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Childhood maltreatment is longitudinally associated with cardiometabolic biomarkers through marital quality: Do health locus of control and eating habits matter?

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Abstract

Childhood maltreatment influences adult physical health through cascading effects over the life course and it is critical to identify intervening processes. Marital quality has significant implications for adult physical health via cognitive, emotional, and behavioral pathways and may be a viable pathway. Given that cardiometabolic biomarkers are associated with the leading causes of death in the United States, the current study longitudinally investigated marital quality, health locus of control, and eating habits in a serial mediation model linking childhood maltreatment to high density lipoprotein (HDL) and low density lipoprotein (LDL). Using a sample of 352 adults from the study of Midlife Development in the United States, we used three waves of data to test our hypotheses. Results of structural equation models indicate that although all the hypothesized direct effects were statistically significant, the serial indirect effects were non-significant. Childhood maltreatment was associated with a lower quality marriage, marital quality was associated with higher levels of health locus of control which, in turn, was associated with healthier eating habits. Finally, healthier eating habits were associated with greater HDL, but not lower LDL. Additionally, marital quality exerted a direct effect on LDL and mediated the relationship between maltreatment and LDL, but not HDL. For researchers, marital quality appears to be a mechanism linking childhood maltreatment to cardiometabolic biomarkers, yet health locus of control and eating habits do not appear to

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have strong effects. For clinicians, strengthening the couple relationship among survivors of maltreatment appears to have health promotive effects over time.

Keywords
Childhood maltreatment, marital quality, cholesterol, high density lipoprotein, low density lipoprotein, social determinants of health, eating habits, health locus of control

Childhood maltreatment is one of the greatest threats to public health. More than three million children are reported to child protective services each year following suspected abuse or neglect (Sedlak et al., 2010) and millions more experience abuse and neglect, but do not come to the attention of the authorities. In fact, more than 1 in 3 adults report being either abused or neglected in childhood (Center for Disease Control, 2023). The adverse childhood experiences study (ACE) highlighted the dose-response relationship between child adversity and distal health outcomes (Felitti et al., 1998). While the ACEs study clearly document that adversity is associated with health problems, more contemporary research has noted that all ACEs are not created equal (Negriff, 2020) and childhood maltreatment, compared to household dysfunction, tends to exert stronger effects on adult health (Iob et al., 2021; Rampersaud et al., 2022). Some research demonstrates a dose-response relationship between childhood maltreatment and adult physical health (Fitzgerald & Notice, 2023), while specific types of maltreatment have also been shown to exert differential effects on adult physical health (Danese et al., 2007; Nelson et al., 2017). Therefore, to fully understand the effects of maltreatment on adult health, it will be critical to investigate both cumulative maltreatment as well as specific subtypes. Specific maltreatment subtypes may differentially influence possible life course pathways to poor physical health (McLaughlin et al., 2021).

Cardiometabolic biomarkers (e.g., cholesterol) are critical pre-clinical indicators of risk for the leading causes of death in the United States (Félix-Redondo et al., 2013). Cholesterol is divided into two forms: high density lipoprotein (HDL) and low density lipoprotein (LDL). HDL is colloquially termed "good cholesterol" and has health benefits, while LDL is referred to as the "bad cholesterol" which is a risk factor for future health problems (CDC, 2023). Recent research has connected childhood maltreatment to HDL and LDL (Ho et al., 2020), but there has been little investigation into the relationship between maltreatment and HDL and LDL levels over time and few mediating pathways have been identified.

In an effort to reduce health care utilization, medication use, and poor health outcomes associated with cholesterol, it is critical for prevention efforts to identify mediating processes that contribute to changes in cholesterol over time, and marriages may be one such pathway. Marital quality is a compelling pathway for several reasons including (1) marriages are ubiquitous in the United States with approximately 90% of adults marrying at some point in their lives (Cherlin, 2009); (2) marital processes and quality have been shown to have associations with HDL and LDL (Bennett-Britton et al., 2017); and (3) maltreatment does not appear to select individuals into or out of relationships (Colman &

Widom, 2004), but does influence marital quality and satisfaction (Zamir, 2022). Despite findings that marital processes are related to cardiometabolic indicators, there remains a lack of clarity on the mechanisms linking marital processes to HDL and LDL. For example, the *Journal of Couple and Family Psychology* and *Health Psychology* have each created a special issue in 2023 devoted, in part, to better understand processes that link social relationships to physical health. In concert with these calls for additional research, we propose that health locus of control and eating behavior are critical factors connecting marriage to HDL and LDL (Lewis et al., 2006; Maki, 2020; Newby et al., 2004) and may ultimately be a part of the cascading effects from maltreatment to negative cardiometabolic biomarkers. To test this proposition, we conducted a serial mediation model examining marital quality, health locus of control, and eating habits as mediators linking maltreatment and HDL and LDL over time.

Literature review

Childhood maltreatment and cardiometabolic biomarkers

Given the notoriety of the ACEs study, it comes as no surprise that research on childhood adversity and cardiometabolic biomarkers such as HDL and LDL has largely focused on combining the maltreatment and household dysfunction items into an overall ACE score (Riem & Karreman, 2019). Relatively few studies have considered the unique association between maltreatment and HDL and LDL, yet those who have examined such relationships have found somewhat contradictory evidence. On one hand, the effects of maltreatment on HDL and LDL may vary across maltreatment subtypes (e.g., emotional abuse, physical neglect), while others have found a dose-response relationship between maltreatment and higher levels of LDL and lower levels of HDL (Kisely et al., 2022). To fully understand how maltreatment influences cardiometabolic biomarkers, it is critical to determine whether specific subtypes of maltreatment heighten cardiometabolic risk or, alternatively, determine if the associations are based on a dose-response relationship (McLaughlin et al., 2021).

One possible solution to the discrepant findings could be attributable to the effects of maltreatment on mediating variables. Consistent with attachment theory (Bowlby, 1969/1982), childhood maltreatment disrupts children's attachment security that manifests in poorer quality relationships and marriages with partners in adulthood (Zamir, 2022). Evidence from prospective and retrospective research consistently docments that maltreatment is associated with poorer quality marriages (Colman & Widom, 2004; Whisman, 2014) and influences both specific dimensions of marriages such as trust, conflict, support, intimacy, dyadic coping, and aggression (DiLillo et al., 2009; DiLillo et al., 1999; Fitzgerald & Esplin, 2023; Fitzgerald & Shuler, 2023; Walker et al., 2009, 2011) as well as overall appraisals of marital quality (Fitzgerald & Morgan, 2023; Riggs et al., 2011). Thus, inquiry into marriages is a particularly compelling pathway due to the amount of influence marriages have on cognitive, emotional, and behavioral domains that can ultimately influence health (see Thoits, 2011 for review).

Marriage and physiology

Marriage has robust and consistent associations with physiological processes (see Kiecolt-Glaser & Newton, 2001; Robles et al., 2014; Robles, 2021 for reviews) indicating that both the legal status of being married as well as specific marital processes (e.g., interactions, overall quality) contribute to health. Kiecolt-Glaser and Newton (2001) proffered a conceptual model linking marital processes to biomarkers. They contend that positive and negative dimensions of marital functioning, defined by interactive, psychological, and cognitive processes that occur during marital interactions, predict mediating processes such as psychopathology and health behavior. Psychopathology (e.g., major depression) and health behavior (e.g., eating habits) are theorized to influence numerous physiological systems including the endocrine, immune, and cardiovascular systems (Kiecolt-Glaser & Newton, 2001). For example, studies have linked marital interaction such as support and strain to inflammatory biomarkers (Donoho et al., 2013) and glycemic control (Stokes & Barooah, 2021). Further, Kiecolt-Glaser and Newton (2001) and Gottman (2014) commonly suggest that marital interactions can directly elicit physiological responses where supportive and positive interactions decrease physiological reactivity and strained, negative interactions increase physiological reactivity. Not surprisingly, marital quality has been recently proposed as a mediator linking childhood maltreatment to the number of chronic health conditions over time (Fitzgerald & Morgan, 2023) and may similarly serve as a mechanism to cholesterol.

Empirical research has supported the aforementioned conceptual and theoretical foundations and research has suggested that eating habits may be particularly relevant to marriage and cholesterol (Bennett et al., 1994; Cheng et al., 2016; Cobb-Clark et al., 2014; Helmer et al., 2012). For example, research has shown that spouses' support and encouragement increases positive health behavior and criticism decreases health hindering behavior (Thoits, 2011; Umberson, 1992; Whisman & Baucom, 2012) while also jointly engagin in health promotive lifestyle changes including healthier eating habits and increasing exercise (Brazeau & Lewis, 2021; Ristovski-Slijepcevic & Chapman, 2005; Rowland et al., 2018). Eating habits are a particularly salient health behavior that is strongly associated with cholesterol levels (Kopčeková et al., 2020) and is a possible pathway linking marriage to health (Markey et al., 2016). Through eating meals together, marital partners are aware of eating habits and can exert social control over their partner's habits via positive and negative interaction, and influence dietary choices. Yannakouila et al. (2008) suggested that eating habits may mediate the association between marital status and cholesterol, while Markey et al. (2001) found that marital quality interacted with self-esteem in predicting unhealthy dieting behaviors. More recently, Castro et al. (2020) found that marital quality was associated with positive social control of eating patterns among adults with a spouse with type II diabetes. Due to an underdeveloped knowledge base regarding the longitudinal associations between marital quality and cholesterol, we will focus on the association between marital quality and cholesterol, which has also been noted in the literature using primarily cross sectional data (e.g., Bennett-Britton et al., 2017; Gallo et al., 2003; Hogue et al., 2022; Kiecolt-Glaser, et al., 2015; Ross et al., 2018; Wilson et al., 2020).

Kiecolt-Glaser and Newton's conceptual model places a strong emphasis on marital interactions, and while there is clear specification of individual processes (e.g., cognition), there is substantially less focus on such processes. Lewis et al. (2006) suggests that, in addition to an individual's health behaviors being inextricably shaped by the interactions between themselves and their partners (e.g., support, strain, conflict) or lack thereof (e.g., disengagement, stonewalling), cognitive processes (e.g., attributions, appraisals) are also critical. One cognitive process particularly salient in relation to health is health locus of control. Health locus of control is conceptualized as one's beliefs regarding their ability to influence their own health (Wallston & Wallston, 1982) and has both an internal and external dimension. Internal health locus of control refers to an individual's ability to influence their own health outcomes (e.g., agency, control) while external locus of control reflects a belief that their health is governed by external factors (e.g., doctors, others, and chance). Internal health locus of control has been associated with greater physical activity and healthier eating habits (Cheng et al., 2016; Mercer et al., 2018), greater medication adherence (Náfrádi et al., 2017; West et al., 2018), and reduced health care utilization (Berglund et al., 2014; Cheng et al., 2016). Married adults, compared to their non-married counterparts, demonstrated greater treatment adherence and increased self-efficacy, which has been suggested to be, in part, a function of health locus of control (Juárez-Ramírez et al., 2015; Lindstrom & Rosvall, 2012; Wong & White, 2002). For example, one partner may not view a health-related event (e.g., finding out that they have high cholesterol) as a potential threat to short or long-term health while their partner may evaluate that same event as a significant threat. In response to high LDL and low HDL levels, spouses may become distressed (Ayotte et al., 2010) and conflict may ensue due to differences in appraisal. Maki (2020) found that both marital support and strain were uniquely associated with health locus of control, which mediated the effect from marital interactions to greater glycemic control.

The present study

The purpose of the study was to examine the indirect effect of maltreatment to HDL and LDL over time via serial mediation model through marital quality, health locus of control, and eating habits. It was hypothesized that childhood maltreatment would be associated with lower levels of marital quality and indirectly associated HDL and LDL via marital quality, health locus of control, and eating habits. Further, it was presumed that there will be no direct effects from maltreatment to health locus of control, eating habits, and cardiometabolic biomarkers. We operationalized childhood maltreatment from a dose-response relationship that has been previously found to influence marital quality (e.g., Fitzgerald, 2022) and hypothesized that maltreatment severity would be associated with lower levels of marital quality. Second, we expected that marital quality would be associated with greater health locus of control and would remain significantly associated with higher levels of HDL and lower levels of LDL (i.e., partial mediation) consistent with models demonstrating direct effects between social relationships and physiological processes (Gottman, 2014; Kielcolt-Glaser & Newton, 2001). We did not expect that marital quality would be associated with eating habits as the effect would be mediated via

health locus of control (Lewis et al., 2006). We hypothesize that health locus of control would be associated with better eating habits as well as higher levels of HDL and lower levels of LDL; we expect only partial mediation as eating habits are only one form of health behavior that can influence cholesterol levels. Finally, we expect that better eating habits would be linked to lower levels of LDL and greater levels of HDL. As a sensitivity analysis, we also tested the maltreatment subtypes model to determine if there were specific types of maltreatment that were particularly influential. To best test the proposed hypotheses, we included numerous covariates. Researchers previously have found higher BMI, smoking cigarettes, and alcohol problems to be associated with decreased HDL and increased LDL (Laclaustra et al., 2018; Minzer et al., 2020; Rao Ch & Subash, 2013; Shamai et al., 2011). Moreover, HDL and LDL trajectories are different across the life course in men and women (Swiger et al., 2014). Lower education and more depressive symptoms also negatively influence eating habits (Fard et al., 2021; Mills et al., 2018).

Method

Data from the current study are from the longitudinal study of midlife development in the United States (MIDUS), which has been continually funded by the John D. and Catherine T. MacArthur Foundation. Since 1995–1996 (MIDUS 1), the MIDUS study has collected data every 9 years, including follow-up waves in 2004–2006 (MIDUS 2), and 2013–2014 (MIDUS 3), on the health and wellbeing of adults in the United States. The original MIDUS data collection was comprised of individuals from four discrete groups: (1) a national random digit dialing (RDD) sample (n = 3,487); (2) city oversamples in the United States (n = 757); (3) siblings of individuals from the RDD sample (n = 950); and (4) a national RDD sample of twin pairs (n = 1,914). MIDUS 2 retained 4,963 participants and MIDUS 3 retained 3,294 individuals. For attritional analyses across the MIDUS study, see papers by Radler and colleagues (Radler & Ryff, 2010; Song et al., 2021). Following MIDUS 2 and MIDUS 3, a subproject collected biological samples and additional self-report data, including the MIDUS 2 biomarker (2005–2009; n = 1,255) and MIDUS 3 biomarker (2017–2022; n = 787). Additionally, twins who did not participate in the MIDUS 2 biomarker were invited to participate in the MIDUS 3 biomarker. The average time between the MIDUS 2 biomarker and MIDUS 3 biomarker was approximately 12 years. Participants were included in the study if (1) they participated in the biomarker at MIDUS 2 and MIDUS 3, and (2) were married at MIDUS 3. We first excluded all adults who were unmarried, and if there were twin pairs where both twins were married, we randomly eliminated one of the twin pairs because having both twin pairs in the analysis violates assumptions of independence of residuals. For reliability of the constructs, Omega (ω; Hancock & An, 2020) is reported for scale reliability due to numerous issues with Cronbach's alpha, particularly that assumptions of alpha are almost never met in practice resulting in lower reliability estimates (McNeish, 2018).

Participants

The final sample size included 352 married adults. Regarding race, participants in the study were predominantly White (94.6%) and the others were racial minorities (5.4%), including 1.7% African American, 0.6% Native American, 0.3% Asian or Pacific Islander, 2.6% other, and 0.3% unknown. The sample was split evenly across gender (50% women), the majority reported having an opposite-sex spouse (99.7%), and the sample had a mean age of 55.63 at the MIDUS 2 biomarker (wave 1). Roughly one fifth of the sample had a high school education or less (18.8%), 19.7% reported some college but no bachelor's degree, 10.3% reported an associate degree or vocational training, 24.4% reported a bachelor's degree, 19.7 reported a master's degree, 4.6% reported a doctoral or other professional degree, and the remaining 2.6% reported some graduate school but no degree. 1.2% of the sample reported being permanently disabled at the MIDUS 2 biomarker.

Measures

Childhood Trauma Questionnaire. Childhood Trauma Questionnaire (CTQ; Bernstein et al., 2003). The CTQ is a 25-item scale assessing five types of childhood abuse and neglect prior to the age of 18. Subscales include emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect. Items are scored on a five-point Likert scale, ranging from (1) *Never* to (5) *Very Frequently*. The CTQ has been found to have adequate construct validity and criterion-related validity (Bernstein et al., 2003). For the current study, the mean scores for each of the five subscales were used as indicators for a latent variable representing childhood maltreatment. Example items include "People in my family said hurtful or insulting things to me," "People in my family hit me so hard that it left me with bruises of marks," "Someone molested me," "I felt loved," and "My parents were too drunk or high to take care of me." ω of the five subscales ranged from .70 to .94. The CTQ was measured at the MIDUS 2 biomarker.

Marital quality. For the current study, marital quality was conceptualized as a multidimensional construct (Bryant et al., 2016) using four indicators: support, strain, joint decision making, and marital risk. Each of the indicators are coded such that higher scores represent a higher quality marriage (e.g., high support, low strain). The marital support indicator consisted of six items measured on a frequency scale ranging from (1) *A Lot* to (4) *Not at All*. An example item was, "Can you open up to him or her if you need to talk about your worries?" Items were reverse coded, and a mean score of the six items was taken where higher scores reflect greater spousal support. The second indicator of marital quality was marital strain. Marital strain was measured with six items rated on a 4-point frequency (1) *Often* to (4) *Never*. An example item was "Does he or she make you feel tense?" A mean score of the six items was taken. The third indicator of marital quality was joint decision making. The four items on the joint decision making scale were assessed on a 7 point Likert scale ranging from (1) *Strongly Agree* to (7) *Strongly Disagree*. We summed the items together. An example item from the scale was "My partner and I are a team when it comes to making decisions." Finally, marital risk consisted of two items

(with one reverse coded). The first item was "During the past year, how often have you thought your relationship might be in trouble?" and it was rated on a five point Likert scale (1) *Never* to (5) *All the time*; the second item was "It is always difficult to predict what will happen in a relationship, but realistically, what do you think the chances are that you and your partner will eventually separate?" (Reverse coded) and was scored on a four point scale ranging from (1) *Very likely* to (4) *Not likely at all*. We followed the MIDUS recommended scale scoring procedures for the four indicators. ω for support = .90, strain = .88, joint decision making = .91, and marital risk ω could not be computed due to having only 2 items. Marital quality was measured at MIDUS 3.

Health locus of control. Health locus of control was measured using four items assessing health locus of control-self. All items were rated on a 7-point Likert scale ranging from (1) *Strongly agree* to (7) *Strongly disagree* and the four items were averaged. An example item is "Keeping healthy depends on things that I can do" and "There are certain things I can do for myself to reduce the risk of a heart attack." ω = .70. Health locus of control was measured at MIDUS 3.

Healthy eating habits. The MIDUS study constructed a healthy eating habit index (Echeverría et al., 2023). The index consisted of 14 items. Items were scored based on the level of daily consumption of various foods (e.g., fruits and vegetables) and beverages (e.g., sugary beverages). For healthy foods, participants would be given a minimal score (0), intermediate score (.5), maximal score (1), or a maximal double score (2) based on the serving size per day. For example, for fruits and vegetables, participants received a 0 if they eat no fruits and vegetables, .5 points if they ate 1–2 servings, 1 point if they consumed 3–4 servings, and 2 points if they consumed five or more servings. Overall, higher scores reflect more frequent consumption of healthy foods/drinks and less frequent consumption of unhealthy foods/drinks. Scores could range from 0–11. A more detailed description of the 14 items and scoring procedures can be found in the MIDUS documentation (https://midus-study.github.io/public-documentation/M3P4/Documentation/M3_P4_Documentation_for_PsychoSocial_Constructs_and_Composite_Variables.pdf). Eating habits were measured at the MIDUS 3 biomarker.

High and low density lipoprotein. Participants in the MIDUS 2 and 3 biomarker stayed overnight at one of three centers' general clinical research centers. Similar procedures were undertaken at MIDUS 2 and MIDUS 3 in obtaining HDL and LDL samples. HDL and LDL were drawn from fasting blood samples collected from each participant before breakfast on Day 2 of their stay. Frozen samples were stored in a −60°C to −80°C freezer until shipped on dry ice to the MIDUS Biocore Lab. The frozen serum and plasma in 1 mL aliquots were shipped to the MIDUS Biocore Lab monthly for the following biomarker assays. More detailed information regarding the blood draws can be found in the biomarker documentation. HDL and LDL were measured at the MIDUS 3 biomarker.

Covariates (all variables were measured at MIDUS 2 unless otherwise noted). Several covariates were included in the model. HDL and LDL measured at the MIDUS 2 biomarker

study were included as covariates and were measured in the same way as above. Age was entered in as a continuous variable. Educational achievement was measured with scores ranging from 1 (No schooling or some grade school) to 12 (PhD or other professional degrees). Body mass index of participants was calculated by dividing their weight (kg) by their height (meters). Smoking cigarettes was assessed by one item asking participants if they were ever a regular smoker and they responded either affirmatively (1) or negatively (2). Alcohol problems were assessed using a measure based on the Michigan Alcohol Screening Test (Selzer, 1971). If respondents answered affirmatively to any of five severe symptoms (e.g., increased desire or urge to drink) indicative of alcohol problems, then they received a 1 (alcohol problem) and if they responded negatively, they received a 2 (no alcohol problem). Gender was coded as (1) male and (2) female. Depressive symptoms were assessed using the Composite International Diagnostic Interview Short Form (Kessler et al., 1998) which was based on criteria from the DSM-III major depressive disorder (APA, 1987), respondents answered 7 yes/no questions related to depressed mood and anhedonia occurring for at least 2 weeks out of the past 12 months. The 7 dichotomous items were summed to create a count variable of the number of depressive symptoms.

Statistical analysis

A multistep statistical process was utilized to examine the associations between childhood maltreatment, marital quality, health locus of control, eating habits, and cholesterol. First, descriptive and bivariate statistics were generated in SPSS. Second, structural equation modeling (SEM) was utilized to examine the proposed relationships among maltreatment, marital quality, health locus of control, eating habits, and HDL and LDL using Mplus v 8.10 Within the SEM analysis, maltreatment and marital quality were first modeled as latent constructs to examine the factor structure (e.g., measurement model). Following evaluation of the measurement model for adequate model-data fit, the full structural model was examined. SEMs' model-data fit were evaluated using numerous fit indices including the Chi-square test, Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Squared Residual (SRMR). Values above .90 for the CFI and TLI are considered acceptable and values above .95 are ideal. Values below .08 for the SRMR and RMSEA are acceptable and values below .06 are preferred. A non-significant chi-square test is preferable, but is rarely achieved in practice and can lead to the rejection of otherwise good fitting models (Hu & Bentler, 1999).

For all models, we employed robust maximum likelihood (MLR) with Bentler-Satorra chi-square correction, which addresses non-normality by adjusting the chi-square statistic and providing robust standard errors (Muthen & Muthen, 1998–2017). Using MLR in Mplus precludes the use of bootstrapping procedures, but it provides nearly identical estimates and addresses any non-normality in the data, and was evaluated to be the better statistical approach. Maximum likelihood (ML) estimates with bootstrapped samples may have incorrect standard errors and biased test statistics (Muthen & Muthen, 1998–2017).

Missing data in the current study were minimal and covariance coverage was greater than 96.6% for all bivariate pairs of variables. The data were considered missing at random (MAR), which presumes that variables in the model are predictive of missingness.

Additionally, when there are low levels of missing data (e.g., <10%), the use of modern missing data methods such as multiple imputation, full-information maximum likelihood, or Bayesian estimation will not make a meaningful difference in parameter estimates, standard errors, or increase statistical power (Enders, 2023).

Results

We present the correlations, means, and standard deviations of the study variables in Table 1 and the path model in Figure 1. Using cutoff scores (Walker et al., 2009), 21.3% reported emotional abuse, 23% reported physical abuse, 15.9% reported sexual abuse, 14.2% reported emotional neglect, and 20.2% reported physical neglect.

The SEM measurement model was first constructed by estimating the marital quality and childhood maltreatment latent variables, and the covariance between them. The measurement model demonstrated adequate fit (χ^2 (26) = 48.56, $p < .001$, CFI = .98, TLI = .98, RMSEA = .05). The standardized factor loadings of the maltreatment variable were .87, .76, .39, .80, and .66 for emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect, respectively (all *p*s < .001). The standardized loadings for the marital quality latent variable were .94, .75, .73, and .74 for support, marital risk, strain, and joint decision making respectively. Marital support had a substantively stronger factor loading compared to the other indicators, which can be an indicator of

Table 1. Correlations, means, and standard deviations of study variables.

	1	2	3	4	5	6	7	8	*M* (*SD*)
1. Child maltreatment	-								37.00 (13.01)
2. Marital strain	.12*	-							2.91 (1.41)
3. Marital support	−.13*	−.61***	-						2.06 (.63)
4. Marital decision making	.14*	−.70***	−.68***	-					3.64 (.53)
5. Marital risk	−.15*	.51***	.50***	−.71***	-				24.80 (4.65)
6. Health locus of control	−.04	−.13*	−.10	.17***	.16**	-			6.10 (0.76)
7. Health eating index	−.09	−.02	−.00	.02	.09	.21***	-		5.53 (1.39)
8. High density lipoprotein	−.06	−.05	−.08	.05	.00	.19***	.23***	-	53.22 (16.87)
9. Low density lipoprotein	.09	.18***	.08	−.19***	−.07	.02	.10	.19***	99.57 (34.15)

Note. *$p < .05$, **$p < .01$, ***$p < .001$. Childhood maltreatment was measured at the MIDUS 2 biomarker. Marital strain, support, decision making, and risk, and health locus of control were assessed at MIDUS 3. The healthy eating index, high density lipoprotein, and low density lipoprotein were measured at the MIDUS 3 biomarker.

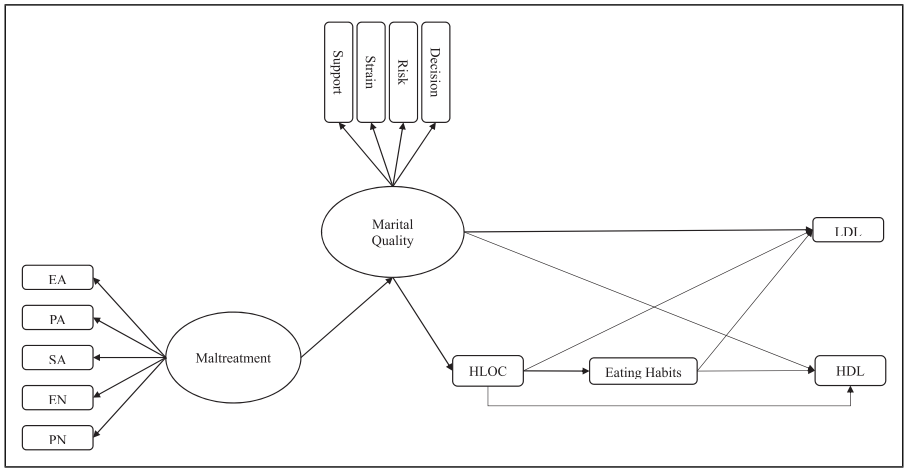

Figure 1. Path model depicting the hypothesized serial mediation model. *Note.* HLOC = health locus of control, LDL = low density lipoprotein, HDL = high density lipoprotein, EA = emotional abuse, PA = physical abuse, SA = sexual abuse, EN = emotional neglect, PN = physical neglect.

model misspecification. To assess for possible misspecification, we first explored covariances between the residuals of the marital quality indicators (Brown, 2015). When covarying the residuals among each possible pair of indicators, factor loadings did not meaningfully change, thus no residual covariances were retained. We also employed a second analysis to assess possible misspecification by fitting a bi-dimensional model with two latent constructs: positive (support and decision making) and negative marital quality (strain and risk). The positive and negative relationship quality factors are theoretically consistent with previous literature (e.g., Fitzgerald et al., 2020; Rogge et al., 2017). For all indicators, the factor loadings were fixed to 1 and the positive and negative relationship quality factors were correlated with each other (Rogge et al., 2017). The bi-dimensional model yielded an improper solution (Heywood case). Thus, mounting evidence suggests that the unidimensional construct was the best fit to the data and we found no evidence of significant model misspecification.

Next, we entered in the covariates, mediators, and outcome variables in a sequential manner to test for possible model specification and identification issues. We first included mediating and outcome variables then included covariates one at a time. We included depressive symptoms into the analysis; however, we obtained a non-positive definite solution in the first order derivative matrix, making results uninterpretable. We believe this is due to depressive symptoms having a low variance; depressive symptoms were not retained in the final model.

Results of the model are shown in Figure 2. The final model-data fit demonstrated good fit (χ^2 (105) = 176.521, $p < .001$, CFI = .96, TLI = .93, RMSEA = .04). Childhood maltreatment was inversely associated with marital quality ($\beta = -.17$, $p = .01$) such that more severe maltreatment was associated with a poorer quality marriage. Higher levels of

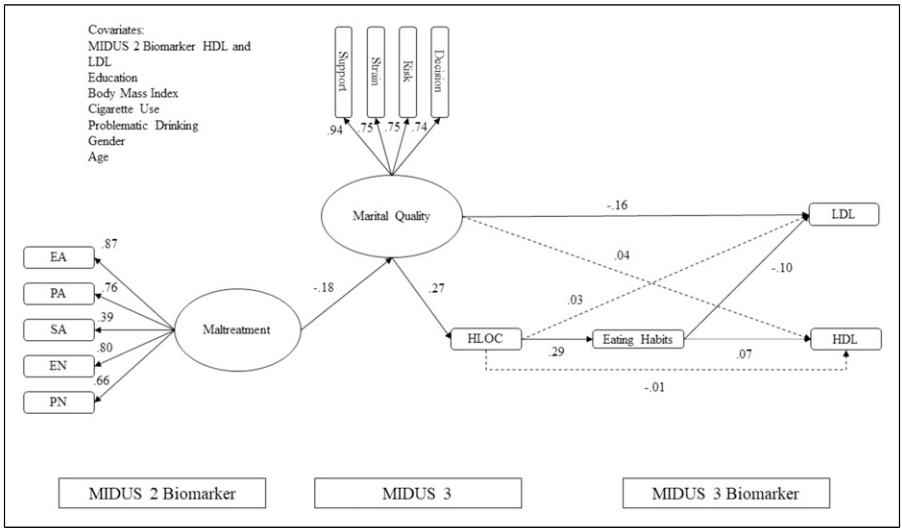

Figure 2. Path model depicting the standardized results of the structural equation mediation model linking child maltreatment to HDL and LDL via marital quality and health locus of control and eating habits. *Note*. Dashed lines indicate non-significant standardized parameter estimates. HLOC = health locus of control, LDL = low density lipoprotein, HDL = high density lipoprotein, EA = emotional abuse, PA = physical abuse, SA = sexual abuse, EN = emotional neglect, PN = physical neglect.

marital quality were associated with lower levels of LDL ($\beta = -.18$, $p = .002$), but was not associated with HDL ($\beta = -.02$, $p = .57$). Marital quality was also positively associated with greater health locus of control ($\beta = .27$, $p = .001$). Health locus of control was not associated with either HDL ($\beta = .03$, $p = .30$) or LDL ($\beta = .06$, $p = .32$), but was associated with healthier eating habits ($\beta = .29$, $p < .001$). Greater eating habits were, in turn, associated with higher HDL ($\beta = .10$, $p = .003$), but were not associated with LDL ($\beta = .07$, $p = .18$).

The indirect effects were only estimated if there was a significant direct effect among the independent variables and the mediators, meaning the indirect effect from maltreatment to HDL through marital quality and the indirect effects from maltreatment to HDL and LDL through marital quality and health locus of control were not estimated. The first indirect effect from maltreatment to LDL through marital quality was significant ($\beta = .03$, 95% CI [.001, .055]), indicating the relationship between childhood maltreatment and LDL over time was mediated by marital quality, independent of health locus of control, eating habits, and the covariates. The serial indirect effect from maltreatment to HDL through marital quality, health locus of control, and eating habits was non-significant ($\beta = .00$, 95% CI [-.001, .001]).

Sensitivity analyses

The first sensitivity analysis that we ran was to account for the measurement of HDL and LDL over time. First, we analyzed HDL and LDL as a difference score for HDL and LDL and we found no notable differences between the models as no paths were substantively different nor were any substantive conclusions. Second, we broke down childhood maltreatment into the five subtypes to discern whether specific forms of abuse and neglect were more or less influential. None of the maltreatment subtypes predicted marital quality, any of the mediators, and the outcome variables. Additional information is presented in the online supplemental material.

Discussion

Childhood maltreatment is a known risk factor for cardiometabolic problems (Ho et al., 2020; Kisely et al., 2022), and social determinants of health including marital quality, health locus of control, and eating habits have been recognized as factors that may influence cardiometabolic health (Maki, 2020; Newby et al., 2004) and may be mediating pathways. The current study examined a serial mediation model between childhood maltreatment and HDL and LDL cholesterol over time through marital quality, health locus of control, and eating habits. We found that the relationship between childhood maltreatment and LDL over time was mediated by marital quality. However, the serial indirect effect from maltreatment to HDL and LDL through marital quality, health locus of control, and eating habits was non-significant.

The findings make several contributions to existing knowledge. First, the current study demonstrates that marital quality may mediate the relationship between maltreatment and LDL, but not HDL, over time. Previous research has shown that childhood maltreatment negatively influences marital relationships (Fitzgerald, 2022; Fitzgerald & Morgan, 2023; Zamir, 2022) which can be attributed to disruptions in attachment (Riggs et al., 2011). Likewise, previous studies have also documented that marriage contributes to cholesterol levels (Bennett-Britton et al., 2017; Gallo et al., 2003). For example, spouses in higher quality marriages can encourage health promoting behavior, exert forms of social control, and discourage health hindering behavior (Ristovski-Slijepcevic & Chapman, 2005; Rowland et al., 2018; Thoits, 2011; Umberson, 1992). Our findings indicate that marital quality may be a mechanism connecting childhood maltreatment to cardiometabolic biomarkers and expand these findings by utilizing a longitudinal design, overcoming limitations of cross-sectional research (e.g., Ho et al., 2020). A poorer quality marriage may be characterized by disengagement and detachment where partners rarely interact. Due to disengagement, spouses may not attempt to model, guide, or shape health behavior of each other, leaving adults to manage their health individually (Thoits, 2011). Consistent with application of interdependence theory to health behavior (Lewis et al., 2006), partners who are disengaged and live parallel to each other may not talk about or make behavior changes if there are preclinical indicators of disease (e.g., high LDL). Alternatively, poorer quality marriages experience less support and greater conflict and strain, which likewise can reduce the health benefits. For example, couples may engage in

greater health hindering behavior such as substance use (Whisman & Baucom, 2012), which increases cardiometabolic risk (Kim et al., 2021; O'Keefe et al., 2014).

In contrast to previous findings (e.g., Kisely et al., 2022) we found that different maltreatment types were not related to HDL and LDL, and instead the relationship was cumulative. One possibility may be attributed to sampling differences, but we believe the longitudinal nature of our study also plays a critical role. There may be initial differences in maltreatment subtypes on HDL and LDL (e.g., time 1) through domain specific cascades. Although varying maltreatment types share numerous characteristics (e.g., fear, shame), research has documented that some forms of maltreatment exert a stronger effect on specific outcomes, such as emotional maltreatment playing a particularly strong role in the etiology of depressive symptoms (Nelson et al., 2017). Considering additional domain specific mediations linking maltreatment to HDL and LDL over time would provide a valuable contribution to the literature. Alternatively, the association between maltreatment and marital quality tends to be small to moderate (Zamir, 2022), and significant effects may go undetected due to low statistical power.

In contrast to our hypothesis, the serial indirect effect from maltreatment to HDL and LDL through marital quality, health locus of control, and eating habits was non-significant. First, each of the direct effects were statistically significant, providing some evidence for existing theory (Kiecolt-Glaser & Netwon, 2001; Lewis et al., 2006; Thoits, 2011); however, the indirect effect was not significant. This effect may be non-significant due to the number of mediators present and small parameter estimates. Indirect effects are calculated by multiplying the regression coefficients together and the small to moderate size of the four paths would create a very small indirect effect, and as a result, the study may have needed a larger sample size in order to detect the small effect size. While the indirect effect was statistically non-significant, there may be practical implications. For example, diet is a nearly ubiquitous prescription for increasing physical health among physicians; however, the effect sizes of diet on health are unimpressive (e.g., Widmer et al., 2015). There may also be sample and analytic characteristics that may contribute to the non-significant effect. While we had a large sample of adults (n = 352), using larger sample sizes may increase statistical power (e.g., decrease 95% confidence intervals) to detect the hypothesized indirect effects (MacKinnon et al., 2007), and this is particularly true for the detection of small effect sizes (e.g., eating habits to cholesterol).

Second, the non-significant indirect effect may indicate that the proposed relationships do not occur within the overall population of midlife and older adults. The lack of any significant mediated effect could very well be attributed to a non-significant effect in the population, and in that case, adapting current theoretical and conceptual foundations to more accurately reflect how maltreatment influences cardiometabolic health in adulthood is needed. For example, theoretical frameworks tend to focus on either the relationship between childhood maltreatment and adult relational health (e.g., Riggs et al., 2011; Zamir, 2022) or adult social relationships and health (Kiecolt-Glaser & Newton, 2001; Robles et al., 2014) with far fewer frameworks integrating trauma, relationships, and health despite mounting evidence (Fitzgerald & Morgan, 2023; Widom et al., 2018). Identification of novel theoretically derived pathways unique to those who experienced maltreatment would provide an invaluable contribution to the literature and could inform

prevention and intervention efforts (e.g., screening tools, community-based research). It is critical to replicate these findings in future studies to discern whether power is problematic and additional theoretical work will be critical to advance basic and applied science focused on reducing cardiometabolic risk.

Contrary to expectations, health locus of control was not associated with either HDL or LDL. Health locus of control may not be related to HDL or LDL because people need a combination of both high internal and high external locus of control to improve health (Norman et al., 1998). For example, people may feel that they are able to influence their own cholesterol levels, but will have only limited success without proper guidance from their physicians. For example, those who have high LDL and low HDL levels that have connections to underlying health conditions or genetic predisposition may not be able to lower their cholesterol without medication (Schade et al., 2020; Weissglas-Volkov & Pajukanta, 2010).

Limitations and future directions

Despite the strengths of the current study, findings should be interpreted in light of the limitations. First, childhood maltreatment was measured retrospectively and could be subject to recall bias; using prospective methods to measure the relationship between maltreatment and cardiometabolic health would provide a substantive improvement. Second, the internal health locus of control measure could be improved by assessing a wider range of beliefs and behaviors that likely play a critical role in shaping health behavior (Norman et al., 1998), and may be missing a key factor in health behavior. A third limitation is that cholesterol has a genetic component that we were unable to account for and is likely to be a contributing factor. Fourth, marital quality and health locus of control as well as eating habits and cardiometabolic biomarkers were measured at the same wave, precluding true longitudinal mediation among those variables. Another limitation is that the MIDUS did not differentiate between gender and biological sex and the social construct of gender was used in the current analysis. Therefore, we cannot differentiate between biological sex and gender. Likewise, race and ethnicity was conflated in the current analysis and future research should consider both race (e.g., Black) and cultural heritage (e.g., Italian). Our sample consisted of only married adults as to create a homogenous sample from which to test our hypotheses which is a strength and increases internal validity, but significantly hampers generalization to other relationship types (e.g., cohabitating). Research should address other forms of relationship status.

Conclusion

Our study provides longitudinal evidence that marital quality may be a possible pathway that connects child maltreatment to lower LDL levels. Although we found some support for health locus of control and eating habits serving as possible pathways, the mediated effect was small and non-significant. Further clarification on the processes by which marital quality may influence health is required, but our results lend further support that marriage appears to be a fruitful pathway from childhood maltreatment to cardiometabolic

biomarkers. These findings have implications for clinicians, researchers, and policy makers, and further highlight the potential for marital quality to be a source of prevention and intervention.

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Open research statement

As part of IARR's encouragement of open research practices, the Michael Fitzgerald and Viktoria Papp have provided the following information: This research was not pre-registered. The data used in the research are from a publicly available data set. The data can be obtained at: Inter-University Consortium for Political and Social Research. The materials used in the research are also available through Inter-University Consortium for Political and Social Research.

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Supplemental Material

Supplemental material for this article is available online.

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