



The Association Between Perceived Stress and Hypertension Among Asian Americans: Does Social Support and Social Network Make a Difference?

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Abstract

Prior research suggests that stress plays role in the etiology and progression of hypertension. To lend a more accurate depiction of the underlying mechanisms between stress and hypertension, this study aims to assess the associations between perceived stress and hypertension across varying levels of social support and social network among Asian Americans. We conducted a cross-sectional study using data on 530 Chinese, Korean and Vietnamese Americans recruited from a liver cancer prevention program in the Washington D.C.—Baltimore metropolitan area. Hypertension prevalence was 29.1%. Individuals with high perceived stress were 61% more likely to have hypertension compared to those with low levels of perceived stress (odds ratio 1.61, 95% confidence interval 1.15, 2.46). There was no evidence that social support and social network acted as effect modifiers. Social support had a direct beneficial effect on hypertension, irrespective of whether individuals were under stress. The relationship between perceived stress and hypertension was modified by gender and ethnicity whereby a significant positive association was only observed among male or Chinese participants. Our study highlights the importance of understanding the associations between stress, social support, and hypertension among Asian American subgroups. Findings from the study can be used to develop future stress management interventions, and incorporate culturally and linguistically appropriate strategies into community outreach and education to decrease hypertension risk within the Asian population.

Keywords Hypertension · Asian American · Stress · Social support · Social network

Introduction

Hypertension is a major risk factor for the development of cardiovascular disease (CVD), and a main cause of morbidity and mortality worldwide [1]. Asian Americans, a rapidly growing minority population in the U.S., have been found to have a high prevalence of hypertension. According to data from the National Health and Nutrition Examination Survey (NHANES), about one-quarter (25.6%) of Asian

Americans 20 years of age and older had hypertension during 2011–2012 [2]. While there is a lack of national studies that observe the prevalence of hypertension in Asian American subgroups, local data reveals that significant differences in hypertension prevalence across various Asian American subgroups [3–5].

Emerging evidence indicates that chronic exposure to psychological stress/stressors plays a central role in the pathophysiology of hypertension and CVD [6, 7]. Stress is a complex process and can influence the pathogenesis of physical disease by exerting direct effects on biological processes or indirect effects on behavioral patterns [8]. When stress exceeds adaptive capacity, it results in maladaptive processes that negatively impact cardiovascular health [9]. Prior evidence suggests that perceived stress contributes to the elevated blood pressure and to the development of hypertension and CVD [10, 11].

Regarding social relationships, a growing body of literature indicates that social support and social isolation can have a direct effect on hypertension [12–16]. Prior research suggests

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that a low level of social support is a risk factor for the development of CVD in healthy individuals [17–19]. In terms of social network, several studies have shown that a smaller social network is associated with higher blood pressure levels [20–22]. Social isolation limits the amount of interactions and support that this population needs in order to maintain a healthy lifestyle. Failure to comply with certain medical recommendations because of social isolation could increase blood pressure in stressful situations. To the contrary, a large social network and strong social support may attenuate the negative cardiovascular response in situations of stress, thereby avoiding the increase in blood pressure [23].

Prior research has examined the mechanisms of social support and social network that underlie the association between stress and hypertension. In 1985, Cohen and Wills introduced two mechanisms in which social support may contribute to health: the Main Effect Hypothesis and the Stress-Buffering Hypothesis [24]. The Main Effect Hypothesis proposes that social resources have a beneficial health effect by providing positive experience and stability in life situation, irrespective of whether persons are under stress or not [15, 24]. The expression of negative feelings, for example, could lead to positive physiological, and concurrent, immunological benefits. The Stress-Buffering Hypothesis predicts that social support will have stronger positive effects on adjustment and physical well-being when a stressor becomes more intense or persistent [24]. Unfortunately, there is a lack of studies of the inter-relationship between perceived stress, social support, social network, and hypertension, particularly among Asian Americans.

To bridge the missing gaps in previous literature, this study aims to: (1) assess the relationship between perceived stress and hypertension among Chinese, Korean and Vietnamese Americans in the Washington, DC metropolitan area; (2) test the main effect hypothesis by examining the direct effects of social support and social network on hypertension; and (3) test the stress-buffering hypothesis by assessing the relationship between perceived stress and hypertension across varying levels of social support and social network. Given the high prevalence of hypertension among Asian Americans, utilizing multiple psychosocial measures allows us to capture the differences in the associations between various psychosocial aspects and hypertension, and to better understand the contributing psychosocial factors to hypertension.

Methods

Study Population and Recruitment Procedure

We used the baseline survey data collected for the Asian American Liver Cancer Prevention Program (a randomized

controlled trial to increase hepatitis B vaccination) for this ancillary study [25]. To examine the relationship between perceived stress and hypertension, foreign-born Asian American adults, aged 18 years and older, were recruited from the community in the Baltimore-Washington Metropolitan Area. After obtaining informed consent, all the participants were asked to complete a self-administered questionnaire in English, Chinese, Korean, or Vietnamese, with the assistance of a bilingual interviewer when necessary. While completing the survey, blood pressure was measured three times by the research team at the study site. This study was approved by the Institutional Review Board at Johns Hopkins Bloomberg School of Public Health.

Of the 645 eligible volunteers, 30 did not participate in the program and 15 of those who attended the program did not complete either the survey or the hepatitis B screening. Thus, a total of 600 participants (201 Chinese, 198 Korean, and 201 Vietnamese) completed the screening and survey. We excluded 70 participants who had missing values on the following variables: social support ($N = 19$), stress ($N = 32$), social network index ($N = 11$), education ($N = 6$), employment ($N = 3$), body mass index (BMI) ($N = 3$), smoke ($N = 7$), binge drinking ($N = 7$), and self-rated identity ($N = 3$). The final sample included 530 subjects for descriptive and regression analyses. Compared to the excluded sample ($N = 70$), women remaining ($N = 530$) in the analysis sample tended to be more educated, employed, self-identified very Asian, and more likely to smoke. We addressed this potential selection bias in the [Discussion](#) section (see [Table 6](#) in [Appendix](#)).

Measures

Dependent Variable

While participants were seated, three readings of blood pressure were taken at 5-min intervals in the right arm using the OMRON HEM 907 blood pressure monitor. Based on the American Heart Association (AHA)'s recommendations [26], the mean of the latter two readings were used in the analysis. The following criteria were used to define hypertension in this study: (1) systolic blood pressure (SBP) of 140 mmHg or higher or diastolic blood pressure (DBP) of 90 mmHg or higher; or (2) use of antihypertensive drugs. Participants were considered to be aware of their hypertension status if they answered yes to the question “Have you been told by a doctor or other healthcare professional that you have hypertension or high blood pressure?”.

Independent Variable

Perceived Stress

Perceived stress was measured using the 10-item version of Perceived Stress Scale (PSS) which captures how unpredictable, uncontrollable, and overloaded respondents find their lives [8]. Response categories are based on a 5-point Likert scale ranging from never (0) to very often (4) [27]. PSS scores can range from 0 to 40, with a higher score indicates more perceived stress. Cronbach's alpha for the scale with our data is 0.77. We categorized the PSS score based on the median into low (0–15) and high (16 and above) groups.

Social Support

Social support was assessed using the 8-item version of the Duke-UNC Functional Social Support Questionnaire (DUFSS) which measures the amount and type of perceived functional social support. The 8-item version of the DUFSS includes two subscales: 6-item confidant support (including having someone to talk to, trust with, socialize with, receive advice from, and receive help from) and 2-item affective support (being shown love and affection). The responses are on 5 point Likert scale, ranging from 5 (as much as I would like) to 1 (much less than I would like). The scale yields a single total support score, ranging between 8 and 40. The higher total score reflects a higher perceived social support. Cronbach's alpha for this scale with our data is 0.94. We categorized the DUFSS score based on the median into low (0–30) and high (31 and above) groups.

Social Network Index Score

Social network index was measured using Berkeman and Syme's Social Network Index (SNI). This measure is a composite score of four types of social connections: marital status (married vs. not); sociability (number and frequency with close relatives and close friends); church membership (yes vs. no); and membership in other community organizations (yes vs. no) [28]. The SNI allows researchers to categorize individuals into four levels of social connection: socially isolated, moderately isolated, moderately integrated, and socially integrated [28]. The SNI considers both the number and the relative importance of social ties across these four network categories and combines this information into a single summary measure (ranging from 0 to 4). Four network categories were developed to reflect differences in type and extent of social contact: married (no = 0; yes = 1); close friends and relatives (0–2 friends and 0–2 relatives (including children) = 0; all other scores = 1); group participation (no = 0; yes = 1); and participation in religious meetings or services (never or almost never = 0; greater than or equal

to once or twice a month = 1). Scores were summed: 0 or 1 was the most isolated category (socially isolated); 2 (moderately isolated), 3 (moderately integrated), and 4 (socially integrated) formed the other three categories of increasing social connectedness. The procedures by which this index was developed and the precise description of methods used to score it are available elsewhere [28–30].

Covariates

Based on existing literature, the following confounders were included in the analysis: age, gender, ethnicity, education, employment status, marital status, body mass index (BMI), smoking, binge drinking, self-rated identity and English speaking. We obtained information on these variables from the self-administered questionnaire mentioned previously. Since age was not linearly related to the outcome based on LOWESS analysis [31, 32], age was categorized into 3 groups: less than 40 years, 40–59 years, and 60 years and over. With regards to education, we categorized participants into three groups: less than high school, high school or some college, college graduate or higher. We collapsed the marital status variable into two categories: married/living with a partner, or others (separated/divorced/widowed/never married). Employment status was dichotomous: employed versus unemployed. BMI was assessed as a continuous variable using anthropometric measure of weight and height, and was defined as body weight (in kilograms) divided by the square of height (in meters). Smoking was grouped as smoke (had smoked at least 100 cigarettes in entire life) versus non-smoke. Binge drinking status was categorized as yes (women had 4 or more drinks on an occasion during the past 30 days; men had 4 or more drinks on an occasion during the past 30 days) versus no (reference level). For the acculturation variables, English proficiency was measured as fluent, well, so-so, poorly, or not at all. Due to the low cell counts, we collapsed this variable into three groups: native/very well, so-so, and poorly/not at all. Self-rated identity was assessed using a single item measure on a 5-point scale: very Asian, mostly Asian, bicultural, mostly westernized, and very westernized. The last three self-rated identity categories were combined into one group: bicultural/westernized.

Statistical Analysis

Descriptive statistics calculated included estimating means of continuous variables and proportions of categorical variables. Hypertension status was compared by acculturation and covariates using the t-test for continuous variables and the Pearson's chi-squared test for categorical variables. The statistical significance was based on a p value less than 0.05.

Age-adjusted logistic regression and multiple logistic regression were performed to assess the association between

each psychological measure and hypertension. Potential moderation by social support, social network index, age categories, gender, education, employment status, self-identity, English proficiency, obesity, smoking and binge drinking were examined by including the corresponding interaction term. The potential moderators were selected based on prior literature. The stratified analysis was conducted if the interaction term was significant. The statistical analysis of the study was performed using SAS 9.4 (SAS Institute, Cary, NC).

Results

Participant characteristics are presented in Table 1. Of the 530 participants, the majority (63%) were between age of 40 and 59 years. About 58% were female and most of the participants were married (78%). Chinese, Korean, and Vietnamese ethnic composition was about the same, each making up one-third of the sample. About half of the study population received a college education or higher while 18% reported a history of smoking and 17% were binge drinkers. Based on the objective measure of BMI, 31% of the participants were overweight ($BMI > 25 \text{ kg/m}^2$).

The mean of the perceived stress score in our sample was 15.5 ($SD = 5.8$). The level of perceived stress varied with ethnicity groups, English proficiency, and social support. A larger proportion of Korean Americans reported high perceived stress compared to Chinese and Vietnamese Americans (64% vs. 48% and 45%, $p < 0.01$). In addition, those with high level of perceived stress tended to receive less social support and rate their English fluency as “poorly/not at all” or “so-so”. In regards to social support, 53% of the participants reported low level of social support. The level of social support also differed by gender and English proficiency. Females and individuals who spoke English well tended to receive a high level of social support. For the social network index score, 13% were socially isolated, 22% were moderately isolated, 30% were moderately integrated, and 35% were socially integrated. Socially isolated individuals tended to be less than 40 years or older than 60 years, not married, more Korean than Chinese or Vietnamese Americans, lower educated, not employed, and rated their English fluency as “poorly/not at all”.

The overall prevalence of hypertension in this population was 29%. As shown in Table 1, those with hypertension tended to be older, male, less educated, higher BMI, rate their English fluency as “poorly/not at all” or “so-so”, and have a history of smoking compared to those without hypertension. Perceived stress and social support were significantly associated with hypertension in the bivariate analyses.

Table 2 shows age-adjusted models for the association between psychological factors and hypertension. Individuals

who had high level of perceived stress were 71% more likely to have hypertension as compared to those with low level of perceived stress (odds ratio (OR) 1.71, 95% confidence interval (CI) 1.15, 2.54) after adjusting for age. Participants with high social support were 51% less likely to have hypertension comparing with those with low social support (OR 0.49, 95% CI 0.33, 0.74). However, social network index score was not significantly associated with hypertension after controlling for age.

Table 3 reports multivariable adjusted models for the association between psychological factors and hypertension. Age and BMI had the largest confounding effect among all covariates. After adjusting for other variables, individuals who had a high level of perceived stress were 61% more likely to have hypertension as compared to those with low level of perceived stress (OR 1.61, 95% CI 1.15, 2.46). Social support also had a direct impact to hypertension: participants with high social support were 48% less likely to have hypertension comparing with those with low social support (OR 0.52, 95% CI 0.33, 0.81). However, social network index score was not significantly associated with hypertension in general. Moderately integrated individuals were 58% less likely to have hypertension than socially isolated individuals (OR 0.42, 95% CI 0.19, 0.92). Interactions between perceived stress and social support or social network index were not statistically significant.

There was a significant interaction between perceived stress and gender (Table 4), suggesting that perceived stress had a stronger association with hypertension in men than in women. Male participants with high level of perceived stress were 95% more likely to have hypertension compared with those with low level of perceived stress (OR 1.95, 95% CI 1.05, 3.60). This association was not significant in women.

The relationships between perceived stress and hypertension also varied by three ethnic groups (Table 5). The adjusted model suggests that Chinese participants who had a high level of perceived stress were 278% more likely to have hypertension compared to those with low level of perceived stress (OR 3.78, 95% CI 1.13, 6.80). Similar to perceived stress, Chinese participants with high social support were 64% less likely to have hypertension as compared to those who had low social support (OR 0.36, 95% CI 0.15, 0.87). Among Korean and Vietnamese groups, no significant difference in hypertension status was found for various psychological measures.

Discussion

Our study is one of the first studies to examine multiple measures of psychosocial factors in relation to hypertension among Asian Americans overall and by ethnicity. The findings in this study clearly indicate that perceived stress

Table 1 Baseline characteristics of the participants (N = 530)

	Total N = 530	Non-hypertensive N = 376	Hypertensive N = 154	p value
Age				<0.01
< 40 years	126 (23.8)	111 (29.5)	15 (9.8)	
40–59 years	335 (63.2)	227 (60.4)	108 (70.1)	
60 years and over	69 (13.0)	38 (10.1)	31 (20.1)	
Gender				<0.01
Male	224 (42.3)	131 (34.8)	93 (60.4)	
Female	306 (57.7)	245 (65.2)	61 (39.6)	
Ethnicity				0.07
Chinese	177 (33.4)	137 (36.4)	40 (26.0)	
Korean	179 (33.8)	121 (32.2)	58 (37.7)	
Vietnamese	174 (33.8)	118 (31.4)	56 (36.3)	
BMI (mean[SD])	23.4 (3.4)	22.6 (3.1)	25.4 (3.2)	<0.01
Marital status				0.29
Married	411 (77.6)	287 (76.3)	124 (80.5)	
Not married	119 (22.4)	89 (23.7)	30 (19.5)	
Education				<0.01
Less than high school	68 (12.8)	40 (10.6)	28 (18.2)	
High school or some college+	202 (38.1)	135 (35.9)	67 (43.5)	
College graduate +	260 (49.1)	201 (53.5)	59 (38.3)	
Employment status				0.77
Employed	356 (67.2)	122 (32.4)	52 (33.8)	
Unemployed	174 (32.8)	254 (67.6)	102 (66.2)	
Self-rated identity				0.07
Very Asian	304 (57.2)	205 (54.5)	99 (64.3)	
Mostly Asian	88 (16.5)	63 (16.8)	25 (16.2)	
Bicultural/westernized	140 (26.3)	108 (28.7)	30 (19.5)	
English speaking				0.0017
Poorly/not at all	194 (36.6)	126 (33.5)	68 (44.2)	
So-so	207 (39.1)	143 (38.0)	64 (41.5)	
Native/very well	129 (24.3)	107 (28.5)	22 (14.3)	
Smoke				<0.01
Smoker	94 (17.7)	51 (13.6)	43 (27.9)	
Non-smoker	438 (82.3)	325 (86.4)	111 (72.1)	
Binge drink				0.31
Yes	67 (12.6)	44 (11.7)	23 (14.9)	
No	463 (82.4)	332 (88.3)	131 (85.1)	
Perceived stress				0.01
Low	251 (47.2)	192 (51.1)	59 (38.3)	
High	281 (52.8)	184 (48.9)	95 (61.7)	
Social network index score				0.84
Socially isolated	67 (12.6)	46 (12.2)	21 (13.6)	
Moderately isolated	115 (21.6)	83 (22.1)	31 (20.1)	
Moderately integrated	162 (30.5)	117 (31.1)	44 (28.6)	
Socially integrated	188 (35.3)	130 (34.6)	58 (37.7)	
Social support				<0.01
Low	282 (53.0)	179 (47.6)	101 (65.6)	
High	250 (47.0)	197 (52.4)	53 (34.4)	

Table 2 Age adjusted logistic regression models of psychological factors and hypertension (N = 530)

	Model 1	Model 2	Model 3
Perceived stress			
Low	Ref		
High	1.71 (1.15, 2.54)*		
Social network index score			
Socially isolated		Ref	
Moderately isolated		0.66 (0.33, 1.34)	
Moderately integrated		0.60 (0.31, 1.17)	
Socially integrated		0.65 (0.34, 1.24)	
Social support			
Low			Ref
High			0.49 (0.33, 0.74)*
Age			
< 40 years	Ref	Ref	Ref
40–59 years	3.52 (1.95, 6.33)*	3.88 (2.11, 7.12)*	3.50 (1.94, 6.32)*
60 years and over	6.18 (3.00, 12.74)*	6.45 (3.10, 13.39)*	5.69 (2.76, 11.75)*

*p < 0.05

is a strong predictor of hypertension. Our results support the main effect hypothesis that social support had a direct beneficial effect on hypertension, irrespective of whether persons were under stress. However, a stress-buffering effect of social support or social network was not demonstrated in this study. Our findings also suggest the relationship between perceived stress and hypertension was modified by gender. Among Asian American men, those with high level of perceived stress were significantly more likely to develop hypertension compared to those with low level of perceived stress. For women, no association between perceived stress and hypertension was found. In addition, the impact of perceived stress on hypertension may differ by Asian American subgroups as the significant association between perceived stress and hypertension was only observed among Chinese Americans.

The prevalence of hypertension was found to be slightly higher among Asian Americans in our sample (29.1%) compared to the data of NHANES 2011–2012 (25.6%) [2]. This is probably because our sample was mostly comprised of a foreign-born population. According to the NHANES data, the prevalence of hypertension was higher among foreign-born (26.1%) individuals compared to those U.S.-born (21.2%) [2]. Regarding the disaggregated data, consistent with a study that observed differences in hypertension prevalence among Asian subgroups [5], we found some variations in hypertension prevalence: hypertension prevalence was highest among Vietnamese Americans (33%), followed by Korean (31%) and Chinese Americans (23%).

Another notable finding is the level of perceived stress observed among Asian Americans in this study. The mean of the perceived stress score in our sample was 15.5, which is slightly higher than the mean score reported among Whites

in the study by Cohen et al. (15.2) [33]. Prior evidence has suggested that immigrant population experienced more psychosocial stress compared to dominant western cultural groups [34]. Studies have shown that most common difficulties which immigrants experience include language barriers, adjusting to an unfamiliar environment, differences between Asian and American cultures, and problems relating to children who are often more acculturated than their parents [35]. Our study also found that perceived stress was strongly related to acculturation whereby those with perceived low stress tended to rate English as “native fluency/well” or “so-so” (37% native fluency/well vs. 35% so-so vs. 29% poorly/not at all, $p < 0.01$). In addition, our data suggests that a larger proportion of Korean Americans reported high perceived stress relative to Chinese and Vietnamese Americans (64% vs. 48% and 45%, $p < 0.01$). This finding is consistent with previous studies that reveal high levels of psychosocial stress, anxiety, and depression in Korean Americans [36–38]. Potential explanatory factors may include higher rates of under-employment (a better education but lower-prestige jobs); limited ability in English; and a higher concentration in small business located in high-risk minority districts [39].

A strong relationship between perceived stress and hypertension among Asian Americans was concluded in our study. Prior research connecting stress with hypertension has produced mixed findings, with some studies identifying a positive association [40, 41], some showing no correlation [37] while others even demonstrating a negative correlation [42]. However, few of these studies were conducted among Asian Americans [37]. Logan et al. explored the relationship between perceived stresses and blood pressure among 102 Korean Americans in North Carolina [37]. They found

Table 3 Multivariate logistic regression models of psychological factors and hypertension (N = 530)

	Model 1	Model 2	Model 3
Perceived stress			
Low	Ref		
High	1.61 (1.03, 2.51)*		
Social network index score			
Socially isolated		Ref	
Moderately isolated		0.51 (0.23, 1.12)	
Moderately integrated		0.42 (0.19, 0.92)*	
Socially integrated		0.52 (0.25, 1.12)	
Social support			
Low			Ref
High			0.52 (0.33, 0.81)*
Age			
< 40 years	Ref	Ref	Ref
40–59 years	3.04 (1.54, 5.98)*	3.52 (1.72, 7.22)*	3.13 (1.59, 6.20)*
60 years and over	4.32 (1.86, 10.06)*	4.82 (2.01, 11.52)*	4.18 (1.79, 9.76)*
Gender			
Male	Ref	Ref	Ref
Female	0.43 (0.26, 0.73)*	0.44 (0.26, 0.74)*	0.47 (0.28, 0.80)*
BMI (mean [SD])	1.28 (1.19, 1.38)*	1.29 (1.20, 1.39)*	1.30 (1.21, 1.39)*
Education			
Less than high school	Ref	Ref	Ref
High school or some college+	0.85 (0.44, 1.65)	0.86 (0.43, 1.69)	0.89 (0.46, 1.74)
College graduate +	0.54 (0.26, 1.09)	0.57 (0.28, 1.17)	0.56 (0.28, 1.15)
Employment status			
Unemployed	Ref	Ref	Ref
Employed	0.89 (0.54, 1.47)	0.94 (0.56, 1.56)	0.85 (0.51, 1.41)
Self-rated identity			
Very Asian	Ref	Ref	Ref
Mostly Asian	1.05 (0.57, 1.94)	1.06 (0.57, 1.98)	1.08 (0.58, 2.02)
Bicultural/westernized	0.67 (0.38, 1.19)	0.64 (0.36, 1.15)	0.70 (0.39, 1.23)
English speaking			
Poorly/not at all	Ref	Ref	Ref
So-so	1.07 (0.63, 1.81)	1.06 (0.63, 1.81)	1.09 (0.64, 1.85)
Native/very well	0.57 (0.27, 1.23)	0.49 (0.23, 1.05)	0.60 (0.28, 1.30)
Smoke			
Non-smoker	Ref	Ref	Ref
Smoker	1.24 (0.67, 2.29)	1.30 (0.71, 2.39)	1.28 (0.70, 2.36)
Binge drink			
No	Ref	Ref	Ref
Yes	0.90 (0.46, 1.77)	0.95 (0.49, 1.87)	0.92 (0.47, 1.81)

*p < 0.05

that there was no significant association between perceived stress and SBP/DBP.

The mechanisms by which stress may be linked to hypertension are complex and involve a variety of interrelated physiological and behavioral pathways [43]. Early studies have shown that the primary biological pathway linking emotions to disease is hormone [44]. Excessive discharge of certain hormones have been implicated in the pathogenesis

of cardiovascular disease and diseases involving the immune system including cancer, infectious diseases, and autoimmune diseases [44]. Behavioral changes may also occur as adaptations to stressors. People exposed to stressors or with perceived stress tend to engage in poor health behaviors, such as smoking, alcohol consumption, inactivity, unhealthy diets, and poor sleep patterns [27, 45]. Additionally, it is believed that immigrants change their lifestyle to cope with

Table 4 Logistic regression models of psychological factors and hypertension by gender (N=530)

	Male N=224	Female N=306
Perceived stress		
Low	Ref	Ref
High	1.95 (1.05, 3.60)*	1.53 (0.78, 3.00)
Social network index score		
Socially isolated	Ref	Ref
Moderately isolated	0.22 (0.07, 0.71)	1.22 (0.35, 4.29)
Moderately integrated	0.23 (0.07, 0.76)	0.79 (0.24, 2.66)
Socially integrated	0.25 (0.08, 0.82)	1.03 (0.31, 3.36)
Social support		
Low	Ref	Ref
High	0.50 (0.26, 0.93)*	0.48 (0.24, 0.94)*

Adjusted for age, gender, BMI, education, employment status, self-identity, English speaking, smoke and binge drinking

* $p < 0.05$

the increased stress [46]. These lifestyle changes, such as unhealthy diet, have been found to increase vulnerability to developing hypertension [46, 47]. Therefore, well-established behavioral risk factors may represent an intermediate stage through which stress increases hypertension risk [48]. However, the established risk factors do not account completely for the stress and CVD association. Consistent with earlier studies [49], our study found adjusting for intermediate behavioral health indicators (smoking, binge drinking and BMI) resulted in only a small change in the strength of associations of perceived stress with hypertension.

We found mixed evidence regarding the effects of social relationship on hypertension. In this analysis, social support was significantly associated with hypertension.

Similar findings have been reported from Tomaka et al. [50]. They examined relations between social support and health outcomes in a senior sample from New Mexico. The results show that the odds of hypertension were 24% lower for a one unit increase in the social support score (OR 0.76, $p < 0.05$). Inconsistent with prior studies [20, 51, 52], we found there was no significant association between social network and hypertension. In addition, we observed no difference in the associations between perceived stress and hypertension across various levels of social support or social network. This suggests that the impact of the subjective experience of stress on hypertension was not moderated by social network or social support. But the stress-buffering effect of social support was demonstrated in other studies [53, 54]. The findings from these studies highlight the importance of examining the joint contribution of stress and coping resources to hypertension.

The gender discrepancies in the association between stress and hypertension found in our study is consistent with prior research [30, 55]. Our results revealed that Asian American men with a high level of perceived stress were significantly more likely to develop hypertension compared to those with a low level of perceived stress. Interestingly enough, there was no association between perceived stress and hypertension among women. The mechanism for these gender differences of stress-related hypertension remains unclear. It has been reported that Asian men experience a more difficult time in adjusting to new cultures compared with Asian women [55]. Asian culture had instilled in these men more authority that the impact of stress would be more profound [55]. In addition, prior research has observed gender differences in the use of stress coping strategies [56]. Women preferred the emotion-focused coping strategy to mobilize their social

Table 5 Logistic regression models of psychological factors and hypertension by ethnicity (N=530)

	Chinese N=177	Korean N=179	Vietnamese N=174
Perceived stress			
Low	Ref	Ref	Ref
High	3.78 (1.13, 6.80)*	1.03 (0.46, 2.31)	1.73 (0.84, 3.57)
Social network index score			
Socially isolated	Ref	Ref	Ref
Moderately isolated	0.28 (0.07, 1.06)	2.03 (0.26, 16.08)	0.64 (0.16, 2.53)
Moderately integrated	0.29 (0.07, 1.24)	0.89 (0.11, 6.95)	0.57 (0.16, 2.03)
Socially integrated	0.40 (0.10, 1.65)	0.94 (0.13, 7.03)	1.02 (0.28, 3.73)
Social support			
Low	Ref	Ref	Ref
High	0.36 (0.15, 0.87)*	0.47 (0.20, 1.07)	0.58 (0.26, 1.29)

Adjusted for Age, gender, BMI, education, employment status, self-identity, English speaking, smoke and binge drinking

* $p < 0.05$

networks, especially peers, to talk about what was troubling them as a way of releasing stress; while men usually repressed their emotions to either fight or escape [57]. Although this stress-buffering effect was not observed in our data, social support has been demonstrated as an effect modifier in other research [53, 54].

Another noteworthy finding is the heterogeneity among Asian subgroups in the associations between psychosocial factors and hypertension. Stratified analyses concluded that the significant associations between perceived stress, social support and hypertension only presented among Chinese participants. This suggests that the negative effect of perceived stress and positive effect of social support on hypertension may be particularly potent among Chinese Americans. Chinese culture emphasizes interdependence and values group consensus more than individual attributes [35]. In the current study, we also found the mean of social support score was higher among Chinese (30.2) than Korean (28.1) and Vietnamese Americans (29.0). Future study may elucidate the underlying mechanisms in the heterogeneous associations among Asian subgroups by examining the culturally relevant stress and social support measures.

We acknowledge a number of limitations in this study. First, our study was based on cross-sectional data and does not lend itself to causal inference. Future studies using longitudinal data are needed to corroborate our findings. Second, the study used non-probability sampling methods because the target population is a hard-to-reach population; however, our sample composition closely follows the composition of the United States 2010 Census data [58]. Therefore, generalizability of the study may not be largely compromised. Third, the majority of our study population was first generation immigrants because the goal of the parent study was to study hepatitis B. Thus, variability for perceived stress and social support might have been smaller than studies that included more US-born Asian Americans. This might have reduced our ability in detect potential associations between psychosocial factors and hypertension. Fourth, we did not have data on a number of established risk factors for hypertension that are also related to stress. Physical activity and diet are known to be associated with the risk of hypertension [59, 60], but these information were not available in our data.

Nevertheless, this study advanced our understanding of psychosocial factors and hypertension among Asian

Americans. To our best knowledge, this is one of the first studies examining the synergistic effect of perceived stress, functional social support, and structural social support on hypertension among Asian Americans. By using a large sample size, this study focused on three of the largest Asian American populations: Chinese, Koreans, and Vietnamese. This highlights the importance of identifying differences in health effects of perceived stress among disaggregated Asian Americans subgroups. Moreover, as opposed to using self-reported hypertension information, our study used objective measure of hypertension as our outcome. Three blood pressure readings were taken at the time of the survey for increased accuracy. There is ample evidence in previous literature of large disparities between the objective and subjective health measures in even very high quality surveys [61].

The implication of this work is directed towards expanding our understanding of the interrelationship between stress, social support, and hypertension among Asian Americans. It is critical to this discussion that researchers and clinicians understand the fundamental cultural differences that Asian Americans have relative to the general population. At the same time, it is also essential to recognize the diversity that exists within the Asian American culture. Because of this, our study underlines the importance of identifying differences in health effects of stress among disaggregated Asian American subgroups in order to help health professionals prioritize which subgroups need the most urgent intervention in terms of stress management. Successful interventions to reduce the modifiable risk factors among individuals under stress may prevent the risk of long-term health hazards. In general, findings from the study can be used to develop future stress management interventions, and incorporate culturally and linguistically appropriate strategies into community outreach and education to decrease hypertension risk within the Asian Americans.

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Compliance with Ethical Standards

Conflict of interest Xiaoxiao Lu, Hee-Soon Juon, Xin He, Cher M Dallal, Ming Qi Wang, and Sunmin Lee declare that they have no conflict of interest.

Table 6 Compare characteristics between analysis sample and excluded sample with missing values

	Analysis sample (n = 530)	Excluded sample (n = 70)	p value
Age			0.10
< 40 years	126 (23.8)	10 (14.3)	
40–59 years	335 (63.2)	46 (65.7)	
60 years and over	69 (13.0)	14 (20.0)	
Gender			0.72
Male	224 (42.3)	28 (40.0)	
Female	306 (57.7)	42 (60.0)	
Ethnicity			0.49
Chinese	177 (33.4)	24 (34.3)	
Korean	179 (33.8)	19 (27.1)	
Vietnamese	174 (33.8)	27 (38.6)	
BMI (mean[SD])	23.4 (3.4)		
Marital status			
Married	411 (77.6)		
Not married	119 (22.4)		
Education			<0.01
Less than high school	68 (12.8)	18 (25.7)	
High school or some college+	202 (38.1)	21 (30.0)	
College graduate +	260 (49.1)	25 (35.7)	
Missing	0	6 (8.6)	
Employment status			<0.01
Employed	356 (67.2)	42 (60.0)	
Unemployed	174 (32.8)	25 (35.7)	
Missing	0	3 (4.3)	
Self-rated identity			<0.01
Very Asian	304 (57.2)	37 (52.9)	
Mostly Asian	88 (16.5)	11 (15.7)	
Bicultural/westernized	140 (26.3)	19 (27.1)	
Missing		3 (4.3)	
English speaking			0.31
Poorly/not at all	194 (36.6)	31 (44.3)	
So-so	207 (39.1)	27 (38.6)	
Native/very well	129 (24.3)	12 (17.1)	
Missing	0		
Smoke			<0.01
Smoker	94 (17.7)	10 (14.3)	
Non-smoker	438 (82.3)	54 (77.1)	
Missing	0	6 (8.6)	
Binge drink			0.53
Yes	67 (12.6)	63 (90.0)	
No	463 (82.4)	7 (10.0)	

Appendix

See Table 6

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