Original Research Article

Relationship Between Psychosocial Stress and Blood Pressure: The National Heart, Lung, and Blood Institute Family Heart Study

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Abstract

Introduction: Various domains of psychosocial stress have been significantly related to blood pressure. However, ambiguity is present in how these relationships are defined in the literature.

Objective: To add to the existing literature and examine the relationship between psychosocial stress (financial strain and job strain) and other cofactors on blood pressure.

Methods: This secondary analysis is designed to analyze the relationship between levels of job and financial stress and blood pressure outcomes among participants in the National Heart, Lung, and Blood Institute (NHLBI) Family Heart Study 2004–2008. The descriptive, cross-sectional design uses data from a subset of study participants, 350 White and 195 Black (n = 545), 338 female (62%), and all aged 18–56 years. Psychosocial stress was measured using the Singh Stress Scale. Resting systolic (SBP) and diastolic (DBP) blood pressure values obtained on a stress reactivity protocol day in the primary study, as well as calculated mean arterial pressure (MAP) were used for this analysis. Multivariate linear regression analyses were used to explore the relationship between psychosocial stress and blood pressure.

Results: In this young cohort, self-report of either financial strain or job strain was associated with lower blood pressure levels than those of participants who reported neither stressor. Differential sex and race effects appear to contribute to these results. Blood pressure levels were not significantly associated with self-report of both stressors.

Conclusion: Understanding the effects of various forms of stress on blood pressure may inform more precise HTN risk-factor screening and interventions to improve BP management.

Keywords

hypertension, psychosocial stress, risk factors, gender diffefrences, adult health

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Introduction

High blood pressure, or hypertension, occurs when pressure in the blood vessels consistently exceeds 140/90 mmHg (Aggarwal et al., 2021) Hypertension serves as one of the leading causes of mortality and disability globally (Padmanabhan, et al., 2021). In the United States, the prevalence of hypertension among adults is approximately 45%, with African-American men and women having the highest prevalence (Ogunniyi, et al., 2021). In addition, there has been a rise in hypertension prevalence in young to middle aged adults, making it an urgent public health challenge (Hinton et al., 2020).

Hypertension is a complex, multifactorial disease process with genetic, environmental, demographic, and social factors contributing to its prevalence (Tanira & Al Balushi, 2005).

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Psychosocial stress, defined as a social stressor, induced by situations of social threat (Kogler et al., 2015), is a social factor associated with blood pressure (BP) outcomes. Multiple domains of psychosocial stress exist, including job/work-related problems and financial strain, which have been reported to be associated with BP. However, the level of evidence across studies demonstrating the association have varied (Georgiades et al., 2009; Guimont et al., 2006; Light et al., 1992; Schnall et al., 1992; Steptoe et al., 2005) and even been contradictory (Agyei et al., 2014; Ford et al., 2016; Veenstra, 2012).

Review of Literature

A majority of US adults spend a great amount of time in the workplace, where demands have been shown to affect blood pressure. A number of longitudinal studies have demonstrated that high job stress or strain is associated with higher BP and the development of hypertension (Guimont et al., 2006; Markovitz et al., 2004; Öhlin et al., 2007; Tobe et al., 2007). High job strain has also been associated with high ambulatory BP at work, at home, and during sleep as well as increased left ventricular mass, consistent with the effects of sustained BP elevation (Spruill, 2010). Additionally, studies such as Kai et al. (2018), which examined the impact of different types of occupational stress on changes in arterial SBP and incident cases of hypertension, found that job strain and having lack of job recognition at the workplace had significant associations with increased SBP (Kai et al., 2018).

Similar to job stress, financial stress has been significantly linked to hypertension. Specific income categories have been associated with higher blood pressures (Bird et al., 2017). In addition to income level, those who struggle to provide for their families and pay for bills and day-to-day basic necessities have been found to be at greater risk for high blood pressure (Matthews et al., 2002; Steptoe et al., 2005).

Across the literature, different domains of psychosocial stress demonstrated varied influence on blood pressure. In addition, limited studies have examined specific stress domains or other co-factors that maybe explain the rise in prevalence of hypertension among young adults, especially African-American. Because of this variance, the purpose of this study was to add to the existing literature and examine the relationship between psychosocial stress (financial strain and job strain) and other cofactors on blood pressure among the NHLBI Family Heart Study participants.

Methods

Design

A descriptive, retrospective cross-sectional design was used to perform a secondary analysis on a national dataset, the National Heart, Lung, and Blood Institute (NHLBI) Family Heart Study 2004–2008 (the NHLBI Family Heart Study study will be referred to as the primary study from here on out).

Research Objective

The purpose of this study was to add to the existing literature and examine the relationship between psychosocial stress (financial strain and job strain) and other cofactors on blood pressure among the NHLBI Family Heart Study participants.

Setting and Sample

Data for the primary study were collected from participants who were recruited to take part in the Family Heart Study between 2004–2008.

The sample of the primary study was comprised of individuals who were qualified to participate and completed the stress reactivity protocol during data collection (Brummett et al., 2010). Those included scored either high or low for hostility on the 27-item Cook- Medley scale and recruited a sibling to participate in the study. Relatives were not screened for their level of hostility prior to inclusion in the study.

Inclusion and Exclusion Criteria

Brummett et al. (2010) provide an overview of inclusion and exclusion criteria. For the purposes of this current study, our sample included 545 individuals who had complete variable data for our secondary analysis of the relationship between psychosocial stress, SBP, and DBP.

Institutional Review Board Approval

This current study was approved by the Institutional Review Boards (IRBs) of Duke University, Durham, NC, and Winston-Salem State University, Winston-Salem, NC. The data for the primary study were collected between 2004–2008 from participants at a major academic medical center in the Southeastern U.S, following Institutional Review Board approved informed consent.

Measurements

Our primary dependent variables were blood pressure levels (SBP, DBP, and mean arterial pressure; MAP) as continuous outcome variables. BP values were gathered minute-by-minute using a Dynamap XL 9300 (Johnson & Johnson Health Care System, Inc.). Baseline SBP, DBP, and heart rate (HR) were represented by the mean of the last 5 min of a 10-min resting baseline (Brummett et al., 2009). Resting SBP and DBP values were obtained on a stress-reactivity protocol day of the main study. Participants' MAPs were calculated using the formula: $MAP = [SBP + 2\ (DBP)]/3$.

The main independent variable in our study was psychosocial stress, measured using the Singh Stress Scale (Singh et al.,

2015). The original Singh Stress Scale is a composite of participant questionnaire scores in five domains drawn from the Multi-Ethnic Study of Atherosclerosis (MESA): ongoing serious health problems, serious health problems of someone close, work-related problems, financial strains, and difficulties in relationships. Scores are quantified on an ordinal scale ranging from 0 to 5 (Singh et al., 2015). Response data from the primary study indicated that only two of the five domains were represented among participant data (self-reported financial strain, job strain, or both), so scores were quantified on an ordinal scale ranging from 0 (neither financial nor job strain), 1 (financial or job strain), and 2 (both financial and job strain).

Other co-factors examined were race/ethnicity, gender (dichotomous variables), and depression as measured with the CES-D, a 20-item questionnaire with scores ranging from 0 to 60 (Radloff, 1977). We accounted for hostility because it was a defining characteristic of eligible participants in the primary study, measured using the 27-item Cook-Medley tool (Brummett et al., 2010). Both hostility and depression were coded as continuous variables. The multiplicative interaction terms Stress*Race, Stress*Depression, and Stress*Gender were included in post-hoc exploratory analyses.

Data Analysis

For all statistical models, we employed a robust function-weighting term to account for family grouping since the dataset included siblings as part of the original study's design (Brummett et al., 2010); we attained robust standard errors. We used Stata/SE version 13.1 (StataCorp, 2013) to analyze descriptive statistics and to conduct univariate linear regression and multivariate linear regression analyses. Means, standard deviations, and frequencies were used for descriptive statistics. Univariate linear regression models were used to examine the relationships between stress and SBP, stress and DBP, and stress and MAP. Multivariate linear regression models were then used to examine the relationship between stress and SBP, stress and DBP, and stress and MAP while controlling for race, gender, depression, hostility, and the interaction terms Stress*Race, Stress*Depression, and Stress*gender. Separate multivariate linear regression models stratified by race were used to explore racial differences in the relationships between stress and BP outcomes (SBP, DBP, and MAP), controlling for the covariates previously listed. We present adjusted and unadjusted linear regression models and 95% confidence intervals with significance set at $p < .05$.

Results

Sample Characteristics

Table 1 presents the results for the descriptive statistics. Participants' mean age was 28.8 (SD = 8.73) years; 62.02% were women; and 35.78% were African Americans. Table 2 shows that of the 545 participants, 249 (45.69%) reported no stress; 236 reported either financial or job stress (43.3%); and 60 reported both financial and job stress (11.01%). Mean SBP was 117.39 (SD = 14.31). Mean DBP was 65.24 (SD = 9.01). Mean SBP levels were higher among those having both financial and job strain (119.95, SD = 12.33) compared to those with either one or none of the stressors. Additionally, mean hostility (12.7, SD = 4.87) and depression scores (12.75, SD = 9.54) were higher among those having both financial and job strain compared to those who had none (9.93, SD = 4.91; 7.49, SD = 7.02) or only one of the stressors (10.29, SD = 5.19; 10.36, SD = 8.41).

Table 1. Participant Characteristics, NHLBI Family Heart Study.

Variables	n	%
Psychosocial Stress		
No Strain	249	45.69
Financial or job strain	236	43.3
Both financial and job strain	60	11.01
Race		
African-American	195	35.78
White	350	64.22
Gender		
Female	338	62.02
Male	207	37.98

Systolic Blood Pressure and Psychosocial Stress

The univariate linear regression model (Table 3) detected no significant relationship between psychosocial stress and SBP. However, having financial or job strain was associated with 2.8–8.65 mmHg lower SBP (models 2, 3, 4, and 5), when all other variables were held constant ($p < .05$). Men's SBP was approximately 9.29–11.44 mmHg higher (models 2, 3, 4, and 5) than women's ($p < .001$); Whites' SBP was approximately 7.08 – 7.1 (models 2 and 3) and 4.33 – 6.73 (models 4 and 5; $p < .01$) mmHg lower than African Americans' when all other variables were held constant.

The race-stratified univariate linear regression model for African Americans (Table 4) associated financial or job strain with 6.6 mmHg lower SBP ($p < .05$). When controlling for gender, stress*gender, and depression (model 2), financial or job strain was associated with 6.96 mmHg lower SBP ($p < 0.01$), but being male was associated with 10.56 mmHg higher SBP ($p < .01$). Additionally, in models 3 and 4, respectively, men had a 10.75 and 10.76 mmHg higher SBP than women ($p < .01$). In model 5, having financial or job strain was associated with a 7.12-unit decease in SBP ($p < .01$), and men's SBP was 9.2 mmHg higher than women's ($p < .001$).

The race-stratified multivariate linear regression model for Whites (Table 5) showed that White men had approximately 9.24–12.01 mmHg higher SBP (models 2, 3, 4 and 5) than

women ($p < .001$). Moreover, when controlling for gender, stress*gender, depression, and stress*depression (model 3), every unit increase in depression scores (CES-D) was associated with 0.31 mmgH lower SBP ($p < .05$). When controlling for all covariates among Whites (model 4), a unit increase in depression scores was associated 0.38 mmHg lower SBP ($p < .01$). The interaction term between stress and depression was associated with 0.33 mmHg higher SBP ($p < .05$). Every unit increase in Cook-Medley hostility scores (model 4 and 5) among Whites was associated with a 0.34–0.36 unit increase in SBP ($p < .05$).

Diastolic Blood Pressure and Psychosocial Stress

The univariate linear regression models and multivariate linear regression models (Table 6) found no significant relationship between psychosocial stress and DBP. However, when controlling for gender, race, depression, and hostility (model 5), men had 1.89 mmHg higher DBP ($p < .05$) than women. Furthermore, Whites had between 3.12–3.91 mmHg lower DBP (models 2, 3, 4, and 5) than African Americans when all other variables were held constant ($p < .01$).

When stratified by race (Table 7), univariate and multivariate linear regressions for African Americans demonstrated no significant relationship between stress and DBP, nor did any other covariates serve as significant predictors of DBP.

Table 2. Psychosocial Stress and Blood Pressure, NHLBI Family Heart Study.

	Overall				
Variables	n	Mean	SD	Min.	Max.
Systolic Blood Pressure	509	117.39	14.31	83	181
Diastolic Blood Pressure	509	65.24	9.01	43	96
Mean Arterial Pressure	509	82.62	9.46	60	119
Depression	545	10.391	5.09	0	26
Cook-Medley Hostility	545	10.39	5.09	0	26
Neither financial or job strain					
Systolic Blood Pressure	234	117.85	15.14	85	181
Diastolic Blood Pressure	234	65.4	9.42	43	96
Mean Arterial Pressure	234	82.88	10.05	61	119
Depression	249	7.49	7.02	0	40
Cook-Medley Hostility	249	9.93	4.91	0	26
Financial or job strain					
Systolic Blood Pressure	218	116.22	13.82	83	176
Diastolic Blood Pressure	218	65.22	8.67	44	87
Mean Arterial Pressure	218	82.22	9.02	60	108.67
Depression	236	10.36	8.41	0	46
Cook-Medley Hostility	236	10.29	5.19	1	25.
Both financial and job strain					
Systolic Blood Pressure	57	119.95	12.33	90	146
Diastolic Blood Pressure	57	64.67	8.68	45	96
Mean Arterial Pressure	57	83.09	8.69	63.67	112.67
Depression	60	12.75	9.54	0	44
Cook-Medley Hostility	60	12.7	4.87	3	23

Among Whites (Table 8), univariate and multivariate linear regression demonstrated no significant relationship between stress and DBP but White men's DBP was between 2.29–2.96 mmHg higher (models 2, 3, 4, and 5) than White women's ($p < .05$).

Mean Arterial Pressure and Psychosocial Stress

The univariate linear regression model (Table 9) detected no significant relationship between psychosocial stress and MAP. However, men's MAP was 4.35–5.16 mmHg higher (models 2, 3, 4, and 5) than women's ($p < .001$), and Whites' was 3.52–4.92 mmHg lower (models 2, 3, 4, and 5) than African Americans' ($p < .001$).

When stratified by race (Table 10), the univariate linear regression model for African Americans (model 1) demonstrated that those having financial or job strain had 3.58 mmHg lower MAP ($p < .05$). When controlling for gender and the interaction term between stress and gender (model 2), African Americans who had financial or job strain had 4.03 mmHg lower MAP ($p < .05$). When controlling for gender, depression, and hostility (model 5), African-Americans with financial or job strain had 3.51 mmHg lower MAP ($p < .05$) than those with none or both stressors, and African-American men had 3.7 mmHg higher MAP than African-American women ($p < .01$).

The univariate linear regression model and multivariate linear regression models for Whites (Table 11) found no significant relationship between psychosocial stress and MAP. However, when controlling for other variables (models 2, 3, 4, and 5), White men's MAP was 4.61–5.98 mmHg higher than White women's ($p < .001$).

Discussion

This study examined the relationship between blood pressure and two psychosocial stress factors, financial strain and job strain, among participants in the NHLBI Family Heart Study, 2004–2008. The main aim of this study was to determine whether psychosocial stress levels were significant predictors of high blood pressure. Although we hypothesized that psychosocial stress levels would be firstly, significant predictors of high blood pressure and secondly, stronger predictors of higher blood pressure among African Americans than Whites, we found that having both stressors, financial and job strain, was not significantly related to blood pressure. We would have expected that if having two stressors was not significant, then having only one would also not be significant. On the contrary, we found that having one or the other was negatively associated with blood pressure, particularly in African American's SBP and MAP results. Hassoun et al. (2015) found similar results in examining the relationship between objectively and subjectively measured perceived stressors on blood pressure. They measured perceived chronic stress using a 12-item screening subscale

Table 3. Multivariate Linear Regression Analysis of Psychosocial Stress and Systolic Blood Pressure, NHLBI Family Heart Study.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Financial or job strain	−1.621	−8.085*	−8.652*	−8.496*	−2.798*
	(1.363)	(3.638)	(3.753)	(3.751)	(−1.312)
Both financial and job strain	2.101	−8.62	−10.32	−10.52	0.319
	(1.901)	(6.292)	(6.581)	(6.546)	(1.905)
Gender		11.20***	11.44***	11.26***	9.288***
		(1.769)	(1.757)	(1.734)	(1.226)
Race		−7.077***	−7.103***	−6.733**	−4.325**
		(2.01)	(2.004)	(2.048)	(1.368)
Stress*Race		3.493	3.451	3.389	
		(1.902)	(1.902)	(1.904)	
Stress*Gender		−2.545	−2.656	−2.779	
		(1.746)	(1.741)	(1.739)	
Depression			−0.17	−0.213	−0.116
			(0.121)	(0.128)	(0.0862)
Stress*Depression			0.112	0.121	
			(0.134)	(0.133)	
Cook-Medley Hostility				0.2	0.191
				(0.135)	(0.133)
_cons	117.8***	119.3***	120.4***	118.6***	116.8***
	(0.99)	(1.914)	(2.013)	(2.464)	(1.995)
N	509	509	509	509	509
R-sq	0.007	0.124	0.127	0.131	0.121
adj. R-sq	0.003	0.113	0.113	0.116	0.111
Rmse	14.29	13.48	13.48	13.46	13.5

Standard errors in parentheses.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 4. Multivariate Linear Regression Analysis of Psychosocial Stress and Systolic Blood Pressure among African-Americans in the NHLBI Family Heart Study.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Financial or job strain	−6.604*	−6.955**	−5.793	−5.792	−7.117**
	(2.614)	(2.665)	(2.947)	(2.948)	(2.593)
Both financial and job strain	−1.173	−1.595	1.347	1.352	−2.268
	(2.868)	(3.585)	(4.841)	(4.985)	(2.868)
Gender		10.56**	10.75**	10.76**	9.199***
		(3.56)	(3.571)	(3.539)	(2.349)
Stress*Gender		−1.5	−1.751	−1.751	
		(2.748)	(2.703)	(2.712)	
Depression			0.0824	0.0828	−0.0436
			(0.26)	(0.28)	(0.148)
Stress*Depression			−0.129	−0.129	
			(0.209)	(0.215)	
Cook-Medley Hostility				−0.00168	0.0121
				(0.233)	(0.225)
_cons	122.6***	120.3***	119.7***	119.7***	120.8***
	(2.019)	(2.298)	(2.611)	(3.277)	(3.217)
N	180	180	180	180	180
R-sq	0.043	0.117	0.12	0.12	0.117
adj. R-sq	0.032	0.097	0.09	0.084	0.091
Rmse	14.92	14.41	14.47	14.51	14.45

Standard errors in parentheses.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 5. Multivariate Linear Regression Analysis of Psychosocial Stress and Systolic Blood Pressure among Whites in the NHLBI Family Heart Study.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Financial or job strain	0.127	0.54	−1.822	−1.48	−0.721
	(1.569)	(1.734)	(2.168)	(2.129)	(1.493)
Both financial and job strain	1.641	4.345	−1.699	−2.404	0.864
	(2.838)	(3.399)	(4.372)	(4.372)	(2.743)
Gender		11.51***	12.01***	11.81***	9.243***
		(2.056)	(2.03)	(2.003)	(1.441)
Stress*Gender		−3.633	−4.013	−4.295	
		(2.294)	(2.281)	(2.273)	
Depression			−0.310*	−0.379**	−0.154
			(0.138)	(0.143)	(0.106)
Stress*Depression			0.333	0.334*	
			(0.17)	(0.166)	
Cook-Medley Hostility				0.359*	0.343*
				(0.159)	(0.159)
_cons	116.2***	111.8***	113.9***	111.0***	110.5***
	(1.113)	(1.227)	(1.644)	(2.05)	(1.794)
N	329	329	329	329	329
R-sq	0.001	0.124	0.138	0.152	0.132
adj. R-sq	−0.005	0.113	0.122	0.133	0.119
Rmse	13.79	12.95	12.89	12.8	12.91

Standard errors in parentheses.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 6. Multivariate Linear Regression Analysis of Psychosocial Stress and Diastolic Blood Pressure, NHLBI Family Heart Study.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Financial or job strain	−0.177	−2.676	−2.663	−2.692	−0.617
	(0.851)	(2.297)	(2.393)	(2.394)	(0.86)
Both financial and job strain	−0.735	−5.205	−5.399	−5.361	−1.418
	(1.298)	(4.217)	(4.499)	(4.498)	(1.32)
Gender		1.88	2.032	2.066	1.888*
		(1.192)	(1.196)	(1.201)	(0.823)
Race		−3.809**	−3.834**	−3.905**	−3.120***
		(1.248)	(1.242)	(1.261)	(0.854)
Stress*Race		1.15	1.089	1.101	
		(1.214)	(1.214)	(1.215)	
Stress*Gender		−0.152	−0.241	−0.217	
		(1.169)	(1.168)	(1.169)	
Depression			−0.0956	−0.0873	−0.0617
			(0.0784)	(0.0799)	(0.0529)
Stress*Depression			0.0364	0.0347	
			(0.0692)	(0.0694)	
Cook-Medley Hostility				−0.038	−0.0386
				(0.0785)	(0.078)
_cons	65.40***	67.60***	68.26***	68.62***	67.91***
	(0.616)	(1.161)	(1.282)	(1.516)	(1.255)
N	509	509	509	509	509
R-sq	0.001	0.03	0.033	0.034	0.032
adj. R-sq	−0.003	0.018	0.018	0.016	0.02
Rmse	9.023	8.926	8.927	8.934	8.916

Standard errors in parentheses.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 7. Multivariate Linear Regression Analysis of Psychosocial Stress and Diastolic Blood Pressure among African-Americans in the NHLBI Family Heart Study.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Financial or job strain	−2.072	−2.565	−2.344	−2.26	−1.707
	(1.485)	(1.603)	(1.799)	(1.793)	(1.501)
Both financial and job strain	−2.531	−3.796	−3.759	−3.47	−2.018
	(1.95)	(2.614)	(3.399)	(3.47)	(2.009)
Gender		−1.286	−1.043	−0.793	0.952
		(2.074)	(2.044)	(2.051)	(1.33)
Stress*Gender		1.993	1.891	1.879	
		(1.776)	(1.772)	(1.774)	
Depression			−0.114	−0.0867	−0.0748
			(0.123)	(0.128)	(0.0698)
Stress*Depression			0.0257	0.0158	
			(0.0954)	(0.0967)	
Cook-Medley Hostility				−0.111	−0.113
				(0.12)	(0.12)
_cons	68.29***	68.57***	69.32***	70.26***	69.81***
	(1.159)	(1.364)	(1.65)	(2.026)	(1.846)
N	180	180	180	180	180
R-sq	0.014	0.02	0.027	0.032	0.027
adj. R-sq	0.003	−0.003	−0.006	−0.008	−0.001
rmse	8.828	8.852	8.869	8.875	8.844

Standard errors in parentheses.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 8. Multivariate Linear Regression Analysis of Psychosocial Stress and Diastolic Blood Pressure among Whites in the NHLBI Family Heart Study.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Financial or job strain	0.125	0.262	−0.29	−0.262	−0.0861
	(1.04)	(1.172)	(1.415)	(1.422)	(1.051)
Both financial and job strain	−1.262	−0.544	−1.963	−2.022	−1.233
	(1.767)	(2.129)	(2.852)	(2.864)	(1.77)
Gender		2.808*	2.960*	2.944*	2.290*
		(1.413)	(1.432)	(1.434)	(1.03)
Stress*Gender		−0.956	−1.074	−1.097	
		(1.557)	(1.578)	(1.588)	
Depression			−0.0945	−0.1	−0.0442
			(0.101)	(0.102)	(0.0785)
Stress*Depression			0.083	0.0831	
			(0.107)	(0.107)	
Cook-Medley Hostility				0.0297	0.0256
				(0.101)	(0.1)
_cons	64.43***	63.34***	63.98***	63.74***	63.62***
	(0.713)	(0.842)	(1.067)	(1.298)	(1.137)
N	329	329	329	329	329
R-sq	0.001	0.018	0.021	0.021	0.018
adj. R-sq	−0.005	0.006	0.003	0	0.003
rmse	9.017	8.969	8.984	8.997	8.983

Standard errors in parentheses.
*$p < .05$, **$p < .01$, ***$p < .001$.

of the Trier Inventory for the Assessment of Chronic Stress (TICS-SSCS), which accounts for chronic worrying, work-related and social overload, excessive demands, and lack of social recognition, and their bivariate tests found that it was negatively associated with both SBP ($\beta = -0.16$, $p < .001$) and DBP ($\beta = -0.10$, $p < .001$).

Table 9. Multivariate Linear Regression Analysis of Psychosocial Stress and Mean Arterial Pressure, NHLBI Family Heart Study.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Financial or job strain	−0.658	−4.479	−4.659	−4.627	−1.344
	(0.898)	(2.406)	(2.487)	(2.499)	(0.889)
Both financial and job strain	0.21	−6.343	−7.041	−7.082	−0.839
	(1.32)	(4.321)	(4.527)	(4.527)	(1.308)
Gender		4.988***	5.167***	5.130***	4.354***
		(1.217)	(1.218)	(1.215)	(0.834)
Race		−4.898***	−4.924***	−4.847***	−3.522***
		(1.325)	(1.318)	(1.352)	(0.901)
Stress*Race		1.931	1.877	1.864	
		(1.263)	(1.261)	(1.266)	
Stress*Gender		−0.95	−1.046	−1.071	
		(1.18)	(1.179)	(1.177)	
Depression			−0.12	−0.129	−0.0798
			(0.0788)	(0.0814)	(0.0557)
Stress*Depression			0.0616	0.0635	
			(0.0799)	(0.0797)	
Cook-Medley Hostility				0.0412	0.0379
				(0.0852)	(0.0842)
_cons	82.88***	84.82***	85.65***	85.27***	84.22***
	(0.658)	(1.248)	(1.351)	(1.641)	(1.344)
N	509	509	509	509	509
R-sq	0.001	0.072	0.076	0.077	0.071
adj. R-sq	−0.003	0.061	0.061	0.06	0.06
rmse	9.476	9.171	9.168	9.175	9.176

Standard errors in parentheses.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 10. Multivariate Linear Regression Analysis of Psychosocial Stress and Mean Arterial Pressure among African-Americans in the NHLBI Family Heart Study.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Financial or job strain	−3.583*	−4.028*	−3.494	−3.437	−3.510*
	(1.619)	(1.719)	(1.952)	(1.951)	(1.641)
Both financial and job strain	−2.078	−3.062	−2.057	−1.863	−2.102
	(1.977)	(2.622)	(3.399)	(3.496)	(1.973)
Gender		2.663	2.889	3.057	3.701**
		(2.241)	(2.246)	(2.241)	(1.416)
Stress*Gender		0.829	0.677	0.669	
		(1.811)	(1.806)	(1.814)	
Depression			−0.0488	−0.0302	−0.0644
			(0.136)	(0.146)	(0.0815)
Stress*Depression			−0.0258	−0.0324	
			(0.114)	(0.117)	
Cook-Medley Hostility				−0.0747	−0.0712
				(0.137)	(0.135)
_cons	86.40***	85.81***	86.11***	86.74***	86.80***
	(1.265)	(1.481)	(1.739)	(2.178)	(2.072)
N	180	180	180	180	180
R-sq	0.028	0.055	0.06	0.061	0.061
adj. R-sq	0.017	0.034	0.027	0.023	0.034
Rmse	9.422	9.342	9.373	9.392	9.342

Standard errors in parentheses.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 11. Multivariate Linear Regression Analysis of Psychosocial Stress and Mean Arterial Pressure among Whites in the NHLBI Family Heart Study.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Financial or job strain	0.126	0.355	−0.801	−0.668	−0.298
	(1.073)	(1.19)	(1.444)	(1.445)	(1.054
Both financial and job strain	−0.294	1.086	−1.875	−2.149	−0.534
	(1.854)	(2.253)	(2.961)	(2.981)	(1.807)
Gender		5.709***	5.976***	5.898***	4.607***
		(1.433)	(1.445)	(1.437)	(1.034)
Stress*Gender		−1.849	−2.053	−2.163	
		(1.571)	(1.592)	(1.594)	
Depression			−0.166	−0.193	−0.0808
			(0.0985)	(0.101)	(0.0789)
Stress*Depression			0.166	0.167	
			(0.112)	(0.111)	
Cook-Medley Hostility				0.14	0.132
				(0.105)	(0.105)
_cons	81.70***	79.48***	80.60***	79.50***	79.25***
	(0.751)	(0.861)	(1.108)	(1.363)	(1.194)
N	329	329	329	329	329
R-sq	0	0.065	0.074	0.078	0.067
adj. R-sq	−0.006	0.054	0.056	0.058	0.053
Rmse	9.362	9.08	9.067	9.059	9.084

Standard errors in parentheses.
*$p < .05$, **$p < .01$, ***$p < .001$.

In a similar study, Lee et al. (2016) examined the impact of stress (general, racial, financial, occupational, and psychological) on cardiovascular disease risk among African-American college students aged 18–27 years. They found no significant relationship between financial or occupational stress and blood pressure, while other domains, such as racial stress, had significant effects on DBP ($F = 3.31$, $p \leq .05$).

The negative relationship between financial or job strain and blood pressure might be explained by other variables not measured in this study, such as social support and social roles. Social support, which can be defined as emotional support, financial support, and marital status, has been shown to decrease risk for hypertension, particularly among racial/ethnic minorities (Bell et al., 2010; Hernandez et al., 2014). Orden et al. (1995) examined the impact of social roles, such as wife, mother, and worker, on blood pressure among African-American and White women. They found that well-educated African-American women with multiple roles had 1.3–8.0 mmHg lower mean BP than those with fewer roles and White women who had similar social roles (Orden et al., 1995). Our study sample consisted of 195 African-American participants, 140 of whom were women. Though social roles were not explored, if the African-American women in this study were mothers, married, and well-educated, it might explain why their BP was significantly lower than that of White women.

Guimont et al. (2006) and Kai et al. (2018) found different significant outcomes. Both studies used longitudinal designs to examine the effects of job strain on blood pressure over time. They found significant associations between job strain and increases in SBP, although the Kai study was conducted in France, which limits its generalizability to the United States. Moreover, financial strain alone has been associated with increased risk for hypertension (Bird et al., 2017; Bosworth et al., 2003; Steptoe et al., 2005). In particular, Matthews et al. (2002) found that African Americans who had financial strain or difficulties paying for basic necessities were at greater risk for hypertension ten years later (OR = 1.27)

Gender was found to be a significant predictor of blood pressure across models. Being male was significantly associated with higher SBP, DBP, and MAP than being female. This result was not surprising, as studies show that men are more prone to hypertension than women, especially those below the age of 50 (Everett & Zajacova, 2015). After 50 years, women are at a higher risk for the disease (Sandberg & Ji, 2012). For instance, Artinian et al. (2006) examined the relationship between depression, stress, and blood pressure among African-American women with a mean age of 61 years. They found that women with higher depression scores were more likely to have higher DBP and increased reports of stress (Artinian et al., 2006). Our study sample had a mean age of 28 years, which may explain this finding among men, not women.

Race was also found to be a significant predictor of blood pressure across the models. Being White predicted a lower SBP, DBP and MAP than African Americans'. Similar results have been found in other studies (Bosworth et al.,

2003). Overall prevalence of hypertension and CVD rates are highest among African Americans compared to other racial/ethnic groups (Ogunniyi et al., 2021). Therefore, it was no surprise that being White was significantly associated with lower blood pressures than non-White groups.

In this study, depression significantly predicted lower SBP in Whites. This finding was unanticipated as several studies in the literature have demonstrated that individuals experiencing depression are at high risk for developing hypertension (Almas et al., 2014; Davidson et al., 2000; Ginty et al., 2013; Rubio-Guerra et al., 2013). For instance, Yan et al. (2003) found that depression among Whites was positively associated with very high blood pressure, defined as a SBP >160 mm Hg, DBP >95 mm Hg or taking antihypertensive medication. Though this significant association was not evident among African Americans, other studies, such as that of Davidson et al. (2000), found that African Americans with depressive symptomatology or CESD scores ≥ 8 were at a significant risk for hypertension.

Additionally, in the overall model of the present study, when adjusting for other variables, hostility remained a significant predictor of higher SBP in Whites. However, we anticipated this result based on the Cook-Medley hostility index inclusion criterion in the primary NHLBI study (Brummett et al., 2010). Nevertheless, similar significant relationships between hostility and blood pressure were found in a study conducted by Yan et al. (2003), where higher scores were evident among Whites and significantly associated with risk for developing hypertension 15 years after study baseline. Zhang et al. (2005) examined whether having high levels of suppressed hostility predicted incident hypertension in 627 nonhypertensive men in the Normative Aging Study. They found that among middle-aged men ($\leq$ 60 years) with high hostility suppression, a 1-point decrease in the Cook-Medley hostility score was associated with an 18% increase in hypertension risk ($p < .05$). Hostile individuals, especially men, are not only at high risk for hypertension, but also more likely to die from CVD than less hostile men (Matthews et al., 2004).

Limitations

Suitable power to identify significant differences in this study's sample may have been limited, particularly with group stratifications or variable outcomes, making type I error a concern. Second, minority groups included only African Americans, limiting generalizability to other racial/ethnic groups. However, the total of 195 African Americans (35.78%) was higher than that in comparable studies (Bhelkar et al., 2018; Hassoun et al., 2015). Third, participants were fairly young, with a mean age of 28.8 years (SD = 8.73). Increases in blood pressure are typically noted in older populations due to vascular changes (Simon, 2004) and comorbidities (Noh et al., 2016; Schmieder & Ruilope, 2008) which may explain why stress was not associated with increased BP levels. However, even though high blood pressure is less common among young adults, young adulthood and early middle age are critical periods for the development of hypertension and other risk factors for heart disease (Grebla et al., 2010). New studies have shown that the prevalence of hypertension in adults aged 24–32 years is beginning to rise, and its effects are more severe among African Americans (De Venecia, et al., 2016).

Finally, in this study, psychosocial stress was only represented in the existing data by two of the five domains from the Singh Stress Scale (Singh et al., 2015). The other domains, including ongoing serious health problems, serious health problems of someone close, and relationship difficulties, have all been significantly associated with high blood pressure and depression (Huurre & Aro, 2002; Smith et al., 2009; Teo et al., 2013; Whisman & Bruce, 1999). However, were unaccounted for in this secondary analysis.

Implications

Overall, findings from this study have several implications for promoting improved blood pressure screening and measurement. Financial and job strain, race/ethnicity, gender, depression, and hostility had varied influences on hypertension risk. Development and successful implementation of strategies for recognizing, modifying, alleviating, and managing harmful psychosocial stressors at the personal, clinical, and community level could have important implications for the prevention and management of hypertension and cardiovascular disease.

Future Studies

This study focused on the effects of psychosocial stress on blood pressure. Significant findings shed light on how financial and job strain and other study co-factors, such as race/ethnicity, gender, depression, and hostility influence blood pressure levels. Future studies should explore other domains of psychosocial stress and their relationship to blood pressure among young-to-middle-aged adults, adequately powered for ethnic/racial effects that may explain increases in the prevalence of hypertension.

Conclusion

In conclusion, we observed that the presence of two different psychosocial stress domains, financial or job strain, had varied influence on blood pressure levels (SBP, DBP, and MAP); such psychosocial stress levels inconsistently predicted blood pressure levels. However, covariates, such as depression, hostility, and gender, predicted significant decreases or increases in blood pressure. Precision assessment of such factors in young adults may improve screening and prevention.

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Data Accessibility Statement

The study dataset will be available, upon request, from Duke University Medical Center (DUMC) Behavioral Medicine Research Group for collaborative use as permitted by the Duke University IRB and respective Study Committee.

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