

ORIGINAL RESEARCH

Perceived Discrimination and Hypertension Risk Among Participants in the Multi-Ethnic Study of Atherosclerosis

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BACKGROUND: Black Americans have a higher risk of hypertension compared with White Americans. Perceived discrimination is a plausible explanation for these health disparities. Few studies have examined the impact of perceived discrimination on the incidence of hypertension among a racially diverse sample. Our study examined associations of everyday and lifetime discrimination with incidence of hypertension and whether these associations varied by sex, discrimination attribution, and racial residential segregation.

METHODS AND RESULTS: The study included 3297 Black, Hispanic, Chinese, and White participants aged 45 to 84 years from the Multi-Ethnic Study of Atherosclerosis who were without hypertension at exam 1 (2000–2002) and who completed at least 1 of 5 follow-up exams (2002–2018). Cox proportional hazards regression was used to estimate associations of perceived discrimination with incident hypertension. Over the follow-up period, 49% (n=1625) of participants developed hypertension. After adjustment for age, sex, socioeconomic status, hypertension risk factors, and study site, Black participants reporting any lifetime discrimination (compared with none) were more likely to develop hypertension (hazard ratio [HR], 1.35; 95% CI, 1.07–1.69). In fully adjusted models, everyday discrimination (high versus low) was associated with a lower risk for hypertension among Hispanic participants (HR, 0.73; 95% CI, 0.55–0.98). Statistically significant interactions of perceived discrimination (everyday and lifetime) with sex, discrimination attribution, and racial residential segregation were not observed.

CONCLUSIONS: This study suggests that lifetime, but not everyday discrimination is associated with incident hypertension in Black Americans.

Key Words: blood pressure ■ discrimination ■ ethnicity ■ hypertension ■ multiethnic study of atherosclerosis ■ race ■ racial residential segregation

There are profound and persistent cardiovascular health disparities that negatively impact racial and ethnic minorities in the United States. Specifically, Black Americans have the greatest risk for cardiovascular disease compared with other racial and ethnic groups in the United States.^{1–3} Higher rates of hypertension among racial and ethnic minorities suggest that this risk factor may partly underlie these cardiovascular disease disparities.^{1,3,4} Given these disparities, research has focused on understanding perceived discrimination

as a contributing factor and the specific mechanisms through which perceived discrimination may affect hypertension. Perceived interpersonal or individual level discrimination (henceforth referred to as discrimination) may be linked to hypertension via dysregulation of the stress response system (i.e., activation of the sympathetic nervous system and hypothalamic-pituitary-adrenal axis to increase blood pressure), as well as through unhealthy behaviors (e.g., diet, smoking, alcohol use) used to cope with stress from discrimination.^{5–8}

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CLINICAL PERSPECTIVE

What Is New?

- To our knowledge, this is one of the first longitudinal studies to use a large multi-ethnic cohort to demonstrate a link between greater perceived discrimination over the life course and incidence of hypertension.
- Lifetime discrimination was associated with a higher risk for incident hypertension among Black Americans.

What Are the Clinical Implications?

- Discrimination occurring across one's lifetime may contribute to disparities in hypertension.
- Discrimination may be an important life stressor experienced by Black Americans and may contribute to higher risk for hypertension in this population.

Nonstandard Abbreviations and Acronyms

MESA Multi-Ethnic Study of Atherosclerosis

While there is evidence linking discrimination to hypertension, existing studies have been largely cross-sectional⁹⁻¹² and most have focused on populations across the African Diaspora. Despite the variation in reporting of discrimination across race/ethnicity in the United States, with Black, Hispanic, and Asian participants reporting more discrimination than their White counterparts,¹³⁻¹⁵ studies of the relation between discrimination and hypertension development in multi-ethnic samples residing in the United States remain scarce¹⁶ (see Beatty-Moody et al, 2019 for an exception to this).¹⁷

In addition to the need to examine how discrimination affects the health of different racial and ethnic groups, there is a need to examine whether these associations are modified by other factors such as residential segregation. Racial residential segregation (henceforth referred to as segregation) has been linked to unhealthy environments conducive to increased risk of cardiovascular disease¹⁸⁻²⁰ (e.g., unsafe areas for physical activity, limited access to healthy food sources, tobacco and alcohol marketing), but segregation may also protect against the harmful effects of discrimination.^{18,21,22} This is because racial and ethnic minorities who live in neighborhoods with higher clustering of their own racial or ethnic group may have a stronger system of social support and social cohesion to help cope with

discrimination.²² Studies by Hunt et al and Dailey et al^{23,24} found that racial and ethnic minorities who resided in segregated areas reported less discrimination compared with their counterparts who resided in integrated areas. Thus, it is plausible that segregation may modify the relationship between discrimination and hypertension incidence.^{23,24}

Discrimination may also differentially impact hypertension based on sex²⁵⁻²⁸ and the reason for discrimination (henceforth referred to as discrimination attribution).²⁶ This is because differences may exist in the discrimination experiences of men and women, where women hold a “double minority status” (woman and racial minority), whereas, men encounter more discrimination by the police than women. Racial factors have been posited to be a more intense form of discrimination affecting racial and ethnic minority groups relative to non-racial forms of discrimination.²⁹ We used longitudinal data from the MESA (Multi-Ethnic Study of Atherosclerosis) to examine whether discrimination was associated with incident hypertension in a multiethnic cohort and if the association was modified by sex, discrimination attribution and segregation.

METHODS

The MESA data and materials can be requested from the MESA committee at <http://www.mesa-nhlbi.org>.

MESA is a population-based cohort study designed to examine risk factors for subclinical atherosclerosis among men and women (n=6814) aged 45 to 84 years. Black (n=1891), Hispanic/Latino (n=1496), Chinese-American (n=804), and White (n=2623) participants without cardiovascular disease were recruited from 6 field centers in the United States (Baltimore, Maryland; Los Angeles, California; Chicago, Illinois; St. Paul, Minnesota; New York, New York; and Forsyth County, North Carolina) between 2000 and 2002. After the first exam, data from participants were collected at 5 subsequent follow-up exams (exam 2, 2002 to 2004; exam 3, 2004 to 2005; exam 4, 2005 to 2007; exam 5, 2010 to 2011; exam 6, 2016 to 2018). The study was approved by the institutional review board at the MESA Coordinating Center and at each of the 6 field centers. Written informed consent was obtained from all participants. Additional details about the study design and sampling methods have been described elsewhere.³⁰

Three separate resting blood pressure measurements were obtained from seated participants using an automated oscillometric sphygmomanometer (Dinamap Pro 100; Critikon, Tampa, Florida). The final clinical blood pressure measurement was calculated using the average of the last 2 blood pressure measurements. Incident hypertension was assessed at follow-up visits (exams 2 through 6) using a derived

definition of hypertension that includes measured systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or self-reported antihypertensive medication use.³¹

Both everyday discrimination and lifetime discrimination were assessed at exam 1 (Table S1). Everyday discrimination was measured using the Everyday Discrimination Scale (Cronbach's $\alpha=0.88$),³² which captured the occurrence and frequency of recurrent episodes of unfair treatment(s) or episodic hassles experienced by respondents in their day to day lives. Everyday discrimination was operationalized for this study as the mean of 9 everyday discrimination scale items. Everyday discrimination scores ranged from 1 to 6 (continuously), with higher scores representing more everyday discrimination. In addition, tertiles were used to assess everyday discrimination in this study because of the large number of participants reporting never having experienced any form of discrimination and the skewed distribution of responses (Table S1).

Lifetime discrimination was measured at exam 1 using the Lifetime Discrimination Scale (Cronbach's $\alpha=0.61$), which captured whether participants ever experienced any of the 6 items of unfair treatment in their lifetime (yes/no).³³ Responses were averaged across the 6 items (range, 0–6). We created a dichotomous measure of lifetime discrimination (any, values ≥ 1 ; none, no discrimination) because of the large number of participants reporting never having experienced any form of discrimination and the skewed distribution of responses (Table S1).

Participants were also asked to answer a separate question about the main reason for all experiences of lifetime discrimination. They were required to attribute their experiences with lifetime discrimination to either age, sex, race/ethnicity, religion, physical appearance, sexual orientation, income/social class, and other reasons. Based on the responses to this question, we created 2 categories for lifetime discrimination attribution (racial factors, non-racial factors).

Segregation was measured using the Getis-Ord G_i^* statistic³⁴ (henceforth referred to as G_i^* statistic) and calculated separately for White, Chinese, Black, and Hispanic participants. The G_i^* statistic measures clustering or the extent to which the racial/ethnic composition of the population within the census tract and the neighboring census tracts resemble the racial/ethnic composition of the larger areal unit that surrounds the census tract.¹⁹ The G_i^* statistic produces z-score values for a 95% CI (–1.96 to 1.96), with higher values representing more clustering and lower values representing less clustering. Based on prior work,^{35,36} we created 3 levels of neighborhood segregation: (1) low segregation neighborhoods (no clustering characterized by a G_i^* statistic < 0), (2) medium segregation neighborhoods (clustering characterized by G_i^* statistic 0–1.96), and

(3) high segregation neighborhoods (clustering characterized by a G_i^* statistic > 1.96). While many studies use census tract racial/ethnic composition based on percentage of racial/ethnic groups as a proxy for segregation, the G_i^* statistic was preferred in this study, because it captured racial/ethnic composition in larger area units and adjacent census tracts.³⁴

Self-reported age (continuous), sex, race/ethnicity (White, Chinese, Black, Hispanic), and socioeconomic status (captured by level of education and family annual income) at exam 1 were included as covariates. Hypertension risk factors included body mass index (continuous weight in kilograms divided by height in meters squared), smoking status (never, former, current), alcohol use (never, former, current), dietary intake (non-ideal and ideal, based on intake of fruits and vegetables, fish, sodium, sugary beverages, and whole grains),³⁷ and physical activity (continuous moderate/vigorous activity based on the rate of energy expended per week, also referred to as metabolic equivalents calculated as the ratio of working metabolic rate relative to resting metabolic rate).³⁸ Additional covariates included study site and nativity status (US-born, foreign-born).

We first described the characteristics of the study population across hypertension status. Next, we reported the proportion of participants who developed hypertension and the age- and sex-adjusted rates of hypertension (number of events of hypertension per 100 person-years at risk) for each type of discrimination (everyday, lifetime) measured within each racial/ethnic group. Participants who did not develop hypertension were censored at their last exam. The time of diagnosis for participants who developed hypertension during the study was only known to have occurred between subsequent study visits (e.g., interval-censoring). Therefore, we used a Cox proportional hazards regression approach, which accommodates interval-censored outcomes to estimate adjusted hazard ratios (HRs) and corresponding 95% CIs to measure the associations between discrimination (at exam 1) and incident hypertension (at exams 2 through 6). Self-reported discrimination tends to occur more frequently among Black Americans,³⁹ and as a result, their experiences may differ from that of other racial/ethnic groups. The literature suggests that the relationship between discrimination and health differs by race/ethnicity, thus the models were stratified by race/ethnicity and the results were reported for each race/ethnicity. The first model was adjusted for age, sex, education, and family annual income. Hypertension risk factors (body mass index, smoking, alcohol use, diet, physical activity), study site and nativity status (only for analyses with Chinese and Hispanic participants) were added to age, sex, education, and family annual income in a second model. Interaction terms were included in the

fully adjusted models to test whether sex and segregation measured at exam 1 each modified the relationship between discrimination and hypertension. Analyses were performed using Statistical Analysis Software (SAS version 9.4; SAS Institute, Inc., Cary, NC).

RESULTS

Of the 6814 MESA participants recruited at exam 1, we excluded 3058 participants with prevalent hypertension at exam 1 (prevalence at exam 1 for White, 39% [n=1012]; Chinese, 37% [n=301]; Black, 59% [n=1124]; Hispanic, 41% [n=621]); with missing information on hypertension at exam 1 (n=172), and with missing data on discrimination measures and covariates at exam 1 (n=287). This left a final sample of 3297, which included 1454 White, 474 Chinese, 626 Black, and 743 Hispanic participants for the analyses. Of these, 3173 had available data on segregation and were included in the segregation analyses.

Over the follow-up period, 49% (n=1625) of participants developed hypertension (White, 45% [n=652]; Chinese, 47% [n=222]; Black, 61% [n=380]; Hispanic, 50% [n=371]). Overall, White participants were more likely to be women, college educated, have a higher income and be current alcohol users than Chinese, Black, and Hispanic participants. Chinese participants had a lower average body mass index, healthier dietary behaviors, and were more likely to live in highly segregated neighborhoods. Black participants were more likely to have a higher body mass index, be current smokers, and engage in more physical activity than White and Chinese participants (Table 1). Overall, 39.8% of White, 23.0% of Chinese, 65.2% of Black, and 42.4% of Hispanic participants reported any lifetime discrimination (Table 2); and 31.9% of White, 19.6% of Chinese, 51.6% of Black, and 25.6% of Hispanic participants reported high levels of everyday discrimination (Table S2).

Lower age- and sex-adjusted hypertension incidence rates were observed for Chinese and Hispanic participants reporting high levels of everyday discrimination compared with those reporting low levels (although CIs overlapped). However, no consistent dose response trends in the association of everyday discrimination and incident hypertension were observed for White and Black participants. Higher rates of hypertension were observed among all racial/ethnic groups reporting any lifetime discrimination compared with no lifetime discrimination, although differences were small in White and Chinese participants (and CIs overlapped) (Table 3).

There were no statistically significant associations between everyday discrimination (continuous

or tertiles) and incident hypertension among White, Chinese, or Black participants (Table 4, model 2). However, after adjustment for age, sex, education, family annual income, hypertension risk factors, nativity status, and study site, Hispanic participants reporting high levels of everyday discrimination had a lower risk of hypertension compared with those reporting low levels (HR, 0.73; 95% CI, 0.55–0.98). Chinese participants reporting high levels of everyday discrimination also had a lower risk of hypertension, but CIs were wide (HR, 0.70; 95% CI, 0.46–1.08) in the fully adjusted model. Lifetime discrimination was not associated with incident hypertension for White, Chinese, or Hispanic participants, but lifetime discrimination was associated with an increased risk of hypertension (HR, 1.35; 95% CI, 1.07–1.69) in Black participants after adjustment for age, sex, education, family annual income, hypertension risk factors, and study site (Table 4, model 2).

Neither sex or segregation modified the associations of everyday discrimination or lifetime discrimination with incident hypertension in any racial/ethnic group (*P* value for interaction >0.05). The association between lifetime discrimination and incident hypertension was also not modified by discrimination attribution for any racial/ethnic group (*P* value for interaction >0.05).

DISCUSSION

Prior work linking discrimination to hypertension has been mostly cross-sectional, has had limited discrimination measures, has used self-reported hypertension, and lacked racially and ethnically diverse samples.^{11,40} Our study adds to the literature on discrimination and hypertension by using a large population-based study of White, Black, Chinese, and Hispanic participants to prospectively examine the associations between multiple measures of discrimination (everyday, lifetime) and objective measures of incident hypertension, as well as to assess effect modification by segregation.

Our study found that lifetime discrimination was associated with incident hypertension in Black participants. The hazard ratios for Chinese and Hispanic participants were in the same direction as that of Black participants, but they were not statistically significant. These findings suggest that experiences of discrimination over the life course may have deleterious health effects for racial and ethnic minority groups, particularly Black participants. These findings are consistent with those of 2 studies that examined the effects of lifetime discrimination on hypertension among Black participants in the Jackson Heart Study. Sims et al found an association between lifetime discrimination and prevalent hypertension,¹² and Forde et al expanded upon

Table 1. Distribution of Exam 1 Characteristics of Participants in MESA by Race/Ethnicity and Hypertension Status

| | White | | | Chinese | | | Black | | | Hispanic | | |
|-------------------------------------------|----------------------------------------------------|----------------------------------------------|---------|-----------------------------------------------------|----------------------------------------------|---------|----------------------------------------------------|----------------------------------------------|------|----------------------------------------------------|----------------------------------------------|---------|
| | Did Not Develop Hypertension n=802 % or mean±SD | Developed Hypertension n=652 % or mean±SD | P* | Did Not Develop Hypertension n=252 % or mean ±SD | Developed Hypertension n=222 % or mean±SD | P* | Did Not Develop Hypertension n=246 % or mean±SD | Developed Hypertension n=380 % or mean±SD | P* | Did Not Develop Hypertension n=372 % or mean±SD | Developed Hypertension n=371 % or mean±SD | P* |
| Study site | | | 0.92 | | | ... | | | ... | | | ... |
| Forsyth County, North Carolina | 19.3 | 19.8 | | 0.0 | 0.0 | | 21.1 | 20.0 | | 0.0 | 0.3 | |
| New York, New York | 9.6 | 10.1 | | 0.8 | 0.0 | | 21.5 | 22.9 | | 29.6 | 34.2 | |
| Baltimore, Maryland | 16.7 | 16.4 | | 0.0 | 0.0 | | 24.4 | 26.3 | | 0.0 | 0.0 | |
| St. Paul, Minnesota | 23.7 | 24.1 | | 0.0 | 0.0 | | 0.0 | 0.0 | | 31.2 | 32.9 | |
| Chicago, Illinois | 25.8 | 23.8 | | 42.1 | 37.4 | | 23.2 | 19.5 | | 0.0 | 0.0 | |
| Los Angeles, California | 4.9 | 5.8 | | 57.1 | 62.6 | | 9.8 | 11.3 | | 39.2 | 32.6 | |
| Age, y | 58.5±9.6 | 61.7±9.7 | <0.0001 | 57.7±9.5 | 61.3±9.7 | <0.0001 | 57.5 ±10.1 | 58.7±9.3 | 0.15 | 56.5±9.4 | 59.4±9.7 | <0.0001 |
| Sex | | | 0.70 | | | 0.52 | | | 0.34 | | | 0.69 |
| Women | 52.9 | 51.8 | | 51.2 | 48.2 | | 50.8 | 54.7 | | 48.1 | 49.6 | |
| Nativity status | | | 0.37 | | | 0.07 | | | 0.89 | | | 0.74 |
| US-born (50 United States or Puerto Rico) | 93.4 | 92.2 | | 5.6 | 2.3 | | 87.8 | 88.2 | | 42.5 | 43.7 | |
| Foreign-born | 6.6 | 7.8 | | 94.4 | 97.7 | | 12.2 | 11.8 | | 57.5 | 56.3 | |
| Education | | | 0.05 | | | 0.17 | | | 0.28 | | | 0.20 |
| <High school diploma/GED | 2.6 | 4.6 | | 19.1 | 20.7 | | 7.3 | 8.4 | | 37.9 | 43.9 | |
| High school/some college | 37.5 | 40.3 | | 32.9 | 39.6 | | 48.4 | 53.7 | | 48.9 | 45.6 | |
| College degree or higher | 59.9 | 55.1 | | 48.0 | 39.7 | | 44.3 | 37.9 | | 13.2 | 10.5 | |
| Family annual income | | | 0.08 | | | 0.03 | | | 0.89 | | | 0.10 |
| \$<20 000 | 7.5 | 8.7 | | 32.5 | 39.2 | | 17.5 | 16.6 | | 35.5 | 32.1 | |
| \$20 000–49 999 | 27.1 | 31.6 | | 29.8 | 34.7 | | 32.9 | 34.7 | | 40.6 | 48.2 | |
| \$≥50 000 | 65.4 | 59.7 | | 37.7 | 26.1 | | 49.6 | 48.7 | | 23.9 | 19.7 | |

(Continued)

Table 1. Continued

| | White | | | Chinese | | | Black | | | Hispanic | | |
|-------------------------------------------------|----------------------------------------------------|----------------------------------------------|---------|-----------------------------------------------------|----------------------------------------------|-------|----------------------------------------------------|----------------------------------------------|-------|----------------------------------------------------|----------------------------------------------|---------|
| | Did Not Develop Hypertension n=802 % or mean±SD | Developed Hypertension n=652 % or mean±SD | P* | Did Not Develop Hypertension n=252 % or mean ±SD | Developed Hypertension n=222 % or mean±SD | P* | Did Not Develop Hypertension n=246 % or mean±SD | Developed Hypertension n=380 % or mean±SD | P* | Did Not Develop Hypertension n=372 % or mean±SD | Developed Hypertension n=371 % or mean±SD | P* |
| Body mass index (kg/m ²) | 26.3±4.6 | 27.6±4.7 | <0.0001 | 23.2±3.1 | 24.0±3.1 | 0.005 | 28.4±5.3 | 29.7±5.9 | 0.006 | 28.0±4.4 | 29.8±5.4 | <0.0001 |
| Smoking status | | | 0.50 | | | 0.27 | | | 0.57 | | | 0.43 |
| Never | 45.5 | 43.1 | | 78.5 | 72.5 | | 41.4 | 45.8 | | 55.4 | 51.4 | |
| Former | 41.3 | 44.3 | | 16.7 | 20.3 | | 35.4 | 32.9 | | 29.6 | 34.0 | |
| Current | 13.2 | 12.6 | | 4.8 | 7.2 | | 23.2 | 21.3 | | 15.0 | 14.6 | |
| Alcohol use | | | 0.88 | | | 0.64 | | | 0.28 | | | 0.23 |
| Never | 7.1 | 6.5 | | 48.0 | 52.2 | | 10.2 | 14.5 | | 22.3 | 27.2 | |
| Former | 17.5 | 17.6 | | 17.9 | 15.8 | | 31.7 | 29.2 | | 25.3 | 21.6 | |
| Current | 75.4 | 75.9 | | 34.1 | 32.0 | | 58.1 | 56.3 | | 52.4 | 51.2 | |
| Diet | | | 0.79 | | | 0.07 | | | 0.02 | | | 0.44 |
| Non-ideal | 63.0 | 63.6 | | 35.3 | 27.5 | | 70.7 | 61.3 | | 67.5 | 70.1 | |
| Intermediate/ideal | 37.0 | 36.4 | | 64.7 | 72.5 | | 29.3 | 38.7 | | 32.5 | 29.9 | |
| Moderate/vigorous physical activity, MET-min/wk | 5930±5037 | 5901±5801 | 0.92 | 4140±4478 | 4037±3890 | 0.79 | 7418±7313 | 7107±6196 | 0.57 | 7076±6734 | 6688±6343 | 0.42 |
| Everyday discrimination† | | | | | | | | | | | | |
| Continuous | 1.6±0.5 | 1.6 +/0.5 | 0.61 | 1.5±0.6 | 1.4±0.5 | 0.004 | 2.0±0.9 | 2.0±0.8 | 0.72 | 1.6±0.7 | 1.5±0.7 | 0.008 |
| Categorical | | | 0.71 | | | 0.02 | | | 0.15 | | | 0.01 |
| Low, 1.00–1.11 | 26.4 | 27.6 | | 38.9 | 50.0 | | 17.0 | 14.0 | | 36.6 | 47.2 | |
| Medium, 1.22–1.78 | 40.8 | 41.6 | | 37.7 | 34.7 | | 28.9 | 36.0 | | 33.6 | 31.5 | |
| High, 1.88–6.00 | 32.8 | 30.8 | | 23.4 | 15.3 | | 54.1 | 50.0 | | 29.8 | 21.3 | |
| Lifetime discrimination† | | | | | | | | | | | | |
| Continuous | 0.6±0.9 | 0.6±0.9 | 0.55 | 0.4±0.8 | 0.3±0.7 | 0.75 | 1.3±1.4 | 1.4±1.4 | 0.69 | 0.7±1.0 | 0.7+/1.0 | 0.47 |
| Categorical | | | 0.78 | | | 0.67 | | | 0.21 | | | 0.85 |
| None, 0.00–0.00 | 59.9 | 60.6 | | 77.8 | 76.1 | | 37.8 | 32.9 | | 57.3 | 58.0 | |
| Any, 1.00–6.00 | 40.1 | 39.4 | | 22.2 | 23.9 | | 62.2 | 67.1 | | 42.7 | 42.0 | |

(Continued)

Table 1. Continued

| | White | | | Chinese | | | Black | | | Hispanic | | |
|-----------------------------------------------------|---------------------------------------|---------------------------------|--------|---------------------------------------|---------------------------------|------|---------------------------------------|---------------------------------|-------|---------------------------------------|---------------------------------|-------|
| | Did Not Develop Hypertension n=802 | Developed Hypertension n=652 | P* | Did Not Develop Hypertension n=252 | Developed Hypertension n=222 | P* | Did Not Develop Hypertension n=246 | Developed Hypertension n=380 | P* | Did Not Develop Hypertension n=372 | Developed Hypertension n=371 | P* |
| | % or mean±SD | % or mean±SD | | % or mean ±SD | % or mean±SD | | % or mean±SD | % or mean±SD | | % or mean±SD | % or mean±SD | |
| Attribution of lifetime discrimination [§] | | | 0.85 | | | 0.51 | | | 0.56 | | | 0.77 |
| Non-racial | 89.4 | 89.9 | | 55.4 | 49.1 | | 24.8 | 27.5 | | 47.2 | 45.5 | |
| Racial | 10.6 | 10.1 | | 44.6 | 50.9 | | 75.2 | 72.5 | | 52.8 | 54.5 | |
| Segregation (G-statistic) | | | 0.82 | | | 0.94 | | | 0.04 | | | 0.09 |
| Low, <0 | 45.6 | 43.9 | | 4.1 | 4.6 | | 23.0 | 16.6 | | 21.8 | 16.6 | |
| Medium, 0-1.96 | 41.1 | 42.3 | | 17.4 | 17.7 | | 27.7 | 23.9 | | 17.0 | 14.6 | |
| High, >1.96 | 13.3 | 13.8 | | 78.5 | 77.7 | | 49.3 | 59.5 | | 61.2 | 68.8 | |
| Time lived in neighborhood, y [¶] | 18.0±14.1 | 20.9±14.8 | 0.0002 | 10.9±10.0 | 10.5±9.5 | 0.66 | 16.4±12.6 | 19.3±13.0 | 0.007 | 15.6±12.9 | 18.5±14.1 | 0.004 |

GED indicates general equivalency diploma; MESA, the Multi-Ethnic Study of Atherosclerosis; and MET, metabolic equivalent.

*P values based on χ^2 and t-tests.

[†]Median [25th and 75th percentile]; White (yes hypertension, 1.55 [1.11 and 1.94]; no hypertension, 1.55 [1.11 and 2.00]); Chinese (yes hypertension, 1.17 [1.00 and 1.56]; no hypertension, 1.33 [1.00 and 1.78]; Black (yes hypertension, 1.83 [1.44 and 2.44]; no hypertension, 1.89 [1.44 and 2.44]; Hispanic (yes hypertension, 1.22 [1.00 and 1.67]; no hypertension, 1.33 [1.00 and 2.00]).

[‡]Median [25th and 75th percentile]; White (yes hypertension, 0.00 [0.00 and 1.00]; no hypertension, 0.00 [0.00 and 1.00]); Chinese (yes hypertension, 0.00 [0.00 and 0.00]; no hypertension, 0.00 [0.00 and 0.00]); Black (yes hypertension, 1.00 [0.00 and 2.00]; no hypertension, 1.00 [0.00 and 2.00]); Hispanic (yes hypertension, 0.00 [0.00 and 1.00]; no hypertension, 0.00 [0.00 and 1.00]).

[§]Attribution: White (no hypertension, n=321; yes hypertension, n=56; yes hypertension, n=257); Chinese (no hypertension, n=53; yes hypertension, n=153; yes hypertension, n=255); Hispanic (no hypertension, n=159; yes hypertension, n=156).

^{||}Segregation: White (no hypertension, n=768; yes hypertension, n=631); Chinese (no hypertension, n=247; yes hypertension, n=215); Black (no hypertension, n=235; yes hypertension, n=373); Hispanic (no hypertension, n=348; yes hypertension, n=356).

[¶]Time lived in the neighborhood was restricted to those with data on segregation.

Table 2. Distribution of Exam 1 Characteristics of Participants in MESA by Race/Ethnicity and Categories of Lifetime Discrimination

| | White | | Chinese | | Black | | Hispanic | |
|-------------------------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | None* (n=875) | Any* (n=579) | None* (n=365) | Any* (n=109) | None* (n=218) | Any* (n=408) | None* (n=428) | Any* (n=315) |
| | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* |
| Age, y | 61.1±10.1 | 58.2±9.0 | 60.1±9.7 | 57.1±9.3 | 59.9±10.0 | 57.3±9.4 | 58.7±9.9 | 56.9±9.3 |
| Sex | | | | | | | | |
| Women | 52.5 | 52.3 | 52.0 | 42.2 | 68.3 | 45.1 | 55.8 | 39.4 |
| Nativity status | | | | | | | | |
| US-born (50 US states or Puerto Rico) | 92.2 | 93.8 | 3.0 | 7.3 | 83.0 | 90.7 | 36.0 | 52.7 |
| Foreign-born | 7.8 | 6.2 | 97.0 | 92.7 | 17.0 | 9.3 | 64.0 | 47.3 |
| Education | | | | | | | | |
| < High school diploma/GED | 4.9 | 1.4 | 23.3 | 8.3 | 11.0 | 6.4 | 46.3 | 33.6 |
| High school diploma/GED/some college | 43.2 | 32.1 | 36.7 | 33.9 | 57.8 | 48.3 | 43.9 | 51.8 |
| College diploma or higher | 51.9 | 66.5 | 40.0 | 57.8 | 31.2 | 45.3 | 9.8 | 14.6 |
| Family annual income | | | | | | | | |
| \$<20 000 | 8.3 | 7.6 | 40.0 | 21.1 | 20.6 | 14.9 | 34.3 | 33.0 |
| \$20 000–49 999 | 27.3 | 31.8 | 31.0 | 35.8 | 38.1 | 31.9 | 47.9 | 39.7 |
| \$≥50 000 | 64.4 | 60.6 | 29.0 | 43.1 | 41.3 | 53.2 | 17.8 | 27.3 |
| Body mass index, kg/m ² | 26.7±4.6 | 27.1±4.9 | 23.5±3.1 | 23.6±3.1 | 30.1±6.1 | 28.8±5.4 | 28.6±5.0 | 29.2±4.9 |
| Smoking status | | | | | | | | |
| Never | 46.1 | 42.0 | 77.8 | 68.8 | 49.1 | 41.4 | 57.9 | 47.3 |
| Former | 41.1 | 44.9 | 16.2 | 25.7 | 33.5 | 34.1 | 29.7 | 34.6 |
| Current | 12.8 | 13.1 | 6.0 | 5.5 | 17.4 | 24.5 | 12.4 | 18.1 |
| Alcohol use | | | | | | | | |
| Never | 8.5 | 4.3 | 52.6 | 41.3 | 20.6 | 8.6 | 29.9 | 17.8 |
| Former | 16.0 | 19.9 | 15.3 | 22.0 | 31.7 | 29.4 | 22.0 | 25.4 |
| Current | 75.5 | 75.8 | 32.1 | 36.7 | 47.7 | 62.0 | 48.1 | 56.8 |
| Diet | | | | | | | | |
| Non-ideal | 64.1 | 62.0 | 31.0 | 33.9 | 64.2 | 65.4 | 64.2 | 74.9 |
| Intermediate/ideal | 35.9 | 38.0 | 69.0 | 66.1 | 35.8 | 34.6 | 35.8 | 25.1 |
| Moderate/vigorous physical activity, MET-minutes/week | 5868±5368 | 5990±5429 | 3863±3966 | 4859±4879 | 6385±5592 | 7681±7122 | 6574±6191 | 7301±6975 |

(Continued)

Table 2. Continued

| | White | | Chinese | | Black | | Hispanic | |
|--------------------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | None* (n=875) | Any* (n=579) | None* (n=365) | Any* (n=109) | None* (n=218) | Any* (n=408) | None* (n=428) | Any* (n=315) |
| | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* | % or Mean±SD* |
| Segregation (G-statistic) [†] | | | | | | | | |
| Low (<0) | 43.2 | 47.3 | 3.4 | 7.4 | 19.3 | 19.0 | 18.6 | 20.0 |
| Medium (0–1.96) | 43.4 | 39.1 | 18.1 | 15.7 | 29.0 | 23.4 | 14.8 | 17.0 |
| High (>1.96) | 13.4 | 13.6 | 78.5 | 76.9 | 51.7 | 57.6 | 66.6 | 63.0 |
| Time lived in neighborhood in years [‡] | 20.4±15.1 | 17.7±13.4 | 10.6±9.4 | 11.3±10.8 | 19.1±13.6 | 17.7±12.6 | 17.6±13.8 | 16.5±13.3 |

GED indicates general equivalency diploma; MESA, the Multi-Ethnic Study of Atherosclerosis; MET, metabolic equivalent; and SD, standard deviation.

*Lifetime discrimination categories: None: 0.00 to 0.00; Any: 1.00 to 6.00.

[†]Segregation: White (none: n=841; any: n=558); Chinese (none: n=354; any: n=108); Black (none: n=207; any: n=401); Hispanic (none: n=404; any: n=300).

[‡]Time lived in the neighborhood was restricted to those with data on segregation.

this cross-sectional study to report an association with lifetime discrimination and incident hypertension.⁸ Another longitudinal study by Cozier et al did not observe an association between lifetime discrimination and self-reported incident hypertension among Black women, but found limited support for an association between lifetime discrimination and self-reported incident hypertension among the subgroup of Black women in the cohort born outside of the United States.⁴¹ Unlike Cozier et al, we included men and women, used the entire lifetime discrimination scale, and used objective measures of hypertension, which may explain why our findings differed from that of Cozier et al.

In contrast to our findings on lifetime discrimination, everyday discrimination did not predict increased risk for incident hypertension for Black participants, which is consistent with findings from previous longitudinal studies on everyday discrimination and incident hypertension.^{8,17,41} The everyday discrimination scale was designed to capture minor daily occurrences of discrimination, which may influence changes in blood pressure over a short period. Observing the effects of everyday discrimination may therefore be more apparent for ambulatory blood pressure measurements. On the other hand, the lifetime discrimination scale captures major occurrences of discrimination over the lifetime and may therefore capture long-term cumulative effects on chronic health outcomes, such as incident hypertension.

One surprising result was the unexpected association of higher reports of everyday discrimination with lower incidence of hypertension among Chinese (not statistically significant in the fully adjusted model) and Hispanic participants. These findings are in contrast to the null findings on everyday discrimination and objective hypertension incidence among Chinese and Hispanic middle-aged women in the study by Moody et al.¹⁷ Our unexpected results did not appear to be driven by differential distribution of covariates across levels of everyday discrimination because the patterns were similar for all racial/ethnic groups, and point estimates remained largely unchanged after adjustment. It is also possible that the measurement properties (including validity) of the everyday discrimination scale vary across different racial/ethnic groups (and also by place of birth, a significant proportion of Hispanic and Chinese participants were foreign born) and could have contributed to these unexpected results.⁴²

Consistent with previous studies, neither sex or discrimination attribution (for lifetime discrimination) modified the association of discrimination and hypertension.^{8,12,43} Among the 3 longitudinal studies that previously examined the association of discrimination (everyday, lifetime) with incident hypertension, none of these studies explored effect modification by segregation.^{8,17,41} Our study did not observe effect modification by segregation for lifetime or everyday discrimination,

Table 3. Age- and Sex-Adjusted Incidence Rates of Hypertension by Race/Ethnicity and Categories of Discrimination Among Participants in MESA

| | White | | Chinese | | Black | | Hispanic | |
|-------------------------|------------------------------------|-------------------------------------------------|------------------------------------|-------------------------------------------------|------------------------------------|-------------------------------------------------|------------------------------------|-------------------------------------------------|
| | No. of Incident Hypertension Cases | Hypertension Rate per 100 Person-Years (95% CI) | No. of Incident Hypertension Cases | Hypertension Rate per 100 Person-Years (95% CI) | No. of Incident Hypertension Cases | Hypertension Rate per 100 Person-Years (95% CI) | No. of Incident Hypertension Cases | Hypertension Rate per 100 Person-Years (95% CI) |
| Everyday discrimination | | | | | | | | |
| Low, 1.00–1.11 | 180 | 4.2 (3.3–5.2) | 111 | 6.0 (4.6–7.7) | 53 | 6.9 (4.6–10.4) | 175 | 6.5 (5.3–8.0) |
| Medium, 1.22–1.78 | 271 | 4.3 (3.6–5.1) | 77 | 4.4 (3.3–5.9) | 137 | 8.6 (7.1–10.5) | 117 | 5.7 (4.5–7.2) |
| High, 1.88–6.00 | 201 | 4.5 (3.7–5.5) | 34 | 3.6 (2.2–5.8) | 190 | 7.1 (5.8–8.8) | 79 | 5.2 (3.7–7.3) |
| Lifetime discrimination | | | | | | | | |
| None, 0.00–0.00 | 395 | 4.3 (3.7–5.0) | 169 | 4.6 (3.8–5.6) | 125 | 6.4 (5.0–8.2) | 215 | 5.7 (4.7–6.9) |
| Any, 1.00–6.00 | 257 | 4.4 (3.8–5.2) | 53 | 5.0 (3.4–7.3) | 255 | 8.1 (6.8–9.5) | 156 | 6.2 (5.1–7.6) |

MESA indicates the Multi-Ethnic Study of Atherosclerosis.

which is consistent with previous studies on obesity⁴⁴ and health behaviors.⁴⁵

Several limitations should be noted when interpreting our study findings. While the MESA cohort included a large sample, participants were only recruited from 6 study sites in the United States and they were not representative of these cities or the national population, which may limit the generalizability of our findings to other locations. In addition, the number of Chinese participants was small relative to White, Black, and Hispanic participants. As a result, power, particularly for interaction analyses was limited. The data in our study did not include repeated measures of discrimination or the specific time that discrimination occurred, which limited our ability to capture the impact of changes in discrimination experiences on hypertension development over the follow-up period. It is also possible that the everyday discrimination scale captures more generic daily hassles not specifically linked to racial discrimination, and that the impact of these factors on hypertension is different than what could be observed for more specific measures of racial discrimination (although attribution did not modify the associations of lifetime measures with hypertension). Hypertension was assessed using objective blood pressure measurements and self-reported medication use, but there is evidence to suggest that ambulatory blood pressure measurements may be more appropriate for detecting the effects of discrimination on blood pressure.¹⁰

There is also the possibility that participants who were included in the study represent a selected sample who survived to older ages without developing hypertension. This group may be less likely to develop hypertension for reasons other than discrimination and could therefore be less vulnerable to the deleterious health consequences of discrimination. In addition, it is possible that prior discrimination had an impact on the earlier development of hypertension for those who were excluded for having prevalent hypertension at exam 1, which could result in an underestimation of the true association of discrimination with incident hypertension in our analyses. Unfortunately, limited sample size did not allow us to investigate whether associations of perceived discrimination with incident hypertension differed by birth cohort.

Our study had several strengths, which included the prospective study design, long follow-up period, racially and ethnically diverse study population, multiple dimensions of discrimination (everyday, lifetime), objective measures of hypertension (measured blood pressure, medication use), segregation, and numerous confounders and mediators relevant to the discrimination and hypertension association.

Table 4. Hazard Ratios of Incident Hypertension by Race/Ethnicity and Categories of Discrimination Among Participants in MESA

| | White | | Chinese | | Black | | Hispanic | |
|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | Model 1* HR (95% CI) | Model 2† HR (95% CI) | Model 1* HR (95% CI) | Model 2† HR (95% CI) | Model 1* HR (95% CI) | Model 2† HR (95% CI) | Model 1* HR (95% CI) | Model 2† HR (95% CI) |
| Everyday discrimination | | | | | | | | |
| Continuous (SD units) | 1.09 (0.99–1.21) | 1.09 (0.99–1.20) | 0.79 (0.64–0.96) | 0.83 (0.67–1.01) | 1.00 (0.91–1.08) | 1.00 (0.91–1.08) | 0.92 (0.82–1.03) | 0.89 (0.79–1.00) |
| Low, 1.00–1.11 (ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Medium, 1.22–1.78 | 1.11 (0.91–1.34) | 1.10 (0.91–1.34) | 0.77 (0.57–1.04) | 0.82 (0.60–1.12) | 1.24 (0.89–1.72) | 1.30 (0.92–1.83) | 0.90 (0.71–1.15) | 0.86 (0.68–1.11) |
| High, 1.88–6.00 | 1.15 (0.93–1.43) | 1.14 (0.92–1.42) | 0.63 (0.42–0.94) | 0.70 (0.46–1.08) | 1.07 (0.78–1.48) | 1.12 (0.80–1.56) | 0.79 (0.59–1.04) | 0.73 (0.55–0.98) |
| Lifetime discrimination | | | | | | | | |
| None, 0.00–0.00 (ref) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Any, 1.00–6.00 | 1.04 (0.88–1.22) | 1.04 (0.88–1.23) | 1.19 (0.86–1.64) | 1.18 (0.86–1.64) | 1.29 (1.03–1.61) | 1.35 (1.07–1.69) | 1.14 (0.92–1.41) | 1.13 (0.91–1.41) |

*Model 1: Adjusted for age, sex, education, and family annual income.

†Model 2: Adjusted for model 1 + body mass index, smoking, alcohol, diet, physical activity, nativity status (sample with Chinese and Hispanic participants), and study site.

Perspectives

Our study offers new evidence in support of an association between experiences of discrimination and incident hypertension in Black participants. Future studies should measure discrimination at multiple time points to capture the impact of recurring instances of unfair treatment on risk for hypertension and measure psychosocial resources which may modify or reduce the impact of discrimination on hypertension development. Lastly, additional studies should include a larger sample of Chinese participants, as well as participants from other regions of the United States to confirm the findings in our study. Our study also highlights the potential public health importance of discrimination as a contributor to incident hypertension and to adverse cardiovascular health outcomes in Black participants.

ARTICLE INFORMATION

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Disclosures

None.

Supplementary Material

Table S1–S2

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SUPPLEMENTARY MATERIAL

Perceived Discrimination and Hypertension Risk among Participants in the Multi-Ethnic Study of Atherosclerosis (MESA)

Allana T. Forde, PhD, MPH; Tené T. Lewis, PhD; Kiarri N. Kershaw, PhD, MPH; Scarlett L. Bellamy, ScD; Ana V. Diez Roux, MD, PhD, MPH

| Table S1. Discrimination Measures in MESA | | | |
|----------------------------------------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dimension/Construct | Subscales | Items | Responses (for each item) |
| Everyday Discrimination | Occurrence and frequency | <ul style="list-style-type: none"> • you are treated with less courtesy than others • you are treated with less respect than others • you received poorer service than others at restaurants or stores • people act as if they think you are not smart • people act as if they are afraid of you • people act as if they think you are dishonest • people act as if they are better than you are • you are called names or insulted • you are threatened or harassed | <ul style="list-style-type: none"> • never • less than once a year • a few times a year • a few times a month • at least once a week • almost every day |
| Major Life Events | Occurrence | <ul style="list-style-type: none"> • unfairly fired or denied a promotion • unfairly not being hired • mistreated by the police • being discouraged in education • being prevented from moving into a neighborhood • experiencing poor treatment by neighbors | <ul style="list-style-type: none"> • no • yes |
| MESA indicates the Multi-Ethnic Study of Atherosclerosis | | | |

Perceived Discrimination and Hypertension Risk among Participants in the Multi-Ethnic Study of Atherosclerosis (MESA)

Allana T. Forde, PhD, MPH; Tené T. Lewis, PhD; Kiarri N. Kershaw, PhD, MPH; Scarlett L. Bellamy, ScD; Ana V. Diez Roux, MD, PhD, MPH

| | | | | | | | | | | | | |
|------------------------------------------------------|-------------|-------------|-------------|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Low (<0) | 40.5 | 42.3 | 51.8 | 2.5 | 1.8 | 13.0 | 20.4 | 18.7 | 18.9 | 15.0 | 22.0 | 22.5 |
| Medium (0-1.96) | 43.6 | 45.0 | 35.7 | 16.3 | 21.4 | 13.1 | 27.3 | 18.7 | 29.0 | 16.1 | 18.1 | 12.4 |
| High (>1.96) | 15.9 | 12.7 | 12.5 | 81.2 | 76.8 | 73.9 | 52.3 | 62.6 | 52.1 | 68.9 | 59.9 | 65.1 |
| Time Lived in Neighborhood, years[‡] | 21.4 ± 14.7 | 19.4 ± 15.0 | 17.5 ± 13.4 | 8.9 ± 8.2 | 11.8 ± 10.2 | 13.0 ± 11.4 | 19.3 ± 14.0 | 19.3 ± 13.3 | 17.1 ± 12.3 | 17.3 ± 14.2 | 16.8 ± 13.6 | 17.1 ± 12.5 |

MESA indicates the Multi-Ethnic Study of Atherosclerosis; SD, standard deviation; GED, general equivalency diploma; MET, metabolic equivalent.

*Everyday discrimination tertiles: Low: 1.00-1.11; Medium: 1.22-1.78; High: 1.88-6.00.

†Segregation: White (Low tertile: n=378; Medium tertile: n=573; High tertile: n=448); Chinese (Low tertile: n=202; Medium tertile: n=168; High tertile: n=92); Black (Low tertile: n=88; Medium tertile: n=203; High tertile: n=317); Hispanic (Low tertile: n=299; Medium tertile: n=227; High tertile: n=178).

‡Time lived in the neighborhood was restricted to those with data on segregation.