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The Role of Stress in the Relationship Between Shift Worked and Hypertension

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Shift Worked and Hypertension

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ABSTRACT

Purpose: Individuals working non-daytime shifts have been reported to have an increased risk for many negative health outcomes, including poor cardiovascular health. This study aims to examine the relationship between shift worked and hypertension—a major risk factor for cardiovascular disease. Of particular interest in this study was the role of stress and type of shift worked (day, evening, night, or rotating) in this relationship.

Methods: The study utilized National Health and Nutrition Examination Survey data collected between 2005 and 2010. The study population was limited to adult workers 20 years of age and older (n=9356). Initial descriptive statistics of demographic characteristics and stress measurements were obtained. Analyses were stratified by smoking status. The adjusted odds ratios (ORs) were obtained for each relevant risk factor, followed by final multivariate model selection for each smoking and non-smoking populations.

Results: In the non-smoking model only known risk factors gave significantly higher odds of hypertension when adjusting for other covariates in the model. Sleeping more hours per night (OR 0.92, 95% confidence interval (CI) 0.87, 0.98) and working night shift (OR 0.57, CI=0.34, 0.95) had statistically significant protective effects in non-smokers. Among smokers, a statistically significant interaction between age and night shift work was found (OR 1.05, 95% CI=1.02, 1.08).

Conclusions: Shift worked and stress may be significant factors in the development of hypertension, though the relationship is complex. Sleep may play an important protective role against hypertension. Additionally, smoking night shift workers may be at an increased risk for hypertension with increasing age.

INTRODUCTION

Risks associated with non-daytime working schedules have been previously examined by many studies. Workers of abnormal shifts may work at night, evenings, or other non-standard working hours, including rotating or extended shifts. These alternative shift workers may be at an increased risk for cardiac events, cancers, and other negative health outcomes [1]. Additionally, associations between shift worked and elevated blood pressure have been suggested [2].

Hypertension is a major risk factor for cardiovascular disease, and affects approximately a quarter of U.S. adults [3]. Hypertension is often treated with lifestyle changes in addition to medication and is considered a modifiable risk factor [4]. The negative impact of hypertension on cardiac health and the potential for treatment with lifestyle changes make the condition an excellent candidate for health interventions.

The true effects of abnormal working shift on blood pressure are unclear. While some studies have reported increased rates of hypertension in night shift workers [5-7] others have failed to replicate the association [8-10]. Many of these studies have examined distinct, high stress, occupational groups [5, 6, 8]. Factors of stress including job stressors, race, and socioeconomic stressors may contribute to hypertension [11]. This study aims to elucidate the role of stress in the relationship between hypertension and shift worked, utilizing a large nationally representative sample of US adults from all job sectors.

LITERATURE REVIEW

A literature review was conducted to examine existing knowledge on the topics of shift work and stress in relation to hypertension. PubMed and Google Scholar were utilized in the search process. Search terms included: hypertension, shift work, night shift, rotating shift, stress, psychological stress, self-reported stress, overtime, job strain. Results were limited to those available in English language.

Hypertension

Hypertension is a major risk factor for developing cardiovascular disease (stroke, heart failure, coronary heart disease, and other related conditions), a leading cause of death in the U.S. [12]. High blood pressure, or hypertension, is typically defined as an individual having systolic blood pressure greater or equal to 140 mmHg, diastolic blood pressure greater or equal 90 mmHg, or currently taking a medication to treat high blood pressure. Hypertension may be treated with lifestyle modifications (diet and exercise) as well as pharmaceuticals [4]. In the United States, 24% of adults suffer from hypertension [3].

In a 1998 prospective cohort study, 28% of coronary heart disease in males and 29% in females was deemed attributable to elevated blood pressure [13]. Thus, addressing the causes of hypertension is necessary in order to reduce the burden of cardiovascular disease. Risks for hypertension include both modifiable and non-modifiable factors. Non-Hispanic black, male, obesity, and older age characteristics are associated with a higher likelihood of hypertension [12, 14]. Additionally, some evidence exists that working non-standard daytime shifts may be linked to cardiovascular disease [15].

Shift Work

Working non-standard daytime shifts may have a significant impact on health outcomes. In addition to excess risk of cardiovascular disease, the literature suggests that individuals working non-standard daytime shifts are at an increased risk for gastrointestinal illness, breast cancer, and poor pregnancy outcomes [1].

Previous studies on shift work have examined both nighttime workers and rotating shift workers compared to their daytime counterparts to investigate whether the risk of hypertension varies across the three groups. In a meta-analysis examining pooled odds ratios of shift work status and hypertension, rotating shift workers were found to have elevated odds of hypertension relative to daytime workers, while the risk of hypertension among night shift workers did not deviate appreciably from that of daytime employees [2].

Many studies have examined the relationship between hypertension and shift worked using an occupation-specific study population. Certain industries or professions may be more likely to require employees to work irregular or nighttime shifts. Factory laborers [6, 9, 16-18], law enforcement [5], and health care [8, 10, 19] populations were frequently utilized in the studies reviewed. Results in these studies varied significantly. A historical cohort study of Japanese steel workers found alternating shift work to be associated with an increase in blood pressure [6]. Conversely, a cross-sectional study of 725 nurses found no difference in hypertensive status between day and night shift workers [19]. Significant differences in methodologies and study populations, as well as the distinction between night and rotating shift work, may be a factor in these contradicting conclusions.

Working abnormal shifts, particularly at night and long hours, may contribute to immediate blood pressure changes. A 2016 study showed an increase in blood pressure taken after a 12-hour shift in female police officers [5]. Similarly, emergency room medical residents showed abnormal blood pressure readings when monitored over a 24-hour shift [10]. Conversely, multiple studies note an increased risk of hypertension for long-term night and rotating shift workers [7, 17].

Stress

Stress may be defined in many ways. Individuals may be considered to be under stress based on objective measures of poor socio-economic or health status. For example, a cross-sectional study conducted by Theall and colleagues was designed to examine psychosocial stress by neighborhood, utilizing objective measures of stress like poverty and neighborhood level factors [20]. Alternatively, stress may be measured as a self-report of psychological stress. Established cognitive assessments for measuring psychological stress emphasize feelings of control and coping, irritability, and nervousness [21]. A study by Adler, et al. reported that an individual's subjective rating of their own stress may be a truer measure of stress than objective measures [22]. In opposition, a study examining objective and subjective job stress found significant associations between hypertension and objective stressors, but not self-reported stressors. The authors suggest self-reported stressors may fail to produce strong associations due to denial of stress by individuals [23]. In a review by Nyklíček, et al., studies utilizing objective measures of stress found

associations with hypertension more consistently than those using subjective self-reports [24].

Nonetheless, psychological stress, by many definitions, has been shown to be associated with hypertension. A 2010 study of 12,166 individuals compared hypertensive individuals and non-hypertensive individuals. Individuals in the hypertensive population had increased anxiety, sleep disturbances, and reported lower psychological well-being [25]. Suggested mechanisms for stress-induced hypertension include repeated elevations of blood pressure by external stressors leading to long term hypertension [11].

Job stress, or job strain, refers to stressors derived exclusively from work. Defined aspects of job strain vary by study, but frequently include regular fatigue, lack of control in the workplace, high demand, and irritability [26-28]. In a case-control study of 215 men, job strain was concluded to elevate odds of hypertension [28]. Another important facet of job strain is amount of time worked. In a cohort study evaluating overtime work in males, individuals regularly working overtime, defined as 60 or more hours per month, had higher blood pressure than those working standard hours. Similarly, individuals working overtime had elevated blood pressure during working hours [29].

An interesting pattern exists in some studies of stress and hypertension. Multiple studies report inverse associations with stress and elevated blood pressure [30, 31]. In a study of city bus drivers, scores on a stressor index indicating a high level of stress were inversely associated with hypertension [30]. A Japanese study of 52,365 workers found increased

overtime work negatively associated with hypertension [31]. These authors suggest self-report measures and inventories may be an invalid measure of true stress or that employees in poor health may avoid working long hours.

METHODS

This study utilizes data from the National Health and Nutrition Examination Survey (NHANES) [32] to examine the impact of shift worked and stress on blood pressure. In this cross-sectional study, variables of interest were chosen based on previous literature. Proportions of demographic variables in the study population were calculated, while accounting for the complex survey nature of the NHANES data. A formal analysis was further performed, using logistic regression to assess the degree of association between risk factors of interest and hypertension while still accounting for NHANES survey weights.

NHANES

NHANES study population includes U.S. non-institutionalized civilians with oversampling of minority groups to obtain a representative sample of the U.S. population [33, 34]. In order to account for the complex survey design of NHANES, sampling weights were utilized in the analyses. Participants provide questionnaire data. Some individuals complete additional physical and laboratory assessments, including height, weight, and blood pressure measurements [35].

Cross-sectional data from NHANES 2005-2010 was used in this study. Data was limited to working individuals ages 20 and over, resulting in the total unweighted sample size of 9356 survey participants.

Hypertension

Blood pressure is measured during the medical examination portion of NHANES data collection. Either a physician or health technician may take blood pressure measurements using an approved sphygmomanometer. Individuals are asked to sit quietly with their feet flat on the floor for five minutes prior to collection. Three measurements are collected [35]. In this study, systolic and diastolic measurements were separately averaged to create two mean blood pressure scores for each participant. Additionally, participants report whether or not they are currently taking a prescribed medication for hypertension [36].

For the purposes of this study, hypertension is defined as having a mean diastolic blood pressure $\geq$ 90 mmHg, mean systolic blood pressure $\geq$ 140 mmHg, or currently taking a prescription medication for hypertension [3, 8, 31]. Individuals need only to meet one of the three criteria to be considered hypertensive in this study. Individuals not meeting these criteria were not considered to have hypertension.

Shift Worked and Stress Measurements

Individuals were asked during the questionnaire portion of NHANES data collection how would they describe the type of hours they work. Answer options included a regular daytime, evening, night shift, rotating shift, or another schedule [36]. For analyses in this

study, rotating shift and another schedule responses were combined into a rotating

category. Individuals refusing or responding "don't know" were excluded from analyses

(n=7,926).

Five items were chosen to represent stress or job strain based on previous literature, three

of which were based on the subjective self-reports of stress. The first subjective

measurement of stress was the number of days in the last 30 days the survey participant

felt their mental health, including stress, was not good. Similarly, the second subjective

measurement was participant's answer to the question: "During the past 30 days, for about

how many days have you felt worried, tense, or anxious?" These two items were

categorized for the purpose of descriptive tables (Tables 1-2), but were treated as

continuous variables in the logistic regression analysis. The third item was participants'

recall of how often in the last two weeks they had felt tired or had little energy. Participants

were able to respond with several days, half of the days, nearly every day, or not at all. The

answers were categorized into yes and no for the purposes of analyses [36].

Two objective measures were included in the analyses. Individuals reported number of

hours worked last week as ≤ 45 hours, 46-55 hours, or ≥ 56 hours. The measure remained

categorical in all analyses. Lastly, participants reported average hours of sleep on a

weekday or workday. This measure was reported in categories for proportions in Tables 1-

2, but was treated as a continuous variable in the regression analysis. Data was limited to

those reporting less than 13 hours per night of sleep [36].

Job Category

Reported job category was also recorded. This information was not included in the analyses due to large amounts of missing data and crude categorization, but was examined. The 22 occupation groups available in the NHANES data were condensed into the 10 following job categories: STEM, Production and Transport, Management and Business, Healthcare, Food and Sales, Farming and Grounds, Education, Construction, Arts and Social Sciences, and Administrative [36].

Known Predictors

Known predictors of hypertension were included in the study. These included age, smoking status, sex, race and ethnicity, body mass index (BMI), and education. Age was categorized as less than 50 years or older in descriptive analyses, but remained a continuous variable in later regression-based inference. Similarly, standard BMI categories (normal/underweight, overweight, obese) were utilized in descriptive analyses only. BMI calculations are based on height and weight measurements collected during NHANES study examinations [35]. Smoking status was defined as current smoker or non-smoker. Race and ethnicity was categorized as non-Hispanic white, non-Hispanic black, or Hispanic and other [36].

Statistical Analysis

R version 3.3.2 was used for all study analyses. To examine the distribution of job categories across different shifts, data was compiled into a stacked bar chart showing the proportion of shift types in each category using unweighted counts. Weighted proportions of study variables by shift worked were calculated for the study population. Due to notable

differences in smoking and non-smoking populations, descriptive statistics were stratified by smoking status and all statistical analyses were carried out separately. Smoking status information was not available for 12 individuals. These observations were excluded from analyses.

Regression adjusting for age was then conducted for each covariate by the outcome of interest—hypertension for each group, smokers and non-smokers. Finally, multivariate logistic regression was conducted. Two final models were selected, one for each smokers and non-smokers, using backward elimination.

RESULTS

Hypertension Prevalence

Consistent with previous literature, the prevalence of hypertension in the study population was 24.0%. The prevalence was 25.3% among non-smokers and 19.5% among smokers.

Descriptive Analysis

Descriptive statistics for all study participants were calculated. Characteristics for non-smokers can be seen in Table 1 and for smokers and in Table 2. Over half of respondents in the study population are male (53.9%). This is true of both the non-smoking (52.2%) and smoking (59.7%) groups. The study population is 68.3% non-Hispanic white. Comparing demographics in smoking and non-smoking populations, smokers have larger proportions of individuals with high school or less education (56.4%), compared to their non-smoking

counterparts (33.1%). The proportion of obese individuals in the smoking population is lower (27.2%) than in the non-smoking population (34.8%).

Fifty-seven percent of all participants report sleeping 7-8 hours per night, only 12.9% report sleeping 6 or fewer hours per night. Conversely, 38.1% of all night shift workers report sleeping less than 6 hours per night. This pattern is consistent across smoking statuses (Tables 1 and 2). Comparing stress between smoking statuses, 81.4% of non-smokers report low numbers (0-4/30 days) of poor mental health days, compared to 69.1% of smokers.

To visualize the job categories worked by shift a stacked bar chart was created as seen in Figure 1. Production and Transport, Food and Sales, and Healthcare categories have the greatest number of non-standard daytime shift workers in the chart.

Age Adjusted Odds Ratios: Non-Smokers

Analysis of covariates for non-smokers adjusted for age can be seen in Table 3. Age adjusted analysis for smokers may be seen in Tables 4.

Final Model Selection

Backward elimination at a p<0.05 significance level was performed to select the final two models for non-smokers (Table 5) and smokers (Table 6).

Final Model: Non-Smokers

The final model of hypertension in non-smokers includes shift worked, hours of sleep per night, age, sex, race/ethnicity, and BMI. The model indicates significantly decreased odds of hypertension for individuals working night shifts (OR=0.57, 95% CI=0.34, 0.95), adjusting for other covariates in the model. Similarly, individuals sleeping more hours per night (OR=0.92, 95% CI=0.87,0.98) have decreased odds of hypertension adjusting for other variables in the model. No other measurement of stress was included in either model. Known risk factors, non-Hispanic black race, male sex, and elevated BMI are associated with increased odds of hypertension in the model.

Final Model: Smokers

Shift worked, age, sex, BMI, and an interaction between shift and age are included as covariates in the final model of hypertension in smokers. Increased age (OR=1.08, 95% CI=1.07,1.10) and BMI (OR=1.08, 95% CI=1.05, 1.11) are significant risk factors for hypertension in the model. Sex is a known risk factor, but was not a significant predictor of hypertension in the model. A significant interaction exists between shift worked and age. Individuals working night shift have excess odds of hypertension with increasing age in the model (OR=1.05, 95% CI=1.02, 1.08).

DISCUSSION

The study goal was to elucidate important variables in the relationship between shift worked and hypertension. Specifically, the study was interested in expanding previous stress and shift work studies performed in niche occupational groups to a nationally

representative sample. Using NHANES data, the study was able to perform analyses on sample generalizable to the U.S. population.

Stratification controlled for potential confounding by smoking status. Non-day shift workers have larger proportions of smokers. Notably night shift workers have a 14.2% greater proportion of current smokers compared to all shifts combined. Smoking and hypertension are considered two of three key risk factors for heart disease[37]. Smokers are at an increased risk for hypertension. The study stratifies based on current smoking status, though former smokers may also be at an increased risk [38]. Additionally, smokers are more likely to heavily consume alcohol [39]. Alcohol risk was considered as a possible covariate in the study, but was not found to be significantly associated with hypertension in age-adjusted analyses.

Hours of sleep per night was the only measurement of stress significantly associated with hypertension in the study. Sleeping more hours per night gave significantly reduced odds of hypertension in non-smokers controlling for other covariates. Similarly, working night shift was protective in non-smokers only. These findings were not replicated in smokers, excess risk was associated with working night shift with increasing age. Other significant findings were largely established predictors of hypertension.

While the association between shift worked and hypertension remains unclear, shift worked has been established as a significant predictor of cardiovascular disease [15]. Workplace interventions targeting heart health, including risk factors for cardiovascular

disease, including hypertension, should be implemented. Focus may be on sectors employing large numbers of non-standard shift workers (Transportation and Production, Food and Sales, Healthcare). Additionally, interventions may focus on adequate sleep for individuals working non-standard daytime shifts.

Limitations

While the height, weight, and blood pressure measurements of participants were collected by health professionals, much of the information collected, including prescription medication use, relies on accurate self-reporting. Additionally, blood pressure measurements collected in a single session may not be as representative of an individual's hypertensive status as those collected over a longer period of time.

 Several previous studies have found inconsistencies in outcomes when using self-reported measures of stress[22-24]. This study was unable to find any significant associations between self-reported stress measures and hypertension, except hours of sleep per night. This may be due to issues with participant reporting or a true lack of association.

A larger than expected proportion of night shift workers reported sleeping very small amounts. The NHANES survey question states "How much sleep do you usually get at night on weekdays or workdays?" [36] It is possible that night shift workers answered the question literally, giving extremely low answers because much of their sleep occurs during daytime hours. This literal interpretation of this question may have impacted our results.

Other limitations include using 2005-2010 survey results instead of more recently

collected data. Questions required to determine shift worked were not asked in more

recent survey years.

Future Directions

The overall study goal of examining the role of stress in the relationship of shift worked

and hypertension in the U.S. population was achieved. Additionally, the identification of

sleep as a protective factor may be utilized in health interventions targeting blood

pressure.

Future studies may focus on factors alleviating the negative health outcomes of shift work.

Items of interest may include physical activity, social engagement, or similar. Additionally,

future work may aim to improve the validity of self-reported stress.

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Table 1. Weighted proportions (95% CI), of study population demographics for non-smokers by shift worked.

Shift (Unweighted Count)	Day (n=5516)	Evening (n=330)	Night (n=292)	Rotating/Other (n=1108)
Sex				
Female	48.3 (48.3, 48.3)	47.8 (47.7, 47.9)	40.7 (40.6, 40.8)	46.9 (46.9, 46.9)
Male	51.7 (51.7, 51.7)	52.2 (52.1, 52.3)	59.3 (59.2, 59.4)	53.1 (53.1, 53.1)
Age				
< 50	64.7 (64.7, 64.7)	73.1 (73.0, 73.2)	80.6 (80.5, 80.7)	66.2 (66.1, 66.3)
≥ 50 Years	35.3 (35.3, 35.3)	26.9 (26.8, 27.0)	19.4 (19.3, 19.5)	33.8 (33.7, 33.9)
Race/Ethnicity				
Non-Hispanic White	68.8 (68.7, 68.9)	64.7 (64.6, 64.8)	44.2 (44.1, 44.3)	68.6 (68.5, 68.7)
Non-Hispanic Black	9.4 (9.4, 9.4)	15.3 (15.2, 15.4)	24.9 (24.8, 25.0)	13.1 (13.1, 13.1)
Hispanic and Other	21.8 (21.8, 21.8)	20.0 (19.9, 20.1)	30.9 (30.8, 31.0)	18.2 (18.2, 18.2)
Body Mass Index				
Normal/Underweight	29.5 (29.5, 29.5)	31.3 (31.2, 31.4)	22.2 (22.1, 22.3)	30.1 (30.1, 30.1)
Overweight	36.5 (36.5, 36.5)	29.3 (29.2, 29.4)	39.9 (39.8, 40.0)	32.5 (32.4, 32.6)
Obese	34.0 (34.0, 34.0)	39.4 (39.3, 39.5)	37.9 (37.8, 38.0)	37.3 (37.2, 37.4)
Highest Education				
Less than High School	12.0 (12.0, 12.0)	14.9 (14.8, 15.0)	16.7 (16.7, 16.7)	14.2 (14.2, 14.2)
High School Graduate	20.6 (20.6, 20.6)	25.3 (25.2, 25.4)	28.7 (26.6, 28. 8)	16.9 (16.9, 16.9)
Some College/AA Degree	28.8 (28.8, 28.8)	43.0 (42.9, 43.1)	40.4 (40.3, 40.5)	37.3 (37.3, 37.3)
College Graduate or Above	38.6 (38.6, 38.6)	16.8 (16.7, 16.9)	14.2 (14.1, 14.3)	31.6 (31.6, 31.6)
Days/month stressed				
0-4	82.1 (82.1, 82.1)	82.4 (82.3, 82.5)	79.1 (79.0, 79.2)	77.8 (77.8, 77.8)
5-10	7.3 (7.3, 7.3)	9.6 (9.5, 9.7)	9.8 (9.7, 9.9)	8.4 (8.4, 8.4)
>10	10.7 (10.7, 10.7)	8.0 (8.0, 8.0)	11.1 (11.0, 11.2)	13.8 (13.8, 13.8)
Days/month anxious				
0-4	71.2 (71.2, 71.2)	78.4 (78.3, 78.5)	76.7 (76.6, 76.8)	66.8 (66.7, 66.9)
5-10	10.3 (10.3, 10.3)	7.0 (6.9, 7.1)	8.4 (8.3, 8.5)	13.4 (13.4, 13.4)
>10	18.5 (18.5, 18.5)	14.6 (14.5, 14.7)	14.9 (14.8, 15.0)	19.8 (19.7, 19.9)
Low energy last two weeks				
No	53.6 (53.6, 53.6)	51.2 (51.1, 51.3)	49.6 (49.5, 49.7)	49.6 (49.5, 49.7)
Yes	46.4 (46.4, 46.4)	48.8 (48.7, 48.9)	50.4 (50.3, 50.4)	50.4 (50.3, 50.5)

Table 1 cont.

Hours worked last week				
<46 hours	71.6 (71.6, 71.6)	73.9 (73.8, 74.0)	71.6 (71.5, 71.7)	59.6 (59.5, 59.7)
46-55 hours	18.2 (18.2, 18.2)	15.4 (15.4, 15.4)	11.6 (11.6, 11.6)	15.0 (15.0, 15.0)
>55 hours	10.2 (10.2, 10.2)	10.7 (10.6, 10.8)	16.7 (16.6, 16.8)	25.2 (25.1, 25.3)
Hours Sleep/Night				
<6	9.9 (9.9, 9.9)	11.2 (11.2, 11.2)	36.6 (36.5, 36.7)	15.7 (15.7, 15.7)
6	25.2 (25.2, 25.2)	32.6 (32.5, 32.7)	21.2 (21.1, 21.3)	23.8 (23.8, 23.8)
7-8	61.7 (61.7, 61.7)	51.8 (51.7, 51.9)	37.0 (36.9, 37.1)	54.6 (54.5, 54.7)
≥9	3.2 (3.2, 3.2)	4.3 (4.3, 4.3)	5.1 (5.1, 5.1)	5.9 (5.9, 5.9)

Table 2. Weighted proportions (95% CI), of study population demographics for smokers by shift worked.

Shift (Unweighted Count)	Day (n=1489)	Evening (n=141)	Night (n=126)	Rotating/Other (n=348)
Sex				
Female	37.9 (37.9, 37.9)	44.0 (43.9, 44.1)	42.0 (41.9, 42.1)	49.2 (49.1, 49.3)
Male	62.1 (62.1, 62.1)	56.0 (55.9, 56.1)	58.0 (57.9, 58.1)	50.8 (50.7, 50.9)
Age				
< 50	76.2 (76.2, 76.2)	76.5 (76.4, 76.6)	84.0 (83.9, 84.1)	79.6 (79.5, 79.7)
≥ 50 Years	23.8 (23.8, 23.8)	23.5 (23.4, 23.6)	16.0 (15.9, 16.1)	20.4 (20.3, 20.5)
Race/Ethnicity				
Non-Hispanic White	71.3 (71.2, 71.4)	64.3 (64.2, 64.4)	74.9 (74.8, 75.0)	66.5 (66.4, 66.6)
Non-Hispanic Black	8.9 (8.9, 8.9)	17.0 (16.9, 17.1)	12.2 (12.1, 12.3)	16.1 (16.0, 16.2)
Hispanic and Other	19.8 (19.7, 19.9)	18.7 (18.6, 18.8)	12.9 (12.8, 13.0)	17.4 (17.3, 17.5)
Body Mass Index				
Normal/Underweight	38.1 (38.0, 38.2)	39.7 (39.6, 39.8)	39.6 (39.5, 39.7)	41.7 (41.6, 41.8)
Overweight	34.1 (34.0, 34.2)	37.1 (37.0, 37.2)	34.1 (34.0, 34.2)	31.6 (31.5, 31.7)
Obese	27.8 (27.8, 27.8)	23.2 (23.1, 23.3)	26.3 (26.2, 26.4)	26.8 (26.7, 26.9)
Highest Education				
Less than High School	25.7 (25.6, 25.8)	29.5 (29.4, 29.6)	25.4 (25.3, 25.5)	22.3 (22.2, 22.4)
High School Graduate	28.7 (28.7, 28.7)	35.7 (35.6, 35.8)	45.8 (45.6, 46.0)	33.4 (33.3, 33.5)
Some College/AA Degree	29.1 (29.1, 29.1)	29.5 (29.4, 29.6)	22.4 (22.3, 22.5)	36.5 (36.4, 36.6)
College Graduate or Above	16.2 (16.2, 16.2)	5.3 (5.2, 5.4)	6.4 (6.3, 6.5)	7.7 (7.7, 7.7)
Days/month stressed				
0-4	71.4 (71.4, 71.4)	72.6 (72.5, 72.7)	59.4 (59.2, 59.6)	61.0 (60.9, 61.1)
5-10	12.0 (12.0, 12.0)	5.7 (5.7, 5.7)	7.2 (7.1, 7.3)	13.6 (13.5, 13.7)
>10	16.7 (16.7, 16.7)	21.6 (21.5, 21.7)	33.4 (33.2, 33.6)	25.4 (25.3, 25.5)
Days/month anxious				
0-4	65.7 (65.7, 65.7)	70.5 (70.4, 70.6)	61.2 (61.0, 61.4)	57.9 (57.8, 58.0)
5-10	10.8 (10.8, 10.8)	3.0 (3.0, 3.0)	8.2 (8.1, 8.3)	10.5 (10.5, 10.5)
>10	23.5 (23.5, 23.5)	26.5 (26.4, 26.6)	30.5 (30.3, 30.7)	31.6 (31.5, 31.7)
Low energy last two weeks				
No	44.4 (44.3, 44.5)	54.7 (54.6, 54.8)	42.2 (42.1, 42.3)	47.2 (47.1, 47.3)
Yes	55.6 (55.5, 55.7)	45.3 (45.2, 45.4)	57.8 (57.7, 57.9)	52.8 (52.7, 52.9)

Table 2 cont.

Hours worked last week				
<46 hours	69.0 (69.0, 69.0)	75.5 (75.4, 75.6)	69.4 (69.3, 69.5)	66.4 (66.3, 66.5)
46-55 hours	19.6 (19.6, 19.6)	7.6 (7.5, 7.7)	15.0 (14.9, 15.1)	10.0 (10.0, 10.0)
>55 hours	11.4 (11.4, 11.4)	16.9 (16.8, 17.0)	15.7 (15.6, 15.8)	23.6 (23.5, 23.7)
Hours Sleep/Night				
<6	15.7 (15.7, 15.7)	17.9 (17.8, 18.0)	40.8 (40.7, 40.9)	17.3 (17.2, 17.4)
6	25.9 (25.9, 25.9)	25.5 (25.4, 25.6)	26.4 (26.3, 26.5)	30.5 (30.4, 30.6)
7-8	53.9 (53.9, 53.9)	44.2 (44.1, 44.3)	26.8 (26.7, 26.9)	44.9 (44.8, 45.0)
≥9	4.4 (4.4, 4.4)	12.4 (12.3, 12.5)	6.0 (5.9, 6.1)	7.3 (7.2, 7.4)

Table 3. Logistic regression of hypertension and population demographics of non-smokers adjusted for age (OR 1.01, 95% CI=1.01,1.01).

	OR	95% CI	p-value
Sex			
Female	---	---	---
Male	1.04	(1.00, 1.07)	<0.05
Race/Ethnicity			
Non-Hispanic White	---	---	---
Non-Hispanic Black	1.11	(1.07, 1.16)	2.76e-05
Hispanic and Other	0.97	(0.95, 0.99)	0.02
Body Mass Index			
BMI (kg/m^2)	1.02	(1.01, 1.02)	6.55e-14
Highest Education			
Less than High School	---	---	---
High School Graduate	1.00	(0.96, 1.06)	0.86
Some College/AA Degree	1.01	(0.96, 1.07)	0.62
College Graduate or Above	0.94	(0.90, 0.98)	0.009
Days/month stressed			
Reported Days	1.00	(1.00, 1.00)	0.70
Days/month anxious			
Reported Days	1.00	(1.00, 1.00)	0.49
Low energy last two weeks			
No	---	---	---
Yes	1.03	(1.00, 1.06)	0.05
Hours worked last week			
<46 hours	---	---	---
46-55 hours	1.02	(0.98, 1.07)	0.28
>55 hours	1.02	(0.98, 1.07)	0.30
Hours Sleep/Night			
Hours/Night	0.98	(0.97, 0.99)	1.46e-05

Table 4. Logistic regression of hypertension and population demographics of smokers adjusted for age (OR 1.01, 95% CI=1.01, 1.01).

	OR	95% CI	p-value
Sex			
Female	---	---	---
Male	1.00	(0.95, 1.06)	0.90
Race/Ethnicity			
Non-Hispanic White	---	---	---
Non-Hispanic Black	1.07	(1.00, 1.13)	0.04
Hispanic and Other	0.98	(0.94, 1.02)	0.38
Body Mass Index			
BMI (kg/m^2)	1.01	(1.01, 1.02)	2.92e-05
Highest Education Attained			
Less than High School	---	---	---
High School Graduate	1.02	(0.98, 1.07)	0.37
Some College/AA Degree	0.96	(0.90, 1.02)	0.21
College Graduate or Above	0.96	(0.90, 1.03)	0.23
Days/month stressed			
Reported Days	1.00	(1.00, 1.00)	0.66
Days/month anxious			
Reported Days	1.00	(1.00, 1.00)	0.84
Low energy last two weeks			
No	---	---	---
Yes	1.00	(0.95, 1.06)	0.99
Hours worked last week			
<46 hours	---	---	---
46-55 hours	1.02	(0.93, 1.13)	0.64
>55 hours	0.97	(0.91, 1.04)	0.46
Hours Sleep/Night			
Hours/Night	0.99	(0.98, 1.01)	0.38

Table 5. Final model of hypertension for non-smokers.

	Adjusted OR	95% CI	p-value
Shift Worked			
Day	---	---	---
Evening	0.70	(0.41, 1.19)	0.20
Night	0.57	(0.34, 0.95)	0.04
Rotating	1.20	(0.83, 1.74)	0.35
Hours Sleep/Night			
Hours/Night	0.92	(0.87, 0.98)	0.001
Age			
Age (years)	1.10	(1.09, 1.10)	< 2e-16
Sex			
Female	---	---	---
Male	1.33	(1.07, 1.64)	0.02
Race/Ethnicity			
Non-Hispanic White	---	---	---
Non-Hispanic Black	1.61	(1.24, 2.08)	0.001
Hispanic and Other	0.87	(0.73, 1.03)	0.12
Body Mass Index			
BMI (kg/m^2)	1.11	(1.09, 1.12)	5.80e-12

Table 6. Final model of hypertension for smokers.

	Adjusted OR	95% CI	p-value
Shift Worked			
Day	---	---	---
Evening	2.00	(0.78, 5.14)	0.16
Night	1.54	(0.99, 2.40)	0.07
Rotating	0.91	(0.57, 1.44)	0.68
Age			
Age (years)	1.08	(1.07, 1.10)	3.94e-09
Sex			
Female	---	---	---
Male	0.96	(0.63, 1.46)	0.84
Body Mass Index			
BMI (kg/m^2)	1.08	(1.05, 1.11)	3.75e-05
Interaction Shift:Age			
Day:Age	---	---	---
Evening:Age	1.05	(0.99, 1.12)	0.11
Night:Age	1.05	(1.02, 1.08)	0.005
Rotating:Age	1.00	(0.95, 1.05)	0.97

Figure 1. Frequency of job category and shift worked in study population.