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Social inequalities in accelerated aging among southern U.S. women: an analysis of the biosocial and behavioral pathways linking social determinants to telomere length

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ABSTRACT

Few studies have examined the biosocial pathways linking socioeconomic status (SES) to accelerated aging in a population-based sample of southern US women. Even fewer have examined the importance of chronic compared to perceived stress in linking SES to women's salivary telomere length (STL). Using data from a probability-based sample of 156 US women and structural equation modeling, we examined three pathways – chronic stress exposure, stress appraisal, and coping behavior – linking SES to STL. SES was positively associated with STL ($\beta_{TE} = 0.16$, $p < .05$). Everyday discrimination was negatively associated with STL ($\beta_{DE} = -0.21$, $p < .05$), but perceived stress was positively associated with STL ($\beta_{DE} = 0.20$, $p < .05$). Current smoking decreased STL ($\beta_{DE} = -0.19$, $p < .01$). Perceived stress acted to suppress the negative relationship of chronic stress exposure on STL. Given the dearth of STL studies that include measures of both perceived and chronic stress, our study supports the importance of disentangling stress measures and a biosocial approach to the study of accelerated aging.

Introduction

Telomeres are nucleoprotein structures that protect the ends of human chromosomes. Telomeres shorten with each cell division and are implicated in cellular aging (Mather et al. 2011). In stressful environments, telomeres can shorten at an accelerated rate, a process referred to as accelerated aging (Geronimus et al. 2010; Oliveira et al. 2016). Premature telomere shortening can have significant implications for the early appearance of disease processes, such as compromised immune response, oxidative stress, and inflammation (Mather et al. 2011).

Research on accelerated cellular aging has provided mixed support for the association between social disadvantage and accelerated aging. Socioeconomic status, which refers to a person's life chances based on education, income, and occupation, has been more consistently associated with telomere length (TL), with low SES groups having shorter TL (Oliveira et al. 2016). When findings differ, these differences are often due to the measure of SES used (e.g., income or education) (Needham et al. 2013). The weathering hypothesis posits that because racial and ethnic minorities are disproportionately exposed to chronic social stressors, including racism and discrimination, they are also at a heightened risk of

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Supplemental data for this article can be accessed on the publisher's website.

accelerated aging (Geronimus et al. 2006, 2010). Nevertheless, research has not consistently supported this hypothesis (Needham et al. 2013), with some studies showing shorter TL in African-Americans and Hispanics (Diez Roux et al. 2009; Geronimus et al. 2015) and other studies showing shorter TL in whites (Brown, Needham, and Ailshire 2017). **Inconsistency in the findings on race/ethnicity and TL may be due to a number of reasons, including the confounding of SES and race (LaVeist 2005), possible racial differences in TL at birth** (Drury et al. 2015)**, the differential capacity of racial and ethnic minorities to access social and cultural resources (e.g., social cohesion)** (Geronimus et al. 2015)**, and methodological differences in the sampling design or how TL is assayed** (Brown, Needham, and Ailshire 2017).

Mixed findings on stress and TL have also been attributed in part to gender- and environment-based variations in these relationships (Adler & Stewart 2010). Women may have longer TL than men on average (Mayer et al. 2006). Women and men may also experience stress differently, with women reporting higher levels and different types of stress and coping strategies than men (Matud 2004). Social environments can also alter the types of stressors that someone encounters, their level of exposure to those stressors, and the resources that individuals have available to cope with stressors (Adler & Stewart 2010; Brown, Mitchell, & Ailshire 2020). Nevertheless, research that examines environmental variations in these relationships has been limited. For example, in the US, researchers using national datasets are often unable to examine specific regional or state patterns of accelerated aging. When not based on nationwide samples, data often come from convenience samples of specific populations. Our study addresses this need for gender- and place-specific analyses of accelerated aging.

Biosocial and Behavioral Pathways

Figure 1 illustrates our conceptual model. Biosocial approaches posit the presence of different pathways from distal social conditions to proximal individual behaviors and biological outcomes. Our model features age, race, and SES as distal social determinants embedded in specific social environments. These determinants influence accelerated aging through social (i.e., chronic stress exposures), psychosocial (i.e., stress appraisal), and behavioral pathways.
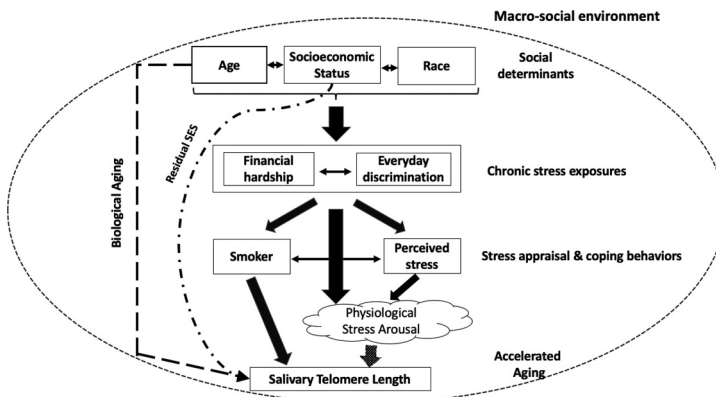

Figure 1. Conceptual model.

The body's stress response system is a central feature in the model since the physiological regulation and experience of stress can have lasting health effects. The body's stress response modulates the impact of chronic and perceived stress on health (Mathur et al. 2016). Prolonged stress places the body in a constant state of homeostatic imbalance, affecting the body directly through the dysregulation of the hypothalamic-pituitary-adrenocortical (HPA) axis and sympathetic-adrenal-medullary (SAM) systems (Daniel, Moore, and Kestens 2008). Protracted dysregulation of these systems can lead to allostatic overload, oxidative damage, and the early onset of ill health and disease (Daniel, Moore, and Kestens 2008).

Social Determinants

Age is often treated primarily in biological terms. Yet, social dimensions of aging may also influence cellular aging through social, psychosocial, and behavioral factors. Stress can change in older age from being episodic to chronic, with implications for stress appraisal and coping behaviors (Aldwin et al. 1996).

Research on SES and health has emphasized the complex and multiple mechanisms through which SES influences health (Baum, Garofalo, and Yali 1999). These include material, psychosocial, and behavioral mechanisms. Low SES groups are more exposed to chronic stressors, often with few resources to buffer the effects of chronic stress on health (Baum, Garofalo, and Yali 1999). Our model posits that SES may affect women's risk of accelerated aging directly and indirectly through social, psychosocial, and behavioral mechanisms.

Finally, our model considers race and ethnicity to represent social not biological categories. We examine potential racial and ethnic differences in salivary TL (STL) as operating indirectly through social processes that may disproportionately expose racial and ethnic minorities to certain levels or types of chronic stressors (Williams 1999) or differentially pattern the way in which racial and ethnic groups might appraise or respond to stressors.

Chronic Stress Exposures

Chronic stress may directly and indirectly affect women's STL. Direct effects of chronic stress may represent the non-conscious processing of social disadvantage in a way that places the body in a prolonged state of homeostatic imbalance (Daniel, Moore, and Kestens 2008). Financial hardship and discrimination represent two dimensions of chronic stress. Financial hardship reflects the challenges that individuals and families face in purchasing basic necessities and meeting daily expenses (Conger, Conger, and Martin 2010). Discrimination refers to interpersonal and institutional practices that treat members of certain social groups as inferior and unequal (Williams 1999). Discrimination is considered a psychosocial stressor that becomes chronic when maltreatment is repeated and persistent. Carter et al. (2019) and Chae et al. (2020) have shown discrimination related to short TL in African-American women.

Stress Appraisal

Stress appraisal captures the psychosocial and cognitive resources that may mediate the relationship between chronic stress and TL. Higher exposure to chronic stress may increase a person's perceived stress, but this relationship may differ by age and race/ethnicity (Aldwin et al. 1996; Vines et al. 2009). Perceived stress may diverge significantly from the level of

chronic stress that an individual or group reports since individuals experience and appraise their level of stress within particular social environments (Brown, Mitchell, and Ailshire 2020). Findings on the relationship between perceived stress and TL have been mixed. In separate meta-analyses, Mathur et al. (2016) and Schutte and Malouff (2016) reported higher perceived stress associated with small decreases in TL, with both authors suggesting a publication bias in on perceived stress and TL. Studies of perceived stress and TL also tend to be based on data from clinical or other special populations (Schutte and Malouff 2016).

Coping Behaviors

Chronic stress may also trigger maladaptive coping behaviors. Our behavioral path includes smoking as a maladaptive coping behavior related to chronic and perceived stress (Kassel, Stroud, and Paronis 2003). Women, particularly African-American women, may be particularly susceptible to smoking as a means of coping with various social stressors, including higher rates of low SES, single parenthood, and childhood disadvantage (Graham et al. 2006; Manfredi et al. 1992). Findings on smoking and TL have been mixed. Needham et al. (2013) showed smoking and body mass index to mediate partially the relationship between education and TL in a nationwide US sample. Simons et al. (2016), on the other hand, did not find smoking to mediate the relationship between income and epigenetic aging in middle-aged African-American women. In a sample of primarily female caregivers, Chen et al. (2015) showed smokers to have shorter TL than nonsmokers, after adjusting for age and perceived stress.

Using this conceptual framework, we examine the biosocial and behavioral pathways linking socioeconomic status to STL in a sample of women from the southern United States. Racism, discrimination, and higher rates of poverty in the southern US may heighten women's exposure to socioeconomic and race-related stressors. Understanding the pathways from social environments to accelerated aging in particular places might lead to more informed and effective interventions to ameliorate the negative effects of social adversity on health.

Methods

Sample

Data came from the South Carolina Women's Panel (SCWP). SCWP participants were selected randomly with an equal probability of selection from a listing of household telephone and cell numbers of state residents. To be eligible, participants had to be 18 years or older, non-institutionalized, and self-report as female. Interviews were conducted from the University of South Carolina (USC) Survey Research Lab. Participant recruitment and DNA data collection took place over 8 months from October 2017 to May 2018. The study was approved by the Institutional Review Board for Human Subjects research at the USC (Protocol # 00067080).

Measures

Telomere Length
Women who agreed to provide a saliva sample for DNA analysis were mailed an Oragene Discover 500 self-collection kit (n = 316). Of those, 199 women returned the saliva sample

kits for DNA analysis. DNA isolation was performed in Dr. Patel's lab as per the kit instructions (Supplementary Methods File). STL was measured in kilobase units and squared prior to analyses.

Using data from the full sample, we developed the following measures:

Sociodemographic Characteristics

Women's self-reported age was calculated from their year of birth and treated continuously. Women self-reported as belonging to one or more of the following four racial categories: African American, Caucasian, Asian/Asian American, or other. Participants were also asked to self-report if they were of Hispanic, Latino, or Spanish origin.

Socioeconomic Status

Women's SES was based on their household income, educational attainment, and employment status. Participants were asked if their annual income before taxes fell within one of six categories: less than 15,000, USD 15,000 USD – 29,999, USD 30,000 USD – 49,999, USD 45,000 USD – 59,999, USD 60,000 USD – 74,999, USD and greater than 75,000. USD For those missing income (n = 111), we imputed income using information on their educational attainment, employment status, and age. Participants reported their level of educational attainment in six categories: less than high school, high school/GED degree, some college, two-year college degree, four-year college degree and advanced university degree (e.g., Master's, JD, PhD). Employment status was whether participants reported being employed full time or not. Principal factor analysis was used to create a SES variable that summarized women's annual income, educational attainment, and employment status, with these variables loading at 0.65, 0.64 and 0.39 respectively.

Chronic Stress Exposures

Financial Hardships

Per previous research, we used the four-item financial hardship scale developed by Conger, Conger, and Martin (2010). Participants were asked the degree to which they had difficulty affording (1) food, (2) clothing, (3) housing, and (4) medical care, with response options ranging from strongly disagree (1) to strongly agree (5) on a five-point Likert scale. The Cronbach alpha was 0.81.

Everyday Discrimination

To assess everyday discrimination, we used five items from Williams' et al. (1997) nine-item everyday discrimination scale. Using a five-point Likert scale from never (1) to very often (5), women were asked about the frequency of the following experiences over the past year: (1) being treated with less courtesy or respect than other people, (2) receiving poorer service than other people at restaurants or stores, (3) being threatened or harassed, (4) people acting as if they are not smart, and (5) people acting as if they are afraid of them. The Cronbach alpha was 0.71.

Stress Appraisal

Perceived Stress

Cohen's 10-item Perceived Stress Scale (PSS) was used to assess women's generalized appraisal of stress over the past month (Cohen, Kamarck, and Mermelstein 1983). Using a five-point Likert scale (0–4), respondents were asked how often they felt or thought a certain way, such as "having been upset because of something that happened unexpectedly" and "having felt nervous or stressed" (Cohen, Kamarck, and Mermelstein 1983). Higher scores represented higher levels of perceived stress. The Cronbach alpha was 0.80.

Coping Behaviors

Everyday Smoking

Women were asked to self-report if they had smoked at least 100 cigarettes in their lifetime, and if yes, if they smoked cigarettes every day, some days, or not at all. Current smokers were defined as those reporting smoking every day or some days.

Statistical Analyses

Analyses preceded in several phases. First, we calculated the descriptive statistics of the SCWP sample and assessed whether there were significant differences between the full SCWP sample and the subsample that provided useable telomere data. Second, we estimated the correlation among study variables based on Pearson's correlation coefficients with Bonferroni correction (Supplementary Table 1). Third, we used structural equation modeling to estimate the direct, indirect, and total effects characterizing the relationship among study variables. We built four models: (1) a social determinants model, with age and SES directly related to STL; (2) a chronic stress exposure model that added financial hardship and everyday discrimination as intervening variables; (3) a stress appraisal model, which added perceived stress as mediating the relationship among SES, chronic stress exposure, and STL; and (4) a full model that added current smoking status as mediating the relationship between chronic stress exposure and STL. Model fit was evaluated using the root mean square error of approximation (RMSEA), the Coefficient of Determination (CD), Akaike information criteria (AIC) and Bayesian information criteria (BIC). Analyses were conducted in Stata, version 16.

Results

A total of 663 women completed the SCWP questionnaire. Using established guidelines, landline and cell sampling response rates were 19.9% and 8.6% respectively (AAPOR 2016). Of those 663 participants, 156 women agreed to and provided useable saliva samples for STL measurement. Five observations were dropped due to missing information on age, race, or smoking status for a final telomere subsample of 151. Table 1 provides descriptive information on the overall SCWP sample and the STL subsample. ANOVA and chi-square analyses showed no differences between SCWP participants who provided usable DNA data and those who did not. Our STL sample of women averaged 58.2 years and an average STL of 7.15 kbs. Since the majority of women were either Caucasian (65.4%) or African

Table 1. Descriptive statistics, South Carolina women's panel stratified by STL measurement.

	Telomere Subsample (n = 156)	Non-Telomere Sample (n = 506)
	Mean (SE)	Mean (SE)
Salivary Telomere Length (in kb)	7.2 (0.10); n = 156	…
Age	58.2 (1.39)	57.3 (0.83);
	[range: 20–90]; n = 153	[range: 18–90] n = 486
Stress Measures	**n = 156**	**n = 506**
Financial Hardships	8.6 (0.30)	8.1 (0.16)
Everyday Discrimination	8.5 (0.25)	8.4 (0.14)
Perceived Stress	14.2 (0.57)	13.6 (0.31)
	Percentage, (SE)	Percentage, (SE)
Coping behavior	**n = 156**	**n = 502**
Current Smoker	7.8% (0.03)	10.6% (0.02)
Race	**n = 155**	**n = 494**
African Americans	24.2% (0.03)	30.0% (0.02)
Caucasians	65.4% (0.04)	64.6% (0.02)
Other	10.4% (0.02)	5.4% (0.01)
Socioeconomic Status	**n = 156**	**n = 489**
Household income	**n = 156**	**n = 413**
Less than $15,000	26.3% (0.03)	22.5% (0.02)
$15,000 – $29,999	21.1% (0.03)	19.4% (0.02)
$30,000 – $44,999	13.9% (0.03)	14.5% (0.02)
$45,000 – $59,999	16.8% (0.03)	12.6% (0.02)
$60,000 – $74,999	9.5% (0.02)	10.4% (0.02)
$75,000 plus	12.4% (0.03)	20.6% (0.02)
Educational attainment	**n = 156**	**n = 502**
Less than high school	9.7% (0.02)	8.6% (0.01)
High School Diploma/GED	22.1% (0.03)	24.1% (0.02)
Some College	20.8% (0.03)	21.1% (0.02)
Two-Year College	16.9% (0.03)	17.1% (0.02)
Four-Year College	18.8% (0.03)	19.3% (0.02)
Advanced Degree	11.7% (0.03)	9.8% (0.01)
Employment Status	**n = 156**	**n = 506**
Retired	39.7% (0.04)	36.2% (0.02)
Full Time	21.2% (0.03)	31.4% (0.02)
Part Time	9.0% (0.02)	9.9% (0.01)
Disability or Work Leave	12.8% (0.03)	8.3% (0.01)
Homemaker	5.8% (0.02)	5.9% (0.01)
Unemployed	7.1% (0.02)	5.1% (0.01)
Student/Other	4.4% (0.01)	3.2% (0.01)

American (24.2%), we contrasted being African American to being Caucasian/Other in our analyses. Figure 2 shows the direct standardized estimates among study variables with $p < .10$. Table 2 provides the standardized and unstandardized direct (DE), indirect (IE), and total effects (TE) of study variables on TL. Direct-effect estimates among all study variables are in Supplementary Table 2. Our discussion below focuses on the estimates shown in Model 4 (Table 2).

Social Determinants

Older women had shorter STL than younger women ($\beta_{TE} = -0.32$, $p < .001$). Age also provided an indirect protective effect on STL ($\beta_{IE} = 0.05$, $p < .05$), which may be due to lower levels of financial hardship in our sample of older adults. Higher SES women had longer STL than lower SES women ($\beta_{TE} = 0.16$, $p < .05$). SES was negatively related to both financial hardship ($\beta_{DE} = -.42$, $p < .001$) and everyday discrimination ($\beta_{DE} = -0.16$, $p < .05$) (available upon request). **We found no significant differences in STL between African**
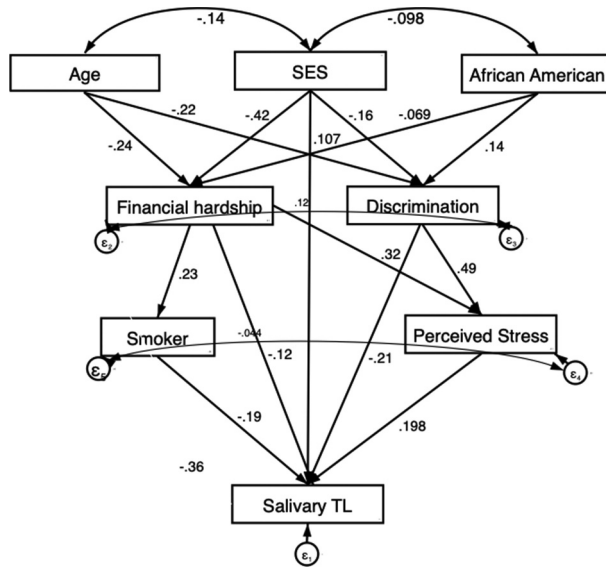
Figure 2. Structural equation model with standardized coefficients estimating the direct effects among model variables. (only those estimates with $p < .05$ shown; boxed estimates represent standardized covariance values).

American and non-African-American women, with and without adjustment for age and SES.

Results showed a complex pattern of relationships among chronic stress exposure, perceived stress, and STL. As expected, chronic stress exposure (particularly everyday discrimination) was related to higher perceived stress ($\beta_{DE} = 0.49$, $p < .001$) (available upon request) and shorter STL ($\beta_{DE} = -0.21$ $p < .05$). Yet, higher perceived stress was related to longer STL in our sample ($\beta_{DE} = 0.20.$ $p < .05$). This finding suggests inconsistent mediation, which happens when the direct and mediated effects of an independent variable on a dependent variable have opposite signs. Stress appraisal acted to suppress the total negative effects of chronic stress exposure on STL.

Finally, our findings showed women who smoked had shorter STL than those who did not ($\beta_{DE} = -0.19$, $p < .01$), with financial hardship being the more salient stress exposure along the coping behavior pathway. The model diagnostics showed the final model to have a close fit, with the final model also having the lowest AIC/BIC and highest CD.

Discussion

Research on social inequalities in accelerated aging have shown inconsistent relationships between measures of SES, chronic and perceived stress, and telomere length. Previous studies have suggested that these inconsistencies may be due to place-based variations in how stressors are experienced, appraised, or addressed. Using data from a probability-based sample of women in the southern United States, our study contributes to this line of research. Our findings support previous research on accelerated aging, but they also raise

Table 2. Direct, indirect, and total effects estimates between predictor and intervening variables and salivary telomere length (n = 151).

Model Variables	Model 1 (Social Determinants)			Model 2 (Stress Exposures)			Model 3 (Stress Exposures + Appraisal)			Model 4 (Full Model)		
	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Age	−0.32*** [−0.32] (0.08)	...	−0.30*** [−0.30] (0.08)	−0.36*** [−0.36] (0.08)	0.04 [0.04] (0.03)	−0.32*** [−0.32] (0.08)	−0.36*** [−0.35] (0.08)	0.04 [0.04] (0.03)	−0.31*** [−0.31] (0.07)	−0.37*** [−0.37] (0.08)	0.05* [0.05] (0.03)	−0.32*** [−0.32] (0.07)
African American	...	...	...	...	−0.01 [−027] (0.66)	−0.01 [−0.27] (0.66)	...	−0.01 [−0.28] (0.66)	−0.01 [−0.28] (0.66)	...	−0.01 [−0.62] (0.55)	−0.02 [−0.62] (0.55)
Socioeconomic status	0.17* [4.00] (1.80)	...	0.17* [4.00] (1.80)	0.11 [2.67] (1.97)	0.06 [1.31] (0.88)	0.17* [3.98] (1.80)	0.13 [3.16] (1.96)	0.05 [1.22] (0.88)	0.18* [4.38] (1.79)	0.10 [2.53] (1.93)	0.06 [1.35] (0.87)	0.16* [3.88] (1.77)
Financial hardship	...	...	...	−0.10 [−1.70] (1.49)	...	−0.10 [−1.70] (1.49)	−0.16^ [−2.77] (1.54)	0.07* [1.22] (0.60)	−0.09 [−1.56] (1.49)	−0.12 [−2.06] (1.54)	0.02 [0.37] (0.73)	−0.10 [−1.69] (1.38)
Everyday Discrimination	...	...	...	−0.09 [−2.61] (2.16)	...	−0.09 [−2.61] (2.16)	−0.20* [−5.42] (2.48)	0.10* [2.88] (1.36)	−0.09 [−2.54] (2.16)	−0.21* [−5.74] (2.43)	0.10* [2.70] (1.33)	−0.11 [−3.04] (2.12)
Perceived stress	...	...	...	...	...	...	0.21* [5.00] (2.27)	...	0.21* [5.00] (2.27)	0.20* [4.66] (2.22)	...	0.20* [4.66] (2.22)
Current smoker	...	...	...	...	...	...	...	...	...	−0.19** [−11.96] (4.68)	...	−0.19** [−11.96] (4.68)
RMSEA		0.00			0.01			0.06			0.03	
(90% CIs)		(0.0–0.18)			(0.0–0.16)			(0.0–0.14)			(0.00–0.09)	
CD		0.14			0.38			0.38			0.39	
AIC		4742.04			4108.92			4032.05			3993.48	
(BIC)		(4793.33)			(4190.39)			(4125.58)			(4065.89)	

Standardized coefficients shown on first row; unstandardized coefficients are bracketed on second row; standard errors are in parentheses.

questions about the complex interaction between chronic stress exposure and stress apprai-sal, and their association with STL.

Social Determinants and STL

Our study showed that women at lower SES had shorter STL than those at higher SES, with the link between SES operating through different biosocial and behavioral pathways. Future research on SES and STL might disentangle the relative importance of income, education, and employment as specific SES mechanisms affecting STL. Research has suggested that racial and ethnic minorities may have shorter TL due to their differential exposure to adverse chronic stressors (Carter et al. 2019; Chae et al. 2020). **Although previous studies have shown racial/ethnic differences in TL, our study did not find STL differences between African-Americans and non-African-Americans. This finding may differ from previous research for a number of reasons, including the particular composition and nature of our sample (e.g., regional instead of nationwide) or the methods used to measure TL (e.g., qPCR versus southern blot)**. Interestingly, our study showed older age to offer certain social protections against shorter STL for women, which may be due to older women in our sample being higher in SES and reporting less financial hardship and everyday discrimination. This finding highlights the challenge in considering STL to be a simple biomarker of "normal" aging: biological aging happens within particular social environments.

Chronic Stress, Stress Appraisal and TL

Research on stress and TL has tended to examine separately if chronic stress or perceived stress is related to TL. Brown, Mitchell, and Ailshire (2020) have argued that nationally representative surveys tend to measure stress exposures and overlook stress appraisal, thereby assuming that individuals and groups perceive stress similarly regardless of the social environments in which they live. Research on perceived stress and TL tends to come from clinical populations that may already be experiencing chronically high levels of stress (Mathur et al. 2016). This disconnect between studies of chronic and perceived stress and TL limits our understanding of how stress exposure and stress appraisal may interact to affect accelerated aging.

Our study showed higher chronic stress associated with higher perceived stress, and higher chronic stress associated with shorter STL. Yet, higher perceived stress was asso-ciated with longer rather than shorter STL. Perceived stress acted as a suppressor variable to the relationship between chronic stress and STL. Perceived stress increased the strength of the direct relationship between financial hardship and everyday discrimination and STL, but lessened the total effect of chronic stress exposure on STL. While unexpected, research has shown that moderate stress may actually enhance psychobiological resilience to oxida-tive damage (Aschbacher et al. 2013). While debate surrounds the concept of eustress, or "good" stress, the concept suggests that stress may be beneficial for health to an optimal level at which further stress erodes health. The moderate stress levels in our sample may have afforded certain resiliency-enhancing benefits (Aschbacher et al. 2013).

Coping Behaviors

Finally, our study showed coping behaviors to act as a key pathway linking SES to STL in women. Similar to other findings on smoking and TL (Chen et al. 2015), smoking decreased STL even after adjusting for perceived stress. While maladaptive coping behaviors, such as smoking, have been shown to reduce TL, there may also be positive coping behaviors, e.g., mindfulness or yoga, that buffer the relationship between SES, stress exposure, and TL. Future research might thus examine other coping responses to stress and their effects on TL.

Limitations

There are several limitations worth noting. First, while the SCWP response rates may appear low, the Pew Research Center reports that response rates to telephone surveys fell to 6% in 2018 (Kennedy and Hartig 2019). Furthermore, research has shown no consistent empirical relationship between response rates and survey accuracy. Surveys with low response rates can still have excellent demographic representativeness (Keeter et al. 2006). Given the additional respondent burden associated with DNA data collection and the mistrust that African-American communities may have of biomedical research (Scharff et al. 2010), it is noteworthy that the overall participation rate in the TL study was 30.1% with no significant sociodemographic or stress-related differences between the SCWP sample and the TL subsample. Second, our overall sample size compares favorably with other seminal studies of SES, stress, and TL. For example, Geronimus et al. (2015) and Simons et al. (2016) studied TL and epigenetic aging with sample sizes of 239 and 100 respectively. Nevertheless, the smaller sample size of African-American women (n = 38) tempered subgroup analyses. Findings suggested that everyday discrimination may be particularly salient for TL among African-American women, but the smaller sample may have reduced the statistical power to capture its significance. Third, although the PSS-10 is a valid and reliable measure of perceived global stress (Cohen, Kamarck, and Mermelstein 1983), other stress appraisal scales (e.g., the Stress Appraisal Measure), might have provided more insight into stress appraisal processes, and the relationship among chronic stress, stress appraisal and STL. Fourth, in ancillary analyses, we assessed whether adding diagnosed health conditions, such as high cholesterol and diabetes, or depression to our models altered our findings. They did not, and because of an already limited sample size, these health variables were not included in our final models. Finally, variability has been reported in telomere length measurements due to DNA extraction methods and storage (Dagnall et al. 2017). Many of these pre-analytic factors are based on the use of quantitative PCR (qPCR) to assess telomere length. To avoid these limitations, terminal restriction fragment (TRF) Southern blot analysis was performed in this study instead of qPCR. TRF Southern blot allows for direct visualization of telomeres and has shown less variability than qPCR measurements (Elbers et al. 2014).

Conclusion

Few studies have assessed the biosocial pathways linking SES to telomere length, particularly in a probability-based sample of southern US women. Using data from this unique sample, our study highlights the complexity of the relationship among SES, chronic and perceived stress, and TL. Moreover, our findings underscore the importance of context and

environment in studying the relationship between stress and STL across the US. Understanding whether and to what degree stress appraisal processes differ regionally would add much to our knowledge of how stress appraisal may buffer or heighten the influence of SES and chronic stress on aging.

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