Skin Color, Social Classification, and Blood Pressure in Southeastern Puerto Rico

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Throughout the Americas, people of African ancestry have higher mean blood pressures and higher rates of hypertension than do others in the same societies. This pattern was first observed in the United States in 1932. Over 70 years later, excess hypertension still contributes more to the diminished life expectancy of African Americans than does any other major cause of death, including cancer, diabetes, stroke, or HIV/AIDS. Although the prevalence of hypertension and the magnitude of inequalities vary by country, a general pattern of elevated blood pressure holds elsewhere in the African Diaspora.

There remains no consensus as to why this pattern exists, leading some to call it "the puzzle of hypertension in African-Americans." One key piece of the puzzle is that, within populations of African ancestry, darker-skinned individuals tend to have higher mean blood pressures than do their lighter-skinned counterparts. Previous researchers have proposed 2 major explanations for this relationship. The first is that dark skin color, as a marker of African ancestry, is linked to a genetic predisposition for high blood pressure. The second is that dark skin color, as a marker of subordinate social status, exposes dark-skinned individuals to racial discrimination, poverty, and other stressors related to blood pressure.

These competing hypotheses—1 genetic, 1 sociocultural—encapsulate the debate over race and health in general, making the skin color–blood pressure relationship a convenient microcosm of the broader problem.

Our purpose was to test competing explanations for the relationship between skin color and blood pressure more directly than has been done before. We address an important limitation of previous studies by recognizing that genetic and sociocultural hypotheses refer to distinct dimensions of skin color. The hypothesis that skin color is linked to a genetic predisposition for high blood pressure refers to the phenotype of skin pigmentation. The hypothesis that skin color is a marker of exposure to social stressors refers to the cultural significance of skin color as a criterion of social classification. These conceptually distinct variables require distinct measurement operations. However, previous studies have not aimed to isolate the cultural and biological dimensions of skin color or to test their associations with blood pressure.

Measuring the biological dimension of skin color is straightforward in principle. Reflectance spectrophotometry provides an objective measurement of skin pigmentation attributable to melanin, the implicit skin color variable in genetic hypotheses for the skin color–blood pressure relationship. The key measurement challenges involve the choice of instrument and use of proper technique. Measuring the cultural dimension of skin color presents a different set of challenges. It first requires a test of the assumption that there is a shared cultural model that assigns meaning to skin color variation. It then requires a way to estimate how the color status of any given individual would be defined according to that model. In short, it requires treating the notion that race is a cultural construct as an empirical matter, not a mantra.

We use data from a preliminary study in Puerto Rico to test the hypothesis that blood pressure is associated with the cultural rather than biological significance of skin color. Two factors make Puerto Rico an appropriate setting. First, an earlier study reported an association between skin pigmentation and systolic blood pressure (SBP) among 4000 urban men, but it did not address the extent to which this association reflected genetic or sociocultural mechanisms. Second, previous ethnography indicates that the local cultural model of color differs from the American model of race in important ways. In particular, color classification is shaped not only by skin color but also by other physical features and, possibly, by social status markers like wealth, family background, or residential area. One consequence is that, for a given level of skin pigmentation, there should be variability in social classification, making it possible to measure the cultural...
and biological dimensions of skin color as distinct variables.

**METHODS**

**Research Setting and Sampling**

The research was set in Guayama, Puerto Rico, a southeastern coastal town of approximately 44,000 residents. Guayama was a center of the Puerto Rican sugar economy in the 19th century and now has a substantial manufacturing base, especially in the petroleum and pharmaceutical industries. This trajectory of economic development ensures adequate variation in 2 key independent variables in our study: skin color and socioeconomic status.

The sample was designed to maximize contrasts in these variables, rather than to estimate population parameters. On the basis of ethnographic data, we identified 4 residential areas that span the range of variation on socioeconomic status and skin color, and selected a probability sample for each area. This strategy was based on previous studies of skin color and blood pressure, and is appropriate when the goal is to maximize internal validity.

The first sampled residential area consisted of the 5 caseríos, or public housing facilities in Guayama. The second was a lower-middle class barrio, the typical residents of which include secretaries, teacher’s assistants, factory workers, and others in the service sector. The third was a large middle-class urbanización, or planned subdivision, the typical residents of which include teachers, bankers, or technical workers in area pharmaceutical plants. The fourth was the only gated urbanización in Guayama, favored by physicians, lawyers, and scientists and engineers from local petroleum and pharmaceutical plants. Further details about the 4 residential strata are given elsewhere. Sampling from these residential types limits the generalizability of our findings, but it improves the efficiency of our attempt to detect sociocultural processes related to class and color.

Within each residential type, we drew a random sample of 25 households. One adult, aged 25–55 years, was selected randomly from each household, for a total sample size of 100. If the sampled household had no eligible members, refused to participate, or could not be reached after 3 attempts, another household was substituted at random. Response rates ranged from 80.6 to 89.3% across neighborhoods, with an overall rate of 85.5%.

Interviews were conducted in participants’ homes by a European American research assistant and a Puerto Rican research assistant, who self-identified as negru, or Black. The interview schedule was designed to be executed with handheld computers and software designed for mobile computer-assisted personal interviewing. The advantages of this technology for data quality are described elsewhere. Data were collected in June and July 2001.

**Skin Color Measures**

Recent developments in culture theory and ethnographic methods allow us to estimate how color is defined according to the salient cultural model in Puerto Rico. Specifically, cultural consensus analysis formally tests the assumption that respondents share a coherent cultural model, and estimates the culturally appropriate responses to a set of questions. Gravlee used cultural consensus analysis to describe the cultural model of color in southeastern Puerto Rico. He asked respondents to identify the color of 72 standardized facial portraits that vary systematically in gender, skin tone, hair texture, nose shape, and lip form; the portraits were originally developed to elicit folk racial categorizations in Brazil. Cultural consensus analysis of respondents’ categorizations in Puerto Rico provides evidence of a shared cultural model of color, which enables classification of the standardized portraits into 5 culturally salient categories.

We matched survey respondents to the same standardized portraits in order to estimate the culturally appropriate classification of each respondent’s color. Interviewers independently selected the portrait that most closely resembled each survey respondent. Initial interrater reliability was moderately strong (κ = 0.64, 95% confidence interval [CI] = 0.51–0.76); disagreements were resolved through discussion. Because cultural consensus analysis estimates the culturally appropriate categorization of each portrait, matching survey respondents to portraits estimates the culturally appropriate categorization of each respondent’s color. This estimate approximates how respondents are perceived by others in mundane social interaction.

Skin pigmentation was measured with a handheld narrow-band reflectometer (Derma-Spectrometer; Cortex Technology, Hadsund, Denmark) designed and validated for measuring human skin pigments. The Derma-Spectrometer emits light at green (568 nm) and red (655 nm) wavelengths. It separates the reflected light attributable to melanin from that attributable to hemoglobin and summarizes this value as the melanin index (M). Analyses here use the mean melanin index from 3 measurements taken at the upper inner arm (an unexposed site), following Shriver and Parra. This index estimates constitutive skin pigmentation, the implicit skin color variable in genetic explanations for the relationship between skin color and blood pressure.

**Blood Pressure and Covariates**

Blood pressure measurements were made with an automatic blood pressure monitor, Omron Model HEM-737AC (Omron Healthcare, Inc., Vernon Hills, IL). This device has been validated for use in population-based studies and has been recommended by the European Society of Hypertension. Three blood pressure measurements were taken at standardized intervals in the beginning, middle, and end of the hour-long interview. Respondents were seated with their left arm supported at heart level. Prior to each blood pressure measurement, respondents had been seated for at least 10 minutes and had not ingested caffeine or tobacco for at least 30 minutes. We measured the circumference of the left arm to determine correct cuff size. Mean SBP and mean diastolic blood pressure (DBP) were computed from 3 measurements and treated as dependent variables.

Standard covariates were used to control for competing explanations: gender (0 = female, 1 = male), age (in years), socioeconomic status (SES), body mass index (BMI), weight in kg/height in m²), and current antihypertensive medication (0 = no, 1 = yes). Weight (±0.1 kg) was measured with a digital scale; height (±1 cm) was measured with a portable stadiometer. Education was measured by self-reported years of schooling completed, and household income was measured by asking respondents which of 9 income ranges they fall into.

ranges described total household income from all sources, before taxes, in the last 12 months. We tested multiple ways of modeling SES, including raw household income, household income adjusted for household size, education (years), highest degree attained, and factor loadings on the first principal component of education (years) and household income. We used the principal component score because it captures in a single measure 88% of the variance in education and income, and because other ways of modeling SES do not alter the substantive results.

**Statistical Analysis**

We conducted multiple regression analysis separately for SBP and DBP. We constructed cross-product interaction terms to test for interactions between color, SES, and gender. Predictors were mean-centered to reduce multicollinearity and to facilitate interpretation of interaction terms. We examined variance inflation factors for evidence of multicollinearity and case diagnostics (Cook’s statistic, studentized residuals, hat matrix values, dfbetas) for evidence of influential observations. Because we did not aim to estimate population parameters, our analyses did not require sampling weights.

In all models, ascribed color was entered as 2 categorical variables using the Helmert coding scheme. The first variable tests for differences between the intermediate category trigueño (literally, “Wheat-colored”) and blanco (White); the second tests for differences between negro (Black) and the mean of trigueño and blanco. This coding scheme reflects both the natural ordering of categories and the expectation from ethnography that the stigmatized category negro would differ from the mean of trigueño and blanco.20

**RESULTS**

Table 1 reports descriptive statistics for study variables in the total sample and within categories of ascribed color: Respondents classified as negro have slightly higher SBP, on average, but this bivariate association is not statistically significant. Women comprise 62% of the sample, attributable to random sampling within residential types and to the uneven gender distribution in public housing facilities.

Figure 1 depicts the relationship between ascribed color and skin pigmentation. As expected, median pigmentation is lightest for respondents assigned to the category blanco and darkest for those assigned to negro. Intermediate pigmentation is evident for trigueño and indio (“Indian”). For our purposes, the distributions of pigmentation by color are more important than are the central tendencies, i.e., the mean, median, or mode. In particular, overlapping interquartile ranges for respondents assigned to trigueño, indio, and negro confirm the expectation that individuals at a given level of skin pigmentation may vary in social classification. This finding makes it possible to evaluate the association of blood pressure with the cultural and biological dimensions of skin color. In subsequent analyses, the 2 respondents assigned to indio are collapsed into trigueño. This coding decision is based on the affinity between these categories in the local cultural model.20

Table 2 gives multiple regression coefficients for SBP and DBP. More complex models (data not shown) provide no evidence of statistical interaction between SES and skin pigmentation or between gender, SES, and color. Table 2 indicates that ascribed color, but not skin pigmentation, is associated with blood pressure. At specific levels of SES, being culturally defined as negro, or Black, is associated with SBP and DBP, independent of skin pigmentation and covariates. Figure 2 illustrates this interaction. At low levels of SES, there is no detectable difference in blood pressure across categories of color. However, as SES increases, those who are estimated to be negro by cultural consensus analysis of matched facial portraits have higher mean blood pressures. Those who are estimated to be trigueño or blanco have lower mean blood pressures as SES increases. This interaction effect and the simple main effect of color explain an additional 7.9% of variance in SBP and 1.7% of variance in DBP, as compared with reduced models omitting these variables (data not shown). There is borderline evidence ($P=.08$) for an association between SBP and skin pigmentation, independent of covariates; the direction of that association is the opposite of that predicted by the genetic hypothesis.

Regression diagnostics were found to be satisfactory. Variance inflation factors (maximum = 2.94) indicate that multicollinearity is not a significant problem. Case diagnostics identify 2 respondents with noteworthy values of Cook’s statistic; excluding these cases does not alter the substantive results.

**DISCUSSION**

We argue that genetic and sociocultural hypotheses for the relationship between skin color and blood pressure entail 2 distinct skin
color variables: the phenotype of skin pigmentation and the cultural significance of skin color as a criterion of social classification. Our measurement strategy operationalizes this distinction, and results suggest that the cultural rather than biological dimension of skin color may be the key variable of interest.

Among respondents who are at or above mean SES, those who are culturally defined as negro, or Black, have higher SBP and DBP, on average, than those who are classified as blanco, White, or trigueño, Intermediate. This relationship holds independent of age, gender, body mass, skin pigmentation, or reported use of antihypertensive medication. We found no evidence of darker skin pigmentation being associated with higher blood pressure in this sample.

The nature of the relationship between ascribed color and blood pressure is consistent with the ethnographic record in Puerto Rico. First, the interaction between color and SES corresponds to ethnographic evidence that status distinctions based on color are relatively insignificant in low-SES contexts, and that racism is most pernicious in the middle and upper classes.28–31 Thus, respondents who are classified as negro in high-SES contexts may experience more frequent, frustrating social interactions as a result of institutional and interpersonal discrimination. Experimental and observational studies suggest that chronic exposure to such interactions may be linked to cardiovascular responses, including sustained high blood pressure.32,33

Second, the absence of statistically significant differences in blood pressure between the categories trigueño and blanco is consistent with ethnographic evidence. One notable feature of ethnic classification in Puerto Rico, as opposed to the mainland United States, is the existence of intermediate categories, such as trigueño, that do not carry the stigma of “Blackness.” Whereas people defined as negro are likely to encounter institutional and interpersonal constraints on social mobility, those defined as trigueño face relatively few such constraints as a consequence of color.30,31 The finding that high-SES respondents estimated to be negro but not trigueño have the highest blood pressures is therefore consistent with the hypothesis that sociocultural processes mediate the link between skin color and blood pressure.

Despite speculation about possible genetic links between skin color and blood pressure,9,10 it should not be surprising that skin pigmentation and blood pressure are not significantly associated in our sample. Recent studies show that skin pigmentation is associated with molecular estimates of continental ancestry, with correlations ranging from weak (Mexico, \( \rho = .21 \)) to moderately strong (Puerto Rico, \( \rho = .63 \)) across populations.34 Yet the

**TABLE 2—Regression of Systolic and Diastolic Blood Pressure on Pigmentation, Ascribed Color, and Covariates (N = 100): June and July 2001**

<table>
<thead>
<tr>
<th></th>
<th>Systolic Blood Pressure</th>
<th>Diastolic Blood Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B (95% CI) P</td>
<td>B (95% CI) P</td>
</tr>
<tr>
<td>Constant</td>
<td>123.99 (119.69, 128.29) .000</td>
<td>.000</td>
</tr>
<tr>
<td>Age, y</td>
<td>1.12 (0.77, 1.48) .000</td>
<td>0.54 (0.29, 0.78) .000</td>
</tr>
<tr>
<td>Gender (1 = male, 0 = female)</td>
<td>0.02 (-0.44, 0.48) .934</td>
<td>0.18 (-0.14, 0.50) .264</td>
</tr>
<tr>
<td>Body mass index</td>
<td>7.25 (1.21, 13.28) .019</td>
<td>1.48 (-2.71, 5.66) .485</td>
</tr>
<tr>
<td>Antihypertensive medication</td>
<td>13.20 (3.75, 22.64) .007</td>
<td>7.05 (0.51, 13.60) .035</td>
</tr>
<tr>
<td>Skin pigmentation, M</td>
<td>-0.60 (-1.28, 0.08) .083</td>
<td>-0.26 (-0.74, 0.21) .268</td>
</tr>
<tr>
<td>Socioeconomic status, SES</td>
<td>-0.68 (-4.45, 3.10) .723</td>
<td>-1.43 (-4.05, 1.18) .279</td>
</tr>
<tr>
<td>Ascribed color</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigueño versus Blanco</td>
<td>3.99 (-4.58, 12.57) .357</td>
<td>0.61 (-5.33, 6.55) .839</td>
</tr>
<tr>
<td>Negro versus Trigueño/Blanco</td>
<td>14.07 (3.94, 24.19) .007</td>
<td>4.29 (-2.72, 11.31) .227</td>
</tr>
<tr>
<td>SES × ascribed color</td>
<td></td>
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</tr>
<tr>
<td>SES × Trigueño versus Blanco</td>
<td>-5.48 (-12.12, 1.16) .105</td>
<td>-1.31 (-5.91, 3.29) .572</td>
</tr>
<tr>
<td>SES × Negro versus Trigueño/Blanco</td>
<td>14.91 (5.89, 23.94) .001</td>
<td>7.31 (1.05, 13.56) .023</td>
</tr>
</tbody>
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Note. B = unstandardized regression coefficient; CI = confidence interval.

*Adjusted R² = 0.403
*Adjusted R² = 0.225
central question is whether continental ancestry is informative about alleles related to blood pressure. Available evidence suggests that it is not. Skin pigmentation is informative about continental ancestry precisely because its distribution differs from most human genetic variation. Most genetic markers show relatively small differences between human populations, but skin pigmentation shows marked regional variation in response to geographic differences in the intensity of ultraviolet radiation. Our findings thus reinforce criticism that skin color should not be used uncritically as a marker of racial–genetic predisposition to disease; genetic hypotheses require genetic data.

Our findings also relate to recent discussions about causal inference and the measurement of “race” as a cultural construct in social epidemiology. Kaufman and Cooper suggest that standard comparisons of racially defined groups are ill suited to explaining racial differences in health. In particular, they point out that causal reasoning in epidemiology is based on a counterfactual framework that asks, “What would the outcome have been if the exposed individual were not exposed to the alleged cause?” When the alleged cause is race, they argue, this model breaks down, because there is no logical counterfactual state: “a Black person who is not Black cannot be considered the same person.”

Yet, as others have noted, the constraint on this counterfactual state is empirical, not logical. To imagine a Black person who is not Black, it is necessary only to distinguish between 2 exposures: having dark skin and being culturally defined as “Black.” It is difficult to operationalize this distinction in the mainland United States, because the prevailing cultural model of racial classification defines dark-skinned people with any detectable trace of African ancestry as “Black.” However, as the Puerto Rican case shows, the relative salience of skin color as a basis of social classification is variable across societies, such that people with a given skin tone may be assigned to different folk ethnoracial categories in everyday social interaction.

A key innovation of our study is the attempt to estimate how survey respondents would be classified in everyday social interaction by linking survey measurement to ethnographic data on the salient cultural model of color. This strategy treats the notion that race is a cultural construct as a mandate for research. Some well-meaning commentators argue that, because race is a cultural construct and not a biological reality, public health researchers should abandon it as a variable. For example, Fullilove asks, “Why continue to accept something that is not only without biological merit but also full of evil social import?”

We suggest that this question contains the answer. Because racial classification in the United States—and other folk classification schemes in other societies—are full of evil social import, social scientists must devise strategies to operationalize racial classification as a sociocultural variable. Our approach to this problem complements other
strategies to explain racial health inequalities, including what Krieger identifies as the direct and indirect impacts of racism on health. Perhaps because research on skin color and blood pressure often reflects the assumptions of a racialized worldview, previous studies have not distinguished between skin pigmentation and the cultural significance of skin color as potentially independent predictors of blood pressure. However, once we recognize that distinction, existing evidence favors the cultural rather than biological significance of skin color. Seven previous studies of skin color and blood pressure measured skin pigmentation with reflectance spectrophotometry; none reported an association between pigmentation and blood pressure in the entire sample after control for age, gender, and SES. One of these studies found an association only in low-SES respondents whereas another reported an association only in Egyptian women. By contrast, 5 studies that measured skin color by observer ratings reported a consistent association between skin color and blood pressure across the sample. Thus, studies that measure skin pigmentation precisely using reflectance spectrophotometry provide the weakest evidence for an association between skin color and blood pressure. Those that approximate social classification with observer ratings provide the strongest evidence of such an association.

This set of findings underscores the importance of our measurement approach. However, limitations of the research design moderate the strength of our results. First, by comparison to previous studies, our sample is small. It is noteworthy that, despite the small sample size, we observed a statistically significant relationship between ascribed color and blood pressure. Case diagnostics also indicate that this relationship does not depend on a small number of unusual cases. Still, it remains to be seen whether our findings can be replicated in other parts of Puerto Rico or elsewhere. A larger sample would also increase the statistical power to detect more complex interactions between SES, color, and other important factors, such as gender, perceived discrimination, or access to health care. Second, although our measure of ascribed color is linked to ethnographic data regarding the salient cultural model, it is unclear how well it estimates everyday social classification. This unresolved question is a critical area for future research. One important extension of this work would be to examine whether nonbiological markers of social status influence the ascription of color and, if so, how this effect alters the association with blood pressure. Third, we did not collect data on dietary intake or energy expenditure. There is evidence that both skin color and exposure to social stressors are associated with blood pressure, independent of such measures.

Given these limitations, our study is significant, more for the questions it raises than for the answers it provides. Skin pigmentation is central to debates about race and genetics, but most researchers fail to distinguish its significance as a biological parameter from its significance as a marker of social status and exposure to stressors. Our measurement strategy provides one way to make this distinction explicit. Our finding that blood pressure is associated with culturally ascribed color—not with skin pigmentation—does not exclude a genetic basis to population differences in blood pressure. Yet it does cast doubt on genetic explanations for the relationship between skin color and blood pressure. This finding highlights the need for testable hypotheses and appropriate measurement operations in future research on the causes of poor health in the African Diaspora.

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C.C. Gravlee originated the study, collected the data, completed all analyses, and led the writing. W.W. Dressler and H.R. Bernard critically reviewed the study design and assisted with the analyses and interpretation of data. All authors reviewed drafts of the article.

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Human Participant Protection
This study was conducted with approval from the institutional review board of the University of Florida.

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