3-2017

Discrimination and Telomere Length Among Older Adults in the United States

Sze Yan Liu
Montclair State University, lius@montclair.edu

Ichiro Kawachi

Research

Public Health Reports

Discrimination and Telomere Length Among Older Adults in the United States: Does the Association Vary by Race and Type of Discrimination?

Public Health Reports
2017, Vol. 132(2) 220-230

DOI: 10.1177/0033354916689613
journals.sagepub.com/home/phr
SAGE

Sze Yan Liu, PhD, MPH[1], and Ichiro Kawachi, MD, PhD[2]

Abstract

Objectives: Chronic stress from experiencing discrimination can lead to long-term changes in psychological and physiologic responses, including shorter leukocyte telomere length. We examined the association between leukocyte telomere length and variations in the association by race or type of discrimination.

Methods: Our study consisted of 3868 US-born non-Hispanic black (hereinafter, black) and non-Hispanic white (hereinafter, white) adult participants from the 2008 Health and Retirement Study biomarker sample with complete sociodemographic and discrimination information. We examined major lifetime unfair treatment and everyday discrimination. Coarsened exact matching matched exposed and unexposed participants on several sociodemographic factors. Coarsened exact matching creates analytic weights for the matched data sets. We applied weighted linear regression to the matched data sets. We conducted 2 subanalyses in which we matched on potential mediators—physical activity, smoking status, and obesity—and examined if racism was associated with shorter telomere length compared with other attributes. All analyses were stratified by race.

Results: We found no difference in telomere length for black and white participants reporting major lifetime unfair treatment ($\beta = 0.09$; 95% CI, –0.33 to 0.15) or everyday discrimination ($\beta = 0.04$; 95% CI, –0.12 to 0.40). Everyday discrimination was associated with shorter leukocyte telomere length among black people ($\beta = -0.23$; 95% CI, –0.44 to –0.01) but not among white people ($\beta = 0.05$; 95% CI, –0.01 to 0.10). Matching on potential mediators generally decreased the effect estimate among black people.

Conclusions: Experiencing everyday discrimination was associated with shortened telomere length among older black adults. Further research is needed to understand the adverse physiologic effects of discrimination to create effective interventions.

Keywords

aging, discrimination, racial disparities

Discrimination is the unfair treatment of people based on their personal characteristics[1]: ancestry or national origin, sex, race, age, weight, physical disability, other aspect of physical appearance, and sexual orientation. Emerging research suggests that perceived discrimination is associated with multiple adverse health outcomes,[2,3] including mortality risk,[4] cardiovascular disease,[5] and metabolic syndrome.[3,6] However, little is known about the biological mechanisms linking discrimination with adverse physical and mental health.[3,7] Discrimination produces heightened physiologic and psychological stress responses that may have direct and indirect effects on health.[3,8-10] It is associated with smoking,[11-13] waist circumference, and obesity.[14-16]

Studies show that chronic stress leads to long-term changes in psychological and physiologic responses,[17-20] including shorter leukocyte telomere length (LTL), a measure of aging at the cellular and systemic level that is associated with increased risk for multiple health outcomes, such as stroke and cardiovascular disease.[5,21,22] A telomere is the protective structure at each end of a eukaryotic chromosome.

[1] Harvard Center for Population and Development Studies, Boston, MA, USA
[2] Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, MA, USA

Corresponding Author:
Sze Yan Liu, PhD, MPH, Harvard Center for Population and Development Studies, 9 Bow St, Cambridge, MA 02138, USA.
Email: szeliu@hsph.harvard.edu

To date, only 1 study has examined whether discrimination is associated with telomere length, and it reported an interaction effect between discrimination and implicit racial bias and shorter LTL.[23] Different types of discrimination elicit different stress responses. Everyday discrimination, a chronic stressor, is characterized as persistent, ongoing, relatively mundane experiences of unfair treatment. Major lifetime unfair treatment is an acute stressor that occurs relatively infrequently.[24,25]

Perceived discrimination may have differential effects on socially disadvantaged and advantaged groups. Under the stress and coping model, an individual's physiologic reaction to stress is influenced by the availability of compensating resources.[26] Compared with other racial/ethnic groups, black people in the United States face a higher burden of discrimination and are less likely to have coping or compensating resources (social, economic, or cultural),[27] thus compounding the effects of discrimination.

This study examined the association between discrimination (major lifetime unfair treatment and everyday discrimination) and LTL. We had 2 study hypotheses: (1) non-Hispanic black (hereinafter, black) adults who experience everyday discrimination will have shorter telomere length than those who do not experience everyday discrimination, and (2) major lifetime unfair treatment will not be associated with shorter telomere length in either race. We also explored if racism, as compared with other subtypes of everyday discrimination, changes the strength of the association. Additionally, we conducted a series of subanalyses in which we matched on plausible mediators—physical activity, smoking status, and obesity[28,29]—to assess any changes in the effect estimate that would indicate mediation by health behaviors.

Methods

Sample

The Health and Retirement Study (HRS) is a national longitudinal study of US adults aged >50. HRS conducted baseline interviews during the enrollment of new birth cohorts in 1992, 1993, 1998, 2004, and 2010 and followed them through core biennial surveys and supplemental data collections during the off years. The telomere data set is supplemental to the HRS, collected for a subset of participants in 2009.[30] We merged information from 3 HRS files—the HRS supplemental telomere data set, the RAND HRS file, and a user-friendly file derived from all waves of the HRS[31]—with self-reported information on discrimination from the Psychosocial Leave-Behind questionnaire administered to a subset of HRS respondents in 2008.[32] Of the 5808 HRS participants with telomere data from saliva samples collected in 2009, 617 were missing information on major lifetime unfair treatment, and 613 were missing information on everyday discrimination. We excluded 4 respondents who were missing data on place of birth, 8 who were missing data on education, and 213 who were missing data on race. Because experiences of discrimination may differ by nativity, we also excluded 354 respondents who were not US born. Finally, because of the small number of Hispanic respondents (n = 131), we included only black and non-Hispanic white (hereinafter, white) respondents. Our analytic sample included 3868 people.

Exposure

To assess everyday discrimination, we used HRS's Everyday Discrimination Scale,[24,25] in which respondents were asked how often they experienced the following: (1) "You are treated with less courtesy or respect than other people"; (2) "You receive poorer service than other people at restaurants or stores"; (3) "People act as if they think you are not smart"; (4) "People act as if they are afraid of you"; (5) "You are threatened or harassed"; and (6) "You receive poorer service or treatment than other people from doctors or hospitals." Each item was scored on a 6-point scale (1 = almost every day, 6 = never). Items were reverse coded. If the respondent answered $\geq$3 items, a continuous everyday discrimination score was created by averaging the scores across the items. Respondents were also asked whether they attributed the unfair treatment described in the scale to ancestry or national origin, sex, race, age, weight, physical disability, other aspect of physical appearance, sexual orientation, religion, financial status, or other.[24] We created dichotomous yes/no variables for each attribute and for whether the respondent had ever experienced everyday discrimination. Respondents were considered to have experienced everyday discrimination if they reported experiencing unfair treatment and attributed the unfair treatment to a personal characteristic. We excluded 508 respondents who reported experiencing unfair treatment but who did not attribute that treatment to any reason. A sensitivity analysis, which included these 508 people as exposed to everyday discrimination, did not substantively change our estimates.

Given that >95% of our sample was born during the de jure segregation period in the United States (pre-1954), as well as the high percentage of black respondents who reported experiences of racism and the documented harmful health effects of racism, we examined racism as an attribute of everyday discrimination. We used participants' responses to the unfair treatment items and attribution of unfair treatment items to create a dichotomous variable: everyday discrimination based on racism or everyday discrimination based on other personal characteristics. We considered attribution of unfair treatment to race, ancestry, or national origin to be racial/ethnic discrimination and attribution to any other reason (eg, age, sex) to be nonracial/ethnic discrimination.

We measured major lifetime unfair treatment by assessing responses to the following questions in the HRS[24,25]: (1) "At any time in your life, have you ever been unfairly dismissed from a job?" (2) "For unfair reasons have you ever not been hired for a job?" (3) "Have you ever been unfairly denied a promotion?" (4) "Have you ever been unfairly prevented

from moving into a neighborhood because the landlord or a realtor refused to sell or rent you a house or apartment?" (5) "Have you ever been unfairly denied a bank loan?" (6) "Have you ever been unfairly stopped, searched, questioned, physically threatened, or abused by the police?" and (7) "Have you ever been unfairly denied health care or treatment?"[24] We created a continuous score by summing the affirmative responses across all items (average = 0.5, SD = 1.0). Because we had no a priori hypothesis about experiences that would be related to LTL and to mirror the everyday discrimination variable, we created a dichotomous (yes/no) variable for exposure to major lifetime unfair treatment.

Outcome

HRS assayed saliva samples with polymerase chain reaction to obtain the T/S ratio (telomere-repeat copy number:single-gene copy number), which is proportional to average telomere length.[33]

Covariates

We chose covariates that may predispose a respondent to discrimination: census region of birth (Northeast, Mid-Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, or Pacific) because the legacy of de jure segregation differs by geography,[34] year of birth (before 1920, standard demographically defined 5-year intervals during 1920-1955, and after 1955) to account for cohort differences in discrimination experiences,[34,35] sex (male and female), education (no degree, high school degree/general equivalency diploma (GED), associate's degree or higher, missing), paternal education (<12 or ≥12 years of school, missing) and maternal education (<12 or ≥12 years of school, missing), and childhood health (excellent/very good, good, fair/poor, missing).

Analysis

The coarsened exact matching (CEM) procedure generates a multivariate imbalance measure, L1 (range, 0-1), indicating balanced to imbalanced data.[36] We compared the L1 before and after the CEM to check for overall balance between the 2 groups. We ran CEM-weighted linear regression models matched on sociodemographic characteristics associated with the probability of discrimination exposure. We also included a CEM-weighted model matched on everyday discrimination to obtain an estimate of how major experiences of unfair treatment affect telomere length. Similarly, we matched on major experiences of unfair treatment to obtain an estimate of how everyday discrimination affects telomere length. We included ordinary least-squares linear regression models for comparison. We conducted race-stratified analysis because risk profiles for short telomere length may differ by race[37,38] and because racial differences in perceived discrimination in the United States[4] are likely to violate the equal variance assumption for an interaction term in linear regression and lead to inflated standard error estimates.

We conducted 2 subanalyses. In the first series of subanalyses, we matched on plausible mediators—physical activity (vigorous or moderate physical activity more than once per week [yes/no]), smoking status (never, former, or current smoker), and obesity (body mass index >30 kg/m^2 based on self-reported height and weight [yes/no]).[28,29] In the second set of subanalyses, we restricted our sample to respondents who reported everyday discrimination and examined whether racism was associated with shorter telomere length. We conducted all analyses using Stata release 13.[39] The Harvard School of Public Health Institutional Review Board determined the study to be exempt from review.

Results

Of the 3868 people in our overall sample, 1318 (34%) reported no perceived discrimination, 341 (9%) reported major lifetime unfair treatment only, 1266 (33%) reported everyday discrimination only, and 943 (24%) reported experiences with both. A higher proportion of black than white participants reported major lifetime unfair treatment (11% vs 8%) or everyday discrimination and major lifetime unfair treatment (37% vs 22%). A smaller proportion of black than white participants reported experiencing only everyday discrimination (28% vs 34%).

Of the 550 black respondents, 335 (64%) were female, 325 (59%) reported maternal education as less than high school, 372 (67%) had at least a high school degree, 363 (66%) had excellent/very good self-rated childhood health, and 442 (81%) were born in the South. Compared with the overall black subsample, a higher proportion in the CEM analytic sample had a parent with <12 years of school, had less than a high school degree, and was born in the South. The average telomere length T/S ratio for black participants was 1.55 (SD = 1.13; Table 1).

Of the 3318 white respondents, 1975 (60%) were female, 1620 (49%) reported maternal education as less than high school, 1713 (52%) reported paternal education as less than high school, 2864 (87%) had a high school degree or higher, 1850 (56%) reported excellent/very good self-rated childhood health, and 1534 (46%) were born in the Northeast (Table 1). CEM resulted in an analytic sample of 1422 white participants for major lifetime unfair treatment, with a decrease in the multivariate imbalance measure L1 from 0.69 to 0.00. For everyday discrimination, CEM resulted in an analytic sample of 1573 white participants, with a decrease in L1 from 0.65 to 0.00. Compared with the overall white subsample, a higher proportion in the CEM analytic sample had a parent with less than a high school degree. The average telomere length for white participants was 1.34 (SD = 0.59; Table 1).

Major lifetime unfair treatment was not associated with a significant decrease in telomere length in the unadjusted, multivariable-adjusted, or CEM-weighted models.

Table 1. Characteristics and mean telomere length of Health Retirement Study respondents in the 2009 telomere sample, by race, reported discrimination experience, and analytic sample

		Non-Hispanic Black, No. (%)							
		Major Lifetime Unfair Treatment				Everyday Discrimination			
		Multivariable		CEM Weighted		Multivariable		CEM Weighted	
Characteristic	Overall	Yes	No	Yes	No	Yes	No	Yes	No
Total	550	266	284	70	70	358	192	60	52
Telomere length[a]	1.55 (1.13)	1.53 (0.94)	1.58 (1.29)	1.41 (0.78)	1.46 (0.58)	1.53 (0.82)	1.60 (1.56)	1.32 (0.46)	1.48 (0.57)
Sex									
Male	197 (36)	110 (41)	87 (31)	22 (31)	20 (29)	131 (37)	66 (34)	18 (30)	19 (37)
Female	353 (64)	156 (59)	197 (69)	48 (69)	50 (71)	227 (63)	126 (66)	42 (70)	33 (64)
Maternal education									
<12 y	325 (59)	145 (55)	180 (63)	51 (73)	54 (77)	215 (60)	110 (57)	45 (75)	38 (73)
≥12 y	149 (27)	88 (33)	61 (21)	11 (16)	9 (13)	93 (26)	56 (29)	9 (15)	7 (13)
Missing	76 (14)	33 (12)	43 (15)	8 (11)	7 (10)	50 (14)	26 (14)	6 (10)	7 (13)
Paternal education									
<12 y	298 (54)	147 (55)	151 (53)	52 (74)	54 (77)	206 (58)	92 (48)	41 (68)	35 (67)
≥12 y	100 (18)	53 (20)	47 (17)	7 (10)	5 (7)	55 (15)	45 (23)	7 (12)	5 (10)
Missing	152 (28)	66 (25)	86 (30)	11 (16)	11 (16)	97 (27)	55 (29)	12 (20)	12 (23)
Own education									
<High school degree	178 (32)	70 (26)	108 (38)	30 (43)	31 (44)	110 (31)	68 (35)	30 (50)	26 (50)
High school degree/GED	272 (49)	135 (51)	137 (48)	37 (53)	36 (51)	174 (49)	98 (51)	29 (48)	25 (48)
Associate's, bachelor's, or graduate degree	100 (18)	61 (23)	39 (14)	3 (4)	3 (4)	74 (21)	26 (14)	1 (2)	1 (2)
Health as child									
Excellent/very good	363 (66)	177 (67)	186 (65)	54 (77)	54 (77)	224 (63)	139 (72)	46 (77)	44 (85)
Good	98 (18)	42 (16)	56 (20)	11 (16)	13 (19)	67 (19)	31 (16)	10 (17)	6 (12)
Fair/poor	32 (6)	18 (7)	14 (5)	2 (3)	2 (3)	23 (6)	9 (5)	1 (2)	1 (2)
Missing	57 (10)	29 (11)	28 (10)	3 (4)	1 (1)	44 (12)	13 (7)	3 (5)	1 (2)
Birth year									
Before 1921	18 (3)	9 (3)	9 (3)	3 (4)	2 (3)	10 (3)	8 (4)	1 (2)	2 (4)
1921-1929	54 (10)	22 (8)	32 (11)	5 (7)	5 (7)	34 (10)	20 (10)	3 (5)	4 (8)
1930-1934	83 (15)	31 (12)	52 (18)	13 (19)	13 (19)	48 (13)	35 (18)	15 (25)	9 (17)
1935-1939	106 (19)	53 (20)	53 (19)	15 (21)	19 (27)	66 (18)	40 (21)	15 (25)	15 (29)
1940-1944	110 (20)	56 (21)	54 (19)	20 (29)	20 (29)	67 (19)	43 (22)	19 (32)	13 (25)
1945-1949	71 (13)	38 (14)	33 (12)	5 (7)	4 (6)	52 (15)	19 (10)	2 (3)	3 (6)
1950-1954	85 (15)	48 (18)	37 (13)	8 (11)	6 (9)	66 (18)	19 (10)	3 (5)	4 (8)
After 1954	23 (4)	9 (3)	14 (5)	1 (1)	1 (1)	15 (4)	8 (4)	2 (3)	2 (4)
Birth region									
New England	2 (<1)	0 (0)	2 (<1)	0 (0)	0 (0)	1 (<1)	1 (<1)	0 (0)	0 (0)
Mid-Atlantic	41 (7)	25 (9)	16 (6)	4 (6)	4 (6)	30 (8)	11 (6)	2 (3)	2 (4)
East North Central	30 (5)	19 (7)	11 (4)	4 (6)	2 (3)	18 (5)	12 (6)	4 (7)	2 (6)
West North Central	21 (4)	13 (5)	8 (3)	0 (0)	0 (0)	17 (5)	4 (2)	0 (0)	0 (0)
South Atlanta	241 (44)	112 (42)	129 (45)	43 (61)	40 (57)	148 (41)	93 (48)	39 (65)	34 (65)
East South Central	115 (21)	54 (20)	61 (21)	11 (16)	14 (20)	75 (21)	40 (21)	11 (18)	8 (15)
West South Central	86 (16)	34 (13)	52 (18)	8 (11)	10 (14)	58 (16)	28 (15)	4 (7)	6 (12)
Mountain	3 (<1)	1 (<1)	2 (<1)	0 (0)	0 (0)	2 (<1)	1 (<1)	0 (0)	0 (0)
Pacific	11 (2)	8 (3)	3 (1)	0 (0)	0 (0)	9 (3)	2 (1)	0 (0)	0 (0)

(continued)

Table 1. (continued)

		Non-Hispanic White, No. (%)							
		Major Lifetime Unfair Treatment				Everyday Discrimination			
		Multivariable		CEM Weighted		Multivariable		CEM Weighted	
Characteristic	Overall	Yes	No	Yes	No	Yes	No	Yes	No
Total	3318	1018	2300	532	890	1851	1467	800	773
Telomere length[a]	1.34 (0.59)	1.31 (0.39)	1.35 (0.66)	1.34 (0.45)	1.36 (0.87)	1.35 (0.69)	1.31 (0.44)	1.35 (0.66)	1.30 (0.37)
Sex									
Male	1343 (40)	499 (49)	844 (37)	232 (44)	303 (34)	791 (43)	552 (38)	303 (38)	280 (36)
Female	1975 (60)	519 (50)	1456 (63)	300 (56)	587 (66)	1060 (57)	915 (62)	497 (62)	493 (64)
Maternal education									
<12 y	1620 (49)	435 (43)	1185 (52)	227 (43)	459 (52)	861 (47)	759 (52)	403 (50)	419 (54)
≥12 y	1485 (45)	522 (51)	963 (42)	301 (57)	426 (48)	882 (48)	603 (41)	387 (49)	345 (45)
Missing	213 (6)	61 (6)	152 (7)	4 (1)	5 (1)	108 (6)	105 (7)	10 (1)	9 (1)
Paternal education									
<12 y	1713 (52)	459 (45)	1254 (55)	252 (47)	495 (56)	927 (50)	786 (54)	442 (55)	457 (59)
≥12 y	1267 (38)	452 (44)	815 (35)	273 (51)	387 (43)	738 (40)	529 (36)	3422 (43)	303 (39)
Missing	338 (10)	107 (11)	231 (10)	7 (1)	8 (1)	186 (10)	152 (10)	16 (2)	13 (2)
Own education									
<High school degree	454 (14)	95 (9)	359 (16)	30 (6)	54 (6)	230 (12)	224 (15)	65 (8)	63 (8)
High school degree/GED	1907 (58)	561 (55)	1346 (59)	311 (58)	612 (69)	1067 (58)	840 (57)	521 (65)	516 (67)
Associate's, bachelor's, or graduate degree	957 (29)	362 (36)	595 (26)	191 (36)	224 (25)	554 (30)	403 (27)	214 (27)	194 (25)
Health as child									
Excellent/very good	1850 (56)	501 (50)	1340 (58)	322 (61)	603 (68)	984 (53)	866 (59)	519 (65)	519 (67)
Good	349 (11)	97 (10)	252 (11)	14 (3)	13 (1)	191 (10)	158 (11)	32 (4)	30 (4)
Fair/poor	119 (4)	46 (5)	73 (3)	7 (1)	7 (1)	76 (4)	43 (3)	7 (1)	7 (1)
Missing	1000 (30)	365 (36)	635 (28)	189 (36)	267 (30)	600 (32)	400 (27)	242 (30)	217 (28)
Birth year									
Before 1921	171 (5)	25 (2)	146 (6)	10 (2)	32 (4)	73 (4)	98 (7)	44 (6)	48 (6)
1921-1929	522 (16)	104 (10)	418 (18)	61 (11)	141 (16)	232 (13)	290 (20)	107 (13)	134 (17)
1930-1934	525 (16)	125 (12)	400 (17)	62 (12)	130 (15)	268 (14)	257 (18)	114 (14)	134 (17)
1935-1939	644 (19)	202 (20)	442 (19)	121 (23)	190 (21)	358 (19)	286 (20)	177 (22)	171 (22)
1940-1944	546 (16)	183 (18)	363 (16)	106 (20)	152 (17)	306 (17)	240 (16)	145 (18)	127 (16)
1945-1949	430 (13)	174 (17)	256 (11)	82 (15)	116 (13)	272 (15)	158 (11)	95 (12)	79 (10)
1950-1954	360 (11)	151 (15)	209 (9)	76 (14)	104 (12)	251 (14)	109 (7)	99 (12)	68 (9)
After 1954	120 (4)	54 (5)	66 (3)	14 (3)	25 (3)	91 (5)	29 (2)	19 (2)	12 (2)
Birth region									
New England	191 (6)	60 (6)	131 (6)	22 (4)	27 (3)	95 (5)	96 (7)	30 (4)	28 (4)
Mid-Atlantic	551 (17)	180 (18)	371 (16)	98 (18)	159 (18)	298 (16)	253 (17)	162 (20)	141 (18)
East North Central	792 (24)	244 (24)	548 (24)	175 (33)	297 (33)	458 (25)	334 (23)	250 (31)	230 (30)
West North Central	489 (15)	131 (13)	358 (16)	72 (14)	146 (16)	267 (14)	222 (15)	114 (14)	123 (16)
South Atlanta	433 (13)	122 (12)	311 (14)	57 (11)	96 (11)	242 (13)	191 (13)	93 (12)	94 (12)
East South Central	219 (7)	67 (7)	152 (7)	30 (6)	42 (5)	120 (6)	99 (7)	42 (5)	39 (5)
West South Central	284 (9)	85 (8)	199 (9)	31 (6)	53 (6)	157 (8)	127 (9)	55 (7)	59 (8)
Mountain	109 (3)	38 (4)	71 (3)	8 (2)	13 (2)	65 (4)	44 (3)	12 (2)	17 (2)

Abbreviations: CEM, coarsened exact matching; GED, general equivalency diploma.
[a]Mean (standard deviation).

Table 2. Race-stratified estimates of the average difference in telomere length between those who perceived major lifetime unfair treatment and those who did not, by unadjusted, multivariable-adjusted, and CEM-weighted models, Health Retirement Study telomere sample, 2009

	Non-Hispanic Black				Non-Hispanic White			
	Unadjusted and Multivariable-Adjusted Models		CEM-Weighted Model[a]		Unadjusted and Multivariable-Adjusted Models		CEM-Weighted Model[b]	
Variable	No.	Estimated Difference in Telomere Length (95% CI)	No.	Estimated Difference in Telomere Length (95% CI)	No.	Estimated Difference in Telomere Length (95% CI)	No.	Estimated Difference in Telomere Length (95% CI)
Unadjusted	550	–0.05 (–0.24 to 0.14)	NA	NA	3318	–0.04 (–0.08 to 0.01)	NA	NA
Adjusted for potential confounders								
Includes place of birth, birth cohort, and sex	550	–0.05 (–0.24 to 0.15)	506	–0.03 (–0.20 to 0.14)	3318	–0.04 (–0.09 to 0.00)	3239	–0.04 (–0.08 to 0.01)
Includes all sociodemographic characteristics	550	–0.07 (–0.27 to 0.13)	140	–0.09 (–0.33 to 0.15)	3318	–0.04 (–0.09 to 0.00)	1422	–0.04 (–0.12 to 0.04)
Includes all sociodemographic characteristics and everyday discrimination	550	–0.06 (–0.26 to 0.15)	126	0.09 (–0.27 to 0.47)	3318	–0.05 (–0.10 to –0.01)	1319	–0.05 (–0.13 to 0.03)
Adjusted for all potential confounders, including plausible mediators between perceived discrimination and telomere length								
Physical activity	543	–0.06 (–0.26 to 0.15)	132	0.02 (–0.34 to 0.38)	3275	–0.05 (–0.09 to 0.00)	1399	–0.05 (–0.13 to 0.02)
Obesity	543	–0.06 (–0.27 to 0.14)	124	–0.02 (–0.30 to 0.25)	3275	–0.05 (–1.00 to 0.00)	1401	–0.02 (–0.09 to 0.04)
Smoking status	543	–0.07 (–0.27 to 0.14)	97	–0.22 (–0.46 to 0.02)	3275	–0.04 (–0.09 to 0.00)	1228	–0.06 (–0.13 to 0.01)

Abbreviations: CEM, coarsened exact matching; CI, confidence interval; NA, not applicable.

[a]In the black subsample, CEM weights range as follows, by model: 0.33-3.00, all sociodemographic characteristics alone; 0.39-2.33, all sociodemographic characteristics and physical activity; 0.27-3.20, all sociodemographic characteristics and obesity; 0.26-2.62, all sociodemographic characteristics and smoking; and 0.20-4.00, all sociodemographic characteristics and everyday discrimination score.

[b]In the white subsample, CEM weights range as follows, by model: 0.08-5.02, all sociodemographic characteristics alone; 0.11-6.34, all sociodemographic characteristics and physical activity; 0.08-6.90, all sociodemographic characteristics and obesity; 0.15-4.94, all sociodemographic characteristics and smoking; and 0.17-4.57, all sociodemographic characteristics and everyday discrimination score.

For example, major lifetime unfair treatment was associated with a –0.09 (95% CI, –0.33 to 0.15) decrease in telomere length after matching on all sociodemographic characteristics. Matching on physical activity, obesity, smoking, or everyday discrimination scores led to additional pruning and smaller sample sizes for the CEM analysis but similar effect estimates (Table 2).

Among white participants, everyday discrimination was associated with longer but not significant telomere length in the unadjusted, multivariable-adjusted, and CEM-weighted models. Among black participants, everyday discrimination was not associated with any difference in telomere length in the multivariable model. However, in the CEM-weighted model, everyday discrimination was associated with a decrease of –0.22 in telomere length (95% CI, –0.44 to –0.01) among black participants (Table 3). This effect estimate was no longer significant when CEM criteria included physical activity ($\beta = -0.03$; 95% CI, –0.29 to 0.23), obesity ($\beta = -0.23$; 95% CI, –0.54 to 0.07), or smoking status ($\beta = -0.19$; 95% CI, –0.55 to 0.16) in telomere length among black participants. Including major lifetime unfair treatment in the matching led to additional pruning, a smaller sample size, and a decrease in the effect estimate ($\beta = -0.06$; 95% CI, –0.35 to 0.23).

Of those who experienced everyday discrimination, 253 of 358 (71%) black respondents, compared with 138 of 1851 (7%) white respondents, attributed it to race, ancestry, or national origin (Figure). The CEM-matched analysis was able to match only a small number of respondents in the black (63 of 358, 18%) and white (183 of 1851, 10%) subpopulations. Among those who experienced everyday discrimination, racism was not associated with a significant difference in telomere length as compared with other types of discrimination attributes in the multivariable-adjusted models for black respondents (regression coefficient for racism vs other discrimination = 0.11; 95% CI, –0.09 to 0.31). Similarly, the CEM-matched analysis comparing racism with other discrimination did not find any significant differences among black respondents (CEM-matched analysis regression coefficient for racism vs other discrimination: 0.11; 95% CI, –0.32 to 0.54) or white respondents (CEM-matched analysis regression coefficient for racism vs other discrimination: –0.19; 95% CI, –0.63 to 0.25).

Table 3. Race-stratified estimates of the average difference in telomere length between those who perceived everyday discrimination and those who did not, by unadjusted, multivariable-adjusted, and CEM-weighted models, Health Retirement Study telomere sample, 2009

	Non-Hispanic Black				Non-Hispanic White			
	Unadjusted and Multivariable-Adjusted Models		CEM-Weighted Model[a]		Unadjusted and Multivariable-Adjusted Models		CEM-Weighted Model[b]	
Variable	No.	Estimated Difference in Telomere Length (95% CI)	No.	Estimated Difference in Telomere Length (95% CI)	No.	Estimated Difference in Telomere Length (95% CI)	No.	Estimated Difference in Telomere Length (95% CI)
Unadjusted	550	–0.07 (–0.27 to 0.13)	NA	NA	3318	0.04 (0.00 to 0.08)	NA	NA
Adjusted for potential confounders								
Includes place of birth, birth cohort, and sex	550	–0.08 (–0.29 to 0.12)	479	–0.21 (–0.47 to 0.05)	3318	0.03 (–0.01 to 0.07)	3288	0.03 (–0.01 to 0.07)
Includes all sociodemographic characteristics	550	–0.07 (–0.28 to 0.14)	112	–0.23 (–0.44 to –0.01)	3318	0.03 (–0.01 to 0.08)	1573	0.05 (–0.01 to 0.10)
Includes all sociodemographic characteristics and major lifetime unfair treatment	543	–0.06 (–0.27 to 0.16)	61	–0.06 (–0.35 to 0.23)	3318	0.04 (0.00 to 0.09)	1138	0.06 (–0.01 to 0.13)
Adjusted for all sociodemographic characteristics and plausible mediators between perceived discrimination and telomere length								
Physical activity	543	–0.06 (–0.27 to 0.15)	65	–0.03 (–0.29 to 0.23)	3275	0.03 (–0.01 to 0.07)	1155	0.07 (0.00 to 0.13)
Obesity	543	–0.07 (–0.28 to 0.14)	70	–0.23 (–0.54 to 0.07)	3275	0.03 (–0.01 to 0.07)	1142	0.07 (0.00 to 0.13)
Smoking status	543	–0.07 (–0.28 to 0.14)	55	–0.19 (–0.55 to 0.16)	3275	0.03 (–0.01 to 0.08)	934	0.05 (–0.03 to 0.13)

Abbreviations: CEM, coarsened exact matching; CI, confidence interval; NA, not applicable.
[a]In the black subsample, the CEM weights range as follows, by model: 0.20-5.50, place of birth, birth cohort, and sex only; 0.28-2.60, all sociodemographic characteristics only; 0.48-1.93, all sociodemographic characteristics and physical activity; 0.45-2.68, all sociodemographic characteristics and obesity; 0.42-1.67, all sociodemographic characteristics and smoking; and 0.45-2.72, all sociodemographic characteristics and major lifetime unfair treatment score.
[b]In the white subsample, the CEM weights range as follows, by model: 0.20-8.20, place of birth, birth cohort, and sex only; 0.14-7.73, all sociodemographic characteristics; 0.19-6.70, all sociodemographic characteristics and physical activity; 0.16-6.83, all sociodemographic characteristics and obesity; 0.17-4.96, all sociodemographic characteristics and smoking; and 0.18-5.27, all sociodemographic characteristics and major lifetime unfair treatment score.

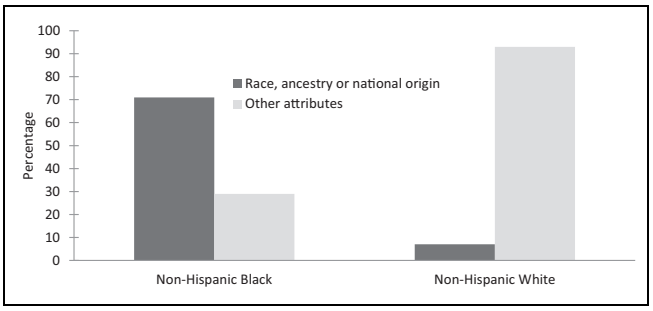

Figure. Among non-Hispanic black and non-Hispanic white respondents reporting everyday discrimination, the percentage attributing these experiences to race, ancestry, or national origin, Health Retirement Study telomere sample, 2009

Discussion

We found discrimination among racial/ethnic minority groups to be a common experience in the United States, similar to previous reports.[7,24,37,40-42] Everyday discrimination was associated with shorter telomere length among older black adults in our CEM model. Matching on major lifetime unfair treatment or on plausible mediators—physical activity, smoking status, or obesity—led to decreases in this effect estimate. We found no significant association between major lifetime unfair treatment and telomere length among black participants nor between either type of unfair treatment or discrimination (everyday or lifetime) and telomere length among older white participants.

Our effect estimates for everyday discrimination differed depending on the model used. CEM is a nonparametric method of controlling for potential confounders in the sample, pruning observations from the data so that the remaining respondents have a better balance between the treated and the control groups. The CEM-weighted model estimate is the local average treatment effect among the treated, whereas the multivariable regression effect estimate is the overall average treatment effect. The difference between the CEM-weighted model estimate and the multivariable estimate among black participants suggests heterogeneity in these effects.

Our results support previous research suggesting that everyday discrimination but not major lifetime unfair treatment is associated with adverse health outcomes. For example, 1 study found that everyday discrimination but not major lifetime unfair treatment was associated with greater depressive symptoms and loneliness.[43] Chronic exposure to everyday discrimination initiates a biological cascade and heightened physiologic stress responses that may lead to a range of adverse health outcomes.[44]

Previous research examining racial differences in the effect of discrimination had mixed results. For example, discrimination has been associated with a worse diurnal cortisol rhythm pattern among white people but a healthier diurnal pattern among black people.[45] Another study reported stronger associations between major discrimination and mental health outcomes in white people than in black people.[37] Conversely, racial discrimination has been associated with higher levels of red blood cell oxidative stress among black people but not white people.[46] These mixed results are likely due to several reasons. First, racial differences in the health effects of discrimination may be caused by the type or dimension of discrimination examined in particular studies. In our sample, the perceived attributes of everyday discrimination differed significantly by race: approximately 93% of black participants and 29% of white participants who reported everyday discrimination attributed it to racism. These differences likely resulted from the larger sociocultural context in which this discrimination occurred. Older black participants in our sample lived through the de jure segregation period, in which structural racism was the norm. Because de jure segregation policies did not apply to white people, the discrimination reported by older white people in our sample probably refers to experiences that differ from those of their black peers. Differential effects by race may also indicate variations in how subgroups of people interpret and process similar situations. White people may have more social and cultural resources than black people to counteract certain experiences of discrimination, such as racism. Further research is needed to better understand why differential effects of discrimination occur by race and whether such differences are the result of unidentified moderators, such as psychological attributes (eg, coping resources) or the larger cultural context (eg, de jure segregation policies), differences in physiologic responses, or limitation measures designed to capture data on multiple dimensions of discrimination (eg, source of discrimination, such as institutional or personal; forms of discrimination, such as differential access to services or differential treatment by others; people's perceived emotional impact of discrimination).

Some evidence also suggests that the biological process may differ by race; that is, the telomeres of black people may shorten more rapidly than the telomeres of white people.[47] Racial differences in telomere length have been reported, with most studies finding longer telomere length among black people than white people.[48-51] However, several studies reported shorter telomere length among black people than white people.[29,52] Differences in study populations and sampling differences may account for some of the conflicting findings. Telomere length reflects genetic, environmental, and behavioral factors,[53,54] which may vary substantially by race/ethnicity. Additional research is needed to understand the biological basis of racial/ethnic heterogeneity in telomere length.

In our analyses matching on plausible mediators, the association between everyday discrimination and shortened LTL was no longer significant. Smoking, lack of physical activity, and obesity are well-known discrimination-related coping strategies[55,56] that can also accelerate the shortening of LTL.[57] Although our findings suggest that these health behaviors are plausible mediators, our data were limited by sample size and by our measures of these health behaviors. We were unable to measure life-course physical activity and obesity, which may have limited the extent to which these behaviors were adequately adjusted for in our models. Our model may have included other mediator-outcome confounders (eg, physical or environmental factors), which may have biased the model estimates. Further research is needed to assess the pathways by which discrimination affects telomere length.

The CEM-weighted models that included major lifetime unfair treatment score as a matching variable decreased the effect estimate associated with everyday discrimination for the black subsample, indicating potential mediation. However, this result should be interpreted with caution given the substantial pruning in this CEM-weighted model. Only 11% (61 of 550) black participants were matched for sociodemographic characteristics and major lifetime unfair treatment score.

We found no significant differences in telomere length between those who experienced racial discrimination and those who attributed discrimination to other reasons. Although the association between racial discrimination and adverse health is increasingly recognized,[11,12,58] few studies have compared racism with other types of discrimination. A recent study in Europe found that respondents who attributed their experiences of discrimination to sociodemographic characteristics (eg, sex, age, sexuality, disability) were significantly more likely to report poor health than respondents who attributed their experiences of discrimination to their race/ethnicity.[58] A study in the United States found that attributing discrimination to race decreased the association between daily discrimination and depression among Caribbean black men but not among women or African American men.[59] Given the high prevalence of racism in the United States, the need exists to investigate the complex role that racial discrimination may play, especially in comparison with (and in the context of) other types of discrimination.

Limitations

This study had several limitations. First, the standard discrimination scales used in HRS have limitations,[25,60] including the inability to assess the stressfulness of the discrimination

experience and the lack of reference to a time frame associated with the discrimination experience. Second, residual confounding may have occurred from potential confounders (eg, hostility and pessimism) that were not available in our data set.[61,62] Similarly, residual confounding may have been caused by the lack of detail on place of birth. HRS provides information on the census region of birth only in the public use data set. Third, several of our CEM-weighted models had small sample sizes, which may have limited the power to detect a significant result. Fourth, the HRS sample consisted of people aged ≥50. Black respondents in our sample may have been the most resilient of their birth cohorts because black people in the United States are more likely than white people in the United States to die at younger ages. If black people in the United States who faced discrimination aged faster and died younger than their white counterparts, the remaining black people would be disproportionately healthy.

Additionally, some measurement error may have been associated with our outcome. HRS does not measure telomerase activity (ie, the enzyme that catalyzes the lengthening of telomeres), which requires fresh blood samples and is not practical in large-scale cohort studies. However, this measurement error should have been random. Finally, this HRS sample may not be generalizable to younger birth cohorts of black and white people in the United States who experienced discrimination in a different context, for several reasons. The HRS telomere sample was collected in 2009, and no collection of data on telomere length has occurred since. The respondents in our sample experienced discrimination during 1 period of US history and 1 period in their lives. The context of discrimination has changed in the United States since the era of de jure discrimination experienced by those in our sample, all of whom were aged ≥50.

Strengths

Our study also had several strengths. The analytic sample was drawn from a nationally representative study and used a CEM approach to increase comparability between those who self-reported exposure to discrimination and those who did not. The HRS data set allowed us to examine major lifetime unfair treatment and everyday discrimination separately for black and white respondents. Furthermore, although study participants may have had experiences that are specific to their birth cohorts, our results still provide useful insight on the association between discrimination and telomere length.

Conclusion

Our study demonstrates the adverse physiologic impact of everyday discrimination for black people in the United States on LTL, a biomarker of cumulative cellular damage.[63,64] Future research should explore whether these results hold for members of other racial/ethnic minority groups and other socially disadvantaged groups. Public health practitioners should consider strategies addressing the detrimental biological effects of experiences of discrimination.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Jary D, Jary J. *Collins Dictionary of Sociology*. 2nd ed. Glasgow, Scotland: HarperCollins; 1985.
2. Paradies Y, Ben J, Denson N, et al. Racism as a determinant of health: a systematic review and meta-analysis. *Plos One*. 2015; 10(9):e0138511.
3. Pascoe EA, Smart Richman L. Perceived discrimination and health: a meta-analytic review. *Psychol Bull*. 2009;135(4): 531-554.
4. Barnes LL, Mendes De Leon CF, Wilson RS, Bienias JL, Bennett DA, Evans DA. Racial differences in perceived discrimination in a community population of older blacks and whites. *J Aging Health*. 2004;16(3):315-337.
5. Haycock PC, Heydon EE, Kaptoge S, Butterworth AS, Thompson A, Willeit P. Leucocyte telomere length and risk of cardiovascular disease: systematic review and meta-analysis. *BMJ*. 2014;349:g4227.
6. Williams DR, Neighbors HW, Jackson JS. Racial/ethnic discrimination and health: findings from community studies. *Am J Public Health*. 2003;93(2):200-208.
7. Williams DR, Mohammed SA. Discrimination and racial disparities in health: evidence and needed research. *J Behav Med*. 2009;32(1):20-47.
8. Krieger N. Embodying inequality: a review of concepts, measures, and methods for studying health consequences of discrimination. *Int J Health Serv*. 1999;29(2):295-352.
9. Clark R, Anderson NB, Clark VR, Williams DR. Racism as a stressor for African Americans: a biopsychosocial model. *Am Psychol*. 1999;54(10):805-816.
10. Mays VM, Cochran SD, Barnes NW. Race, race-based discrimination, and health outcomes among African Americans. *Annu Rev Psychol*. 2007;58:201-225.
11. Borrell LN, Diez Roux AV, Jacobs DR Jr, et al. Perceived racial/ethnic discrimination, smoking and alcohol consumption in the Multi-ethnic Study of Atherosclerosis (MESA). *Prev Med*. 2010;51(3-4):307-312.
12. Borrell LN, Kiefe CI, Diez-Roux AV, Williams DR, Gordon-Larsen P. Racial discrimination, racial/ethnic segregation, and health behaviors in the CARDIA study. *Ethn Health*. 2013; 18(3):227-243.
13. Wiehe SE, Aalsma MC, Liu GC, Fortenberry JD. Gender differences in the association between perceived discrimination and adolescent smoking. *Am J Public Health*. 2010;100(3): 510-516.

14. Cozier YC, Yu J, Coogan PF, Bethea TN, Rosenberg L, Palmer JR. Racism, segregation, and risk of obesity in the Black Women's Health Study. *Am J Epidemiol*. 2014;179(7): 875-883.
15. Hunte HE. Association between perceived interpersonal everyday discrimination and waist circumference over a 9-year period in the Midlife Development in the United States cohort study. *Am J Epidemiol*. 2011;173(11):1232-1239.
16. Hunte HE, Williams DR. The association between perceived discrimination and obesity in a population-based multiracial and multiethnic adult sample. *Am J Public Health*. 2009; 99(7):1285-1292.
17. McEwen BS, Stellar E. Stress and the individual: mechanisms leading to disease. *Arch Intern Med*. 1993;153(18):2093-2101.
18. McEwen BS. Stress, adaptation, and disease: allostasis and allostatic load. *Ann N Y Acad Sci*. 1998;840:33-44.
19. Cohen S, Frank E, Doyle WJ, Skoner DP, Rabin BS, Gwaltney JM Jr. Types of stressors that increase susceptibility to the common cold in healthy adults. *Health Psychol*. 1998;17(3): 214-223.
20. Cohen S, Janicki-Deverts D, Miller GE. Psychological stress and disease. *JAMA*. 2007;298(14):1685-1687.
21. Epel ES, Blackburn EH, Lin J, et al. Accelerated telomere shortening in response to life stress. *Proc Natl Acad Sci U S A*. 2004;101(49):17312-17315.
22. Parks CG, Miller DB, McCanlies EC, et al. Telomere length, current perceived stress, and urinary stress hormones in women. *Cancer Epidemiol Biomarkers Prev*. 2009;18(2):551-560.
23. Chae DH, Nuru-Jeter AM, Adler NE, et al. Discrimination, racial bias, and telomere length in African-American men. *Am J Prev Med*. 2014;46(2):103-111.
24. Kessler RC, Mickelson KD, Williams DR. The prevalence, distribution, and mental health correlates of perceived discrimination in the United States. *J Health Soc Behav*. 1999;40(3): 208-230.
25. Williams DR, Yan Y, Jackson JS, Anderson NB. Racial differences in physical and mental health: socio-economic status, stress and discrimination. *J Health Psychol*. 1997;2(3): 335-351.
26. Folkman S, Lazarus RS, Dunkel-Schetter C, DeLongis A, Gruen RJ. Dynamics of a stressful encounter: cognitive appraisal, coping, and encounter outcomes. *J Pers Soc Psychol*. 1986; 50(5):992-1003.
27. Major B, Quinton WJ, McCoy SK. Antecedents and consequences of attributions to discrimination: theoretical and empirical advances. *Adv Exp Soc Psychol*. 2002;34:251-330.
28. Fitzpatrick AL, Kronmal RA, Gardber JP, et al. Leukocyte telomere length and cardiovascular disease in the Cardiovascular Health Study. *Am J Epidemiol*. 2007;165(1):14-21.
29. Diez Roux AV, Ranjit N, Jenny NS, et al. Race/ethnicity and telomere length in the Multi-ethnic Study of Atherosclerosis. *Aging Cell*. 2009;8(3):251-257.
30. Juster FT, Suzman R. An overview of the Health and Retirement Study. *J Hum Resources*. 1995;30:S7-S56.
31. RAND. *RAND HRS Data, Version P*. Santa Monica, CA: RAND; 2016.
32. Clarke P, Fisher G, House J, Smith J, Weir D. *Guide to Content of the HRS Psychosocial Leave-Behind Participant Lifestyle Questionnaires: 2004 and 2006*. Ann Arbor, MI: University of Michigan: 2008.
33. Institute for Social Research. *Health and Retirement Study, 2008 Telomere Data Set*. Ann Arbor, MI: University of Michigan; 2013.
34. Clotfelter CT. Public school segregation in metropolitan areas. *Land Econ*. 1999;75(4):487-504.
35. Gee GC, Pavalko EK, Long JS. Age, cohort and perceived age discrimination: using the life course to assess self-reported age discrimination. *Soc Force*. 2007;86(1):265-290.
36. Blackwell M, Iacus S, King G, Porro G. Cem: coarsened exact matching in Stata. *Stata J*. 2009;9(4):524-546.
37. Ayalon L, Gum AM. The relationships between major lifetime discrimination, everyday discrimination, and mental health in three racial and ethnic groups of older adults. *Aging Ment Health*. 2011;15(5):587-594.
38. Barnes LL, De Leon CF, Lewis TT, Bienias JL, Wilson RS, Evans DA. Perceived discrimination and mortality in a population-based study of older adults. *Am J Public Health*. 2008;98(7):1241-1247.
39. StataCorp. *Stata Release 13*. College Station, TX: StataCorp; 2013.
40. Krieger N, Smith K, Naishadham D, Hartman C, Barbeau EM. Experiences of discrimination: validity and reliability of a self-report measure for population health research on racism and health. *Soc Sci Med*. 2005;61(7):1576-1596.
41. Pérez DJ, Fortuna L, Alegría M. Prevalence and correlates of everyday discrimination among US Latinos. *J Community Psychol*. 2008;36(4):421-433.
42. Keyes CL. The black-white paradox in health: flourishing in the face of social inequality and discrimination. *J Pers*. 2009; 77(6):1677-1706.
43. Lee H, Turney K. Investigating the relationship between perceived discrimination, social status, and mental health. *Soc Ment Health*. 2012;2(1):1-20.
44. Friedman EM, Williams DR, Singer BH, Ryff CD. Chronic discrimination predicts higher circulating levels of E-selectin in a national sample: the MIDUS study. *Brain Behav Immun*. 2009;23(5):684-692.
45. Fuller-Rowell TE, Doan SN, Eccles JS. Differential effects of perceived discrimination on the diurnal cortisol rhythm of African Americans and whites. *Psychoneuroendocrinology*. 2012; 37(1):107-118.
46. Szanton SL, Rifkind JM, Mohanty JG, et al. Racial discrimination is associated with a measure of red blood cell oxidative stress: a potential pathway for racial health disparities. *Int J Behav Med*. 2012;19(4):489-495.
47. Hunt SC, Chen W, Gardner JP, et al. Leukocyte telomeres are longer in African Americans than in whites: the National Heart, Lung, and Blood Institute Family Heart Study and the Bogalusa Heart Study. *Aging Cell*. 2008; 7(4):451-458.
48. Zhu H, Wang X, Gutin B, et al. Leukocyte telomere length in healthy Caucasian and African-American adolescents:

relationships with race, sex, adiposity, adipokines, and physical activity. *J Pediatr*. 2011;158(2):215-220.
49. Adler N, Pantell MS, O'Donovan, et al. Educational attainment and late life telomere length in the Health, Aging and Body Composition Study. *Brain Behav Immun*. 2013;27(1):15-21.
50. Needham BL, Adler N, Gregorich S, et al. Socioeconomic status, health behavior, and leukocyte telomere length in the National Health and Nutrition Examination Survey, 1999-2002. *Soc Sci Med*. 2013;85:1-8.
51. Geronimus AT, Hicken MT, Pearson JA, Seashols SJ, Brown KL, Cruz TD. Do US black women experience stress-related accelerated biological aging? *Hum Nat*. 2010;21(1):19-38.
52. Honig LS, Kang MS, Cheng R, et al. Heritability of telomere length in a study of long-lived families. *Neurobiol Aging*. 2015; 36(10):2785-2790.
53. Andrew T, Aviv A, Falchi M, et al. Mapping genetic loci that determine leukocyte telomere length in a large sample of unselected female sibling pairs. *Am J Hum Genet*. 2006;78(3): 480-486.
54. Starkweather AR, Alhaeeri AA, Montpetit A, et al. An integrative review of factors associated with telomere length and implications for biobehavioral research. *Nurs Res*. 2014; 63(1):36-50.
55. Cozier YC, Wise LA, Palmer JR, Rosenberg L. Perceived racism in relation to weight change in the Black Women's Health Study. *Ann Epidemiol*. 2009;19(6):379-387.
56. Borrell LN, Diez Roux AV, Jacobs DR Jr, et al. Perceived racial/ethnic discrimination, smoking and alcohol consumption in the Multi-ethnic Study of Atherosclerosis (MESA). *Prev Med*. 2010;51(3-4):307-312.
57. Valdes AM, Andrew T, Gardner JP, et al. Obesity, cigarette smoking, and telomere length in women. *Lancet*. 2005; 366(9486):662-664.
58. Assari S, Watkins DC, Caldwell CH. Race attribution modifies the association between daily discrimination and major depressive disorder among blacks: the role of gender and ethnicity. *J Racial Ethn Health Disparities*. 2015;2(2):200-210.
59. Assari S, Watkins DC, Caldwell CH. Race attribution modifies the association between daily discrimination and major depressive disorder among blacks: the role of gender and ethnicity. *J Racial Ethn Health Disparities*. 2015;2(2):200-210.
60. Krieger N. Methods for the scientific study of discrimination and health: an ecosocial approach. *Am J Public Health*. 2012; 102(5):936-944.
61. O'Donovan A, Lin J, Tillie J, et al. Pessimism correlates with leukocyte telomere shortness and elevated interleukin-6 in post-menopausal women [published erratum appears in *Brain Behav Immun.* 2012;26(6):1017]. *Brain Behav Immun*. 2009; 23(4):446-449.
62. Brydon L, Lin J, Butcher L, et al. Hostility and cellular aging in men from the Whitehall II cohort. *Biol Psychiatry*. 2012;71(9): 767-773.
63. Blackburn EH. Telomere states and cell fates. *Nature*. 2000; 408(6808):53-56.
64. Aviv A. Telomeres and human somatic fitness. *J Gerontol A Biol Sci Med Sci*. 2006;61(8):871-873.