

# Relationships Between Hostility, Anger Expression, and Blood Pressure Dipping in an Ethnically Diverse Sample

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**Objective:** The purpose of this study was to examine relationships between hostility, anger expression, and blood pressure (BP) dipping. **Methods:** A 24-hour ambulatory BP was obtained from 34 African Americans and 52 white Americans who were enrolled in a study of sleep, stress, and BP. Self-report measures were used to assess anger expression and hostility. **Results:** After controlling for body mass index and BP status, African Americans were more likely to be classified as nondippers than white Americans. However, when hostility and anger expression were included in the model, there was no longer a significant relationship between ethnicity and BP dipping. Irrespective of race, high levels of hostility and anger were associated with less nocturnal dipping. **Conclusions:** These findings suggest that psychological factors may be important in understanding ethnic differences in nocturnal BP decline. **Key words:** African Americans, anger expression, blood pressure dipping, hostility.

BP = blood pressure; BMI = body mass index; MAP = mean arterial pressure.

## INTRODUCTION

African Americans are at greater risk for developing hypertension than any other ethnic group in this country (1–4). To explain this disparity, several studies have examined ethnic differences in cardiovascular reactivity and daytime blood pressure (BP) levels (5–9). However, research examining ethnic differences in nighttime BP patterns is scarce.

Nighttime BP may be useful in identifying individuals who are at risk for developing cardiovascular disease (CVD) and end organ damage (10–12). Murphy and colleagues (13) found that left ventricular mass damage was more closely related to nighttime BP than daytime BP, with higher nighttime BP being associated with a greater left ventricular mass index. A nocturnal drop in BP of 10% or more has been established as normal BP dipping, with such individuals being classified as “dippers.” In contrast, those who do not experience at least a 10% drop in BP at night are considered to be “nondippers” and have increased cardiovascular risk.

Research consistently demonstrates that African Americans are more likely to be classified as nondippers than white Americans are (13–21). Although African Americans experience less nighttime BP dipping than white Americans, differences in dipping are not observed between Black Africans and white Americans (13,17). This suggests that psychosocial factors may play an important role in explaining ethnic differences in BP dipping between African Americans and white Americans. Consistent with this, Wilson and colleagues (22) found a positive relationship between exposure to violence and nondipping status in African American adolescents. Furthermore, research suggests that religious coping may be related to greater nocturnal dipping in African Americans (23).

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These findings underscore the importance of understanding psychosocial factors that may be associated with BP dipping.

Certainly, when it comes to considering psychosocial influences on BP, one must acknowledge the considerable literature concerning anger and hostility (7,8,24–29). That literature has considered various dimensions of anger and hostility, such as the amount of anger experienced and whether or not that anger is expressed (29,30). A great deal has been written about ethnic differences in anger and hostility in terms of BP (31–36). However, oddly, very little research has been reported concerning anger/hostility and nocturnal BP dipping.

To date, only one study has examined relationships between ethnicity, hostility, and BP dipping (37). This is surprising because research suggests that nighttime BP dipping is a better indicator of cardiovascular health than daytime BP. In a study examining stress, social support, and hostility as potential mediators of the relationship between race and BP dipping, Ituarte and colleagues (37) failed to find a relationship between hostility and BP dipping. However, these researchers did not control for response bias in the report of hostility. Because previous research suggests that response bias influences the report of hostility (38), it is possible that response bias may have inhibited the ability to detect the relationship between hostility and BP dipping in this study.

The current study sought to extend the literature on anger and BP by examining whether anger expression and hostility moderate the relationship between ethnicity and BP dipping. We expected that African Americans would have less of a drop in nocturnal BP than white Americans. We also wondered whether ethnicity would still significantly relate to BP dipping after accounting for the variance in dipping that was explained by hostility and anger expression. Because defensiveness has been found to relate to BP (39,40) and may influence the report of anger and hostility (38), scores on the Marlowe-Crown Social Desirability Scale were included as a covariate in the study. Finally, we examined the interaction between hostility/anger expression and ethnicity on BP dipping.

## METHODS

### Participants

Sample characteristics are listed in Table 1. Participants consisted of 86 employed (30+ hours/week) men and women recruited from the local community via advertisement and referrals. Of these, 34 were African American

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**TABLE 1. Sample Characteristics**

	Blacks (N = 34)	Whites (N = 52)	p
Education			.18
BA and above	10 (27.0%)	21 (46.7%)	
Partial college	19 (51.4%)	14 (29.2%)	
High school	5 (13.5%)	9 (18.8%)	
Less than High school	3 (8.1%)	1 (2.1%)	
Social class—Hollingshead <sup>a</sup>			.11
Upper class	4 (11.8%)	16 (30.8%)	
Middle class	16 (47.1%)	21 (40.4%)	
Lower class	14 (41.2%)	15 (28.8%)	
Hypertensive	7 (20.6%)	4 (7.7%)	.08
	M ± SEM	M ± SEM	
Age	37.85 ± 1.34	35.12 ± 1.04	.10
Average systolic pressure	128.11 ± 2.73	124.35 ± 1.88	.26
Average diastolic pressure	75.38 ± 1.76	73.4 ± 1.35	.36
Average mean arterial pressure	92.96 ± 1.9	90.38 ± 1.4	.28
Buss-Durkee experience	59.92 ± 6.57	32.34 ± 5.16	.002
Buss-Durkee expression	111.39 ± 6.09	128.21 ± 7.8	.10
State-Trait anger control	23.71 ± .77	26.01 ± .60	.026
State-Trait anger expression	22.40 ± 1.23	17.17 ± .96	.002
State-Trait anger in	15.98 ± .59	13.86 ± .46	.008
State-Trait anger-out	14.13 ± .49	13.32 ± .38	.21
MC social desirability	20.40 ± 6.40	16.17 ± 5.48	<.001

<sup>a</sup> Upper class = Groups I & II; middle class = Group III; lower class = Groups IV & V.

(15 men and 19 women) and 52 were white American (31 men and 21 women). Participants were between the ages of 25 and 52, with an ideal body weight between 90% and 130% (Metropolitan Life tables) (41) and resting BP lower than 180/110 mm Hg at screening. Screening BP was defined as the average of 3 seated BPs. Individuals were excluded from the study with a medical diagnosis other than hypertension, current drug or alcohol abuse, creatinine levels more than 1.4 mg/dl, renal bruit on physical examination, fasting glucose >120 mg/dl, known sleep disorder, or shift work. In addition, women were excluded if postmenopausal, diagnosed with premenstrual syndrome, taking oral contraceptives, or pregnant. Hypertensive patients taking antihypertensive medication were weaned off the drug(s) and closely monitored. If their BP remained >140/90 but <180/110 mm Hg for 3 weeks, they were enrolled in the study. The study was approved by the University of California, San Diego Institutional Review Board.

## Psychological Measures

Subjects completed a number of self-report psychological measures, discussed in the following paragraphs.

### Buss-Durkee Hostility Scale (BD)

This scale consists of 75 true/false items and has been shown to be reliable and valid in a variety of populations (42). It provides a total hostility score as well as a number of subscale scores that can be consolidated into Expression of Anger (indirect hostility, physical assaultiveness, verbal expression) and Experience of Anger (resentment, suspiciousness) (43–45).

### Anger Expression Inventory

This 24-item scale assesses the frequency with which anger is expressed, regardless of the direction of expression (46). Anger expression is conceptualized as having 3 major components. The first component involves the expression of anger toward other people or objects in the environment (anger-out). The second component represents anger that is held in or sup-

pressed (anger-in). Finally, the third component measures the extent to which an individual attempts to control the expression of anger (anger-control). An overall anger expression score can also be calculated using this measure. Individuals high on anger expression experience intense angry feelings, which may be suppressed, expressed in aggressive behavior, or both.

### Marlowe-Crowne Social Desirability Scale (MC)

This scale is composed of 33 true/false items representing behaviors that are considered socially desirable but also have a low probability of occurrence in the general population (47). The scale was originally designed to measure a respondent's attempt to present himself in a socially desirable manner on self-report measures (47). It has also been interpreted as a measure of defensiveness (48), need for approval (49), or the need to protect and maintain vulnerable self-esteem (50). Regardless of the definition, high scores on this measure are reflective of a tendency to underreport information that respondents believe may be viewed in a negative light and to overreport information that they believe may be considered positive by others (38). The MC has been found to have good psychometric properties, with internal consistency coefficients above 0.80.

### Two-Factor Index of Social Position (51)

This 2-factor scale measures an individual's social status. The 2 factors that determine social position include occupation and education. Each factor has a 1 to 7 range, with lower scores representing a higher social status. Scores on the education and occupation factor can be combined to obtain an index of social class. Social Class is scaled in 5 categories, with lower scores representing a higher social class.

### Ambulatory BP Monitoring

Ambulatory monitoring was performed for a 24-hour period using the Spacelabs model 90207 monitor (Redmond, WA). The cuff was programmed to obtain a BP measurement every 15 minutes from 0600 to 2400 and every 30 minutes from 2400 to 0600. Recordings were conducted during a normal workday. Nighttime BP was determined as the period from "lights out" until "lights on." Artifacts were determined through standard Spacelab default as well as visual inspection. During daytime hours, participants were instructed to go about their normal daytime activities. Nighttime mean arterial pressure (MAP) dipping was calculated as the difference between average daytime and average nighttime MAP levels. In general, we have utilized "dipping" as a continuous variable. However, in some of the analyses, we have dichotomized dippers as having >10% reduction in MAP vs. nondippers (<10% reduction).

### Statistical Analysis

Multivariate analyses of variance (MANOVAs) were conducted to examine ethnic differences on measures of anger and hostility. To control for response bias, MC scores were entered as a covariate in the model.

Two models of anger and BP dipping were examined using Buss-Durkee Hostility and Anger Expression. Nighttime MAP dipping was entered as the outcome variable for regression analyses. For each model, hierarchical regression analyses were conducted with body mass index (BMI), screening BP, and MC scores entered on Step 1 of the equation. Ethnicity was entered on Step 2 of the equation. To determine whether anger expression and hostility would explain ethnic differences in BP, measures of anger expression and hostility were entered on Step 3 of the equation. Due to high multicollinearity, the various measures of anger were substituted separately. Finally, interaction terms for ethnicity and measures of hostility/anger expression were entered on Step 4 of the equation to determine whether hostility and anger expression differentially explained BP dipping in African Americans and white Americans.

## RESULTS

### Ethnic Differences on Anger Expression and Hostility

Before controlling for response bias, African Americans had a higher score on Buss-Durkee anger experience than white Americans did (54.19 vs. 36.11,  $p < .05$ ). However, there were no ethnic differences on other measures of anger

TABLE 2. Correlations Between Ethnicity, Marlowe-Crown Scores (MC) and Anger Variables

	MC Social Desirability	State-Trait Anger Expression	State-Trait Anger Control	State-Trait Anger-in	State-Trait Anger-out	BD Expression of Anger	BD Experience of Anger
Ethnicity	.382**	.059	-.101	.014	.002	.044	.305
MC social desirability		-.487**	.209	-.541**	-.298**	-.339**	-.148
State-Trait anger expression			-.823**	.610**	.730**	.629**	.554**
State-Trait anger control				-.150	-.615**	-.473**	-.379**
State-Trait anger-in					.094	.263*	.479**
State-Trait anger-out						.695**	.325**
BD expression of anger							.507**
BD experience of anger							

\*\*  $p < .01$ ; \*  $p < .05$ .

BD = Buss-Durkee Hostility Scale.

and hostility. After controlling for response bias, African Americans had higher scores on Buss-Durkee total hostility (260.97 vs. 203.11,  $p < .01$ ), Buss-Durkee anger experience (59.92 vs. 32.35,  $p < .01$ ), Spielberger anger expression (22.40 vs. 17.17,  $p < .01$ ), and Spielberger anger in (15.98 vs. 13.86,  $p < .01$ ) than white Americans. White Americans had higher scores on Spielberger anger control than African Americans did (26.01 vs. 23.71,  $p < .05$ ). Correlations between Marlowe-Crown scores, ethnicity, measures of anger, and hostility are listed in Table 2.

### Ethnic Differences in BP Dipping

Daytime ambulatory MAP was  $89.9 \pm 1.0$  for white Americans and  $92.6 \pm 1.9$  for African Americans. Nighttime MAP was  $75.7 \pm 1.1$  for white Americans and  $83.4 \pm 2.1$  for African Americans. There was no significant difference in daytime MAP between African Americans and white Americans. However, African Americans had higher nighttime MAP ( $p = .002$ ) and were more likely to be classified as nondippers ( $p = .007$ ) than white Americans were.

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Table 3 lists the results of the regression analyses. Together, BMI, screening BP, and MC scores explained 15.7% of the variance in BP dipping. After controlling for these covariates, ethnicity explained a significant additional proportion of the variance in MAP dipping ( $\Delta R^2 = .48$ ,  $p = .037$ ), with African Americans having less nocturnal dipping than white Americans did.

The following paragraphs summarize the findings using alternate measures of hostility and anger. In 4 of 6 analyses, anger/hostility were significant determinants of dipping, swamping out the relationship between ethnicity and dipping in 3 of these analyses.

### Buss Durkee Hostility

When Buss-Durkee experience was included in the regression equation (Step 3a), ethnicity and the covariates no longer predicted BP dipping. Individuals with higher scores on the anger experience factor had less dipping than those with lower scores,  $\Delta R^2 = 0.10$ ,  $p = .002$  (Figure 1a). There was no

significant interaction between ethnicity and Buss-Durkee experience on BP dipping.

When Buss-Durkee expression was included in the regression equation (Step 3b), the covariates dropped out, but ethnicity remained a significant predictor of BP dipping. Individuals with higher Buss-Durkee expression scores had less dipping than those with lower scores,  $\Delta R^2 = 0.071$ ,  $p = .009$  (Figure 1b). The interaction between ethnicity and Buss-Durkee expression was not significant.

### Spielberger Anger Expression

When anger control was added to the regression equation (Step 3c), ethnicity and the covariates no longer predicted BP dipping. Individuals with higher scores on anger control had more BP dipping than those with lower scores,  $\Delta R^2 = 0.076$ ,  $p = .008$  (Figure 2a). Including the interaction between

TABLE 3. Hierarchical Regression Analysis Summary for the Relationship Between Ethnicity, Anger/Hostility, and Mean Arterial Pressure (MAP) Dipping

Variable	B	SEB	$\beta$	R2	$\Delta R2$
Step 1				.157**	
BMI	-.403	.151	-.299**		
Screening MAP	-.097	.076	-.143		
MC social desirability	-.165	.126	-.139		
Step 2				.205	.048*
Race	-3.651	.72	-.253		
Step 3a				.227	.071**
BD expression of anger	-.043	.016	-.290		
Step 3b				.304	.10**
BD experience of anger	-.065	.02	-.370		
Step 3c				.274	.076**
State-Trait anger control	.462	.171	.287		
Step 3d				.241	.043*
State-Trait anger expression	-.216	.108	-.244		
Step 3e				.246	.0001
State-Trait anger-in	-.004	.241	.002		
Step 3f				.266	.011
State-Trait anger-out	-.258	.266	.108		

\*  $p < .05$ , \*\*  $p < .01$ .

SEB = standard error of beta; BMI = body mass index; MC = Marlowe-Crowne Social Desirability Scale; 3D = Buss-Durkee Hostility Scale.

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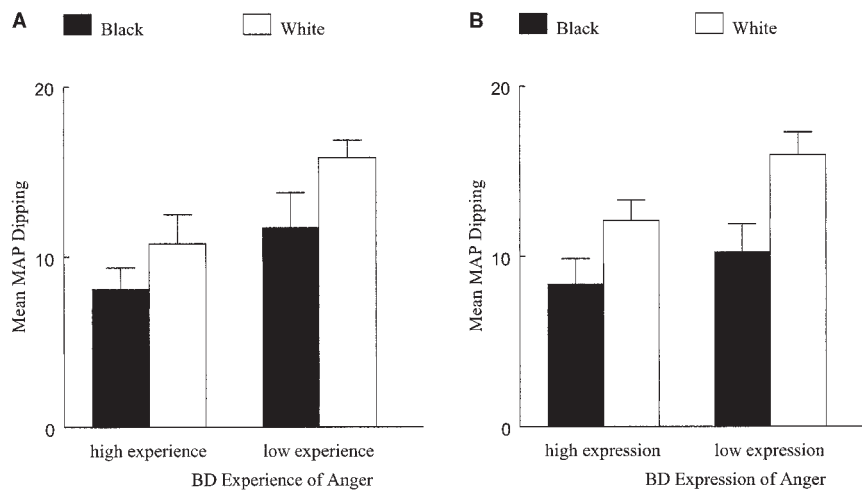


Figure 1. Effects of hostility on mean arterial pressure (MAP) dipping in African Americans and white Americans. Greater experience (a) and expression (b) scores predict less dipping ( $p < .01$ ). Error bars represent means  $\pm$  standard error. BD = Buss-Durkee Hostility Scale.

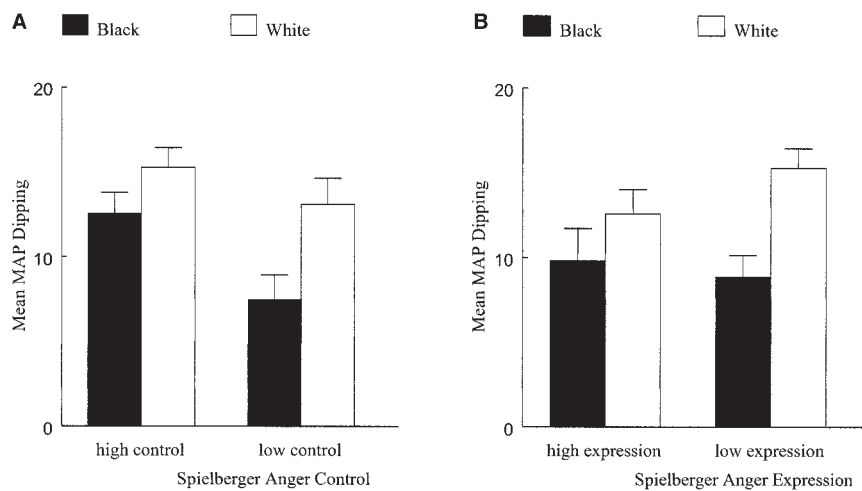


Figure 2. Effects of anger expression on mean arterial pressure (MAP) dipping in African Americans and white Americans. Greater anger control (a) predicts more dipping ( $p < .01$ ). Greater anger expression (b) predicts less dipping ( $p < .05$ ). Error bars represent means  $\pm$  standard error.

ethnicity and anger control did not significantly improve the model.

When anger expression was included in the regression equation (Step 3d), ethnicity and the covariates no longer predicted BP dipping. Individuals with higher scores on anger expression had less BP dipping than those with lower scores,  $\Delta R^2_{\text{change}} = 0.043$ ,  $p = .045$  (Figure 2b). Including the interaction between ethnicity and the expression factor did not significantly improve the model.

There was no significant relationship between BP dipping and anger-in or anger-out scores.

## DISCUSSION

African Americans are at greater risk for developing hypertension than white Americans. Because nighttime BP dipping may be a better prognostic indicator of CVD and mortality than daytime BP levels (13), we examined relationships between hostility, anger expression, and nocturnal dipping in African Americans and white Americans. We found that Af-

rican Americans experienced less nocturnal BP dipping and were more likely to be classified as nondippers than white Americans were. This supports previous research finding that African Americans experience little or no change in BP levels at night (13,14,16–20). We also found that hostility and anger expression have substantial effects on nocturnal dipping. In multivariate equations in which anger was measured in diverse ways, anger superseded the effects of ethnicity on dipping.

Our findings contradict the results of Ituarte and colleagues (37) in which there was no significant relationship between hostility and BP dipping in African Americans. This may be due to methodological differences between the studies. In the current study, we included Marlowe-Crowne scores as a covariate in analyses of the relationship between BP dipping and measures of hostility and anger expression. We made this decision based on studies demonstrating that response bias profoundly affects scores on psychosocial measures in African Americans (46). In this study, African Americans tended to

underreport hostility and anger. Without including response bias as a covariate in the analyses, ethnic differences on hostility and anger expression were undetectable and relationships between these measures and BP dipping were hidden. Ituarte and colleagues (37) did not control for response bias when examining the relationship between hostility and BP dipping. It is possible that this affected their ability to detect relationships between these variables.

After controlling for response bias, African Americans had higher scores on the experience factor of the Buss-Durkee Hostility measure, reflecting the belief that they are the victims of unfair treatment (some of the items making up this scale assess an individual's belief that they have been mistreated by others). They also had higher scores on anger expression and were more likely to direct anger inward. Due to a troubled history of racial interactions in our country, high levels of suspiciousness may serve an adaptive function for this group.

Within the current study, neither scores on anger-in nor anger-out related to BP dipping. Instead, high scores on anger expression predicted less dipping. According to Spielberger and colleagues (46), individuals with high scores on anger expression tend to experience intense angry feelings, which may be suppressed, expressed in aggressive behavior, or both. This suggests that the experience of anger alone can have detrimental effects on BP, independent of the individual's style of expression.

Personality researchers have always faced a dilemma concerning how to construe self-report. Do patients report "the truth"? Do they intentionally dissemble? Are they good observers of their own behavior? It is very difficult to disentangle these questions in a study such as ours. Nevertheless, our data suggest a tendency to underreport anger among African Americans and thus, studies on anger and various measures of BP should keep this in mind. There is substantial literature that defensiveness and repressed anger have adverse effects on BP (39,40,52–56). For instance, Mann and colleagues (57,58) have found that defensiveness is related to the development of hypertension. Furthermore, other studies have shown that unexpressed anger is related to greater cardiovascular reactivity (8). Some researchers have construed MC scores as a measure of defensiveness rather than a measure of conscious impression management (39,55). If this were the case, then higher scores on the MC would indicate anger without the associated conscious feeling (ie, repressed anger). Our data do not allow us to determine whether the MC measures defensiveness or impression management. Future research should be conducted to address this question. However, the data demonstrate that anger, almost no matter which variant of anger is used, was related to nondipping after controlling for MC scores. Perhaps other studies might better address whether 1 variant of anger is particularly important in this matter.

There was no significant interaction between ethnicity and anger expression or hostility on BP. Thus, irrespective of ethnicity, high levels of anger and hostility have a negative effect on nocturnal dipping. Because African Americans had

higher scores on measures of anger and hostility and were also more likely to be classified as nondippers, anger may be important in shedding light on the high rates of hypertension among African Americans in this country.

For more than 50 years, psychosomatic research has suggested that anger and hostility take a cardiovascular toll. This paper suggests yet another pathway by which these emotions may adversely affect cardiovascular functioning. We examined the relationship between anger and BP dipping using 6 different measures of anger. With 4 of these measures, anger was significantly related to dipping. In 3 of the 4 significant models, anger superseded the effect of ethnicity on nighttime dipping, suggesting that the relationship between ethnicity and dipping may partially be explained by anger. Interestingly, the relationship between dipping and 1 of the measures of anger seemed paradoxical; that is, people who scored higher on anger control had more dipping. This could be a chance effect. However, these findings may suggest that the ability to control or resist anger protects individuals from the negative effects of anger on BP. According to Gross (59), the ability to reframe a situation is associated with a reduction in its emotional and physiological impact. Other studies have also found that anger control is associated with positive health effects (60). Thus, our results may not be due to chance, but rather reveal that subjects who engage in reframing to control anger have more dipping. Future research should further explore the relationship between anger control and BP.

Within the current study, 20.6% of African Americans were hypertensive patients compared with 7.7% of white Americans who were hypertensive. This disparity in hypertension rates may be confounded with ethnicity, limiting the ability to detect the true ethnic difference in BP dipping between African Americans and white Americans. However, we attempted to control for the effect of hypertension status on nocturnal dipping by including daytime BP as a covariate in analyses.

The current study examined how ethnicity, anger expression, and hostility relate to BP dipping. We reported MAP as opposed to systolic pressure and diastolic pressure because MAP is a measure of average arterial pressure and is commonly used in the ABPM literature (61). Nonetheless, additional analyses reveal that these results hold regardless of whether systolic pressure, diastolic pressure, or MAP is used to measure dipping.

The current results may be limited by the small sample size on which the study was conducted. To extend these findings to the general population, this study should be replicated in larger community samples. Nonetheless, these findings are important. Given that nocturnal BP dipping has important prognostic implications for CVD, it is very interesting to see that anger and hostility measured in diverse ways correlate with such dipping. Generally, psychology has examined correlates of daytime physiology (eg, anger and reactivity testing). However, in this instance we see glimmerings that anger casts a shadow over BP even during the nighttime. It remains to be seen how extensive a shadow this is, who is most

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vulnerable, and most importantly, whether behavioral interventions can mitigate this shadow.

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