)
Neuroticism	1 to 4	2.05 (0.65)
Number of chronic conditions	0 to 20	4.05 (3.01)
BMI	14.99 to 77.58	29.73 (6.85)
Positive experiences with family (average)	0 to 3	0.49 (0.44)
Negative experiences with family (average)	0 to 2	0.20 (0.26)
IL-6[b]	−2.15 to 3.14	0.72 (0.76)
CRP[b]	−3.00 to 4.37	0.36 (1.20)
RMSSD[b]	1.11 to 5.13	2.96 (0.64)
HF-HRV[b]	0.84 to 9.29	4.97 (1.32)
Life's Simple 7 total score	1 to 14	8.72 (2.39)
	n	Percentage
Women	743	56.54
4-Year college degree or more	616	46.88
White	1,079	82.12
Married	862	65.60
MIDUS Refresher	341	25.95
Currently not smoking	1,132	86.15
Taking medication for hypertension	362	27.55
Taking medication for diabetes	128	9.74

BMI body mass index; *CRP* C-reactive protein; *HF-HRV* high-frequency heart rate variability; *IL-6* interleukin 6; *MIDUS* Midlife in the United States; *RMSSD* root mean squared successive difference.

[a]*N* derived from listwise deletion of missing on independent variables, moderator (age), and covariates.

[b]Logged values were used.

Correlations among study variables are presented in Supplementary Table 3. Daily positive experiences with family was positively correlated with negative family experiences (r = .29, p < .001) and LS7 (r = .08, p = .002), and negatively correlated with IL-6 (r = −.07, p = .012), HF-HRV (r = −.06, p = .033), and RMSSD (r = −.07, p = .022). Having negative experiences with family was positively correlated with LS7 (r = .09, p = .001) and negatively correlated with age (r = −.15, p < .001) and IL-6 (r = −.09, p < .001).

Daily Experiences With Family on Cardiovascular Outcomes and Moderation by Age

Model 2 of Table 2 presents results from regression analyses that tested for the main effects of daily positive and negative experiences with family in the full model. Results showed that for all three sets of outcomes (inflammatory, autonomic functioning, and LS7), there were no significant main effects of positive and negative experiences with family members.

Models 3 and 4 of Table 2 present results that examined the interactions between daily experiences with family and age. For all five outcomes, Model 3 tested the interaction between positive experiences and age, and Model 4 examined the interaction between negative experiences and age. Full results for Models 3 and 4 with interaction terms are presented in Supplementary Tables 4–8 (Supplementary Tables 4 and 5 for inflammatory markers, Supplementary Tables 6 and 7 for autonomic functioning, and Supplementary Table 8 for LS7).

Results showed that there were significant interaction effects between daily family experiences and age on cardiovascular outcomes. For inflammation, there was a significant interaction between daily negative family experiences and age for CRP (B = 0.02, SE = 0.01, p = .017). For autonomic functioning, there were significant interactions between daily negative family experiences and age for RMSSD (B = −0.02, SE = 0.01, p = .022) and between daily positive family experiences and age for HF-HRV (B = −0.01, SE = 0.01, p = .042). Lastly, results also showed a significant interaction between daily negative family experiences and age for LS7 score (B = −0.04, SE = 0.02, p = .040). These indicate that the associations between daily family experiences and inflammatory markers, autonomic functioning, and LS7 score differed by age.

To further examine the interaction effects, this study performed region of significance tests to estimate the associations between daily positive and negative experiences with family and cardiovascular health outcomes at different ages. In addition, based on the results from region of significance tests, this study also plotted the interaction effects to better visualize the results. Plotting of the effects are presented in Figs. 1–4. For all four plots, higher levels of daily negative and positive experiences were drawn at 1 *SD* above the sample mean of daily negative and positive experiences (i.e., average number of negative experiences a day = 0.46; average number of positive experiences a day = 0.93). A lower level of positive experiences was also drawn at 1 *SD* below the sample mean of daily positive experiences (i.e., average number of positive experiences a day = 0.05). A lower level of negative experiences was set at 0 (i.e., no negative experiences) because 1 *SD* below the sample mean of negative experiences had a negative value of −0.06. For age, the midpoint of the age range in which the effects of daily familial experiences were significant was used to plot the interaction effects. In ages where the effects were not significant, the age for younger adults was set at 44 (1 *SD* lower than sample mean age) and at 68 for older adults (1 *SD* higher than sample mean age) for plotting.

Table 2. Linear regression results of the association between daily experiences with family and cardiovascular health and interaction by age

		CRP ln (n = 1,300)		IL-6 ln (n = 1,303)		RMSSD ln (n = 1,191)		HF-HRV ln (n = 1,191)		LS7 total score (n = 1,293)	
		B (*SE*)	*p* value	*B* (*SE*)	*p* value	*B* (*SE*)	*p* value	*B* (*SE*)	*p* value	*B* (*SE*)	*p* value
Model 2	Constant	0.39 (0.11)	<.001	0.95 (0.07)	<.001	3.24 (0.07)	<.001	5.48 (0.14)	<.001	7.74 (0.18)	<.001
	Age	0.004 (0.003)	.150	0.01 (0.002)	<.001	−0.01 (0.002)	<.001	−0.03 (0.004)	<.001	−0.004 (0.01)	.520
	Women	0.39 (0.06)	<.001	0.06 (0.04)	.094	0.03 (0.04)	.365	0.18 (0.08)	.017	0.71 (0.12)	<.001
	Education[a]	−0.18 (0.06)	.004	−0.06 (0.04)	.100	0.02 (0.04)	.591	0.01 (0.07)	.866	0.81 (0.11)	<.001
	White	−0.005 (0.08)	.952	−0.14 (0.05)	.005	−0.21 (0.05)	<.001	−0.45 (0.10)	<.001	0.55 (0.15)	<.001
	Married	0.03 (0.07)	.602	−0.03 (0.04)	.435	−0.09 (0.04)	.034	−0.12 (0.08)	.133	0.27 (0.13)	.035
	Neuroticism	−0.05 (0.05)	.339	−0.01 (0.03)	.663	−0.03 (0.03)	.324	−0.06 (0.06)	.314	−0.23 (0.09)	.013
	MIDUS Refresher	−0.003 (0.07)	.961	−0.08 (0.04)	.067	0.10 (0.04)	.017	0.11 (0.09)	.208	0.48 (0.13)	<.001
	Chronic conditions	0.02 (0.01)	.037	0.03 (0.01)	<.001	−0.01 (0.01)	.072	−0.02 (0.01)	.086	−0.10 (0.02)	<.001
	BMI	0.08 (0.005)	<.001	0.04 (0.003)	<.001	−0.005 (0.003)	.069	−0.01 (0.01)	.026	—	
	Currently smoking (ref)										
	Quit smoking ≤1 year	−0.11 (0.27)	.698	0.06 (0.17)	.728	−0.06 (0.17)	.706	−0.10 (0.34)	.762	—	
	Never smoked or quit smoking >1 year	−0.27 (0.09)	.002	−0.11 (0.06)	.056	−0.15 (0.05)	.005	−0.29 (0.11)	.008	—	
	Hypertensive medication	0.16 (0.07)	.032	0.05 (0.05)	.283	0.07 (0.05)	.134	0.16 (0.09)	.088	−1.38 (0.14)	<.001
	High blood sugar medication	0.01 (0.10)	.956	0.07 (0.07)	.273	−0.08 (0.06)	.191	−0.21 (0.13)	.099	−1.84 (0.20)	<.001
	Positive family experiences	−0.03 (0.07)	.635	−0.07 (0.04)	.105	−0.04 (0.04)	.310	−0.08 (0.09)	.339	0.09 (0.14)	.526
	Negative family experiences	−0.16 (0.12)	.181	−0.08 (0.07)	.269	0.003 (0.07)	.973	−0.06 (0.15)	.697	0.06 (0.23)	.797
	R^2	0.26		0.27		0.11		0.14		0.31	

Table 2. Continued

		CRP ln (n = 1,300)		IL-6 ln (n = 1,303)		RMSSD ln (n = 1,191)		HF-HRV ln (n = 1,191)		LS7 total score (n = 1,293)	
		B (*SE*)	*p* value	*B* (*SE*)	*p* value	*B* (*SE*)	*p* value	*B* (*SE*)	*p* value	*B* (*SE*)	*p* value
Model 3	Positive family experiences × age	−0.004 (0.005)	.473	−0.001 (0.003)	.707	−0.01 (0.003)	.081	−0.01 (0.01)	.042	−0.01 (0.01)	.388
	R^2	0.26		0.27		0.11		0.15		0.31	
Model 4	Negative family experiences × age	0.02 (0.01)	.017	−0.01 (0.01)	.413	−0.02 (0.01)	.022	−0.02 (0.01)	.063	−0.04 (0.02)	.040
	R^2	0.27		0.27		0.11		0.15		0.31	

Notes. Logged values were used for CRP, IL-6, RMSSD, and HF-HRV. Models 2–4 were run as separate sets of analyses with the same covariates. Model 2 tested for the main effects of independent variables of interest, and Models 3 and 4 examined interaction effects of age. This table only presents coefficients for interaction terms for Models 3 and 4. All continuous variables were centered at their sample mean. *B* unstandardized beta coefficient; *BMI* body mass index; *CRP* C-reactive protein; *HF-HRV* high-frequency heart rate variability; *IL-6* interleukin 6; *LS7* Life's Simple 7; *MIDUS* Midlife in the United States; *RMSSD* root mean squared successive difference; *SE* standard error.

[a]Education was coded as 0 = *less than a 4-year college degree* and 1 = *4-year college degree or more.*

For CRP, a region of significance test showed that having more daily negative experiences with family members was significantly associated with lower (i.e., better) levels of CRP for younger adults between the ages of 27 and 48. For example, Fig. 1 shows that for a young adult aged 38, a half-unit increase in negative experiences (e.g., from having no negative experiences to having a negative experience with a family member every other day during the study period) was related to a decrease in CRP by 19.7% (B = −0.50, SE = 0.18, p = .007). For older adults, having more negative experiences was associated with higher (i.e., worse) levels of CRP at marginal levels (p < .1) between ages 79 and 86.

For RMSSD, having more daily negative experiences with family members was significantly associated with higher (i.e., better) RMSSD for younger adults between the ages of 27 and 33 and with lower (i.e., worse) RMSSD for older adults between the ages of 71 and 86. Figure 2 shows that for a young adult aged 30, a half-unit increase in negative experiences was related to an increase in RMSSD by 19.5% (B = 0.33, SE = 0.16, p = .040). For an older adult aged 78, a half-unit increase in negative experiences was related to a decrease in RMSSD by 16.1% (B = −0.39, SE = 0.19, p = .036).

In terms of HF-HRV, region of significance test results showed that having more daily positive experiences with family members was associated with lower (i.e., worse) RMSSD for older adults between the ages of 65 and 86. Figure 3 shows that for an older adult aged 75, a half-unit increase in positive experiences was related to a decrease in HF-HRV by 15.1% (B = −0.36, SE = 0.16, p = .026).

Lastly, for LS7 score, results showed that having more daily negative experiences with family members was marginally associated with higher (i.e., better) LS7 score for younger adults between the ages of 27 and 39 and lower (i.e., worse) levels of LS7 for older adults between the ages of 73 and 86. Figure 4 shows that for a young adult aged 33, a half-unit increase in negative experiences was related to an increase in LS7 score by 0.41 points (B = 0.82, SE = 0.43, p = .060), which is equivalent to scoring approximately 0.17 *SD* higher in the sample distribution of LS7 score. For an older adult aged 79, a half-unit increase in negative experiences was related to a lower LS7 score by 0.50 points (B = −1.01, SE = 0.57, p = .076), which is equivalent to scoring approximately 0.21 *SD* lower in the sample distribution of LS7 score.

Discussion

While prior research has provided mounting evidence demonstrating the strong effects of family relationships on cardiovascular health [36, 37], most have relied on using global measures of family relationships recalled

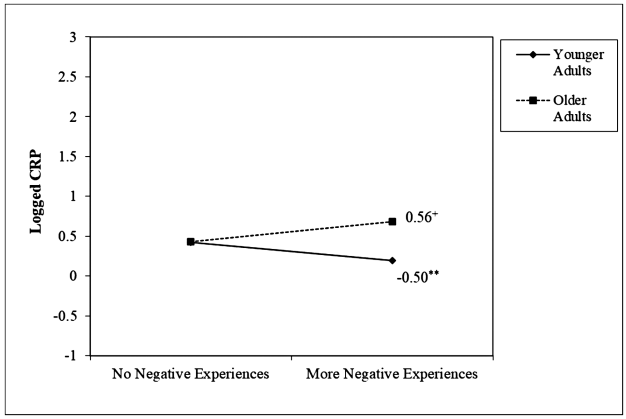

Fig. 1. Interaction effects between daily negative experiences with family and age on CRP. Solid line indicates younger adults at age 38 and dotted line indicates older adults at age 82. *CRP* C-reactive protein; $+p < .1$; $**p < .01$.

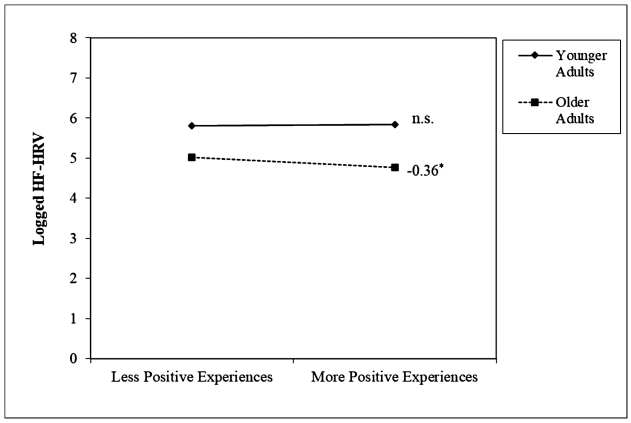

Fig. 3. Interaction effects between daily positive experiences with family and age on HF-HRV. Solid line indicates younger adults at age 44 and dotted line indicates older adults at age 75. *HF-HRV* high-frequency heart rate variability; $*p < .05$.

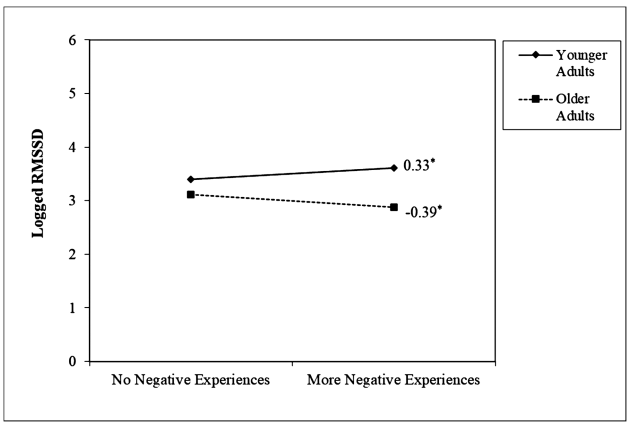

Fig. 2. Interaction effects between daily negative experiences with family and age on RMSSD. Solid line indicates younger adults at age 30 and dotted line indicates older adults at age 78. *RMSSD* root mean squared successive difference; $*p < .05$.

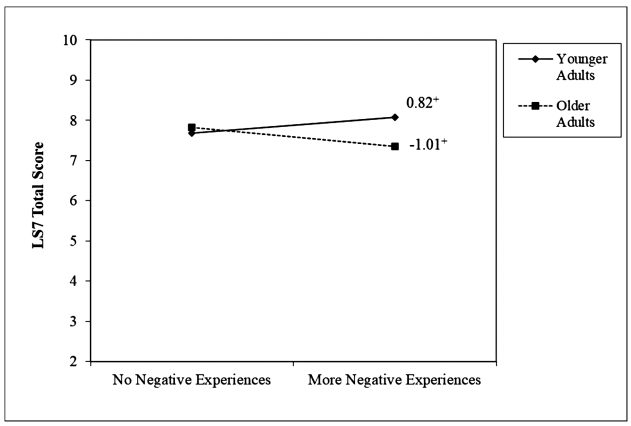

Fig. 4. Interaction effects between daily negative experiences with family and age on Life's Simple 7 score. Solid line indicates younger adults at age 33 and dotted line indicates older adults at age 79; $+p < .1$.

over long periods of time. In order to have a more ecologically valid assessment of individuals' experiences with family members, it is more informative to use microlevel measurements such as daily diary study.

The aims of this study were to examine the associations between daily positive and negative experiences with family members and cardiovascular health outcomes and to test whether the associations differ by age. This study hypothesized that daily negative experiences involving family members would be more health damaging for older adults' cardiovascular outcomes compared with younger adults. Findings from this study showed that there were significant interactions between daily experiences with family members and age on cardiovascular health outcomes, and the interaction patterns were in part consistent with the study hypothesis. For younger adults, results showed that having more negative experiences was associated with better cardiovascular outcomes (i.e., lower CRP, higher RMSSD, higher LS7 score). For older adults, on the other hand, having negative experiences with family members was associated with worse cardiovascular outcomes (i.e., higher CRP, lower RMSSD, lower LS7 score). Surprisingly, having more positive experiences was associated with lower levels of HF-HRV among older adults. The lack of significant findings involving positive experiences compared with negative experiences echo the patterns from previous studies on social relationships and health that found more potent health effects of negative interactions compared with positive interactions [38].

The contrasting associations between daily negative experiences and cardiovascular outcomes among younger and older adults could be understood from age differences in physiological reserve. *Physiological reserve* refers to our body systems' buffer zone that allows individuals to cope with, adapt to, and recover from external stressors [39, 40]. Physiological reserve is typically found to be maintained at high levels during earlier stages of

life and decline with age in older adulthood [41]. Thus, young adults with sufficient levels of reserve are more resilient to stressors with higher physiological capacity to respond to and rapidly recover from stressors. Such resilient response profile is known to have a hormetic effect, where high levels of reserve capacity and fast recovery from stress creates a positive feedback loop that further promotes enhanced stress response system and strengthens the growth of our body's functioning including the cardiovascular system [42, 43]. With sufficient levels of physiological reserve, exposure to manageable acute stressors in daily life can lead to housecleaning in the cells that make them rejuvenated (i.e., improved functioning compared with the baseline) [43]. This is also in line with the positive views of stress arousal where exposure to mild, intermittent stressors is considered to result in physiological toughness that corresponds with better physical health outcomes [44]. While there is a large body of literature that find health costs of stressful relationships [3], these may be tapping more into intense stressors rather than daily hassles. These together suggest that the associations between negative experiences with family members and better cardiovascular outcomes among younger adults could be due to the positive physiological response to daily stressors that is built on high levels of reserve capacity at younger ages.

Given the cross-sectional nature of this study, it is also possible that reverse causation may be at play in explaining the associations between negative experiences with family and cardiovascular health among younger adults. Younger adults with better cardiovascular functioning could be reporting more negative experiences with family members because they are more actively engaged with their family. Negative encounters in relationships are indicative of more complex engagement in close relationships [45, 46], and younger adults with health limitations may not be able to actively engage in their relationships with family members [47] which restrict the opportunities for involvement in daily interactions.

For older adults, the significant decline in physiological reserve that comes with age can undermine their ability to effectively respond to and recover from even relatively minor stressors such as daily hassles with family members in everyday life. Aging is accompanied by decline in multiple physiological systems including changes in cardiovascular physiology, such as endothelial dysfunction, increased arterial stiffness, and attenuated autonomic reflexes [48]. These changes result in homeostatic dysregulation and reduced cardiovascular capacity to cope with stress-induced disruptions, making older adults more vulnerable to the risk of critical cardiovascular conditions [49].

The strength and vulnerability integration model also echoes older adults' physical vulnerability to negative interactions as a source of stress, noting the reduced physiological flexibility that accompanies aging. Experimental studies on cardiovascular responses to stressors show that cardiovascular recovery following an acute stressor was slower for older adults compared with young adults [50, 51]. This is suggestive of the prolonged arousal of cardiac response and the diminished ability to return to homeostasis in later life, which can harm cardiovascular functioning in the long run. Therefore, for older adults, having negative encounters with family members in daily life could be harmful for cardiovascular outcomes due to the age-related loss of physiological reserve and redundancy.

It should also be noted that among the different types of family relationships, negative interactions with spouses in particular, could be driving these associations for older adults. For example, in this study sample, further breakdown of daily negative experiences by relationship type showed that an average of 52.82% of negative experiences with family members reported by older adults involved their spouses or partners (compared with the 27.07% with children and 8% with siblings). This suggests that spouses play a central role in older adults' lives [52]. Studies that specifically focused on marital relationships find that health costs of marital strain and conflict were stronger for older adults compared with younger adults [53, 54], which is in part consistent with this study's findings that showed adverse health implications of negative family experiences for older adults.

Loss of physiological reserve can also aid in explaining the unexpected interaction patterns found for positive experiences and age, which showed that having more positive experiences with family members was associated with worse-functioning HF-HRV among older adults. It may be that the physiological arousal from pleasurable emotions that accompany positive experiences and uplifts also require adaptation that is similar to what is required by negative experiences and stressors [44]. For example, highly fluctuating and unstable positive affect that are vulnerable to external events are found to be associated with worse health outcomes compared with having stable positive emotions over time [55]. Since older adults lack physiological reserve and the capacity to effectively cope with arousals, positive experiences could be taking a toll on older adults' cardiovascular health outcomes via arousals from quickly changing, fragile positive emotions.

Lastly, while this study found significant associations between daily experiences with family members and inflammatory markers of cardiovascular health, results only pertained to CRP and not IL-6. This may be reflective of the potential differences in the stability between the two markers, where CRP is considered to be a more reliable indicator of chronic inflammation with

longer plasma half-life than IL-6 [56]. Accordingly, a vast body of literature evince the consistent and strong relationship between psychosocial stress and CRP [57], and studies that compared the effects of different markers of inflammation on cardiovascular events find stronger associations for CRP compared with IL-6 [56, 58].

There are some limitations to note that warrant caution in the interpretation of the study results. First, this study used cross-sectional data from MIDUS II and Refresher in examining the link between daily family experiences and cardiovascular health. This means that results are only indicative of associations, not causal relationships. Also, there was an average 14-month lag between the respondents' participation in NSDE and the Biomarker Project. Considering that physiological and biological processes that are relevant to cardiovascular disease outcomes evolve under different time scales ranging from immediate responses to distal risk factors [59], more rigorous longitudinal studies that take into account both short-term and long-term processes would be needed.

In addition, the sample used in this study was not racially representative, with the vast majority consisting of white participants (82.12%). This is an important aspect to consider because race is one of the strong demographic determinants of cardiovascular health outcomes. Studies consistently find that racial minorities have worse cardiovascular outcomes and are at higher risk of developing a cardiovascular disease [60, 61]. In order to provide better insights in understanding racial disparities in cardiovascular health, future studies could explore how daily experiences with family members are associated with cardiovascular outcomes using a racially more diverse sample.

Also, significant associations between daily experiences and cardiovascular health found among older adults were limited to the higher end of the age span (e.g., ages 71 through 86 for the association between negative daily experiences and RMSSD). Considering that the proportion of oldest-old adults aged 75 and older in the study sample was relatively small (7.15%), this may limit the generalizability of the study finding to older adults across a wider age range. Therefore, replication of the analyses using a different sample of older adults would be needed to examine the robustness of the study finding.

Lastly, issues regarding the measurement of daily experiences should be noted. Positive and negative experiences to some degree reflect emotional responses involved in these events (e.g., pleasant or irritating), which may influence individuals' accounts of daily experiences. Considering that negative events that elicit negative valence are found to persist longer in memory [62], small daily uplifts involving family members could have been underreported as distinct events compared with negative experiences. Also, while there are various aspects to daily experiences with family members including objective characteristics and subjective appraisal of these experiences [63], this study solely focused on the frequency of positive and negative experiences. Considering the findings from stress literature that show significant health effects of stress processes (e.g., stress severity, reactivity, and spillover) [64, 65], the implications of daily experiences with family members on cardiovascular health may depend not just on exposure but also on other properties such as type, duration, or intensity of these experiences.

Despite the limitations, this study expands prior literature on family relationships and cardiovascular health by measuring individuals' encounters with family members as experienced in their daily lives. Also, rather than focusing on one specific indicator of cardiovascular health, this study covered a wide range of cardiovascular health outcomes including inflammatory markers, autonomic functioning, and a comprehensive metric of cardiovascular health, and found consistent results across these measures. Moving forward, future studies could further examine the health implications of specific properties and contexts of daily experiences involving family members and explore mediating pathways such as health behaviors and psychological characteristics through which daily experiences with family members are linked to long-term cardiovascular health events.

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

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Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards Authors Hye Won Chai and David M. Almeida declare that they have no conflict of interest.

Authors' Contributions H. Chai conceptualized the research, analyzed and interpreted data, and drafted the manuscript. D. M. Almeida provided critical revisions to the manuscript.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The larger MIDUS study protocol was approved by the Institutional Review Boards at the University of Wisconsin-Madison, Georgetown University, and the University of California, Los Angeles.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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