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Original Article

Social Relationships and Salivary Telomere Length Among Middle-Aged and Older African American and White Adults

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Abstract

Objectives: A common mechanism underlying premature morbidity may be accelerated biological aging as reflected by salivary telomere length (STL). This study examined the extent to which social relationships, both positive and negative, can be protective or confer risk relative to biological aging.

Method: Data from the Health and Retirement Study and multiple regression were used to examine cross-sectional associations between STL, self-reported social support, and negative interaction (e.g., conflict, criticism) with family in a nationally representative sample of African American and non-Hispanic White middle-aged and older adults (N = 4,080).

Results: Social support from family was associated with shorter STL. Negative interaction with family had no main effect on STL but interactions characterized by high social support and more frequent negative interactions were associated with longer STL. Negative interaction with family was negatively associated with STL for African Americans and Whites but the magnitude of the effect was greater for African Americans.

Discussion: Study findings highlight the role of social relationships in physiological deterioration among middle-aged and older adults and identify a potential mechanism whereby race is linked to accelerated biological aging. Findings highlight the importance of considering positive and negative aspects of social relationships to understand the consequences of social connections for cellular aging in diverse populations.

Keywords: African Americans—Negative interaction—Social support—Telomere length

Social relationships are an important predictor of health across the life course. Even though social interactions decrease in later life, life satisfaction and subjective well-being are maintained or improved and health and mental health are protected when older adults have access to or are involved in supportive networks. The quality and quantity of social support have been consistently linked to a host of diverse health outcomes among older adults, including mortality (Hill, Uchino, Eckhardt, & Angel, 2016), depression and anxiety (Lincoln et al., 2010), heart disease (Compare et al., 2013), and rheumatoid arthritis (Stephenson, DeLongis, Esdaile, & Lehman, 2014). Social support is also associated with better physiological profiles characterized by reduced levels of blood pressure and cardiovascular reactivity (Steptoe, Lundwall, & Cropley, 2000), lower plasma and urinary catecholamine levels (Grewen, Girdler, Amico, & Light, 2005), lower overall cortisol levels (Rosal, King, Ma, & Reed, 2004), and better immune function (Yang, Schorpp, & Harris, 2014). Social support is thought to confer a health advantage in part because it buffers the potentially harmful influences of stress-induced physiological responses by decreasing deleterious cardiovascular and neuroendocrine changes during stress.

However, the effects of social relationships on health are not consistently positive. Empirical evidence suggests that social interactions such as conflict or receiving social support have negative consequences for physical and mental health and health behaviors (Scholz et al., 2012). The negative effects of social interactions have been attributed to mobilization effects (poor health mobilizes more social support, resulting in a negative association; Uchino, 2009); methodological issues associated with the operationalization of health outcomes and social support (Tay, Tan, Diener, & Gonzalez, 2013); or the effects of mismatched or miscarried support that might render support detrimental to health (Holt-Lunstad, Uchino, Smith, & Hicks, 2007). Together with the multidimensional nature of social resources, inconsistent findings regarding the effects of social interactions on health suggest that a more targeted approach is needed that considers specific sources and types of social relationships to clarify the health-promoting role of social resources.

Studies of social relationships have great potential to provide important mechanistic information on a more general biological mechanism by which aspects of social life may be linked to overall disease morbidity and mortality. For example, biological aging is thought to be a major contributor in the pathology of many chronic diseases (Kennedy et al., 2014). One hallmark indicator of aging at the cellular level is the telomere, a repeat sequence of DNA at the end of chromosomes that shortens over the lifetime. Short telomere length (TL) or greater rates of telomere shortening in later life predict cancer incidence (Lu et al., 2011), cardiovascular disease (Willeit et al., 2010), and earlier mortality (Duggan et al., 2014), making it a valuable marker of risk and cellular aging. Several cross-sectional studies have reported a relationship between shortened TL and life adversity, suggesting that personal experience, psychological processes, and behaviors across the life span may modify the rate of cellular aging (Price, Kao, Burgers, Carpenter, & Tyrka, 2013). However, TL varies depending on context and experiences, including social relationships that are not usually accounted for in most research on biological aging (Carroll, Diez Roux, Fitzpatrick, & Seeman, 2013).

A handful of studies examined the association between social relationships and TL. Despite some methodological limitations (e.g., very small clinical or predominantly White samples, operationalization of social support), findings suggest that unmarried individuals (Mainous et al., 2011) confirmed correct and those with ambivalent social ties (i.e., high social support and high negative interaction; Uchino et al., 2012) have shorter telomeres. One study that considered social support from a support group (along with other behavioral changes including diet, exercise, and stress management) reported telomere lengthening in its sample, although it did not report the unique effect of social support (Ornish et al., 2013). Carroll and colleagues (2013) conducted the first study of social support and TL and used a racially and ethnically diverse sample of middle-aged and older adults (45–84 years). Social support was positively associated with leukocyte TL but only in the oldest age group (65–84 years; Carroll et al., 2013). This study was limited by restricting its sample to respondents with subclinical and clinical cardiovascular disease risk. Although data were available, researchers did not examine racial differences. Therefore, the extent to which the effect of social support on TL is similar in the general population of adults or across racial groups is largely unknown. Another study involving older adults compared leukocyte TL among Australian married adults who did or did not report their spouse as a source of social support (Windsor & Butterworth, 2010). Respondents who lacked a supportive spouse (but received support from other sources) had shorter TL compared to those who received social support from their spouse. Finally, one study found an association between negative interaction with friends and family and TL in a racially diverse sample of adults (Geronimus et al., 2015). However, the small sample size might have been too prohibitive to test for variation in TL by race. Other studies documented associations between negative interaction and other biological risks such as allostatic load (Brooks et al., 2014) and greater cardiovascular (Steptoe et al., 2000) and physiological (King, Atienza, Castro, & Collins, 2002) reactivity.

Collectively, these studies suggest that individuals reporting more positive social relationships have longer TL and that negative interactions have detrimental effects on physiologic processes. However, research on racial differences is limited. Some evidence indicates that social ties vary by race, with African Americans reporting subjectively closer ties (Taylor, Forsythe-Brown, Taylor, & Chatters, 2014), more involvement and interactions with family members (Taylor, Chatters, Woodward, & Brown, 2013), and more strained relationships (Umberson, Williams, Thomas, Liu, & Thomeer, 2014) compared to Whites. Thus, variation in TL by race might be attributable to differences in the type and quality of social ties among African Americans compared to Whites and the extent to which these social interactions buffer stress or promote healthier behavior patterns. Evidence regarding the association between race and TL is mixed, with some studies reporting shorter TL for African Americans compared to Whites (Diez Roux et al., 2009) and others reporting the opposite (Drury et al., 2015). However, scholars generally agree that TL attrition, an indicator of cellular aging predicted by initial TL, is significantly greater among African Americans (Diez Roux et al., 2009; Drury et al., 2015). The extent to which modifiable risk factors can be identified is important for lengthening the health span of African Americans.

In addition to failing to test for moderation by race, extant studies did not give equal consideration to the positive and negative aspects of social relationships. Social support, defined in the current study as the perception that one is loved and cared for, and negative interactions, defined here as unpleasant experiences such as conflict and criticism, are different aspects of social relationships that have distinct effects on health outcomes. Thus, the presence

of social support is not equal to the absence of negative interaction. Both aspects of social interactions should be considered to determine the quality (vs. quantity) of social relationships since it is the quality of social exchange that is a particularly important consideration for research on older adults. Studies have shown an age-related reduction in overall social network size and frequency of contact (Charles & Carstensen, 2010). On the other hand, older adults may have higher-quality relationships in smaller social networks. Socioemotional selectivity theory (Carstensen, 1992) posits that as we age, we become more selective and strengthen emotional ties, dissolving peripheral relationships and creating a smaller number of high-quality relationships. Kahn and Antonucci's (1980) social convoy model suggests that our convoy of relationships changes as we age and highlights the increasing importance of emotional quality, rather than only the quantity, of social contacts in older age.

Another limitation of current studies of social relationships and TL is that investigators either treated social relationships as unidimensional (e.g., positive aspects of social relationships; Carroll et al., 2013) or combined various sources of support (e.g., spouse, child, friend, relatives, siblings; Uchino et al., 2012). The key question for social relationship theory is whether or not social ties are associated with biologically plausible pathways that are implicated in age-related chronic disease risk. Recent studies suggest this could be true (Carroll et al., 2013; Mainous et al., 2011; Ornish et al., 2013; Uchino et al., 2012). Thus it is important to consider (a) the source of support rather than general models that aggregate a variety of sources and (b) how social relationships are measured (e.g., perceptions, receipt, number, size) to understand the effects of various domains on telomere maintenance, lengthening, and shortening. Essentially, studies that employ more precise measures of social relationships are needed to articulate more clearly how social relationships can be augmented to optimize health. Prior studies have not directly tested associations between social relationships with extended family members (e.g., beyond the nuclear family) and TL. Increased longevity, declining marriage rates, fewer children, and increasing childlessness among older adults (Redfoot, Feinberg, & Houser, 2013) highlight the significant need for studies that examine the role of extended family members as sources of social support and care for older adults.

The current study sought to extend findings and address limitations and knowledge gaps in this small but extremely important body of work on social relationships and TL. The primary research question was whether social relationships with extended family members are associated with salivary TL (STL). Using a large representative sample of diverse, community-dwelling, middle-aged and older adults, the association between social relationships (positive and negative) and STL was examined. Because of known differences in TL and social relationships by race, the extent to which race moderated the association between social relationships and STL was also examined. Hypotheses for this study were: (a) social relationships operationalized as perceived emotional support from and negative interaction with extended family members are associated with cellular (biological) aging as indexed by shorter STL; (b) social relationships characterized by high social support and more frequent negative interactions (e.g., ambivalent ties) have more detrimental effects on STL; and (c) the association between social relationships and STL differs by race.

Methods

Sample and Procedures

Data for this study came from public and sensitive data from University of Michigan's Health and Retirement Study (HRS). The HRS is a longitudinal panel study that surveys a nationally representative, community-based, racially and socioeconomically diverse sample of more than 37,000 individuals older than 50 every 2 years. The HRS explores changes in health transitions of individuals toward the end of their work lives and in the years that follow. The 2008 Telomere Data released in December 2013 includes average TL data from a random sample of HRS participants who consented and provided a saliva sample during the 2008 interview wave. All data used in the current study are from the 2008 wave of the HRS. The current study features data from 4,080 respondents.

Measures

Salivary telomere length

Saliva was collected from 5,808 HRS respondents who consented and provided a saliva sample during the 2008 interview wave. TL was measured from saliva. STL correlates highly with TL measured via blood leukocyte (Mitchell et al., 2014) and correlates with other risk factors for adverse health outcomes such as familial risk for depression (Gotlib et al., 2015), tobacco smoking (Chen et al., 2015), perceived stress (Chen et al., 2015), disadvantaged social environments (Mitchell et al., 2014), and hypothalamic–pituitary axis dysregulation (Gotlib et al., 2015). Saliva samples were obtained using an Oragene collection kit and samples were sent to a central laboratory for DNA extraction. All DNA samples were sent in 96-well plates to Telome Health, where they were stored in their original plates in a −80°C freezer upon arrival, thawed on ice, stored at 4°C, and assayed within 1 week. TL assays were performed using quantitative real-time polymerase chain reaction, adapted from the original method described by Cawthon (2002). The ratio of telomere sequence copy number in each respondent's sample to a single gene copy number was determined. This ratio is proportional to mean TL. Genomic DNA from pooled 100 male donors was used as the standard reference. A triplicate serial dilution was used to create a 6-point standard curve containing 5.0000, 1.6667, 0.5556, 0.1852, 0.6173, and 0.0206 ng of DNA

in separate reaction tubes. The quality control success rate was 98.17%.

Social relationships

Perceived emotional support from extended family members was measured with an index created from the mean of three items that assessed the extent to which respondents' family members "understood their feelings" and the extent to which respondents could "rely on them" and "open up to talk." Each item had four response categories (1 = *not at all*, 2 = *some*, 3 = *a little*, 4 = *a lot*) and higher values indicated higher levels of social support (α = .86). Negative interaction with extended family members was measured using an index created from the mean of four items that assessed the extent to which respondents' family members made "too many demands," "criticize you," "let you down," and "get on your nerves." Each item had four response categories (1 = *not at all*, 2 = *some*, 3 = *a little*, 4 = *a lot*) and higher values indicated higher levels of negative interaction (α = .78).

Covariates

Covariates included self-reported race (African American, non-Hispanic White), gender, age in years, combined annual household income in dollars, educational attainment (years completed and top-coded at 17), marital status (previously married, widowed, and never married), and number of chronic health conditions assessed using a checklist of common diseases (e.g., cardiovascular diseases, diabetes, cancer, stroke).

Analyses

All analyses used data weighted for differential probabilities of selection into the HRS sample using the SVY survey analysis procedures of Stata version 11.2. Weighted cross-tabulations and χ^2 or *t*-test statistics were used to describe characteristics of the HRS data by race. The correlation between perceived emotional support and negative interaction was -.20. The distribution of average STL ranged from 0.199 to 21.124 and this variable had a small number of outliers (n = 19), which were top-coded to a value of 5. This resulted in a nearly normal distribution. Ordinary least squares regression models examining social support and negative interaction in relation to STL were specified. Analyses also tested whether the association between social support and STL and negative interaction and STL differed for African Americans and Whites. Finally, the interaction between social support and negative interaction was examined to test for moderation, or a buffering effect, of social support on the association between negative interaction and STL.

Results

African Americans had longer STL, on average, compared to non-Hispanic Whites (1.51 vs. 1.33, respectively; Table 1). On average, African Americans were younger (65.04 years vs. 67.57 years), had lower levels of education (12.06 years vs. 13.35 years) and less household income ($39,164 vs. $75,092) and were less likely to be married (41.58% vs. 67.83%) compared to Whites. African Americans reported more chronic health conditions (2.41 vs. 2.10), higher levels of social support (3.18 vs. 3.16) and more frequent negative interactions with family members (1.87 vs. 1.69) compared to Whites. All of these differences were statistically significant.

Results from multivariable linear regression models are presented in Table 2. Controlling for covariates, race was significantly associated with STL, with African Americans having longer STL than non-Hispanic Whites (Model 1: b = 1.536, SE = 0.098, p < .001). Gender was associated with STL, such that women had longer average STL than men (b = 0.041, SE = 0.016, p < .01). Age was negatively associated with STL (b = −0.033, SE = 0.001, p < .01). Social support was negatively associated with STL, such

Table 1. Descriptive characteristics of African Americans and non-Hispanic Whites (N = 4,515)

	African American (n = 626) M or %	Non-Hispanic White (n = 3,889) M or %	p
Salivary telomere length	1.51	1.33	<.001
Female	59.61	55.22	.107
Age	65.04	67.57	<.001
Education	12.06	13.35	<.001
Household income	39,164.16	75,092.41	<.001
Marital status			<.001
Married or partnered	41.58	67.83	
Separated or divorced	28.29	12.02	
Widowed	21.09	17.16	
Never married	9.05	2.98	
Number of chronic conditions	2.41	2.10	<.001
Social support	3.18	3.16	<.001
Negative interaction	1.87	1.69	<.001

Table 2. Multivariable Linear Regression Analyses of Social Relationships and Salivary Telomere Length Among African Americans and Non-Hispanic Whites (N = 4,080)

	Model 1 *b* (*SE*)	Model 2 *b* (*SE*)	Model 3 *b* (*SE*)
Intercept	1.536 (0.098)***	1.635 (0.112)***	1.617 (0.111)***
African American	0.180 (0.033)***	0.178 (0.033)***	0.480 (0.218)*
Female	0.041 (0.016)**	0.041 (0.016)**	0.041 (0.016)**
Age	−0.003 (0.001)**	0.002 (0.003)**	−0.002 (0.001)**
Education	0.002 (0.003)	0.002 (0.003)	0.002 (0.003)
Household income	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)
Previously married	−0.022 (0.023)	−0.021 (0.023)	−0.022 (0.228)
Widowed	−0.007 (0.022)	−0.005 (0.002)	−0.004 (0.022)
Never married	0.034 (0.045)	0.032 (0.044)	0.032 (0.044)
Chronic conditions	−0.010 (0.005)	−0.010 (0.005)	−0.010 (0.006)
Social support	−0.018 (0.009)*	−0.055 (0.020)**	−0.057 (0.020)**
Negative interaction	−0.003 (0.014)	−0.063 (0.032)*	−0.064 (0.033)
Social support × Negative interaction		0.024 (0.011)*	0.028 (0.012)*
Race × Social support			−0.053 (0.045)
Race × Negative interaction			−0.080 (0.111)†
R^2	.023	.024	.025

Note: Excluded categories: race (0 = White), gender (0 = male), and marital status (0 = married).
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

that respondents who reported higher levels of social support from family members had shorter STL (b = −0.018, SE = 0.009, $p < .05$).

Testing the interactions between social support and negative interaction (Model 2) revealed a significant interaction (b = 0.024, SE = 0.011, p = .046). Tests revealed no significant interaction between race and social support (b = −0.053. SE = 0.045, p = .238; Model 3). However, a significant interaction existed between race and negative interaction (b = −0.080, SE = 0.111, p = .084; Model 3). Choosing a p value of .10 instead of the usual .05 for interaction was recommended by the Food and Drug Administration in 1985 (Fleiss, 1986) to be conservative and this criterion has been used in many clinical studies, becoming a standard for testing interactions (Fernandez y Garcia, Nguyen, Duan, Gabler, & Kravitz, 2010).

To illustrate the interaction between social support and negative interaction, predicted values of STL were constructed. In plotting the relationship between negative interaction and social support from family, negative interaction was dichotomized with the minimum value of the continuous variable representing low negative interaction and the maximum value of the continuous variable representing high negative interaction. Values of 1–4 were used to represent the range of possible scores for social support from family (Figure 1). For the interaction between negative interaction and race, values of 1–4 were used to represent the range of possible scores for negative interaction with family (Figure 2). For all other independent variables, mean values were used to illustrate relationships for the average participant. Because the purpose of our analysis was to detect differences in slopes between groups rather than differences in group means at a particular level of another factor, we did not conduct simple-effects analyses. Essentially, we focused our analysis on how the relationship between family support and STL varied by levels of

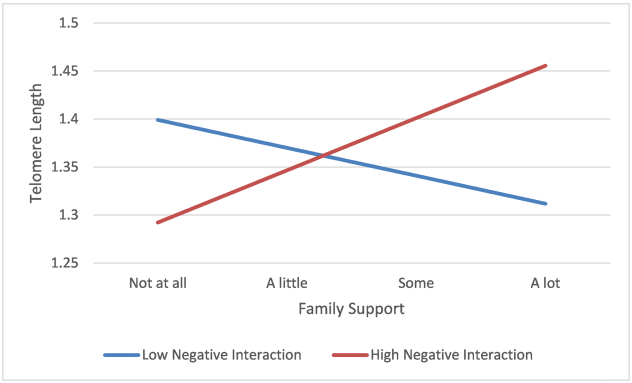

Figure 1. Salivary telomere length by social support and negative interaction among African Americans and non-Hispanic Whites (n = 4,080).

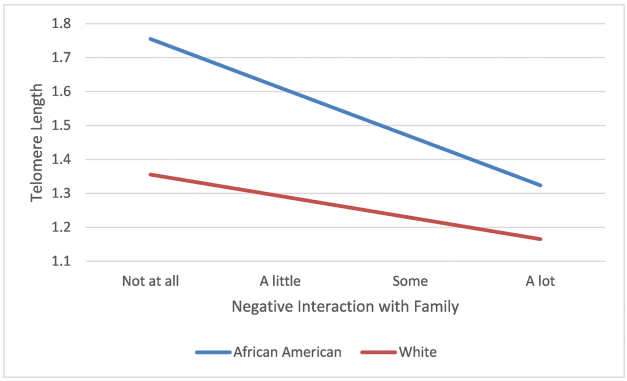

Figure 2. Salivary telomere length by race and negative interaction among African Americans and non-Hispanic Whites (n = 4,080).

negative interaction and how the relationship between negative interaction and STL varied by race. Simple-effects analysis, on the other hand, is used to determine if groups in one factor (e.g., race; African Americans and Whites) differed in their means at a given level of the second factor (e.g., negative interaction; e.g., "not at all").

Findings regarding the interaction between social support and negative interaction indicate that respondents who had low levels of negative interaction with family and high levels of social support had shorter STL. Respondents who had both high social support and more frequent negative interaction had longer STL compared to their counterparts. Findings for the interaction between race and negative interaction indicate that STL decreased at higher levels of negative interaction, albeit at a lower rate for Whites.

Discussion

Findings from this study indicated that positive and negative aspects of social relationships were associated with STL, a marker of cellular aging and longevity, in a large sample of community-dwelling African American and non-Hispanic White middle-aged and older adults. Social support from family members was associated with shorter STL, even when controlling for demographic factors (e.g., race, gender, age, socioeconomic status) and chronic health conditions. When the effects of social relationships were examined by race, the harmful effects of negative interactions on STL were more pronounced for African Americans than non-Hispanic Whites. The interaction between social support and negative interaction highlights the complexity of social relationships and importance of considering both positive and negative aspects of social ties simultaneously to determine their potential as protective or risk factors for cellular aging. Taken together, these findings build on existing studies of social relationships and cellular aging, demonstrate the importance of considering the positive and negative aspects of social relationships in family networks, and highlight the extent to which social connections may vary by race.

Contrary to expectations, social support was associated with shorter STL. Although previous studies have reported positive (Barger & Cribbet, 2016; Carroll et al., 2013) or no association (Uchino et al., 2012) between social support and TL, these studies assessed the number of network members from a variety of sources (Uchino et al., 2012), the availability of emotional support from no identified source (Carroll et al., 2013), or support from a spouse (Barger & Cribbet, 2016). In this study, the availability of emotional support from extended family members (e.g., excluding spouses and children) was measured to determine whether support from relatives is an important determinant of biological processes related to poor health among adults, regardless of their marital and parental status. It is not clear why emotional support from extended family members would be associated with shorter telomeres. Perhaps this measure captured information about miscarried help (Holt-Lunstad et al., 2007), feelings of indebtedness or inequity following support receipt (Tay et al., 2013), or a mismatch between the needs or expectations of the support recipient and support provided (Holt-Lunstad et al., 2007). Support mobilization is also possible; that is, people with poor health profiles, as indexed by shorter telomeres, might receive more support from others (Uchino, 2009). Studies have also shown that visible support (i.e., explicit acts) can increase emotional reactivity and lead to negative health consequences for the recipient, whereas invisible support (e.g., subtle or indirect) can reduce emotional reactivity to stress (Bolger & Amarel, 2007). Clearly, more studies that consider the source and dimension of social support are needed to clarify whether and which sources of social support are protective or confer risk relative to cellular aging.

More frequent negative interaction with family was associated with shorter telomeres for African Americans and Whites. In the current study, African Americans had longer telomeres than Whites, but this advantage substantially diminished in the context of negative interaction with family. Although TL decreased with negative interaction among Whites as well, this reduction was lesser than among African Americans. Only two other studies examined the association between negative interaction (e.g., conflict, disagreements, upset) and TL. One study reported a direct association between negative interaction and TL (Geronimus et al., 2015) but did not test for racial differences, whereas the other found no association (Uchino et al., 2012). Methodological differences between our study and this prior research might help explain these divergent findings, including how the current study operationalized negative interaction to include only extended family members and its use of a racially and economically diverse, nationally representative sample. However, findings from this study are consistent with studies reporting associations between high negative interaction and biological risk such as allostatic load (Brooks et al., 2014), greater cardiovascular reactivity and elevated ambulatory blood pressure (Steptoe et al., 2000), and heightened physiological reactivity (King et al., 2002). The finding that negative interaction had a more robust impact on STL for African Americans than Whites is also supported by previous studies that reported racial variation in social relationships and potential racial differences in the impact of relationships on health (Umberson & Montez, 2010). Some evidence suggests that African Americans report higher levels of strain in their relationships than Whites (Umberson et al., 2014), likely due to several factors including high levels of social adversity and stress exposure and inadequate resources for managing acute and chronic stress (much of which is related to racial discrimination). Significant adversity experienced during the life course can affect social relationships and contribute to inequalities in adult health. This could be the case for African Americans in this sample.

High social support and more frequent negative interaction (e.g., ambivalent ties) were associated with longer STL in this study. This finding was somewhat surprising

given a previous study that linked ambivalent ties with shorter telomeres (Uchino et al., 2012). However, studies of social support and cellular aging are in their infancy. Thus disparate findings are to be expected as different samples and measures are used. Social support can potentially mitigate the effects of negative interaction on STL, especially for those who experience frequent negative interaction with family members. Consistent with the stress-buffering hypothesis (Cohen & McKay, 1984), social support is more beneficial for individuals experiencing high levels of stress than those experiencing no or low levels of stress. Negative interaction is a particular type of interpersonal stress with detrimental health effects.

Classic approaches to ambivalence assume that the positive component of ambivalence exacerbates the harmful effects of negative feelings. Studies of ambivalence also have suggested that the effects of negative interactions on TL might be unaffected by the presence of social support (Gilligan, Suitor, Feld, & Pillemer, 2015). However, the literature on social support suggests that positive feelings may reduce the detrimental effects of negative feelings and interactions (Walen & Lachman, 2000). Indeed, positive relationship quality (Rook, 2001) and emotional support from family (Lincoln & Chae, 2012) have been found to create a buffering effect, especially in the case of close ties. Therefore, rather than ambivalent ties representing contradictory feelings that lead to poor health outcomes, ambivalent ties might reflect close family relationships that may be a normative experience rather than an upsetting one.

Another interesting finding is that respondents who reported less frequent negative interaction and high social support (e.g., optimal or supportive networks) had shorter STL than those with ambivalent ties. Secondary analyses were conducted to test if the interaction between social support and negative interaction is stronger in older adults who might already be showing age-related declines in physiological function or if the association differs by race, given previously reported shorter TL for African Americans (Diez Roux et al., 2009). Neither age nor race moderated the relationship. It is not clear why optimal or supportive networks are associated with shorter STL. However, the possibility of mobilization effects cannot be ruled out; that is, respondents with shorter telomeres might have developed more supportive networks in response to their health needs. Future work is needed to understand why supportive networks (high social support and low negative interaction) are associated with shorter TL.

Findings from this study should be considered in the context of its strengths and limitations. First, the cross-sectional nature of these analyses prevented us from inferring causal relations. Ideally, studies should examine predictors of telomere change over time. Here, although social support was associated with shorter STL in this sample, the possibility that telomere shortening is associated with social support because it is a marker of chronic conditions causally linked to increases in social support cannot be ruled out. For example, underlying morbidities and physical declines in functioning, which may be a consequence of or cause telomere shortening, could mobilize social networks to provide more support or increase social support seeking by the recipient. Future studies are needed that employ repeated assessments of TL over time to test whether social support predicts changes in TL and how TL is related to dynamics of reported social support and negative interaction. A second limitation is the fact that the measure of social support used in this study assessed perceived emotional but not instrumental or informational support, which may have different associations with STL. Future work should consider using other dimensions of social support and measures of equivalence in social exchanges, especially given the known health benefits of reciprocity in social exchange (and the health consequences of nonreciprocal relationships; Wahrendorf, Ribet, Zins, Goldberg, & Siegrist, 2010). It also seems plausible that the negative association of social support with STL is due to unmeasured factors such as personality characteristics that persist across the lifetime and are also associated with social support seeking or higher perceived social support or negative interactions. Likewise, given that adversity is associated with shorter TL (O'Donovan, Neylan, Metzler, & Cohen, 2012), social relationships could be associated with TL through chronic stress, such that individuals may seek assistance from members of their support networks. Future work is needed to identify causal paths using longitudinal analyses.

Strengths of this study include its large, nationally representative sample with positive and negative measures of social relationships. In addition, the analyses statistically controlled for several demographic factors and risk factors with known associations with TL, including race, age, gender, income, and chronic health conditions. Associations between social relationships and STL in middle-aged and older adults remained statistically significant after adjusting for these factors. Findings also indicate that the positive and negative aspects of social relationships have independent associations with STL and that these associations vary based on race. Findings that social support operates differently in relationships described as supportive or optimal (high social support and low negative interaction) and that ambivalent ties (high social support and high negative interaction) might be protective highlight the need for future work that examines different types and sources of social exchange and their distinct roles as protective and risk factors for cellular aging in diverse populations.

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Author Contributions

K. D. Lincoln planned the study, supervised the data analysis, and wrote the paper. D. Lloyd performed all statistical analyses. A. W.

Nguyen performed all analysis for the interactions, created the corresponding figures, and reviewed the manuscript.

Conflict of Interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

References

Barger, S. D., & Cribbet, M. R. (2016). Social support sources matter: Increased cellular aging among adults with unsupportive spouses. *Biological Psychology*, **115**, 43–49. doi:10.1016/j.biopsycho.2016.01.003

Bolger, N., & Amarel, D. (2007). Effects of social support visibility on adjustment to stress: Experimental evidence. *Journal of Personality and Social Psychology*, **92**, 458–475. doi:10.1037/0022-3514.92.3.458

Brooks, K. P., Gruenewald, T., Karlamangla, A., Hu, P., Koretz, B., & Seeman, T. E. (2014). Social relationships and allostatic load in the MIDUS study. *Health Psychology*, **33**, 1373–1381. doi:10.1037/a0034528

Carroll, J. E., Diez Roux, A. V., Fitzpatrick, A. L., & Seeman, T. (2013). Low social support is associated with shorter leukocyte telomere length in late life: Multi-ethnic study of atherosclerosis. *Psychosomatic Medicine*, **75**, 171–177. doi:10.1097/PSY.0b013e31828233bf

Carstensen, L. L. (1992). Social and emotional patterns in adulthood: Support for socioemotional selectivity theory. *Psychology and Aging*, **7**, 331–338. doi:10.1037/0882-7974.7.3.331

Cawthon, R. M. (2002). Telomere measurement by quantitative PCR. *Nucleic Acids Research*, **30**, e47. doi:10.1093/nar/30.10.e47

Charles, S. T., & Carstensen, L. L. (2010). Social and emotional aging. *Annual Review of Psychology*, **61**, 383–409. doi:10.1146/annurev.psych.093008.100448

Chen, X., Velez, J. C., Barbosa, C., Pepper, M., Andrade, A., Stoner, L.,…Williams, M. A. (2015). Smoking and perceived stress in relation to short salivary telomere length among caregivers of children with disabilities. *Stress (Amsterdam, Netherlands)*, **18**, 20–28. doi:10.3109/10253890.2014.969704

Cohen, S., & McKay, G. (1984). Social support, stress, and the buffering hypothesis: A theoretical analysis. In A. Baum, S. E. Taylor, & J. E. Singer (Eds.), *Handbook of psychology and health* (pp. 253–267). Hillsdale, NJ: Lawrence Erlbaum.

Compare, A., Zarbo, C., Manzoni, G. M., Castelnuovo, G., Baldassari, E., Bonardi, A.,…Romagnoni, C. (2013). Social support, depression, and heart disease: A ten year literature review. *Frontiers in Psychology*, **4**, 384. doi:10.3389/fpsyg.2013.00384

Diez Roux, A. V., Ranjit, N., Jenny, N. S., Shea, S., Cushman, M., Fitzpatrick, A., & Seeman T. (2009). Race/ethnicity and telomere length in the Multi-Ethnic Study of Atherosclerosis. *Aging Cell*, **8**, 251–257. doi:10.1111/j.1474-9726.2009.00470.x

Drury, S. S., Esteves, K., Hatch, V., Woodbury, M., Borne, S., Adamski, A., & Theall, K. P. (2015). Setting the trajectory: Racial disparities in newborn telomere length. *The Journal of pediatrics*, **166**, 1181–1186. doi:10.1016/j.jpeds.2015.01.003

Duggan, C., Risques, R., Alfano, C., Prunkard, D., Imayama, I., Holte, S.,… McTiernan, A. (2014). Change in peripheral blood leukocyte telomere length and mortality in breast cancer survivors. *Journal of the National Cancer Institute*, **106**, dju035. doi:10.1093/jnci/dju035

Fernandez y Garcia, E., Nguyen, H., Duan, N., Gabler, N. B., & Kravitz, R. L. (2010). Assessing heterogeneity of treatment effects: Are authors misinterpreting their results? *Health Services Research*, **45**, 283–301. doi:10.1111/j.1475-6773.2009.01064.x

Fleiss, J. L. (1986). Analysis of data from multiclinic trials. *Controlled Clinical Trials*, **7**, 267–275. doi:10.1016/0197-2456(86)90034–6

Geronimus, A. T., Pearson, J. A., Linnenbringer, E., Schulz, A. J., Reyes, A. G., Epel, E. S.,… Blackburn, E. H. (2015). Race-ethnicity, poverty, urban stressors, and telomere length in a detroit community-based sample. *Journal of Health and Social Behavior*, **56**, 199–224. doi:10.1177/0022146515582100

Gilligan, M., Suitor, J. J., Feld, S., & Pillemer, K. (2015). Do positive feelings hurt? Disaggregating positive and negative components of intergenerational ambivalence. *Journal of Marriage and the Family*, **77**, 261–276. doi:10.1111/jomf.12146

Gotlib, I. H., LeMoult, J., Colich, N. L., Foland-Ross, L. C., Hallmayer, J., Joormann, J.,… Wolkowitz, O. M. (2015). Telomere length and cortisol reactivity in children of depressed mothers. *Molecular Psychiatry*, **20**, 615–620. doi:10.1038/mp.2014.119

Grewen, K. M., Girdler, S. S., Amico, J., & Light, K. C. (2005). Effects of partner support on resting oxytocin, cortisol, norepinephrine, and blood pressure before and after warm partner contact. *Psychosomatic Medicine*, **67**, 531–538. doi:10.1097/01.psy.0000170341.88395.47

Hill, T. D., Uchino, B. N., Eckhardt, J. L., & Angel, J. L. (2016). Perceived social support trajectories and the all-cause mortality risk of older Mexican American women and men. *Research on Aging*, **38**, 374–398. doi:10.1177/0164027515620239

Holt-Lunstad, J., Uchino, B. N., Smith, T. W., & Hicks, A. (2007). On the importance of relationship quality: The impact of ambivalence in friendships on cardiovascular functioning. *Annals of Behavioral Medicine*, **33**, 278–290. doi:10.1080/08836610701359795

Kahn, R. L., & Antonucci, T. C. (1980). Convoys over the life course: Attachment roles and social support. In P. B. Baltes & O. G. Brim (Eds.), *Life-span development and behaviour* (Vol. **3**, pp. 253–286). New York, NY: Academic Press.

Kennedy, B. K., Berger, S. L., Brunet, A., Campisi, J., Cuervo, A. M., Epel, E. S.,…Sierra, F. (2014). Geroscience: Linking aging to chronic disease. *Cell*, **159**, 709–713. doi:10.1016/j.cell.2014.10.039

King, A. C., Atienza, A., Castro, C., & Collins, R. (2002). Physiological and affective responses to family caregiving in the natural setting in wives versus daughters. *International Journal of Behavioral Medicine*, **9**, 176–194. doi:10.1207/S15327558IJBM0903_02

Lincoln, K. D., & Chae, D. H. (2012). Emotional support, negative interaction and major depressive disorder among African Americans and Caribbean Blacks: Findings from the National Survey of American Life. *Social Psychiatry and Psychiatric Epidemiology*, **47**, 361–372. doi:10.1007/s00127-011-0347-y

Lincoln, K. D., Taylor, R. J., Bullard, K. M., Chatters, L. M., Woodward, A. T., Himle, J. A., & Jackson, J. S. (2010). Emotional support, negative interaction and DSM IV lifetime disorders among older African Americans: Findings from the

National Survey of American Life (NSAL). *International Journal of Geriatric Psychiatry*, **25**, 612–621. doi:10.1002/gps.2383

Lu, L., Zhang, C., Zhu, G., Irwin, M., Risch, H., Menato, G.,… Yu, H. (2011). Telomerase expression and telomere length in breast cancer and their associations with adjuvant treatment and disease outcome. *Breast Cancer Research: BCR*, **13**, R56. doi:10.1186/bcr2893

Mainous, A. G. 3rd, Everett, C. J., Diaz, V. A., Baker, R., Mangino, M., Codd V., & Samani, N. J. (2011). Leukocyte telomere length and marital status among middle-aged adults. *Age and Ageing*, **40**, 73–78. doi:10.1093/ageing/afq118

Mitchell, C., Hobcraft, J., McLanahan, S. S., Siegel, S. R., Berg, A., Brooks-Gunn, J.,… Notterman, D. (2014). Social disadvantage, genetic sensitivity, and children's telomere length. *Proceedings of the National Academy of Sciences of the United States of America*, **111**, 5944–5949. doi:10.1073/pnas.1404293111

O'Donovan, A., Neylan, T. C., Metzler, T., & Cohen, B. E. (2012). Lifetime exposure to traumatic psychological stress is associated with elevated inflammation in the Heart and Soul Study. *Brain, Behavior, and Immunity*, **26**, 642–649. doi:10.1016/j.bbi.2012.02.003

Ornish, D., Lin, J., Chan, J. M., Epel, E., Kemp, C., Weidner, G.,… Blackburn, E. H. (2013). Effect of comprehensive lifestyle changes on telomerase activity and telomere length in men with biopsy-proven low-risk prostate cancer: 5-year follow-up of a descriptive pilot study. *The Lancet Oncology*, **14**, 1112–1120. doi:10.1016/S1470-2045(13)70366-8

Price, L. H., Kao, H. T., Burgers, D. E., Carpenter, L. L., & Tyrka, A. R. (2013). Telomeres and early-life stress: An overview. *Biological Psychiatry*, **73**, 15–23. doi:10.1016/j.biopsych.2012.06.025

Redfoot, D., Feinberg, L., & Houser, A. (2013). *The aging of the baby boom and the growing care gap: A look at future declines in the availability of family caregivers*. Washington, DC: AARP Public Policy Institute.

Rook, K. S. (2001). Emotional health and positive versus negative social exchanges: A daily diary analysis. *Applied Developmental Science*, **5**, 86–97. doi:10.1207/S1532480XADS0502_4

Rosal, M. C., King, J., Ma, Y., & Reed, G. W. (2004). Stress, social support, and cortisol: inverse associations? *Behavioral Medicine (Washington, D.C.)*, **30**, 11–21. doi:10.3200/BMED.30.1.11-22

Scholz, U., Klaghofer, R., Dux, R., Roellin, M., Boehler, A., Muellhaupt, B.,…Goetzmann, L. (2012). Predicting intentions and adherence behavior in the context of organ transplantation: Gender differences of provided social support. *Journal of Psychosomatic Research*, **72**, 214–219. doi:10.1016/j.jpsychores.2011.10.008

Stephenson, E., Delongis, A., Esdaile, J. M., & Lehman, A. J. (2014). Depressive symptoms and rheumatoid arthritis: Spouse empathic responding as a buffer. *Arthritis Care & Research*, **66**, 532–541. doi:10.1002/acr.22161

Steptoe, A., Lundwall, K., & Cropley, M. (2000). Gender, family structure and cardiovascular activity during the working day and evening. *Social Science & Medicine*, **50**, 531–539. doi:10.1016/S0277-9536(99)00324-X

Tay, L., Tan, K., Diener, E., & Gonzalez, E. (2013). Social relations, health behaviors, and health outcomes: A survey and synthesis. *Applied Psychology. Health and Well-being*, **5**, 28–78. doi:10.1111/aphw.12000

Taylor, R. J., Chatters, L. M., Woodward, A. T., & Brown, E. (2013). Racial and ethnic differences in extended family, friendship, fictive kin and congregational informal support networks. *Family Relations*, **62**, 609–624. doi:10.1111/fare.12030

Taylor, R. J., Forsythe-Brown, I., Taylor, H. O., & Chatters, L. M. (2014). Patterns of emotional social support and negative interactions among African American and Black Caribbean extended families. *Journal of African American Studies (New Brunswick, N.J.)*, **18**, 147–163. doi:10.1007/s12111-013-9258-1

Uchino, B. N. (2009). Understanding the links between social support and physical health: A life-span perspective with emphasis on the separability of perceived and received support. *Perspectives on Psychological Science*, **4**, 236–255. doi:10.1111/j.1745-6924.2009.01122.x

Uchino, B. N., Cawthon, R. M., Smith, T. W., Light, K. C., McKenzie, J., Carlisle, M.,…Bowen, K. (2012). Social relationships and health: Is feeling positive, negative, or both (ambivalent) about your social ties related to telomeres? *Health Psychology*, **31**, 789–796. doi:10.1037/a0026836

Umberson, D., & Montez, J. K. (2010). Social relationships and health: A flashpoint for health policy. *Journal of Health and Social Behavior*, **51 Suppl**, S54–S66. doi:10.1177/0022146510383501

Umberson, D., Williams, K., Thomas, P. A., Liu, H., & Thomeer, M. B. (2014). Race, gender, and chains of disadvantage: Childhood adversity, social relationships, and health. *Journal of Health and Social Behavior*, **55**, 20–38. doi:10.1177/0022146514521426

Wahrendorf, M., Ribet, C., Zins, M., Goldberg, M., & Siegrist, J. (2010). Perceived reciprocity in social exchange and health functioning in early old age: Prospective findings from the GAZEL study. *Aging & Mental Health*, **14**, 425–432. doi:10.1080/13607860903483102

Walen, H. R., & Lachman, M. E. (2000). Social support and strain from partner, family, and friends: Costs and benefits for men and women in adulthood. *Journal of Social and Personal Relationships*, **17**, 5–30. doi:10.1177/0265407500171001

Willeit, P., Willeit, J., Mayr, A., Weger, S., Oberhollenzer, F., Brandstätter, A.,… Kiechl, S. (2010). Telomere length and risk of incident cancer and cancer mortality. *JAMA*, **304**, 69–75. doi:10.1001/jama.2010.897

Windsor, T. D., & Butterworth, P. (2010). Supportive, aversive, ambivalent, and indifferent partner evaluations in midlife and young-old adulthood. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, **65**, 287–295. doi:10.1093/geronb/gbq016

Yang, Y. C., Schorpp, K., & Harris, K. M. (2014). Social support, social strain and inflammation: Evidence from a national longitudinal study of U.S. adults. *Social Science & Medicine (1982)*, **107**, 124–135. doi:10.1016/j.socscimed.2014.02.013