Title
Work Stress and Blood Pressure among Hotel Room Cleaners: Modeling Impact and Information Bias

Author
Feaster, Matthew Mark

Publication Date
2019

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA

Los Angeles

Work Stress and Blood Pressure among Hotel Room Cleaners: Modeling Impact and Information Bias

A dissertation submitted in partial satisfaction of the

requirements for the degree of Doctor of Philosophy

in Epidemiology

by

Matthew Mark Feaster

2019

ABSTRACT OF THE DISSERTATION

Work Stress and Blood Pressure among Hotel Room Cleaners:

Modeling Impact and Information Bias

by

Matthew Mark Feaster

Doctor of Philosophy in Epidemiology

University of California, Los Angeles, 2019

Professor Onyebuchi Arah, Co-Chair

Professor Niklas Krause, Co-Chair

High blood pressure is one of the most ubiquitous medical conditions in the world, and is a major risk factor for cardiovascular morbidity and mortality worldwide. While several risk factors have been described for high blood pressure, work stress particularly among working females, is still being investigated. This dissertation (1) examined the role of work stress for elevated ambulatory blood pressure (ABP) levels among female hotel room cleaners, (2) investigated potential modifying factors of work stress like social support and medication use, and (3) estimated potential bias introduced when using different methods of blood pressure measurement.

The first study investigated the associations between job strain and ABP and pulse pressure (PP) among female hotel room cleaners by time of day, and the modifying effects of social support at home and at work. We found that higher job strain was associated with increased systolic 18-hr ABP, after work hours systolic ABP, and ambulatory PP. Dependents at home but

not social support at work attenuated effects. We also found that among workers with hypertension, anti-hypertensive medication may have mitigated ABP effects of job strain during work hours.

The second study investigated the associations between effort-reward imbalance (ERI) and ABP and PP among female hotel room cleaners by time of day, and the modifying effects of age and the number of dependents at home. We found that ERI was positively associated with ABP, particularly systolic ABP, and the association was modified by age and the number of dependents at home, although the estimates were imprecise.

The third study was designed to suggest an approximation of the effects of job stress, including job strain and ERI, on ABP using measurements of resting blood pressure (RBP) for use in studies of the impact of work stress on blood pressure. We found that estimates using RBP underestimated associations between work stress and systolic blood pressure when compared with ABP, but were less consistent when evaluating associations with diastolic blood pressure.

The findings from this dissertation help strengthen the conclusion that work stress increases blood pressure, particularly systolic blood pressure, in this understudied population of mostly immigrant, female workers. It also suggests that job stress studies using RBP underestimate the risk of elevated ABP levels.

The dissertation of Matthew Mark Feaster is approved.

Michael L. Prelip

Beate R. Ritz

Onyebuchi A. Arah, Committee Co-Chair

Niklas Krause, Committee Co-Chair

University of California, Los Angeles

2019

DEDICATION

To my husband and family for your loving guidance and support.

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LIST OF ABBREVIATIONS

ABP ……………………………………………..……………..……Ambulatory Blood Pressure
BMI …………………………………………..……………………….…… Body Mass Index
BP …………………………..……………………………….……………..…. Blood Pressure
CDC ………………………………………………Centers for Disease Control and Prevention
CHD ……………………………...…………………………………...Coronary Heart Disease
CVD …………………………...………………………………………Cardiovascular Disease
DB……………..……………………………………...……………... Diastolic Blood Pressure
ERI …………………………………………………………………...Effort-Reward Imbalance
HTN ……………………………………………………………….………………… Hypertension
IHD ………………………………..………………………….……… Ischemic Heart Disease
JCQ …………………………..…………………………………...…Job Content Questionnaire
JDC ……………………………..…..…………………………………… Job Demand-Control
JDCS ……………………..……………………………………….….Job Demand-Control-Social Support
No. ……………………………..……………………………………………………………..Number
NIOSH ……………..……………..………National Institute for Occupational Safety and Health
RBP …………………………..……………...……………………..Resting Blood Pressure
SBP …………………………...…………………………………………Systolic Blood Pressure
U.S. …………………..………..……………………………………………………… United States
PP ………………...…………………………………………………………………..Pulse Pressure

ACKNOWLEDGMENTS

To my esteemed committee members: Drs. Onyebuchi Arah, Niklas Krause, Beate Ritz, and Michael Prelip for their infinite wisdom and unparalleled patience. Special gratitude for my committee chairs, Dr. Arah and Dr. Krause for their guidance and input without which these papers would not have been possible. To Dr. Arah, your knowledge and research will inspire a generation of epidemiologists to be better researchers and methodologists, and I count myself lucky to have been in your tutelage. To Dr. Krause, your dedication to occupational research and the students in the ERC will no doubt leave countless workers safer and healthier. It has been a pleasure participating in the Southern California ERC, and learning from all of the professors and students in the EHS230 series. To Dr. Ritz, a true master in teaching confounding and bias even to the novitiates of "Greenland". You taught me to critically evaluate every study and it has made me a better epidemiologist. To Dr. Prelip, for your thoughtful insights and encouragement even though it was a long journey. I am extremely grateful. Each of my committee members has been so supportive and thought-provoking. I thank you all.

Next, I would like to thank the people and workers who made the data used in this dissertation possible. The original study was funded by the Culinary Workers Union Local 226, Las Vegas; grant number: 49825; UNITE HERE International Union, New York, and the Northern California Center for Occupational and Environmental Health, University of California at Berkeley. To the hotel room cleaners who participated and the researchers who collected the data, thank you so much.

I would also like to acknowledge the financial support provided by the Collaborative Research Training Program of the Southern California NIOSH Education and Research Center (ERC), Grant Agreement Number T42 OH0084 from the Centers for Disease Control and Prevention (CDC). As part of this funding opportunity, I was fortunate to have participated in a wonderful collaborative of occupational nurses, industrial hygienists, occupational medicine residents, and other occupational researchers from UCLA and UC Irvine. I would like to thank the years of students, professors, and administration staff who participated in this interdisciplinary program, especially faculty including Dr. Robbins, Dr. Thomas, Dr. Krause, and Dr. Que Hee and admin staff including Dr. Arias, Brenda Diaz and Ani Adzhemyan. The discussions, clinical case work-shops, site visits, and other developmental trainings were invaluable.

Last, I would like to thank my family and friends who have supported me through this process. I want to thank my husband, Anthony Silva, for being a constant font of love and support. I could never have finished without you. To my family, immediate and adopted. First, to my parents, Mark and Mary, for setting a high bar academically, but never making me feel like I could fail. My siblings, for your humor even when I was studying on vacations. To the Silva's, my new LA family, for your love and support while I was in school. Finally, to my public health friends without whom I would never have made it through "23rd grade" specifically Pauline Poysophon, Patricia Cummings, and Drew Westmoreland.

BIOGRAPHICAL SKETCH

2007 B.S., Bioengineering: Pre-Medical

University of California, San Diego

San Diego, California

2009 M.P.H., Epidemiology and Biostatistics

University of Southern California

Los Angeles, California

2019 Ph.D. Candidate, Epidemiology

University of California, Los Angeles

Los Angeles, California

SELECT AWARDS

2013 - 2019 Targeted Research Training Program of the Southern California NIOSH Education and Research Center. Grant Agreement Number T42 OH0084 from the Centers for Disease Control and Prevention National Institute of Occupational Safety and Health.

SELECT PUBLICATIONS

Feaster M, Krause N. Job strain associated with increases in ambulatory blood and pulse pressure during and after work hours among female hotel room cleaners. *Am J Ind Med*. 2018;61(6):492-503. doi:10.1002/ajim.22837.

Feaster M, Arah OA, Krause N. Effort-reward imbalance and ambulatory blood pressure among female Las Vegas hotel room cleaners. *Am J Ind Med*. 2019:ajim.22980. doi:10.1002/ajim.22980.

Rajabiun S, Tryon J, **Feaster M**, Pan A, McKeithan L, Fortu K, Cabral H, Borne D, and Altice FL. "The Influence of Housing Status on the HIV Continuum of Care: Results from a Multisite Study of Patient Navigation Models to Build a Medical Home for People Living with HIV Experiencing Homelessness", American Journal of Public Health 108, no. S7 (December 1, 2018): pp. S539-S545.

CHAPTER 1: INTRODUCTION

1.1 Work Stress in the United States

An average person living in the United States (U.S.) is working more than they are sleeping or doing any other activity any giving workday[1] so it is no surprise that one fourth of the employees in the U.S. see their jobs as their number one stressor in their life[2]. According to the National Institute for Occupational Safety and Health (NIOSH), work stress can be defined as the harmful emotional and physical responses that occur when the requirements of the job do not match the resources, capabilities or needs of the worker[2]. This imbalance between expectations and ability fosters an environment where the insidious effects of work stress can cause damage to the body. Work stress has been linked to acute effects like sleep disturbances, bodily pain, work injuries, and to chronic conditions such as cardiovascular, musculoskeletal, and psychological disorders including depression and suicide among other conditions[2].

One especially large labor-intensive sector of work is among maids and housekeepers. More than 900 thousand workers in the U.S. are employed as maids or housekeeping cleaners, with almost a half million working in traveler accommodation sites including hotels/motels and casino hotels[3]. In the few studies that have looked at job stress in hotel industry workers, stress levels were focused on the inflexibility of schedules or the level of job control among managers and hourly workers[4,5]. In previous papers published on this particular population of female hotel room cleaners from Las Vegas, authors have linked work stress to work-related pain[6], shoulder and neck injury[7,8], general health[9] and work-related health disparities[10]. The effects of work-related stress on blood pressure had yet not been investigated.

1.2 Trends in Elevated Blood Pressure

High blood pressure is one of the most ubiquitous chronic health conditions in the world. It is estimated that one in three adults in the U.S., or about 75 million Americans, and over one billion people worldwide have the condition[11,12]. Of those 75 million Americans, around 35 million are living with uncontrolled hypertension with almost 33% not aware they have hypertension, and almost 50% may be aware they have hypertension but the prescribed treatment (medication or lifestyle change) is not sufficient to control their elevated blood pressure[12]. Uncontrolled hypertension costs the U.S. around $49 billion annually[12], is a major risk factor for cardiovascular disease, stroke, heart and kidney disease, and accounts for almost 13% of all deaths worldwide[11,13–15]. If these trends continue,, by 2030, it is estimated that just under 41% of the U.S. population is projected to have some form of cardiovascular disease (CVD), costing $276 billion in the United States alone[14]. Hypertension generally affects more men than women, but still almost one in three women will have high blood pressure in their lifetime[14]. Understanding the people who are most affected and why, can help attenuate the increasing levels of morbidity and cost due to elevated blood pressure in the U.S.

Known risk factors for hypertension include a wide range of variables such as age, gender, race, socioeconomic status (SES), family history, obesity, tobacco, and diet[16], but the role of occupational risk factors, in particular psychosocial stress, in vulnerable worker groups in the United States is still under-researched. For example, the association between work stress and elevated of blood pressure has been documented in the literature[17–22], however, a recent systematic review reported consistent risks of elevated blood pressure (or hypertension) only for men, while the results were less consistent in women[20]. This dissertation intends to evaluate the association of work stress and blood pressure among women working as hotel room cleaners.

1.3 Research Gaps in Work Stress Literature

A recent systematic review on the association between measures of work stress and blood pressure reported an increase in risk of elevated blood pressure for men, but the results were not as consistent for women[20]. One of the cited reasons for the inconsistent findings among females includes the limited numbers of female subjects[20]. Specifically, the authors of the cited meta-analysis reported that among eleven cross-sectional studies on work stress and blood pressure, only six studies reported gender-specific results, and only one among those reported a significant positive association of work stress and BP for women[20]. Another systematic review of 26 prospective cohort studies from 2006 found consistent positive associations between job stress and CVD risk in male or male-dominated samples, but only for one of the three female samples[23]. The dozens of papers referenced in these reviews document inconsistent associations in the female working population, and establish a case for more research with female participants.

Another oft-cited reason for this inconsistency is the use of resting/casual blood pressure instead of ambulatory blood pressure measurements[20,24,25]. Casual, or resting blood pressure, is generally defined as a measurement recorded at a single timepoint in a day, usually in a doctor's office or by another trained health professional. Ambulatory blood pressure is defined as regular, repeated BP measures throughout a day that are then averaged over certain time periods such as 24 hours, day- or night-time, work- or leisure time, etc.[26,27]. In assessing the effects of work stress on blood pressure, studies have described the "often…poor estimate of risk in an individual"[27] that casual, resting blood pressure can provide due to the natural variability of blood pressure and its sensitivity to acute stimuli like being in the presence of a physician[20,28] or hormonal changes in menopausal women[29]. Because ambulatory blood pressure averages BP over the course of the day, the averages account for the natural variability of blood pressure and better represent the more risk-relevant sustained blood pressure[27,30]. Previous investigators of the role of work stress on blood pressure have commented on the discrepancies between RBP and ABP suggesting that RBP did not accurately capture the increases in blood pressure throughout the day, possible even due to levels of stress itself[28]. Meaning, the use of resting blood pressure in such studies can introduce information bias that could be attenuated by using ambulatory measurements. This dissertation assessed important psychosocial job factors and how different blood pressure measurement methods influenced the estimates of effects work stress has on blood pressure in a female working population of hotel room cleaners.

1.4 Specific Aim

The goal of this dissertation was to evaluate the associations of work stress with blood pressure among female hotel room cleaners from five hotels in Las Vegas, Nevada, and to describe any systematic differences between ambulatory and resting blood pressure values in these work stress studies. Specifically, the aims of this dissertation were:

1) To examine the role of work stress, conceptualized as job strain, on ambulatory blood pressure (ABP) among female hotel room cleaners, and the modifying effects of social support, home life, and anti-hypertension medication.

(2) To investigate the role of work stress, conceptualized as effort-reward imbalance (ERI), and of modifying factors like age in this population.

(3) To develop a measurement error correction model that predicts ambulatory blood pressure (ABP) using resting blood pressure (RBP) and other covariates and to develop a calibration model that can be used in studies of the impact of work stress on blood pressure.

CHAPTER 2: JOB STRAIN ASSOCIATED WITH INCREASES IN AMBULATORY BLOOD AND PULSE PRESSURE DURING AND AFTER WORK HOURS AMONG FEMALE HOTEL ROOM CLEANERS

2.1 Abstract

Background: Previously documented elevated hypertension rates among Las Vegas hotel room cleaners are hypothesized to be associated with job strain.

Methods: Job strain was assessed by questionnaire. Ambulatory blood pressure (ABP) was recorded among 419 female cleaners from five hotels during 18 waking hours. Multiple linear regression models assessed associations of job strain with ABP and pulse pressure for 18-hour, work hours, and after work hours.

Results: Higher job strain was associated with increased 18-hr systolic ABP, after work hours systolic ABP, and ambulatory pulse pressure. Dependents at home but not social support at work attenuated effects. Among hypertensive workers, job strain effects were partially buffered by anti-hypertensive medication.

Conclusions: High job strain is positively associated with blood pressure among female hotel workers suggesting potential for primary prevention at work. Work organizational changes, stress management, and active ABP surveillance and hypertension management should be considered for integrated intervention programs.

2.2 Introduction

Hypertension is one of the most ubiquitous medical conditions in the United States with 1 in 3 adults or about 70 million Americans having the condition[11]. High blood pressure and hypertension are major risk factors for cardiovascular diseases such as stroke and coronary heart disease and also chronic kidney disease[11,13,14]. Over 40% of the U.S. population is projected to have some form of cardiovascular disease by 2030 with total costs exceeding one trillion dollars[14].

While hypertension is more common among men, almost 1 in 3 women will develop the condition[14].

Despite the many studies on work-related risk factors and hypertension among men, studies of women are still accruing. Previous studies have evaluated the effects of job strain on blood pressure and other cardiovascular diseases in other populations,[28,31–35] but few among low wage and mostly immigrant manual workers such as hotel room cleaners. In one such study of hypertension in Haitian immigrant hotel room cleaners, the authors reported that individual and organization level factors such as work hours, workload and social support aided in hypertension management among the cleaners[36]. We intended to look at similar factors that may attenuate the association between job strain and ambulatory blood pressure (ABP) in this paper. In this study population of Las Vegas female hotel room cleaners, previous research has linked work-stress to work-related pain[6], shoulder and neck injury[7], and general health[10], but the effects of work-related stress on blood pressure have not been investigated.

The prevalence of hypertension in this study population of predominantly female, Mexican American, immigrant workers exceeds prevalence rates in their country of origin[37]. Moreover, control of hypertension in this population was found to be about 50% lower than in the general U.S. working population[37]. This indicates that these workers are at increased risk for disabling chronic CVD and premature mortality[37].

To assess why this particular population has such high rates of hypertension, we evaluated potential risk factors for these women. Several risk factors for hypertension like age, gender, socio-economic status (social class), and racial/ethnic disparities have been well-described[13,14], but the specific psychosocial risk factors like work stress that may be responsible for these disparities have only recently been acknowledged by cardiologists[38].

To investigate the association between work stress and blood pressure, we used the most widely applied instruments for measuring psychological work stress factors: standard questionnaires based on the job demand-control (JDC), JDC-social support (JDCS), and the effort-reward-imbalance (ERI) models. The JDC and JDCS models focus on the perceived psychological demands of work in relationship to the amount of control or decision-making latitude the worker has over how to perform job tasks[39]. An imbalance between job demands and the amount of control on the job is hypothesized to cause job strain, or stress, and downstream health risks. The JDC model was later expanded to the JDCS to incorporate social support as a potential buffer to the effect job strain. The combination of high job strain with low social support at work is termed high isostrain, other combinations are referred to as low isotrain[40]. This article will evaluate the effects of job strain and iso-strain; the effects of ERI will be presented elsewhere.

Although job strain is typically positively associated with hypertension[21,28,34,41], some studies report inconclusive results[42–46]. Researchers suggested that the use of resting casual BP instead of ABP may be responsible for inconsistent results, and they also noted the limited number of studies with female subjects[20,24,25]. This study will address this research gap by assessing the association between job strain and ABP in a female working population of mostly immigrant Hispanic hotel room cleaners.

2.3 Methods

Recruitment of Subjects and Administration of Survey Questionnaires

Five unionized Las Vegas hotels were selected for inclusion in the study, representing five different hotel types: upscale, mid-level, convention, all-suite, and older economy. The eligibility, recruitment, and training of the subjects have been described previously[7,9,37]. In short, participation was voluntary and incentives were not offered. Of the eligible 1,276 eligible room cleaners, 941 participated and completed the main 29-page survey containing questions on demographics, self-reported health, health behaviors, physical workload, ergonomic problems, and work-related psychological stressors. The survey was developed using a participatory research approach[47], and was provided in English, Spanish and Serbo-Croatian. Limited resources did not allow for a formal back translation for the Serbo-Croatian survey, but trained administrators who spoke Spanish, Serbo-Croatian, or one or more Asian languages served as translators for illiterate participants. The administrators were local college students trained by the study researchers. Finally, participants met with researchers outside of work where they were informed of the study goals, risks and benefits, and where they completed the written survey.

All workers who completed the questionnaire were also invited to participate in the ABP component of the study. Resources, including staff time and available blood pressure measurement instruments, limited participation in this ABP component to the first 589 participating hotel workers. They received a two-hour training that included a description of the study, informed consent and hands-on training on how to measure and record ABP readings during and after work hours. During the training, study staff also repeatedly measured resting blood pressure and pulse rate and administered a short 2-page questionnaire on demographics, history of hypertension diagnosis and treatment, and current workload. 442 participants completed both the 29-page main questionnaire and the ABP component of the study. Of those, 419 participants answered the questions regarding job strain and social support and constitute the study sample. The study was approved by Institutional Review Boards of the University of California at Berkeley and San Francisco.

Ambulatory Blood Pressure Measurements

ABP and pulse rate were measured with the Omron HEM-630 device attached to the wrist during measurements. Measurements were time-stamped and automatically stored by the device. Study subjects were trained in self-measurement of ABP and how to record ABP and pulse rate directly after activity-related time points that spanned over a total of 18 hours before and after sleep. Upon completion of a pre-described activity, workers were instructed to initiate recording of their blood pressure in a seated position, and to record those measurements on a provided diary card. This diary contained activity pictograms that were matched to the activity they had just performed. The 21 time points listed in the diary included: the beginning and end of their work shift; lunch and other work breaks; specific work-activities like dusting, vacuuming, making beds and pushing/pulling carts; activities after work hours, in the evening and a last measurement before going to bed. When participants returned their OMRON devices, researchers compared the electronically stored blood pressure measurements with the corresponding written entries in the diary form and corrected any transcription errors. Ambulatory systolic and diastolic blood pressure averages were computed for three time periods: 1) the total 18-hour day-time period (as an average of all recordings); 2) time at work from beginning to end of the work shift (on average 8.11 working hours) that included all day-time work-related activities but excluded activities done at home; and 3) after-work hours that included measurements done right after work, after dinner and right before going to bed. 414 out of the 419 participants (98.8%) had at least four ABP measurements during work hours. 395 out of the 419 (94%) had at least one ABP measurement after work hours. Participants did not take blood pressure measurements during sleep because the device required manual initiation of any recording. Pulse pressure was calculated as the individual difference of systolic and diastolic ABP measurements and averaged for each time period.

Job Strain and Iso-strain Assessment

Job strain and iso-strain were assessed by questions on psychological demands (five items), decision latitude (nine items), coworker support (four items), and supervisor support (three items) from Karasek's Job Content Questionnaire[7,39]. Total support was the sum of coworker and supervisor support scales. An additional modifier was applied to supervisor support to equally weight supervisor and coworker support scales. Single, mean value imputation was used for any missing subscale items provided the respondent answered at least 50% of the subscale items. Only 6-15% of the job strain and iso-strain observations were affected by the replacement strategy. Continuous measures of job strain and iso-strain were created following published methods[25]. Job strain ratios were calculated as the psychological demands score divided by the decision latitude score. Iso-strain ratios were calculated as the psychological demands score divided by the sum of the decision latitude and total support scores. The Cronbachs' alpha for the job strain scale was 0.51, slightly lower than the reported reliability of 0.61[39,48]. The Cronbach's alpha was 0.65 for the decision latitude subscale compared to a range of 0.66 to 0.72 in the literature[7,48].

Assessment of Covariates

Sociodemographic factors including age, race/ethnicity, gender, years of education, and place of birth (U.S.- versus foreign-born), and number of dependents at home were assessed by questionnaire. Anthropometric variables (body height and weight) were assessed during survey administration using portable scales. Past and current physical workloads were measured by six variables: number of years worked as a hotel room cleaner, number of hours worked per week, number of beds made per day, a 26-item physical workload index, a 26-item work intensification index, and an 11-item ergonomic index described in more detail previously[49].

Analysis

The distribution of all variables in terms of frequency, range, mean or percentage was described by hypertension status. Mean value replacement of missing values was used for continuous covariates. Measures of stress, including job strain and iso-strain and their respective subscales were re-centered and rescaled to a unit range from zero to two for comparison purposes so that a one-unit change represents half the range for each variable. Linear regression analyses were performed using these continuous measures in age-adjusted models and in fully adjusted models including age plus socio-demographic, anthropometric, behavioral factors and measures of physical workload and ergonomic problems listed in Table 2.1. The hotel site was included to account for type of hotel and any location effects not already captured by the other work-site/workload factors. All data analyses were conducted using Stata statistical software, version 14.0.

2.4 Results

The characteristics of the study sample are summarized in Table 2.1. Of the 419 participants with complete information on job stressors and ABP, 86 (21%) met the definition of hypertension by blood pressure (an average systolic ABP >= 135 mmHg or diastolic ABP of >=85 mmHg (n=35)), by taking hypertension medication (n=33) or fulfilling both criteria (n=18), per published guidelines for daytime ABP[26,27]. Most workers were between the ages of 40-59 (56%), of Mexican or other Hispanic decent (87%), and born outside of the United States (88%).

Table 2.2 show the associations between job strain, job control, psychological demands and average ABP and pulse pressure over 18-hrs of daytime, during work hours, and during after work hours before sleep. In fully adjusted models, one unit of job strain (50% of its range) was positively associated with a 3.1 mmHg (95% CI -0.9-7.3 p=0.13) increase in systolic18-hr ABP and a 2.3 mmHg increase in 18-hr pulse pressure (95% CI 0.1-4.6, p=0.04). Job strain was associated with a 7.3 mmHg (95% CI 1.9-12.6, p<0.01) increase in after-hours systolic ABP and a 6.0 mmHg increase in after hours pulse pressure (95% CI 2.9-9.2, p<0.01). During work-hours, job strain was associated with a consistent though smaller and not statistically significant increase in ABP and pulse pressure.

The subscales of job strain were associated with blood pressure as expected. For example, job control was inversely associated with blood pressure, especially after hours: Job control was associated with a 4.7 mmHg (95% CI -9.6-0.3, p=0.06) decrease in after hours ABP, and decrease of 3.2 mmHg in after hours pulse pressure (95% CI -6.1--0.3, p=0.03). Psychological demands on the other hand were associated with increases in blood pressure. For example, psychological demands were associated with a 3.1 mmHg (95% CI -0.3-6.5, p=0.07) increase in after hours systolic ABP and a 2.9 mmHg (95% CI 0.9-4.9, p<0.01) in pulse pressure.

There were only minimal changes in diastolic blood pressure associated with job strain for any time period in this study population (Table 2.2).

Table 2.3 shows analyses for the association between job strain and blood pressure after stratifying on combinations of hypertension status and self-reported anti-hypertensive medication usage. Among workers without hypertension, job strain was associated with increases in both systolic ABP (4.4 mmHg, 95%CI -1.1-9.8, p=0.12) and pulse pressure (3.4 mmHg, 95% CI 0.0-

6.7, p=0.05) during after work hours. Among workers with hypertension, systolic ABP and pulse pressure showed also substantial positive albeit not statistically significant associations with job strain during after work hours. However, after further stratifying on anti-hypertensive medication among workers with hypertension, job strain was fairly consistently inversely associated with SBP and DBP but positively associated with pulse pressure albeit none of these findings was statistically significant. Finally, among all 357 workers not taking anti-hypertensive medication, job strain was associated with a significant 7.7 mmHg (95% CI 2.0-13.5, p=0.01) increase in afterhours systolic ABP and a 5.2 mmHg (95% CI 2.0-8.4, p<0.01) increase in afterhours pulse pressure.

Analyses limited to the 363 Latina hotel room cleaners performed similarly to the total sample (Table 2.4).

Table 2.5 expands findings reported in Table 2.2 by showing results for models with incremental adjustment for covariates that allow a more detailed assessment of the relative size of confounding effects for different groups of covariates. In general, incremental adjustments increased effect estimates with the exception of adjustment for hotel site, which attenuated associations.

Table 2.6 shows results for iso-strain and its subscales of support. Iso-strain was mildly positively associated with ABP and pulse pressure, though not consistently significant across time periods. Iso-strain was most strongly associated after hours, with an increase of 6.7 mmHg in systolic ABP and 5.4 mmHg in pulse pressure (95% 1.3-2.0, p=0.02 and 95% 2.3-8.6, p<0.01). Among the subscales, supervisor support appeared to be consistently associated with decreases in ABP and pulse pressure over an 18-hr work period and while at work, though not significantly. The association between coworker support and ABP was not consistent in either direction; however, it was associated with an increase of 2.8 mmHg in work hours systolic ABP in the fully adjusted model 4 (95% CI -0.1-5.6, p=0.06). Total support while mostly inversely associated did not show any clear strong associations with ABP or pulse pressure.

Table 2.7 shows the association between job strain and after hours blood and pulse pressure and the modifying effects of the number of dependents in the home on this association. There was a significant negative statistical interaction between job strain and the number of dependents: as the number of dependents increased the effects of job strain on blood pressure and pulse pressure weakened. This attenuation of the job strain effect indicated a protective effect of dependents in the home. Figure 2.1 shows the effects of dependents on the association, whereby as the number of dependents increases the associated change in blood pressure due to job stain decreases. Accounting for this interaction, the average effects of job strain on after hours systolic ABP when the number of dependents is zero were 11.5 mmHg (95% CI 3.9 – 19.4, p <0.01).

2.5 Discussion

Summary

In this study among female hotel cleaners, job strain was associated with higher systolic ABP and pulse pressure, particularly after work hours. These findings are consistent with previous reports on effects of job strain on blood pressure and other cardiovascular diseases in other populations[28,31–35], but for the first time, this study demonstrates such an association for the understudied population of female immigrant Latina workers in the United States, and regardless of the previously described Hispanic Health Paradox[50,51]. Briefly, the Hispanic Paradox, or Latino Paradox, first described by Markides and Coreil, found that despite lower socioeconomic status, immigrant Hispanics tended to have better health than their native-borne U.S. counterparts[50]. However, more recent studies have begun to dispute this phenomenon[52]. Our findings of a positive association with job strain was strongest for systolic ABP (7 mmHg) and pulse pressure (6 mmHg), while associations with diastolic ABP were only apparent among those with hypertension and tended to be negative. A more positive association with SBP as opposed to DBP was observed in a systematic review by Gilbert-

Ouimet et. al., where associations of job strain and SBP and DBP in women were compared[20]. The stronger response to stress in SBP could be due to the natural response by the body to stimuli, where SBP will increase with stimuli like exercise with DBP remaining relatively constant[53,54]. Both studies identified exaggerated systolic response as a risk factor for future hypertension and cardiovascular disease[53,54]. In general, downstream conditions like CHD have been reported to be more strongly associated with systolic than diastolic pressure[55]. Specifically, job strain increased systolic ABP but not diastolic ABP, with the exception of the subgroup of 86 workers with hypertension who experienced a negative association with DBP (-4 mmHg). Among this group of hypertensive workers, those 35 who did not take any anti-hypertensive medications experienced a strong inverse association between job strain and both systolic (-7.7 mmHg) and diastolic (-7.2 mmHg) ABP and little association with pulse pressure (-0.5 mmHg). We have no explanation for the finding in this subgroup but it may point to potentially different ABP response patterns among hypertensive workers that could contribute to inconsistent findings in the literature regarding the association between job strain and BP. Future research should stratify on hypertension status to explore this further.

Effects of job strain on pulse pressure

As people age, arterial walls of the cardiovascular system become stiffer, increasing pulse pressure. A wide, or high, PP has been shown in the literature to be associated with increased cardiovascular mortality[56–59], and it has been cited as the dominant predictor for cardiac events[60–62]. In this study, job strain was most strongly and consistently associated with the measure of pulse pressure. Our findings contradict some recent results from a meta-analysis of large, pooled European population[63] that found no differences between people with and without job strain for systolic or diastolic blood pressure, or pulse pressure[63]. Given that other papers in the literature have cited the importance of pulse pressure as a predictor for cardiovascular mortality; the ease of using pulse pressure as a single measurement for both systolic and diastolic blood pressure; and our own findings that job strain was consistently associated with pulse pressure in this population, we suggest that researchers consider including pulse pressure in their analyses as a dependent variable when evaluating the effects of work stress on the cardiovascular system.

Effects of job strain on blood pressure

The observation that job strain increases blood pressure after work hours (e.g. at home) more than during the day has been reported by others as well[64]. Some studies assessing the heterogeneity of effect of job strain at different hours of the day have found that domestic tasks and workload interact with the effects of job strain, increasing its effect even after work[64,65]. Specifically, the study by Portela *et al*. found that working women exposed to additional domestic workloads experienced a substantially stronger positive association between job strain and systolic blood pressure at home (after work) than women without domestic work[65]. Other studies have posited the effects after work could be a spillover effect. In a study of white collar workers, the men's level of noradrenalin declined after the workday while the female participant's levels remained high after work in the domestic environment, leading to a prolonged effect of work stress[66]. In another study, age and number of children and work-to-family spillover was shown to predict, or increase, work stress[67].

In our study, the stronger association of job strain with systolic blood pressure and pulse pressure after hours seems to indicate a spill-over effect of work stress as seen in other studies[68,69], with some modification by family life. While we observed the most dramatic effects of job strain on after hours blood pressure, it appears the number of dependents in the home attenuated this association. Without dependents, the increase in systolic ABP after hours associated with job strain was 11.5 mmHg, 4.5 mmHg more than in the total sample. Our finding is similar though to results from several studies looking at the work-family dynamic. Findings from a Venezuelan study of working women's health found the number of kids was inversely related with difficulties encountered as part of the work-family relationship[70]. A study among nurses found that family structure and specifically dependents were protective against fatigue (work strain) and did promote recovery[68]. Together with our study among mostly foreign-born Latinas with large families, these finding could point to a possible protective effect via social support from the family. This role of familial social support as a modifier of stress has been discussed before[71]. In the literature, the work-life balance and the role of social support has been generally defined as a modifier, intervening variable, an antecedent or an independent contributor to the balance. In our study, the results indicate that dependents modify the relationship between job strain and blood pressure: as the number of dependents in the household increases the magnitude of the association of job strain with ABP declines. This trend implies that these dependents may be perceived as social support as opposed to an additional burden. The inverse effect of dependents combined with relatively weak effects of co-worker support at any time or supervisor support after hours, indicates that family support may be a more substantial source of social support in this group of hotel room cleaners than social support at work. This is consistent with statements the women in our study made during focus groups, namely that they prefer to not be assigned as teams to clean rooms and that supervisory support and respect was perceived in general as low. And since cleaning hotel rooms is in general and was in our study a mostly solitary job, coworker support, even if present, would be expected to be a minimal contributor to ABP in this population.

In conclusion, this study found that job strain was associated with increases in systolic blood pressure and pulse pressure and that the effects tended to be greatest after work hours. The effect of job strain was not attenuated by social support at work; however, the presence of dependents in the home may serve as a buffer for job strain, possibly through some form of social support at home.

Effect modification by hypertension and anti-hypertensive therapy

Among hotel workers with hypertension, anti-hypertensive medication appears to counteract effects of job strain on systolic blood pressure and pulse pressure during work hours, though the results are less consistent for other time periods. This finding lends support for the need to implement effective BP surveillance and management programs in this working population which at the time of this study experienced health disparities with increased hypertension rates and 50% lower hypertension control rates than comparable working populations[37].

Some of the effect measures in smaller subgroups of workers defined by hypertension treatment have wide confidence intervals and should be interpreted with caution. However, our results are most compatible with a differential impact of job strain on those with and without hypertension. The presence of anti-hypertensive medication may be in part responsible for this modification of the association between job strain and ABP. By stratifying on medication-status, we noted that the association of job strain and blood pressure was attenuated for work hours SBP among those taking medication for hypertension implying it may be an effective strategy to reducing apparent hypertension in this population, but the results were less consistent for after hours and 18-hour blood pressure. The variable findings combined with the fact that anti-hypertension medications cannot ameliorate other health effects of job strain such as musculoskeletal injury, clinical depression, decreased leisure time physical activity, to name a few[7,46,72], implies the necessity for addressing the problem upstream. In the aforementioned study among immigrant, Haitian hotel room cleaners, the authors also recommended looking at individual and organizational level approaches to high blood pressure control[36]. Because of the many adverse health effects of job strain and the possible interaction with hypertension control, an effective approach to workplace health promotion may need to include an entire toolbox of evidence-based workplace interventions like the proposed Total Worker Health initiative by the National Institute for Occupational Safety and Health (NIOSH) that includes policies to increase flexibility and worker control at work, strategies for supervisors to reduce stressful conditions, cardiovascular health promotion efforts, and skill-building interventions for stress management in the workplace[73,74].

Strengths and Limitations

Access to a large sample of mostly immigrant female workers and a comprehensive set of work stress and ABP measurements need to be considered unique strengths of this study. Most previous studies of job strain and blood pressure were restricted to resting blood pressure, while this study included both resting and ABP measures[37]. Ambulatory measures have been shown to better capture pressure variations related to daily activities and reduce information bias, especially the so-called "white-coat" and “masked hypertension” effects[27,28,30]. Studies that compared resting casual (in-clinic) to ambulatory BP measures also found ambulatory measures less prone to measurement error and to be better predictors of cardiovascular disease outcomes[30,75–77]. In fact, a study among workers in a high strain environment similar to hotel room cleaners’ work environment found a higher prevalence of the white-coat effect; emphasizing the importance of supplementing casual in-clinic with ABP measures[78].

Additionally, our study comprehensively assessed both the psychosocial and physical work environment using multiple validated instruments. The questionnaire included several measures of psychosocial factors including job strain, iso-strain, and social support at work and home. It also assessed key potential confounders including health behaviors and extensive occupation-specific measures of physical workload, work intensification, and ergonomic problems.

The following limitations of the present study need to be considered. First, although the high response rate of over seventy percent for the psychosocial measures needs to be considered a strength, selection bias cannot be ruled out and may have attenuated effects. Participation in the ABP study may have been differential by the level of job strain and those with the highest strain may have been less likely to participate in the ambulatory ABP study component because participation required an additional time commitment. However, comparisons between subjects who participated only in the main survey with those who participated in both the survey and ABP study components showed no significant differences in job stressors, hotel site, age or ethnicity.

This study found evidence of the heterogeneity of associations by time of day with after hours BP the most affected by job strain, but was unable to evaluate nighttime associations because participants needed to manually initiate the measurement device to start any BP measurements. Night-time measures are not only desirable for comparisons with other 24-hour ABP studies and for a more complete determination of hypertension prevalence but also for capturing longer spill-over effects from work and detection of any blunted, or non-dipping, nighttime BP pattern that has been previously associated with higher cardiovascular mortality and morbidity compared with normal nighttime BP dips[79–81]. As was the case in this population where the effects of work-related stress carried into after work hours it is possible that the effects of job strain could also have caused a blunting of BP at night. Future 24-hour ABP studies should evaluate this extra risk marker.

Self-initiation of the device also took time away from participants' time to complete tasks. It took the hotel room cleaners approximately 30 seconds to initiate the device, and additional time was needed to fill out the diary and to store items away. Thus, each measurement may have used 1 or 2 minutes of their work time. With an average of 15 activities measured for each participant, it is possible that this slowed them down and cut into their break time that could have introduced extra time pressure. Therefore, the blood pressure measurements may have shown on average slightly higher values, however, this misclassification was probably similar across different job strain levels and therefore was unlikely to introduce a differential misclassification bias.

The assessment of work stress was based on self-report, a method that can be affected by personality and attitudes. It could stand to reason that some perceptions of stress affect how subjects self-report measures of stress. In other publications where authors compared subjective versus objective measures of job stress, these different methods affected the overall results[25,82]. In addition, one item in the psychological demand scale has been interpreted by manual workers in previous studies as 'physically demanding' rather than psychologically demanding, possibly introducing information bias within the job strain measure. However, we did control for several other items that captured physical demands and do not believe that this one item of the job demand scale would confound the overall association.

In this study work stress was assessed by questionnaire and subsequently BP measurements were taken. In this version of the cross-sectional study design, exposure was assessed before the outcome and we have no reason to believe that their perceived stress as reported in the questionnaire would have been differential by their BP measurements therefore, we do not think that the cross-sectional design was biasing the results in this study. Also, job strain was assessed by a series of questions that would not be immediately recognized as the composite measures of stress so it would be unlikely that participants would have responded differential by elevated blood pressure status.

Finally, job strain was only assessed once and there is evidence for repeated measures of stress being better predictors of health[22], but that is more relevant for evaluating stress longitudinally and does not necessarily apply to assessing the point-in-time associations like those in this study.

Conclusions

The multiple measurements of resting and ABP performed in this study including for the first time, measures during work hours, along with measures of work stress, need to be considered an important step towards the primary prevention of health inequalities experienced by this large and expanding immigrant worker population.

This study showed positive associations between job strain and higher ambulatory blood pressure and pulse pressure among female hotel room cleaners, especially after work-hours. Social support at work did not buffer these effects but the number of dependents at home did. Among workers with hypertension, anti-hypertensive medication may have mitigated ABP effects of job strain during work hours. This finding, together with an observed elevated rate of un-controlled hypertension in this population, indicates a need for improving blood pressure surveillance and treatment as integral part of a multi-pronged, evidence-based workplace intervention that combines reduction of organizational work stressors with stress and hypertension management programs. Employer-sponsored health care plans may consider to supplement primary prevention efforts with an active ABP surveillance and clinical hypertension management program as secondary and tertiary prevention modules in a concerted effort to reduce documented health disparities in this population.

2.6 Tables and Figures

Table 2.1: Sociodemographic and job characteristics among female Las Vegas hotel room cleaners by hypertension status (n=419)

	Total (n=419)			Hypertensive* (n=86)		Normotensive (n=333)	
Sociodemographic Factors	**n**	**mean/%**	**range**	**n**	**mean/%**	**n**	**mean/%**
Age	419	41.4	21 - 66	86	49.5	333	39.3
20-39	172	41.1%		9	10.5%	163	49.0%
40-59	235	56.1%		71	83.6%	164	49.3%
60 or older	12	2.9%		6	7.0%	6	1.8%
Race/Ethnicity	419						
White, non-Hispanic	10	2.4%		3	3.5%	7	2.1%
Black, non-Hispanic	20	4.8%		9	10.5%	11	3.3%
Mexican American	228	54.4%		47	54.7%	181	54.5%
Other Hispanic	135	32.2%		20	23.3%	115	34.5%
Other	26	6.2%		7	8.1%	19	5.7%
BMI (kg/m^2)	417	28.6	17.6 - 49.3	86	30.2	331	28.2
Years of Education	403	9.0	0 - 21	78	8.3	325	9.2
Foreign-Born Status	414						
U.S. Born	51	12.3%		13	15.5%	38	11.5%
Born Outside the U.S.	363	87.7%		71	84.5%	292	88.5%
Smoking Status	417						
Smoker	55	13.2%		11	12.8%	44	13.3%
Non-Smoker	362	86.8%		75	87.2%	287	86.7%
No. adults/household	339	3.0	1 - 9	62	3.2	277	3.0
No. children/household	341	2.2	0 - 7	63	2.0	278	2.3
No. dependents/household	372	1.1	0 - 9	72	0.8	300	1.1
Psychosocial Job Factors							
Job Strain[a]	419	0.7	0.2 - 1.8	86	0.7	333	0.7
Psychological Job Demands	419	36.3	18 - 48	86	35.0	333	36.6
Job Control	419	56.1	24 - 86	86	54.8	333	56.4
Total Support at work	416	23.3	11 - 36	86	23.7	330	23.3
Supervisor Support	417	11.8	5 - 20	86	12.0	331	11.7
Co-worker Support	417	11.0	4 - 16	86	11.1	331	11.0
Iso-strain[b]	416	0.5	0.2 - 1.1	86	0.5	330	0.5
Physical Work Load							
No. of hours worked per week	416	39.7	16 - 50	85	39.5	331	39.7
No. of beds serviced per day	417	19.8	4 - 40	82	20.0	331	19.8
Workload Index[c]	417	5.52	0.18- 16.0	86	5.6	331	5.1
Ergonomic Index[d]	418	0.1	-1.9 - 1.2	86	0.0	332	0.1
No. of years as cleaner at a hotel	410	6.5	0.5 -32	83	8.8	327	5.9
Hotel Sites	419						
Hotel A	109	26.0%		25	29.1%	84	25.2%
Hotel B	87	20.8%		11	12.8%	76	22.8%
Hotel C	100	23.9%		20	23.3%	80	24.0%
Hotel D	61	14.6%		7	8.1%	54	16.2%
Hotel E	62	14.8%		23	26.7%	39	11.7%

* Hypertension defined by self-reported use of anti-hypertensive medication or average daytime ambulatory blood pressure (systolic >135 mmHg or diastolic >85 mmHg)

a Job strain ratio: psychological demand divided by decision latitude.

b Iso-strain ratio: psychological demand divided by decision latitude and total support.
c A higher score on the physical workload index indicates more physical work demands.
d A higher score on the ergonomic index indicates greater ergonomic problems.

Table 2.2: Associations between job strain, job control and psychological demands and ambulatory blood pressure by time of day among female Las Vegas hotel room cleaners. (n=419)

	18-hr Ambulatory Blood Pressure						Work Hours Ambulatory Blood Pressure						After Hours Ambulatory Blood Pressure					
	Systolic		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*	
	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*
Job Strain*																		
Age-Adjusted	1.9	0.34	-0.2	0.87	2.1	0.06	1.2	0.55	-0.3	0.83	1.7	0.19	5.6	0.03	1.0	0.56	4.9	<0.01
	-2.1-5.9		-3.0-2.5		-0.1-4.4		-2.8-5.2		-3.1-2.5		-0.8-3.8		0.4-10.7		-2.4-4.4		1.8-7.9	
Fully Adjusted	3.1	0.13	0.8	0.59	2.3	0.04	2.3	0.27	0.8	0.58	1.2	0.21	7.3	<0.01	1.5	0.42	6.0	<0.01
	-0.9-7.3		-2.1-3.7		0.1-4.6		-1.8-6.4		-2.1-3.7		-0.9-3.8		1.9-12.6		-2.1-5.1		2.9-9.2	
Job Control*																		
Age-Adjusted	-1.5	0.43	0.6	0.63	-2.1	0.04	-0.9	0.65	0.9	0.49	-1.6	0.10	-4.3	0.07	-1.6	0.30	-3.1	0.03
	-5.2-2.2		-1.9-3.2		-4.2--0.0		-4.6-2.8		-1.7-3.5		-3.9-0.3		-9.0-0.4		-4.7-1.5		-5.9--0.3	
Fully Adjusted	-1.6	0.39	0.0	0.98	-1.6	0.13	-1.1	0.58	0.1	0.96	-0.7	0.31	-4.7	0.06	-1.8	0.28	-3.2	0.03
	-5.4-2.1		-2.7-2.6		-3.7-0.5		-4.8-2.7		-2.7-2.8		-3.3-1.0		-9.6-0.3		-5.2-1.5		-6.1--0.3	
Psychological Demands*																		
Age-Adjusted	-0.4	0.74	-0.5	0.59	0.1	0.94	-0.7	0.58	-0.5	0.58	-0.2	0.77	1.2	0.43	-0.1	0.91	1.6	0.10
	-2.8-2.0		-2.1-1.2		-1.3-1.4		-3.2-1.8		-2.2-1.2		-1.6-1.2		-1.9-4.4		-2.2-1.9		-0.3-3.4	
Fully Adjusted	1.1	0.38	0.5	0.61	0.7	0.35	0.7	0.57	0.4	0.64	0.2	0.69	3.1	0.07	0.4	0.74	2.9	<0.01
	-1.4-3.7		-1.3-2.3		-0.7-2.1		-1.8-3.3		-1.4-2.3		-1.2-1.8		-0.2-6.5		-1.9-2.7		0.9-4.9	

Fully Adjusted: Age, race, BMI, years of education, foreign-born status, smoking status, self-reported hypertension medication, hours worked in a week, number of beds, workload index, ergonomic index, years as a cleaner, and hotel site.

* Independent variables rescaled to a range of 0 to 2 for comparison. One unit of any rescaled variable equals one-half of the full range of this variable as shown in Table 2.1.

Table 2.3: Associations between job strain and ambulatory blood pressure by time of day, hypertension status, and by self-reported use of medication for hypertension among female Las Vegas hotel room cleaners. (n=405)

	18-hr Ambulatory Blood Pressure						Work Hours Ambulatory Blood Pressure						After Hours Ambulatory Blood Pressure					
	Systolic		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*	
	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*
Workers without Hypertension (n=333)																		
Age-Adjusted	0.7 -2.7-4.1	0.68	-0.2 -2.8-2.4	0.89	0.9 -1.2-2.9	0.39	0.4 -3.2-3.9	0.84	-0.4 -3.1-2.3	0.80	0.7 -1.5-2.9	0.51	3.4 -1.5-8.2	0.17	0.8 -2.7-4.3	0.65	2.5 -0.4-5.5	0.10
Fully Adjusted	1.3 -2.4-5.0	0.50	0.6 -2.2-3.4	0.67	0.7 -1.5-2.9	0.54	0.7 -3.1-4.5	0.72	0.5 -2.4-3.3	0.76	0.3 -2.1-2.6	0.83	4.4 -1.1-9.8	0.12	0.8 -3.0-4.7	0.67	3.4 0.0-6.7	0.05
Workers with Hypertension (n=86)																		
Age-Adjusted	0.9 -7.2-8.9	0.83	-2.8 -8.1-2.6	0.31	3.6 -1.8-9.0	0.19	-0.6 -8.7-7.5	0.88	-2.6 -8.1-2.8	0.34	2.0 -3.6-7.7	0.48	4.8 -6.0-15.6	0.38	-2.1 -8.7-4.4	0.52	7.3 0.0-14.6	0.05
Fully Adjusted	-0.4 -8.9-8.0	0.92	-4.2 -9.9-1.4	0.14	3.8 -2.1-9.7	0.20	-0.4 -9.5-8.8	0.93	-2.8 -8.7-3.1	0.34	2.4 -4.2-9.1	0.46	1.9 -10.2-14.1	0.75	-4.1 -11.5-3.4	0.28	5.1 -3.0-13.2	0.21
Workers with hypertension taking anti-hypertensive medication (n=48)																		
Age-Adjusted	1.0 -10.8-12.9	0.86	-1.3 -8.6-6.0	0.73	2.3 -5.7-10.3	0.56	-1.5 -13.6-10.6	0.80	-0.6 -8.1-7.0	0.88	-0.9 -8.9-7.0	0.81	5.5 -8.8-19.7	0.44	-4.9 -13.3-3.6	0.25	10.3 0.2-20.5	0.05
Fully Adjusted	-3.1 -21.5-15.3	0.73	-0.6 -13.9-17.7	0.93	-2.5 -14.4-9.3	0.66	-7.7 -26.3-10.9	0.40	1.1 -12.6-14.7	0.87	-8.8 -20.1-2.6	0.12	-1.1 -23.3-21.1	0.92	-6.0 -20.2-8.1	0.39	4.9 -11.5-21.3	0.54
Workers with hypertension and not taking anti-hypertensive medication (n=35)																		
Age-Adjusted	-1.2 -11.9-9.5	0.83	-6.1 -11.1--1.1	0.02	4.9 -3.2-13.0	0.23	-1.1 -12.0-9.8	0.84	-6.3 -11.8--0.8	0.03	-5.2 -3.7-14.1	0.24	2.5 -14.5-19.6	0.76	-1.7 -10.2-6.7	0.68	4.5 -7.3-16.3	0.44
Fully Adjusted	-7.7 -23.6-8.3	0.32	-7.2 -16.3-2.0	0.12	-0.5 -12.4-11.4	0.93	-1.1 -20.5-18.2	0.90	-3.2 -12.8-6.3	0.48	-2.1 -12.5-17.7	0.78	-11.7 -32.9-9.5	0.26	-11.7 -22.3--1.0	0.04	2.1 -12.4-17.7	0.77
All workers not taking medication for hypertension (n=357)																		
Age-Adjusted	2.3 -1.8-6.4	0.27	0.3 -2.6-3.2	0.84	2.0 -0.2-4.2	0.07	2.0 -2.1-6.1	0.34	0.1 -2.8-3.1	0.92	1.9 -0.4-4.1	0.11	5.6 0.2-11.0	0.04	2.3 -1.4-5.9	0.22	3.8 0.7-6.9	0.02
Fully Adjusted	3.6 -0.7-7.9	0.10	1.2 -1.9-4.3	0.44	2.4 0.2-4.7	0.04	3.2 -1.1-7.5	0.15	1.1 -2.0-4.2	0.49	2.1 -0.3-4.5	0.09	7.7 2.0-13.5	0.01	2.9 -1.0-6.7	0.15	5.2 2.0-8.4	<0.01

Fully Adjusted: Age, race, BMI, years of education, foreign-born status, smoking status, self-reported hypertension medication, hours worked in a week, number of beds, workload index, ergonomic index, years as a cleaner, and hotel site.

* Independent variables rescaled to a range of 0 to 2 for comparison. One unit of any rescaled variable equals one-half of the full range of this variable as shown in Table 2.1.

Table 2.4: Associations of job strain, job control and psychological demands with ambulatory blood pressure by time of day among Latina Las Vegas hotel room cleaners. (n=363)

	18-hr Ambulatory Blood Pressure						Work Hours Ambulatory Blood Pressure						After Hours Ambulatory Blood Pressure					
	Systolic		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*	
	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*
Job Strain*																		
Age-Adjusted	1.9 -2.6-6.4	0.40	-0.5 -3.6-2.6	0.75	2.4 -0.0-4.9	0.05	1.1 -3.4-5.6	0.64	-0.6 -3.7-2.5	0.71	1.7 -0.9-4.2	0.19	5.3 -0.4-11.1	0.07	0.6 -3.2-4.3	0.77	5.1 1.8-8.5	<0.01
Fully Adjusted	3.1 -1.3-7.5	0.17	1.0 -2.1-4.1	0.53	2.1 -0.3-4.5	0.09	2.3 -2.1-6.7	0.31	1.1 -2.1-4.2	0.51	1.2 -1.3-3.7	0.35	6.7 0.8-12.5	0.03	1.3 -2.7-5.2	0.54	5.7 2.2-9.1	<0.01
Job Control*																		
Age-Adjusted	-0.6 -4.7-3.6	0.79	1.4 -1.4-4.3	0.32	-2.0 -4.3-0.3	0.08	0.1 -4.0-4.2	0.96	1.7 -1.2-4.6	0.25	-1.6 -4.0-0.7	0.18	-3.0 -8.3-2.2	0.26	-0.5 -4.0-2.9	0.77	-3.0 -6.1-0.1	0.06
Fully Adjusted	-0.8 -4.8-3.3	0.72	0.5 -2.4-3.4	0.74	-1.2 -3.5-1.0	0.28	-0.2 -4.2-3.9	0.93	0.6 -2.3-3.5	0.71	-0.7 -3.1-1.6	0.53	-3.1 -8.5-2.3	0.26	-0.9 -4.5-2.7	0.63	-2.5 -5.7-0.6	0.12
Psychological Demands*																		
Age-Adjusted	-0.1 -2.8-2.6	0.93	-0.3 -2.1-1.6	0.78	0.1 -1.3-1.6	0.85	-0.5 -3.1-2.2	0.71	-0.3 -2.1-1.6	0.74	-0.2 -1.7-1.3	0.80	1.8 -1.7-5.2	0.31	1.8 -2.1-2.4	0.88	1.8 -0.2-3.9	0.08
Fully Adjusted	1.6 -1.1-4.4	0.24	1.1 -0.8-3.0	0.28	0.6 -0.9-2.1	0.45	1.2 -1.5-3.9	0.38	1.1 -0.9-3.0	0.29	-0.2 -1.4-1.7	0.83	3.7 0.1-7.3	0.05	0.9 -1.5-3.4	0.46	3.0 0.8-5.1	<0.01

Fully Adjusted: Age, race, BMI, years of education, foreign-born status, smoking status, self-reported hypertension medication, hours worked in a week, number of beds, workload index, ergonomic index, years as a cleaner, and hotel site.

* Independent variables rescaled to a range of 0 to 2 for comparison. One unit of any rescaled variable equals one-half of the full range of this variable as shown in Table2.1.

Table 2.5: Associations of job strain, job control and psychological demands with ambulatory blood pressure by time of day among female Las Vegas hotel room cleaners with incremental adjustment for potential confounding factors (n=419)

	18-hr Ambulatory Blood Pressure						Work Hours Ambulatory Blood Pressure						After Hours Ambulatory Blood Pressure					
	Systolic		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*	
	mmHg	*p*	mmHg	*p*	mmHg	*p*	mmHg	*p*	mmHg	*p*	mmHg	*p*	mmHg	*p*	mmHg	*p*	mmHg	*p*
Job Stain*																		
Model 1	1.9	0.34	-0.2	0.87	2.1	0.06	1.2	0.55	-0.3	0.83	1.5	0.19	5.6	0.03	1.0	0.56	4.9	<0.01
Model 2	3.1	0.13	0.2	0.87	2.9	0.01	2.3	0.27	0.1	0.92	2.1	0.07	6.5	0.02	1.1	0.53	5.6	<0.01
Model 3	3.8	0.07	1.0	0.51	2.8	0.01	3.0	0.15	1.0	0.50	2.0	0.10	7.2	0.01	1.4	0.44	6.1	<0.01
Model 4	3.1	0.13	0.8	0.59	2.3	0.04	2.3	0.27	0.8	0.58	1.5	0.21	7.3	<0.01	1.5	0.42	6.0	<0.01
Job Control*																		
Model 1	-1.5	0.43	0.6	0.63	-2.1	0.04	-0.9	0.65	0.9	0.49	-1.8	0.10	-4.3	0.07	-1.6	0.30	-3.1	0.03
Model 2	-1.9	0.32	0.3	0.80	-2.2	0.04	-1.3	0.49	0.5	0.69	-1.9	0.09	-4.4	0.07	-1.5	0.34	-3.3	0.02
Model 3	-2.3	0.24	-0.3	0.83	-2.0	0.06	-1.7	0.36	-0.2	0.88	-1.5	0.16	-4.6	0.06	-1.8	0.27	-3.1	0.03
Model 4	-1.6	0.39	0.0	0.98	-1.6	0.13	-1.1	0.58	0.1	0.96	-1.1	0.31	-4.7	0.06	-1.8	0.28	-3.2	0.03
Psychological Demands*																		
Model 1	-0.4	0.74	-0.5	0.59	0.1	0.94	-0.7	0.58	-0.5	0.58	-2.1	0.77	1.2	0.43	-0.1	0.91	1.6	0.10
Model 2	0.6	0.64	-0.1	0.94	0.7	0.36	0.2	0.89	-0.1	0.88	0.3	0.67	2.2	0.18	0.1	0.92	2.2	0.02
Model 3	1.3	0.32	0.4	0.63	0.1	0.23	0.8	0.51	0.4	0.67	0.5	0.54	3.0	0.07	0.2	0.83	3.0	<0.01
Model 4	1.1	0.38	0.5	0.61	0.7	0.35	0.7	0.57	0.4	0.64	0.3	0.69	3.1	0.07	0.4	0.74	2.9	<0.01

Model 1: Adjusted for Age

Model 2: Adjusted for age, race, BMI, years of education, foreign-born status and smoking status

Model 3: Adjusted for variables in Model 2 plus self-reported hypertension medication, hours worked in a week, number of beds, workload index, ergonomic index, & years as a cleaner

Model 4: Adjusted for variables in Model 3 plus hotel site

* Independent variables rescaled to a range of 0 to 2 to facilitate comparisons. One unit of any rescaled variable equals one half of the full range of this variable as shown in Table 2.1.

Table 2.6: Associations of Isostrain, supervisor support, co-worker support, and total support with ambulatory blood pressure by time of day among Latina Las Vegas hotel room cleaners. (n=363)

	18-hr Ambulatory Blood Pressure						Work Hours Ambulatory Blood Pressure						After Hours Ambulatory Blood Pressure					
	Systolic		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*	
	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*	mmHg 95% CI	*P*
Iso-strain Score*																		
Age-Adjusted	1.7 -2.2-5.5	0.40	-0.2 -2.8-2.5	0.91	1.8 -0.3-4.0	0.10	1.1 -2.8-5.0	0.59	-0.3 -3.0-2.5	0.85	1.3 -0.9-3.6	0.24	4.7 -0.3-9.7	0.06	0.9 -2.4-4.2	0.58	4.2 1.2-7.1	0.01
Fully Adjusted	2.9 -1.1-6.9	0.16	1.0 -1.2-3.8	0.49	1.9 -0.3-4.1	0.10	2.2 -1.8-6.2	0.29	1.0 -1.9-3.9	0.49	1.2 -1.1-3.5	0.32	6.6 1.3-12.0	0.02	1.5 -2.1-5.1	0.42	5.4 2.3-8.6	<0.01
Supervisor Support*																		
Age-Adjusted	-1.8 -4.1-0.6	0.14	-0.4 -2.0-1.4	0.66	-1.4 -2.7--0.1	0.04	-1.7 -4.1-0.6	0.15	-0.3 -2.0-1.4	0.72	-1.4 -2.8--0.1	0.04	-1.1 -4.1-2.0	0.49	-0.3 -2.3-1.6	0.73	-0.9 -2.7-0.9	0.33
Fully Adjusted	-2.0 -4.5-0.6	0.13	-0.8 -2.6-1.0	0.36	-0.8 -2.6-1.0	0.36	-1.8 -4.4-0.7	0.15	-0.9 -2.7-1.0	0.35	-1.0 -2.4-0.5	0.19	-2.0 -5.4-1.4	0.24	-0.6 -2.9-1.6	0.59	-1.5 -3.3-0.5	0.14
Coworker Support*																		
Age-Adjusted	1.9 -0.9-4.7	0.18	1.7 -0.3-3.6	0.09	0.2 -1.3-1.8	0.77	2.2 -0.6-5.0	0.13	2.0 0.0-4.0	0.05	0.2 -1.4-1.8	0.83	0.8 -2.8-4.3	0.67	-0.4 -2.7-2.0	0.76	0.9 -1.3-3.0	0.43
Fully Adjusted	2.6 -0.3-5.4	0.08	1.4 -0.6-3.4	0.17	1.2 -0.4-2.7	0.14	2.8 -0.1-5.6	0.06	1.7 -0.3-3.8	0.10	1.0 -0.6-2.7	0.21	1.1 -2.6-4.9	0.55	-0.9 -3.4-1.6	0.46	1.8 -0.4-4.0	0.11
Total Support*																		
Age-Adjusted	-1.0 -4.1-2.1	0.52	0.2 -1.9-2.3	0.84	-1.2 -2.9-0.5	0.16	-0.9 -3.9-2.2	0.58	0.4 -1.7-2.6	0.68	-1.3 -3.1-0.4	0.14	-0.8 -4.7-3.1	0.70	-0.8 -3.4-1.7	0.53	-0.3 -2.6-2.0	0.80
Fully Adjusted	-0.9 -4..1-2.4	0.59	-0.4 -2.7-1.9	0.75	-0.5 -2.3-1.3	0.58	-0.7 -3.9-2.6	0.68	-0.2 -2.6-2.1	0.86	-0.5 -2.3-1.4	0.62	-1.6 -5.9-2.7	0.47	-1.5 -4.3-1.4	0.32	-0.5 -3.0-2.1	0.72

Fully Adjusted: Age, race, BMI, years of education, foreign-born status, smoking status, self-reported hypertension medication, hours worked in a week, number of beds, workload index, ergonomic index, years as a cleaner, and hotel site.

* Independent variables rescaled to a range of 0 to 2 for comparison. One unit of any rescaled variable equals one-half of the full range of this variable as shown in Table 2.1.

Table 2.7. Modifying effects of the number of dependents on the association between job strain and after hours ambulatory blood pressure (ABP) among female Las Vegas hotel room cleaners (n=405)

	Systolic ABP			Diastolic ABP			Pulse Pressure		
	mmHg	95% CI	*p*	mmHg	95% CI	*p*	mmHg	95% CI	*p*
Job Strain									
Model 4	7.3	1.9-12.6	<0.01	1.5	-2.1-5.1	0.42	6.0	2.9-9.2	<0.01
Model 5	11.6*	3.9-19.4	<0.01	4.1**	-1.2-9.3	0.13	8.0+	3.5-12.5	<0.01

Model 4: Adjusted for Age, Race, BMI, years of education, foreign-born status and smoking status, self-reported hypertension medication, ergonomic index, number of beds, workload index, hours worked in a week, years as a cleaner, and hotel site. Model 5: Model 4 plus number of dependents and interaction term (job strain X number of dependents). The effects shown in the table for model 5 refer to those without dependents at home.

* Interaction term of dependents and job strain statistically significant (B=-6.74, 95% CI -13.46, -0.03, p=0.05)

** Interaction term of dependents and job strain statistically significant (B=-3.80, 95% CI -8.38, 0.78, p=0.10)

+ Interaction term of dependents and job strain (B=-3.00, 95% CI -6.93,0.93, p-0.14)

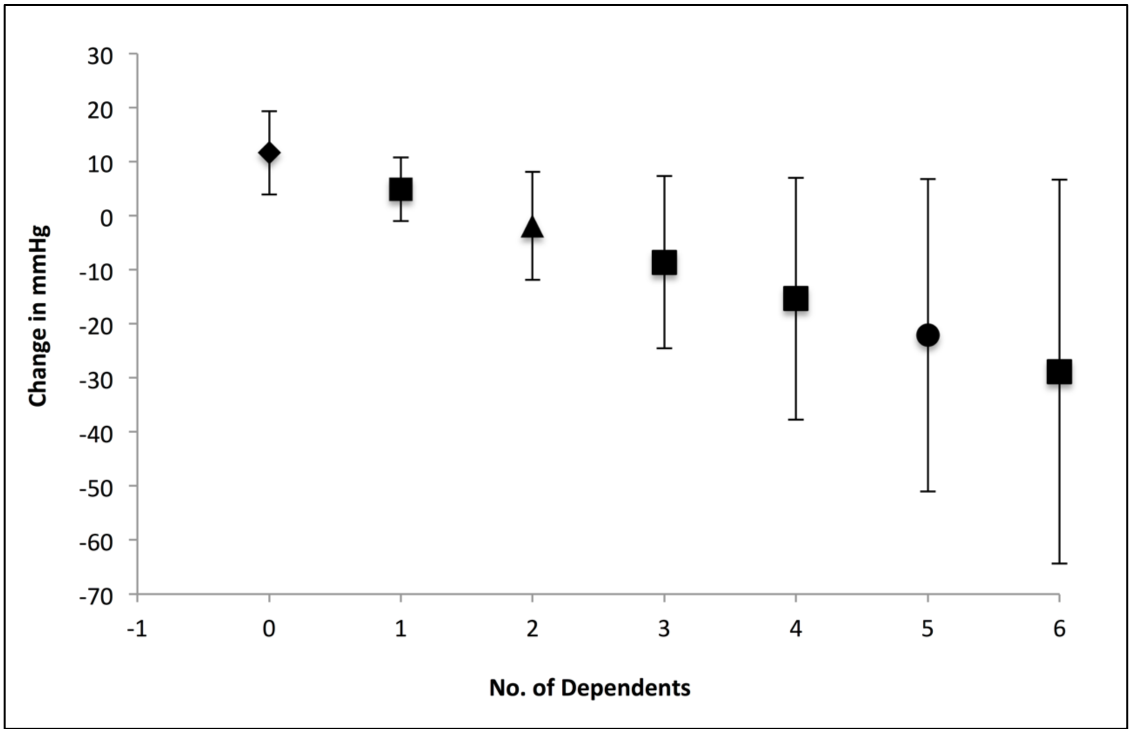

Figure 2.1: Measures of association and confidence intervals for the change in after-work hours SBP due to job strain in mmHg with increasing number of dependents.

CHAPTER 3: EFFORT-REWARD IMBALANCE AND AMBULATORY BLOOD PRESSURE AMONG FEMALE LAS VEGAS HOTEL ROOM CLEANERS

3.1 Abstract

Background Effort-reward imbalance (ERI) was hypothesized to be associated with ambulatory blood pressure (ABP) and pulse pressure (PP) among female hotel room cleaners.

Methods ERI, ABP, and PP were assessed among 419 cleaners from five hotels during 18 waking hours. Adjusted linear regression models were used to assess associations of ERI with ABP and PP during 18-hours, work hours, and after work hours.

Results There was a pattern of higher ERI being associated with higher 18-hr systolic ABP and 18-hr PP although the results were imprecise. An increase of ERI by half its range was associated with a 1.6 mmHg (95%CI -1.6, 4.7) increase in 18-hr systolic blood pressure (SBP) and a 0.7 mmHg (95% CI -1.1, 2.5) increase in 18-hr PP. An increase in rewards by half its range was associated with a 2 mmHg decrease in after-hours SBP (-2.2, 95%CI -5.4, 1.0) and after-hours PP (-1.9, 95%CI -3.8, 0.0). Among females 45 years or older, ERI was associated with 2.1 and 2.2 mmHg increase in 18-hr and work hours diastolic ABP, respectively, compared to a 0 mmHg change in 18-hr and work hours diastolic ABP in younger women. Finally, the number of dependents at home attenuated the association.

Conclusions ERI was positively associated with ABP, particularly SBP, and the association was modified by age and the number of dependents at home, although the estimates were imprecise. Workplace interventions that integrate stress management and active ABP surveillance appear warranted. However, larger studies with Latina women need to confirm our results.

3.2 Introduction

Stress, in a broad sense, is the body’s way of responding to strenuous stimuli. Stress can be part of a positive, life-saving response, activating the body’s fight or flight mechanisms. Stress can also be an insidious, chronic response to routine stressors experienced during work, family, or household life[83]. Such a chronic state of stress can cause both physical and mental harm[83]. People experience stressful situations throughout their life, especially while on the job. The National Institute of Occupational Safety and Health defines job stress as harmful physical and emotional responses when the requirements of the job do not match the capabilities, resources or needs of the worker[2]. Surveys of the American workplace have found that nearly 25% view their job as the number one stressor in their life and 75% of the workers surveyed believe the job is more stressful now than a generation ago[2].

Over the last 40 years, researchers used different theoretical models to assess occupational stressors and their effects on workers' health. Work stress has been linked to acute effects like sleep disturbances, bodily pain, work injuries, and to chronic conditions such as cardiovascular, musculoskeletal, and psychological disorders including depression and suicide among other conditions[2]. To investigate the association between work stress and blood pressure in this study, we used the effort-reward-imbalance (ERI) model of work stress. The ERI model presumes the source of work-related stress to be the result of an imbalance between individual workers' extrinsic efforts (e.g. working under time pressure, being pressed to work overtime, experiencing increasing work demands, interruptions of work) and the rewards received through work such as income, respect, esteem and occupational status control[84]. Workers are expected to experience worse health outcomes when they are in a high extrinsic effort, low reward work environment. Other widely applied measures of work stress, specifically job strain and iso-strain, were found to be positively associated with ABP in this population[85]. Previous research in this population of predominantly female, Mexican American, immigrant workers linked ERI to shoulder and neck injury[7], general health[9], and health disparities[10] including an increased prevalence of hypertension among the Latina immigrant hotel workers that exceeded prevalence rates in their country of origin[37].

Risk factors for hypertension like age, gender, smoking, socio-economic status (social class), and racial/ethnic disparities have been well-described[13,14], but the potential detrimental effects of ERI on the cardiovascular system appears to be less consistent for women than for men[21,22,24,86–88] A review by Gilbert-Ouimet et. al found that of the few papers that evaluated job stress and blood pressure among both sexes, the adverse effects were observed more consistently among men compared to women[20]. At the time, none of the cross-sectional studies had used ambulatory blood pressure or evaluated the association in Latina, immigrant populations. More recent studies have reported ERI increased SBP[22] and hypertension[88] but observations were limited to white collar female workers[22,88], and did not address immigrant populations performing heavy physical labor. Conversely, a relevant study of Haitian immigrant hotel room cleaners reported that control of hypertension was aided by organization level factors such as work hours, workload and social support[36]. In this current study, we will address this research gap by assessing the association between ERI and ABP in a population of mostly immigrant Latina hotel room cleaners. The study will control for potential confounders like physical workload and other ergonomic factors.

3.3 Methods

Recruitment of Subjects and Administration of Survey Questionnaires

Five unionized Las Vegas hotels, representing five different hotel types (upscale, mid-level, convention, all-suite, and older economy) were included in this study. The eligibility, recruitment, and training of the subjects have been previously described[7,9,37]. Of the eligible 1,276 room cleaners, 941 (74%) attended an off-worksite meeting where they completed a 29-page main survey containing questions on demographics, self-reported health, health behaviors, physical workload, ergonomic problems, ERI and other work stressors. The survey was developed using a participatory research approach[89], and was provided in English, Spanish and Serbo-Croatian. Trained survey administrators who spoke Spanish, Serbo-Croatian, or one or more Asian languages served as translators for participants with limited reading abilities. Participation was voluntary and incentives were not offered.

All eligible workers were also invited to participate in the ABP component of the study. Resources, including staff time and available blood pressure measurement instruments, limited participation in this ABP component to the first 589 hotel workers who signed up and attended a respective training session. They received a two-hour training that included a description of the study, informed consent and hands-on training on how to measure and record ABP readings during and after work hours. During the training, study staff also repeatedly measured resting blood pressure and administered a short 2-page questionnaire on demographics, history of hypertension diagnosis and treatment, and current workload. 442 of the 589 female participants in the ABP study had previously participated in the main survey meetings described above. Of those, 419 participants answered the questions comprising the effort-reward subscales and constitute this study sample. The study was approved by Institutional Review Boards of the University of California at Berkeley and San Francisco.

Ambulatory Blood Pressure Measurements

Volunteers in the ABP component of the study were invited to a training session on conducting self-measurements of ABP and pulse rate. Trained professionals taught participants how to initiate a measurement, and how to record ABP and pulse rate onto a report card immediately after completing different specific activities at work and before and after sleep distributed over a total of 18 waking hours. These measurements started in the evening after the training, ceased during sleep, and resumed the next morning before work, and continued until the end of their work shift. All measurements were captured with the Omron HEM-630 device attached to the wrist, which has been validated for ambulatory blood pressure recordings[90,91]. Measurements were time-stamped and automatically stored by the device. Upon completion of a pre-described activity, workers were instructed to initiate recording of their blood pressure in a seated position, and to record those measurements on a provided diary card. This diary contained activity pictograms that were matched to the activity they had just performed. The 21 time points listed in the diary included: the beginning and end of their work shift; lunch and other work breaks; specific work-activities like dusting, vacuuming, making beds and pushing/pulling carts; activities after work hours in the evening and one measurement before going to bed. When participants returned their OMRON devices, researchers compared the electronically stored blood pressure measurements with the corresponding written entries in the diary form and corrected any transcription errors. Ambulatory blood pressure averages were computed for three time periods: 1) the total 18-hour day-time period (average of all recordings); 2) time at work from beginning to end of the work shift (on average 8.11 working hours) and 3) after-work hours that included measurements done right after work, after dinner, right before going to bed, and in the morning at home. All but five of the 407 participants (98.8%) had at least four ABP measurements during work hours, and 380 (93.3%) had at least one ABP measurement after work hours. Participants did not take blood pressure measurements during sleep because the device required manual initiation of any recording. Pulse pressure was calculated as the individual difference of systolic and diastolic ABP measurements and averaged for each time period.

Hypertension was defined as an average systolic ABP greater than or equal to 135 mmHg or an average diastolic ABP of 85 mmHg of greater, self-reported usage of hypertension medication, or fulfilling both criteria per published guidelines for daytime ABP[26,27].

Effort-Reward Imbalance (ERI) and Other Psychosocial Stressors

Psychosocial work factors were measured by three standard constructs (job strain, iso-strain, and ERI) and their respective subscales[7,9]. ERI was assessed using the questionnaire developed by Siegrist and Peter[84]. Extrinsic effort was measured with 6 items, of which one item assessed physical effort at work. Reward was measured with 11 items. Overcommitment, an additional construct aimed to assess intrinsic effort, was not measured in this study.

For the effort and reward subscales, mean single imputation methods were applied to the records of those respondents who answered more than 50% of the subscale items as recommended by Siegrist/Peters[8,84]. This affected 8% and 15% of the observations for the effort and reward subscales, respectively.

The effort subscale was summed both with and without the 'physical effort at work' item[92]. To better differentiate psychological from physical efforts, the effort scale without the physical effort item was used to create the final ERI ratio. The ERI ratio was calculated as the efforts score divided by the rewards score. A multiplier was applied to the reward score denominator to equalize the number of items in the subscales. Cronbach's alpha for effort and reward subscales were 0.81 and 0.91, exceeding mean values of about 0.70 reported in the literature[92]. Effort-reward imbalance scores, and the individual effort and rewards subscales, were regressed as continuous measurements standardized to a range from zero to two for comparison purposes.

Job Strain

In this paper, job strain is included only for comparison of work-stress models. Detailed information on assessment and study results have been published separately[85]. In short, job strain was assessed by questions from Karasek's Job Content Questionnaire[7,39]. Job strain ratios were calculated as the psychological demands score divided by the decision latitude score.

Covariates

Sociodemographic factors including age, race/ethnicity, years of education, and place of birth (U.S.- versus foreign-born), and number of dependents at home were assessed by questionnaire. Anthropometric variables (body height and weight) were assessed during survey administration using portable scales. Past and current physical workloads were measured by six variables: number of years worked as a hotel room cleaner, number of hours worked per week, number of beds made per day, a 26-item physical workload index, a 26-item work intensification index, and an 11-item ergonomic index, as previously described[7,49].

Statistical Analysis

The distributions of all variables across hypertension status were summarized using means or frequencies for continuous and nominal variables respectively. Mean value replacement for missing values for covariates was used for continuous variables. Linear regression analyses were performed with standardized continuous scores for effort-reward imbalance, effort and reward scales separately, and job strain. All measures of job stress, including ERI, job strain, and their respective subscales, were re-centered and rescaled to a unit range from zero to two for comparison purposes so that a one-unit change represents half the range for each variable. Regression models incrementally adjusted for age (model 1); then select socio-demographic, behavioral, and anthropometric measures (model 2), and finally worksite and ergonomic and physical workload factors (model 3). The unstandardized coefficients from the regression models are presented in the tables as differences of blood pressure in mmHg associated with a one-unit difference (half the range) in the effort, reward or ERI variable. Finally, to evaluate the statistical interaction of stress and dependents at home, an interaction term was created and defined as ERI score multiplied by the number of dependents. We used Stata statistical software version 14.0 (StataCorp LLC, College Station, Texas) to analyze the study data.

3.4 Results

The characteristics of the study population are presented in Table 3.1. Most workers were under age 60 (97%), with the majority of women below the age of 45 (64%). Most of the participants were of Mexican or other-Hispanic decent (87%) and born outside of the United States (88%). Of the 578 who participated in the ambulatory blood pressure training and had measures for blood pressure, 407 participants, or 70.4%, had ERI score measurements. Of these 407 participants, 83 (20%), met the definition of hypertension by an average systolic ABP (SBP) >= 135 mmHg or diastolic ABP (DBP) of >=85 mmHg (n=35), or by taking anti-hypertensive medication (n=48) or fulfilling both criteria (n=86), per published guidelines for ambulatory daytime blood pressure[26,27]. More than 62% reported relatively low rewards for their efforts (i.e. ERI>1).

Table 3.2 shows, for the entire sample, the associations between ERI and its subscales of effort and rewards (in units of half their range) with average ABP and pulse pressure in mmHg (values are equal to the observed respective regression coefficients) over 18 daytime hours, during work hours, and after work hours, and with incremental adjustment for covariates. In the fully adjusted models (Model 3), ERI was positively associated with ABP (88% of all point estimates) and although all confidence intervals straddled the null effect, their ranges included consistently more values above zero mmHg than below zero mmHg with the only exception of no change in DBP after hours. Specifically, over the total 18 hours, one unit change in ERI (50% of its range) was associated with a 1.6 mmHg (95%CI -1.6, 4.7, p=0.34) higher SBP and a 0.7 mmHg higher pulse pressure (95%CI -1.1, 2.5, p=0.43). After hours, ERI was associated with a 1.3 mmHg higher SBP (95%CI -2.8, 5.4, p=0.53) and 1.3 mmHg higher pulse pressure (95%CI -1.1, 3.7, p=0.29); DBP was not associated with ERI (0.0 mmHg, 95%CI -2.7, 2.7, p=0.99).

Contrary to expectation, efforts were inversely associated with ABP. Higher efforts were associated with 1.5 mmHg lower 18-hr SBP (95%CI -4.3, 1.4, p=0.31), 1.7 mmHg lower work hours SBP (95%CI -4.6, 1.1, p=0.23) and 1.1 mmHg lower after hours SBP (95%CI -4.8, 2.7, p=0.57). Higher efforts were associated with 0.6 mmHg lower 18-hr DBP (95%CI -2.6, 1.4, p=0.55), 0.6 mmHg lower work hours DBP (95%CI -2.6, 1.4, p=0.55) and 1.7 mmHg lower DBP after hours (95%CI -4.1, 0.8, p=0.18). Finally, higher efforts were associated with a 0.9 mmHg lower 18-hr PP (95%CI -2.5, 0.7, p=0.29) and 1.1 mmHg lower work hours PP (95%CI -2.8, 0.6, p=0.19).

Rewards were inversely associated with ABP, particularly after hours. One unit increase in the rewards scale (50% of its range) was associated with an approximately 2 mmHg lower after-hours SBP (-2.2, 95%CI -5.4, 1.0, p=0.18) and after-hours pulse pressure (-1.9, 95%CI -2.8, 0.0, p=0.04). Rewards were not associated with DBP.

Table 3.3 shows the associations of ERI and ABP stratified by age. The table shows that differences by age are most apparent in the associations of ERI and diastolic ABP and consequently PP, especially during work hours. Among females younger than 45 years old, ERI is not associated with DBP, but among females 45 years or older it was associated with 2.1 and

2.2 mmHg increases in 18-hr and work-hour DBP, respectively, albeit measures were imprecise. These differences are reflected in similar size differences (ranging from 2.1 to 2.5 mmHg) of PP measures between age groups: pulse pressure was higher among the younger group and lower among the older group. These patterns were not observed after hours.

In Table 3.4, workers with an effort-reward imbalance score above 1 were compared to those with an ERI ratio 1 and below. In the fully adjusted models, workers with ERI >1 had about 2 mmHg higher SBP and DBP during work hours compared to those without this imbalance, and while all confidence intervals straddled zero, they included more higher positive estimates up to 5.4 mmHg. Specifically, ERI above 1 was associated with a 1.8 mmHg (95%CI -0.2, 3.8, p=0.07) higher DBP during 18 hours, with 2.0 mmHg (95%CI 0.0 , 4.0, p=0.06) during work hours, and with 1.3 mmHg (95%CI -1.1, 3.8, p=0.29) after hours. The respective associations with SBP were 1.9 mmHg (95%CI -1.0, 4.8, p=0.20) over the 18 hour period and 2.4 mmHg (95%CI -0.5, 5.4, p=0.10) during work hours but little change after hours. PP showed no changes with the exception of PP after hours when ERI>1 was associated with a 2.0 mmHg lower PP (95%CI -4.2, 0.3, p=0.08).

Table 3.5 and Figure 3.1 show the associations of ERI with after-hours blood and pulse pressure and the modifying role of the number of dependents in the home on these associations. Although a borderline significant statistical interaction (p<.20) was only reached for DBP (SBP interaction term= -2.04, p=0.76; DBP interaction term= -1.61, p=0.14; PP interaction term= -0.44, p=0.65), an interaction between the number of dependents and ERI is indicated by average ABP being about 2 mmHg lower among those with dependents at home compared to those living without dependents. Figure 3.1 shows the decrease in point effect estimates with increasing numbers of dependents.

3.5 Discussion

Summary

In this study we found consistent, positive associations of ERI with ABP, particularly SBP, and inverse associations with rewards. However, while 88% of the BP measurements were higher relative to higher ERI, most associations were imprecise. Younger age and more dependents at home attenuated the associations between ERI and ABP. Compared to job strain, the associations of ERI with ABP were substantially weaker, though both job measures of job stress were associated with higher ABP.

Effects of Effort-Reward Imbalance on Blood Pressure

Associations between different measures of work stress such as ERI and job strain and elevations of blood pressure have been documented in the literature[17–22], however, a recent systematic review reported consistent risks of elevated blood pressure (or hypertension) for men only, while the results were not consistent for working women[20]. Physiological studies have suggested that ERI can increase allostatic load in women[18,93], but increased cortisol levels were more consistently reported for men than women[94]. The deleterious health effects of ERI with regard to common cardiovascular disease outcomes such as hypertension [21,22,24,86–88], CVD, CHD and IHD[31,95,96] have more consistently been reported for men than women as well. In a 2014 meta-analysis of 11 cross-sectional studies on ERI and blood pressure, only six studies reported gender-specific results, and of those only one found a statistically significant positive association between ERI and BP for women[20]. A systematic review of 26 prospective cohort studies from 2006 found consistent positive associations between job stress CVD risk in male or male-dominated samples but only for one of the three female samples[23]. However, a more recent and larger individual participant meta-analysis of work stress and CHD outcomes from 2012 by the same research group found similarly increased CVD risks for both genders[34]. Still, one of the eleven reviewed female cohorts, the Nurses Health Study of 35,000 female nurses did not find an increased CHD risk[47].

These inconsistent findings for females in the literature could be due to a number of factors. One could be gender differences in physiological responses to stress. Work stressors change hormonal responses like allostatic load[18] and cortisol secretion[93] in both genders but some studies found the response to be stronger among men than women[94]. Fewer female study subjects and inconsistencies due to use of casual instead of ambulatory blood pressure have been cited as other possible explanations[20,24,25]. Our study was restricted to female subjects and used ambulatory measurements and identified positive associations of ERI and inverse associations of rewards with SBP, although the effects were relatively small and mostly imprecise.

Findings may also differ by job stress measure. In our population job strain was more strongly associated with BP than ERI[85]. For example, the association between job strain on after hours ABP was 1.5 to 6 mmHg stronger than for ERI (Table 3.6). Similar differences were observed for 18-hr SBP and pulse pressure. A study of 74 female call handler operators in Italy found similar weak or null associations with ERI's respective subscales [97]. These contrasting findings indicate that job strain and ERI may capture different aspects of job stress in different populations and that researchers should not rely on just one instrument when measuring job stress.

Another possible explanation for the inconsistent findings could be cultural differences between this mostly Latina population and other study populations. For example, the ERI instrument may not accurately capture relevant efforts and rewards in this population. When the ERI effort and reward subscales were analyzed separately, efforts were less associated with ABP than rewards. The resultant ERI construct might not have fully captured the imbalance at work. The ERI scales were originally developed among populations of highly skilled workers in the context of a very comprehensive guaranteed mandatory German benefit package[84]. It could be that the low wage immigrant workers in our study reported higher rewards given their relative stable unionized jobs providing generous health insurance coverage in the context of the US system where low wage immigrant workers generally have little job security, few benefits, and – at least at the time of the study in 2002 – rarely any health insurance coverage. The resultant misclassification of rewards may have led to a weaker relationship with blood pressure than observed in other studies. Since a recent study conducted in Latin America did show the validity of the ERI tool among a group of mostly female Latinx[98], the predominant group in our study population, different perceptions of efforts and rewards due to ethnicity or language alone are not a likely explanation. A more complex intersection of immigration-status, ethnicity and other significant cultural influences may be operative instead. The unexpected findings of a potential buffering effect of higher numbers of dependents needing care at home on the relationship between ERI and ABP observed in our study population could be also be considered an indicator for the possible influence of cultural and contextual factors[85].

Finally, the fact that work stress was assessed based on self-report could have contributed to inconsistent findings. A study by Greiner et al. compared different methods of assessing work stressors, comparing more objective with more subjective measurement methods[82]. Self-reported stressors at the individual level appeared inconsistently associated with hypertension, while more objective group-based and observer-based measures of job stress were more strongly and consistently associated with hypertension[82]. We therefore believe that self-report would most likely have led to an underestimation of the ERI effects in our study and in the literature in general.

Effect Modification by Age

We observed a tendency that ERI had stronger associations with 18-hr and work hours DBP among women above the age of 45. Another study also found the strongest associations among women above 45 years of age[19], further supporting potential effect modification by age. It is possible that the stronger effects in older immigrants reflect more acculturation leading to an attenuation of the potentially protective effects described in the literature as the Hispanic health paradox[37]. In any case, researchers should consider effect modification by age when evaluating the effects of work stress on blood pressure.

Strengths and Limitations

A unique strength of this study was access to a large sample of understudied mostly immigrant low wage female workers combined with a comprehensive set of work stress and ABP measurements. Most of the studies evaluating ERI and blood pressure were limited to using casual/resting blood pressure, while this study used ABP measures to evaluate possible reasons of blood pressure health inequalities that were reported earlier for this population based on resting BP[37]. Ambulatory measures better capture blood pressure variations related to daily activities thereby reducing information bias, especially the so-called "white-coat" and “masked hypertension” effects[27,28,30]. Studies that compared resting/casual (in-clinic) to ambulatory BP measures have found that ambulatory measures are less prone to measurement error and tend to be better predictors of cardiovascular disease outcomes[30,75–77]. Other research suggests that workers in a high strain environment – similar to hotel room cleaners’ work environment – exhibit higher prevalence of the white-coat effect[78]; emphasizing the importance of supplementing casual in-clinic with ABP measures among such populations. ABP measures provide better precision by capturing the BP fluctuations within and between work and home or clinic and make it possible to capture “masked” hypertension, defined as elevated ambulatory BP in the presence of normal resting casual BP. The prevalence of masked hypertension has been estimated to be between 8 –30% in the general population[20,99–102].

In addition, this study assessed both psychosocial and physical work environments. We included key potential confounders including health behaviors and extensive occupation-specific measures of physical workload, work intensification, and ergonomic problems. The questionnaire also included two standard measures of job stress conceptualized as ERI and job strain. Having two key measures of work stress and a comprehensive set of potential confounders allowed us to evaluate the effects of work stress on blood pressure.

In this study, both measures of stress were measured using a validated questionnaire, based on self-report of job stress. Although the questionnaire was developed with participant input and subsequently validated, its measurement perception of stress can be affected by personality, affect, and attitudes. In other publications where authors compared subjective versus objective measures of job stress, these different methods affected the overall results[25,82]. A recent paper by Bell *et al*. discussed the overall content validity of work stress models including the ERI tool[103]. They evaluated the validity of demand, control, effort, and reward subscales via health psychologist expert judgment in terms of relevance and representativeness of each scale and also in terms of discriminant validity. While the JCQ questionnaire was judged to provide valid measures for the demand and control constructs, and the ERI questionnaire for the reward subscale, the ERI's effort items were judged to lack both content and especially discriminant validity. Specifically, only one of five effort items ("My job is physically demanding") was judged to measure effort only while the other four were judged to measure control and effort. Our study excluded this one item from the effort subscale because of its overlap with physical workload measures. Physical workload was also found to be associated with ERI in our population ($B= 0.04$, $p< 0.01$). Because physical workload was associated with ERI, by controlling for physical workload we may have overcontrolled for some of the effects of effort in the ERI scales and could have contributed to the weak associations in the study. This issue may explain why associations with ABP were stronger for reward than for effort subscales in our study and why the ERI model showed an overall weaker prediction compared to the Demand-Control model previously examined in this population[85]. It should also be noted that physical workload was comprehensively controlled for in our analyses which could be expected to weaken the predictive ability of job stress measures that are partially based on physical demands or efforts rather than solely on psychological ones. The greater attenuation of age-adjusted effort effects (compared to attenuation of reward effects) in fully-adjusted models (further adjusting for two physical workload and one ergonomic index measures) observed in our study are consistent with this expectation. Ultimately, these finding suggest that researchers should consider multiple measures of work stress, including ERI and job strain, validate these measures through observer-based assessments and collaborative research like community-based participatory research and evaluate the work stress subscales for their efficacy in their populations while simultaneously control for physical workload and other ergonomic factors.

To our knowledge no other study of ERI and blood pressure controlled for physical workload and other potential confounders in such a comprehensive manner and comparisons of effect measures from our age-adjusted and fully adjusted models (as shown in table 3.2) indicate that weak and inconsistent findings in the literature may be related to insufficient control for these factors.

Our community-based participatory research approach was instrumental in achieving a high response rates of 74% percent for the questionnaire component, making initial selection bias by recruitment unlikely[51,52]. The subsequent self-selection of the first 589 participants in the ABP study component could have introduced selection bias, however, when we compared subjects who participated only in the survey with those who participated in both the survey and the ABP portion, we saw no substantial differences in age, job stress or workload (Table 3.7). There were small differences in proportions of people when stratified on race and hotel site such that the ABP portion tended to have more Mexican Americans and slightly higher representation from Hotels C and E, but those factors were controlled for in the analysis.

In interpreting the point estimates and their confidence intervals overall, we noted that the estimates were consistently positive, and the confidence interval estimates were more straddled above the null than below. We also drew on causal inference literature and guidelines from the American Statistical Association that discourage dichotomous interpretation of results using statistical significance or p-values[106,107]. Further, in line with a recent guideline by a consortium of influential journal editors and recognized by causal inference researchers[108], we focused on interpreting the overall effect and confidence interval estimates in terms of magnitude, direction and precision[109,110]. For the purposes of this study, we interpreted the point estimates[108] accordingly and did not dismiss confidence intervals that included the null as “no association” because the upper bound was “not plausibly excluded”. Our imprecise results seem to be more consistent with “best-supported” positive associations (in the narrow statistical sense of having maximum likelihood)[110] than true null associations or “no associations found”.

Finally, while we followed guidance on interpreting confidence intervals, our point estimates of the measures of the associations had wide confidence intervals, especially in stratified analyses of smaller subgroups. This loss of precision may be explained by the smaller sample size of these subgroups and by a lack of variation in job characteristics since the entire study population performed virtually identical hotel cleaning jobs. Though the ERI scores did vary in our sample, the subjective differences inherent to ERI and respective subscales may not as much reflect objective differences in jobs and working conditions that would be expected to be present in a larger worker population performing a wide variety of jobs in different industries. This lack of variation can lead to parsing apart smaller differences in the ERI score and introduce uncertainty. This was the case in a meta-analysis of job strain and ambulatory BP where weaker associations were found in single-occupation studies than in general population studies, which was likely due to the more restricted range in objective job characteristics in the single-occupation studies[28]. Despite this limitation, the observed positive associations between ERI and ABP and between job strain and ABP lend additional support to a positive association between job stress and elevated blood pressure. While the observed effect sizes in our study of about 1-2 mmHg may be considered relatively small, large cohort studies have shown that 1 mmHg change in SBP alone in the general population could increase heart failure incidence by 13 to 20 cases per 100,000 and 9 to 14 per 100,000 for coronary heart disease at a population level[111].

Conclusions

In this population, ERI was associated with higher systolic blood pressure and pulse pressure, and higher rewards were associated with lower blood pressures as expected, although nearly all confidence intervals straddled zero effects. Effects of ERI on BP were modified by age, where women over age 45 displayed stronger associations between ERI and ABP. Associations with ABP were much stronger for job stress measures based on job strain compared to ERI. Although observed ERI effects on ABP may be considered of relatively little clinical relevance at the individual level, such relatively small increases in blood pressure have been shown to substantially increase CVD incidence at the population level[111,112].

Combined with the myriad other health effects of work stress such as musculoskeletal injury, clinical depression, decreased leisure time physical activity, to name a few[7,46,72,113,114], our findings suggest that comprehensive workplace interventions in this particular population may be warranted that reduce both work stressors and physical workloads. To address the many different adverse health effects of work stress, companies and any worksite wellness or occupational safety and health programs should in general consider multi-pronged, evidence-based worksite interventions similar to Total Worker Health initiatives proposed by the National Institute for Occupational Safety and Health (NIOSH) that include policies to increase worker control and flexibility on how to perform their work tasks, strategies for supervisors to reduce stressful working conditions, specific cardiovascular health promotion efforts, and skill-building interventions for stress management in the workplace[73,74]. Collective bargaining language that reduces physical workloads[89] and may improve support from supervisors for hotel room cleaners also need to be evaluated for their impact on workers' blood pressure and overall health.

In conclusion, our findings, together with a previously observed elevated rate of uncontrolled hypertension in this population[37], indicate a need for multi-pronged workplace interventions that combine systematic blood pressure surveillance with reduction of organizational work stressors and stress management programs in this vulnerable population.

3.6 Tables and Figures

Table 3.1: Sociodemographic and job characteristics of female Las Vegas hotel room cleaners by hypertension status (*n* = 419)

	Total (*n* = 419)			Hypertensive* (*n* = 86)		Normotensive (*n* = 333)	
Sociodemographic Factors	**n**	**mean/%**	**range**	**n**	**mean/%**	**n**	**mean/%**
Age	407	41.6	21,66	83	49.9	324	39.4
20-34	90	22.1%		4	4.8%	86	26.5%
35-44	169	41.5%		14	16.9%	155	47.8%
45-59	136	33.4%		58	69.9%	78	24.1%
60 or older	12	3.0%		7	8..4%	5	1.5%
Race/Ethnicity	407						
White, non-Hispanic	10	2.5%		3	3.6%	7	2.2%
Black, non-Hispanic	18	4.4%		7	8.4%	11	3.4%
Mexican American	222	54.7%		43	51.8%	179	55.3%
Other Hispanic	130	32.0%		23	27.7%	107	33.0%
Other	27	6.4%		7	8.4%	20	6.2%
BMI (kg/m^2)	407	28.6	17.6, 49.3	83	30.1	324	28.2
Years of Education	407	9.0	0, 21	83	8.3	324	9.2
Foreign-Born Status	404						
U.S. Born	50	12.4%		11	13.3%	39	12.2%
Born Outside the U.S.	354	87.6%		72	86.8%	282	87.9%
Smoking Status	405						
Smoker	52	12.8%		10	12.1%	42	13.0%
Non-Smoker	353	87.2%		73	88.0%	280	87.0%
No. Adults/Household	328	3.0	1, 9	62	3.1	266	3.0
No. Dependents/Household	363	1.1	0, 9	72	0.8	291	1.1
Psychosocial Job Factors							
Effort-Reward Imbalance (ERI) Ratio (Continuous)[a]	407	1.5	0.2, 5.0	83	1.4	324	1.5
Effort Subscale	407	21.2	6, 30	83	20.4	324	21.4
Reward Subscale	407	33.8	11, 55	83	34.4	324	33.6
ERI (dichotomous >1)[a]	253	62.2%		50	60.2%	203	62.7%
Job Strain[b]	390	0.7	0.2, 1.8	77	0.7	313	0.7
Demand Subscale	390	36.5	18, 48	77	35.7	313	36.7
Control Subscale	390	56.1	24, 86	77	54.2	313	56.5
Physical Work Load							
No. of hours worked per week	407	39.7	16, 50	83	39.5	324	39.7
No. of beds made per day	407	19.9	4, 40	83	19.8	324	20.0
Workload Index[c]	405	5.5	0.2, 16.0	83	5.4	322	5.6
Ergonomic Index[d]	406	0.1	-1.5, 1.2	83	0.0	323	0.1
No. of years as cleaner at a hotel	407	6.5	0.5, 32.0	83	8.6	324	6.0
Hotel Sites	407						
Hotel A	100	24.6%		25	30.1%	75	23.2%
Hotel B	87	21.4%		10	12.1%	77	23.8%
Hotel C	97	23.8%		19	22.9%	78	24.1%
Hotel D	59	14.5%		6	7.2%	53	16.4%
Hotel E	64	15.7%		23	27.7%	41	12.7%

* Hypertension defined by self-reported use of anti-hypertensive medication or average daytime ambulatory blood pressure (systolic >135 mmHg or diastolic >85 mmHg)

[a] Effort Reward Imbalance (ERI) ratio operationalized at the individual level as continuous variable (effort subscale divided by reward subscale) and as dichotomous variable (quotient of effort and reward subscales > 1 yes/no)
[b] Job Strain defined as continuous variable (psychological job demand subscale divided by decision latitude)
[c] A higher score on the physical workload index indicates more physical work demands.
[d] A higher score on the ergonomic index indicates greater ergonomic problems.

Table 3.2: Associations between effort-reward imbalance ratio (ERI), effort and reward subscales and ambulatory blood pressure by time of day among female Las Vegas hotel room cleaners (*n* = 407)

	18-hr Ambulatory Blood Pressure						Work Hours Ambulatory Blood Pressure						After Hours Ambulatory Blood Pressure					
	Systolic		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*	
	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*
Effort-Reward Imbalance*																		
Model 1	0.5	0.70	-0.5	0.59	1.1	0.19	0.3	0.82	-0.7	0.47	1.0	-0.21	0.0	1.00	-0.8	0.48	0.9	0.39
	-2.3, 3.3		-2.4, 1.4		-0.5, 2.7		-2.5, 3.1		-2.7, 1.2		-0.6, 2.7		-3.6, 3.6		-3.1, 1.5		-1.2, 3.0	
Model 2	1.2	0.42	0.2	0.87	1.0	0.22	1.0	0.49	0.0	0.99	1.0	0.24	0.3	0.88	-0.42	0.73	0.77	0.48
	-1.7, 4.0		-1.8, 2.1		-0.6, 2.6		-1.8, 3.8		-2.0, 2.0		-0.7, 2.7		-3.3, 3.9		-2.8, 2.0		-1.4, 2.9	
Model 3	1.6	0.34	0.8	0.46	0.7	0.43	1.3	0.41	0.8	0.50	0.6	0.55	1.3	0.53	0.0	0.99	1.3	0.29
	-1.6, 4.7		-1.4, 3.0		-1.1, 2.5		-1.8, 4.5		-1.5, 3.0		-1.3, 2.5		-2.8, 5.4		-2.7, 2.7		-1.1, 3.7	
Effort Subscale*																		
Model 1	-2.0	0.11	-1.6	0.05	-0.3	0.62	-2.2	0.08	-1.8	0.04	-0.4	0.55	-2.0	0.21	-1.9	0.06	0.0	0.98
	-4.4, 0.5		-3.3, 0.0		-1.7, 1.0		-4.7, 0.2		-3.5, -0.1		-1.9, 1.0		-5.1, 1.1		-3.9, 0.1		-1.9, 1.8	
Model 2	-1.4	0.26	-1.1	0.19	-0.3	0.69	-1.6	0.20	-1.2	0.15	-0.4	0.63	-1.8	0.28	-1.6	0.12	-0.07	0.94
	-3.9, 1.0		-2.8, 0.6		-1.7, 1.1		-4.1, 0.9		-3.0, 0.5		-1.8, 1.1		-4.3, 0.4		-3.7, 0.4		-1.9, 1.8	
Model 3	-1.5	0.31	-0.6	0.55	-0.9	0.29	-1.7	0.23	-0.6	0.55	-1.1	0.19	-1.1	0.57	-1.7	0.18	0.5	0.63
	-4.3, 1.4		-2.6, 1.4		-2.5, 0.7		-4.6, 1.1		-2.6, 1.4		-2.8, 0.6		-4.8, 2.7		-4.1, 0.8		-1.7, 2.7	
Rewards Subscale*																		
Model 1	-0.6	0.61	0.7	0.38	-1.2	0.05	-0.3	0.81	0.8	0.27	-1.2	0.09	-1.4	0.30	0.1	0.88	-1.7	0.04
	-2.7, 1.6		-0.8, 2.1		2.0, 0.0		-2.4, 1.9		-0.7, 2.3		-2.4, 0.2		-4.2, 1.3		-1.6, 1.9		-3.3, -0.1	
Model 2	-1.0	0.39	0.2	0.83	-1.1	0.08	-0.7	0.51	0.3	0.70	-1.0	0.12	-1.4	0.33	0.0	0.99	-1.9	0.04
	-3.1, 1.2		-1.3, 1.7		-2.4, 0.1		-2.9, 1.5		-1.2, 1.8		-2.3, 0.3		-4.2, 1.4		-1.8, 1.8		-3.8, -0.1	
Model 3	-0.8	0.52	-0.4		-0.8	0.28	-0.5	0.68	0.0	0.96	-0.6	0.45	-2.2	0.18	-0.4	0.74	-1.9	0.04
	-3.3, 1.7		-1.8, 1.7	0.97	-2.2, 0.6		-3.0, 2.0		-1.7, 1.8		-2.0, 0.9		-5.4, 1.0		-2.5, 1.8		-2.8, 0.0	

Model 1: Adjusted for age.

Model 2: Model 1 plus race, BMI, years of education, foreign-born status, smoking status and self-reported hypertension medication.

Model 3: Model 2 plus hours worked in a week, number of beds, workload index, ergonomic index, years as a cleaner, and hotel site.

* Independent variables rescaled to a range of 0 to 2 for comparison. One unit of any rescaled variable equals one half of the full range of this variable as shown in Table 3.1.

Table 3.3: Associations between effort reward imbalance ratio (ERI) and ambulatory blood pressure by age groups and time of day among female Las Vegas hotel room cleaners (*n* = 407)

	18-hr Ambulatory Blood Pressure						Work Hours Ambulatory Blood Pressure						After Hours Ambulatory Blood Pressure					
	Systolic		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*	
	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*
Ages <45 year (n=259)																		
Fully Adjusted	1.0 -2.7, 4.7	0.59	0.0 -2.6, 2.5	0.98	1.0 -1.0, 3.1	0.32	1.2 -2.5, 4.9	0.53	0.0 -2.6, 2.6	1.00	1.2 -1.0, 3.4	0.28	-0.3 -4.9, 4.3	0.89	-0.9 -4.2, 2.4	0.58	0.7 -2.1, 3.4	0.63
Ages $\geq$ 45 years (n=148)																		
Fully Adjusted	0.9 -5.3, 7.0	0.78	2.1 -2.0, 6.3	0.32	-1.2 -4.7, 2.2	0.48	0.4 -5.7, 6.6	0.89	2.2 -2.1, 6.4	0.31	-1.7 -5.4, 1.9	0.35	0.8 -7.5, 9.1	0.85	0.4 -4.6, 5.4	0.88	0.4 -4.3, 5.0	0.87

Fully Adjusted: Age, race, BMI, years of education, foreign-born status, smoking status, self-reported hypertension medication, hours worked in a week, number of beds, workload index, ergonomic index, years as a cleaner, and hotel site.

Independent variables rescaled to a range of 0 to 2 for comparison. One unit of any rescaled variable equals one-half of the full range of this variable as shown in Table 3.1.

Table 3.4: Associations between dichotomized effort-reward imbalance ratio (ERI>1) and ambulatory blood pressure among female Las Vegas hotel room cleaners (*n*= 407)

	18-hr Ambulatory Blood Pressure						Work Hours Ambulatory Blood Pressure						After Hours Ambulatory Blood Pressure					
	Systolic		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*		*Systolic*		*Diastolic*		*Pulse Pressure*	
	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*	mmHg 95% CI	*p*
Effort-Reward Imbalance*																		
Fully Adjusted	1.9 -1.0, 4.8	0.20	1.8 -0.2, 3.8	0.07	0.1 -1.5, 1.7	0.92	2.4 -0.5, 5.4	0.10	2.0 0.0, 4.0	0.06	0.5 -1.3, 2.2	0.60	-0.5 -4.3, 3.2	0.78	1.3 -1.1, 3.8	0.29	-2.0 -4.2, 0.3	0.08

Fully Adjusted: Age, race, BMI, years of education, foreign-born status, smoking status, self-reported hypertension medication, hours worked in a week, number of beds, workload index, ergonomic index, years as a cleaner, and hotel site.

* ERI defined dichotomously as ERI ratio (efforts subscale divided by rewards subscale)>1.

Table 3.5: Modifying effects of the number of dependents on the association between effort-reward imbalance ratio (ERI) and after hours ambulatory blood pressure (ABP) among female Las Vegas hotel room cleaners (*n*=407)

	Systolic ABP			Diastolic ABP			Pulse Pressure		
	mmHg	95% CI	p	mmHg	95% CI	p	mmHg	95% CI	p
Effort-Reward Imbalance ERI									
Model 4	1.06	-3.08, 5.19	0.62	-0.06	-2.79, 2.66	0.96	1.12	-1.30, 3.55	0.36
Model 5	3.36[a]	-1.88, 8.60	0.21	1.81[b]	-1.66, 5.29	0.31	1.54[c]	-1.52, 4.60	0.32

Model 4: Adjusted for age, race, BMI, years of education, foreign-born status, smoking status, self-reported hypertension medication, ergonomic index, number of beds, workload index, hours worked per week, years as a cleaner, and hotel site. The effects shown based on model 4 are average effects not accounting for interaction with number of dependents.
Model 5: Model 4 plus number of dependents and interaction term (ERI multiplied by number of dependents). The effects shown based on model 5 account for interaction with number of dependents and refer to those workers without any dependents at home.

a) Interaction term ERIxDependents not statistically significant (B=-2.04, p=0.76)

b) Interaction term ERIxDepenedents statistically significant (B=-1.61, p=0.14)

c) Interaction term ERIxDependents not statistically significant (B=-0.44, p=0.65)

Table 3.6: Associations of effort-reward imbalance ratio (ERI) and job strain with ambulatory blood pressure among female Las Vegas hotel room cleaners (*n*=407)

	18-hr Ambulatory Blood Pressure									After Hours Ambulatory Blood Pressure								
	Systolic			Diastolic			Pulse Pressure			Systolic			Diastolic			Pulse Pressure		
	mmHg	95% CI	p	mmHg	95% CI	p	mmHg	95% CI	p	mmHg	95% CI	p	mmHg	95% CI	p	mmHg	95% CI	P
Effort-Reward Imbalance*																		
Fully Adjusted	1.6	-1.6, 4.7	0.34	0.8	-1.4, 3.0	0.46	0.7	-1.1, 2.5	0.43	1.3	-2.8, 5.4	0.53	0.0	-2.7, 2.7	0.99	1.3	-1.1, 3.7	0.29
Job Strain*																		
Fully Adjusted	3.1	-0.9, 7.2	0.13	0.8	-2.1, 3.7	0.59	2.3	0.1, 4.6	0.04	7.3	1.9, 12.6	0.01	1.5	-2.1, 5.1	0.42	6.0	2.9, 9.2	<0.01

Fully Adjusted: Age, race, BMI, years of education, foreign-born status, smoking status, self-reported hypertension medication, hours worked per week, number of beds, workload index, ergonomic index, years as a cleaner, and hotel site.

* Independent variables rescaled to a range of 0 to 2. One unit of any rescaled variable equals one-half of the full range of this variable as shown in Table 3.1.

Table 3.7: Sociodemographic and job characteristics of female Las Vegas hotel room cleaners — full sample versus participants in the ambulatory blood pressure sub-study

	Total (*n*=941)			Ambulatory BP Sub-study (*n*=454)		
Sociodemographic Factors	**n**	**mean/%**	**range**	**n**	**mean/%**	**range**
Age	917	41.7	20,67	454	41.6	21,66
Gender	922			454		
Female	913	99.0%		442	98.8%	
Male	9	1.0%		5	1.1%	
Race/Ethnicity*	928			451		
White, non-Hispanic	55	5.9%		10	2.2%	
Black, non-Hispanic	51	5.5%		20	4.4%	
Mexican American	421	45.4%		241	53.4%	
Other Hispanic	289	31.1%		153	33.9%	
Other	112	12.1%		27	6.0%	
BMI (kg/m^2)	941	28.6	17.6, 49.3	454	28.7	17.6, 49.3
Years of Education	941	9.3	0, 22	454	9.1	0, 21
Foreign-Born Status	919			447		
U.S. Born	138	15.0%		52	11.6%	
Born Outside the U.S.	781	85.0%		395	88.4%	
Smoking Status	732			451		
Smoker	116	15.9%		58	12.9%	
Non-Smoker	616	84.2%		393	87.1%	
No. Adults/Household	671	3.0	1, 9	368	3.0	1, 9
No. Dependents/Household	805	1.0	0, 9	393	1.0	0, 9
Psychosocial Job Factors						
Effort-Reward Imbalance (ERI) Ratio (Continuous)[a]	845	1.4	0.2, 5.0	413	1.5	0.2, 5.0
Effort Subscale	908	20.8	6, 30	443	21.1	6, 30
Reward Subscale	856	35.4	11, 55	415	33.9	11, 55
ERI (Dichotomous >1)[a]	845	57.2%		413	61.7%	
Job Strain[b]	881	0.7	0.2, 1.8	425	0.7	0.2, 1.8
Demand Subscale	893	56.1	24, 88	433	56.4	24, 86
Control Subscale	893	36.6	12, 48	433	36.3	18, 48
Physical Work Load						
No. of hours worked per week	941	39.8	3, 50	454	39.7	16, 50
No. of beds made per day	941	19.4	2, 40	454	19.8	4, 40
Workload Index[c]	933	5.4	0, 16	452	5.5	0, 16
Ergonomic Index[d]	930	0.0	-2.1, 1.2	452	0.1	-2.1, 1.2
No. of years as cleaner at a hotel	941	6.3	0.5, 32	454	6.5	0.5, 32
Hotel Sites*	941			454		
Hotel A	271	28.8%		116	25.6%	
Hotel B	228	24.2%		96	21.2%	
Hotel C	197	20.9%		108	23.8%	
Hotel D	141	15.0%		65	14.3%	
Hotel E	104	11.1%		69	15.2%	

* Significant difference ($p<0.05$)
[a] Effort Reward Imbalance (ERI) ratio operationalized at the individual level as continuous variable (effort subscale divided by reward subscale) and alternatively as dichotomous variable (quotient of effort and reward subscales > 1 yes/no)
[b] Job Strain defined as continuous variable (psychological job demand subscale divided by decision latitude)
[c] A higher score on the physical workload index indicates more physical work demands.
[d] A higher score on the ergonomic index indicates greater ergonomic problems.

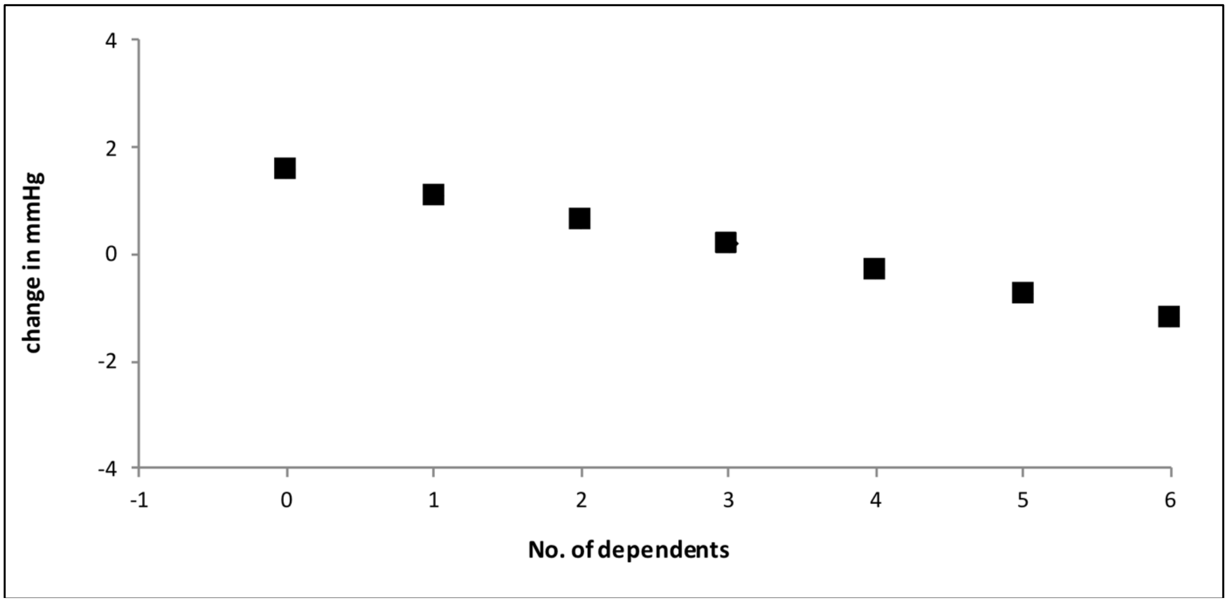

Figure 3.1: Association of after-work hours SBP in mmHg with increasing number of dependents.

CHAPTER 4: DEVELOPMENT AND APPLICATION OF A MEASUREMENT ERROR CORRECTION MODEL USING RESTING BLOOD PRESSURE TO PREDICT AMBULATORY BLOOD PRESSURE IN A STUDY OF THE ASSOCIATION OF WORK STRESS WITH BLOOD PRESSURE

4.1 Abstract

Objective This study aimed to develop a measurement error correction model that predicts ambulatory blood pressure (ABP) using resting blood pressure (RBP) and other covariates. The measurement error model could be used for regression calibration in studies of the impact of work stress on blood pressure.

Background Studies that used RBP instead of ABP are believed to underestimate the effect of work stress on blood pressure. ABP is a preferred blood pressure measure, although RBP is more readily available.

Methods Work stress, ABP, and RBP were assessed among 391 room cleaners from five hotels during 18 waking hours. A predictive measurement model of ABP was developed using the measured ABP, RBP and covariates. Linear regression models in bootstrapped samples were used to assess associations of measures of work stress—job strain and ERI—with the measured and predicted ABP, compared to RBP.

Results In the adjusted models, a one unit increase in job strain was associated with a 1.9 mmHg increase in systolic RBP (sRBP) (95% CI -2.4, 6.1) and a 3.0 mmHg increase in sRBP (95%CI -0.2, 6.7) using calibrated RBP measurements. For diastolic blood pressure, a one unit increase in job strain was associated with a 0.9 increase (95% (CI -2.1, 3.9) in uncalibrated diastolic RBP (dRBP) and a 1.3 increase (95%CI -2.8, 5.4) in calibrated dRBP. A one unit increase in ERI was associated with a 1.0 mmHg (95% CI -2.4, 4.3) increase in sRBP and a 1.6 mmHg (95% CI -3.8,

6.9) increase in calibrated sRBP. For diastolic blood pressure, a one unit increase in ERI was associated with a 1.4 mmHg increase (95% (CI -0.8, 3.6) in dRBP and a 1.3 increase (95%CI -1.2, 5.2) in calibrated dRBP. The association estimates for SBP for both job strain and ERI were underestimated by a factor of around 1.6 to 1.7 if using RBP versus ABP, respectively. For diastolic BP and job strain, the estimates were approximately the same (0.9 vs. 0.9) for RBP and ABP, with some increases in precision (narrower confidence intervals) among ABP estimates. Finally, among diastolic BP and ERI estimates, it appeared the RBP overestimated the risks compared to ABP.

Conclusions In this population, resting blood pressure underestimated the association between measures of work stress and systolic blood pressure when compared with ambulatory blood pressure. These data show that ABP can be successfully predicted from RBP after applying calibration factors in studies with limited covariates and that only have RBP.

4.2 Introduction

Blood pressure (BP) has been used as a clinical measurement to capture the force of blood pushing against the arterial walls of the body's vasculature since the 1700s[115,116]. At chronically high levels, blood pressure has been implicated as a risk factor for several serious health conditions like coronary heart disease, heart failure, stroke, renal failure and many more[116]. Blood pressure is an informative measurement for researchers and clinicians alike, providing a valuable quantitative measure to assess cardiovascular health and risk for heart-related morbidity and mortality. Researchers conducting observational studies on blood pressure must make choices about measuring blood pressure for the assessment of downstream health risks. Like all measures in epidemiological studies, different measurement techniques introduce varying levels of measurement error. Information bias introduced as a mismeasured variable may make it difficult for a researcher to rule out systematic error as the reason for finding an association, the absence of an association, or the under- or over-estimation of effects.

This has been the case in several studies looking at the effects of work stress and blood pressure. There are two main methods to measure blood pressure: casual, or resting blood pressure (RBP), and ambulatory blood pressure (ABP). Casual, or resting blood pressure is when blood pressure is measured in a relaxing state typically at a single time point in a day. The gold standard for measuring by this method includes using readings taken from a sphygmomanometer and the Korotkoff sound technique by a trained professional[27]. It is preferred for its ease in application, an i*n-situ* measurement for the clinician and the patient. This method can fail, however, to identify true high blood pressure due to the inherent temporal variability of blood pressure during day and activity[117]. A single blood pressure measurement to estimate cardiovascular diseases like hypertension (or chronically high blood pressure), for example, could be overestimated because the person walked up the stairs just before the measurement, or because of the situation in which they are being measured (e.g. the stress of being in the presence of a doctor). Even multiple measurements of RBP, when given in the same setting, can provide a measure of blood pressure that might misrepresent the true health risk. Ambulatory blood pressure uses regular, repeated measures throughout a day to create an average blood pressure measurement[26,27]. This average accounts for the natural variability of blood pressure and has been described to represent the more risky sustained elevated blood pressure[27,30].

In assessing the effects of work stress on blood pressure, studies have described the "often…poor estimate of risk in an individual"[27] casual, resting blood pressure can provide due to the natural variability of blood pressure and its sensitivity to acute stimuli like being in the presence of a physician[20,28]. Previous studies in work stress and blood pressure have reasoned that an absence of an association could be due to the use of resting blood pressure readings[28]. Using resting blood pressure can introduce information bias that could otherwise be attenuated by using ambulatory measurements. Since there are tradeoffs of using ambulatory blood pressure like costly equipment and long-term monitoring especially among workers, there is a benefit to using methods to approximate ABP with RBP measurements.

This study aims to create a regression calibration model for observational studies with RBP, to approximate ambulatory blood pressure using calibrated resting blood pressure. Here we will focus on the observational data analyses from the study of female Las Vegas hotel room cleaners, with emphasis on the influence of ABP calibration for RBP measurements. This study will then evaluate the association estimates of work stress resulting using RBP and calibrated RBP using ABP measurements in the analysis of the relationship between work stress and blood pressure.

4.3 Methods

Study Population

Five unionized Las Vegas hotels, representing five different hotel types (upscale, mid-level, convention, all-suite, and older economy) were included in this study. The eligibility, recruitment, and training of the subjects have been previously described[7,9,37]. Of the eligible 1,276 room cleaners, 941 (74%) attended an off-worksite meeting where they completed a 29-page main survey containing questions on demographics, self-reported health, health behaviors, physical workload, ergonomic problems, job strain, ERI and other work stressors. The survey was developed using a participatory research approach[47], and was provided in English, Spanish and Serbo-Croatian. Trained survey administrators who spoke Spanish, Serbo-Croatian, or one or more Asian languages served as translators for participants with limited reading abilities. Participation was voluntary and incentives were not offered.

All eligible workers were also invited to participate in the ABP component of the study. Resources, including staff time and available blood pressure measurement instruments, limited participation in this ABP component to the first 589 hotel workers who signed up and attended a respective training session. They received a two-hour training that included a description of the study, informed consent and hands-on training on how to measure and record ABP readings during and after work hours. During the training, study staff also repeatedly measured resting blood pressure and administered a short 2-page questionnaire on demographics, history of hypertension diagnosis and treatment, and current workload. 442 of the 589 participants in the ABP study had previously participated in the main survey meetings described above. Of those, 391 participants had measurements for RBP, ABP and answered the questions comprising the effort-reward and job strain subscales. The study was approved by Institutional Review Boards of the University of California at Berkeley and San Francisco.

Blood Pressure Measurements

Volunteers in the ABP component of the study were invited to a training session on conducting self-measurements of ABP. Trained professionals taught participants how to initiate a measurement, and how to record ABP onto a report card immediately after completing different specific activities at work and before and after sleep distributed over a total of 18 waking hours. These measurements started in the evening after the training, ceased during sleep, and were resumed the next morning before work, and continued until the end of their work shift. BP measurements were captured with the Omron HEM-630 device attached to the wrist, which was evaluated for accuracy for at-home measurments[90,91]. Measurements were time-stamped and automatically stored by the device. Upon completion of a pre-described activity, workers were instructed to initiate recording of their blood pressure in a seated position, and to record those measurements on a provided diary card. This diary contained activity pictograms that were matched to the activity they had just performed. The 21 time points listed in the diary included: the beginning and end of their work shift; lunch and other work breaks; specific work-activities like dusting, vacuuming, making beds and pushing/pulling carts; activities after work hours in the evening and one measurement before going to bed. When participants returned their OMRON devices, researchers compared the electronically stored blood pressure measurements with the corresponding written entries in the diary form and corrected any transcription errors. Ambulatory blood pressure averages were computed for three time periods: 1) the total 18-hour day-time period (average of all recordings); 2) time at work from beginning to end of the work shift (on average 8.11 working hours) and 3) after-work hours that included measurements done right after work, after dinner, right before going to bed, and in the morning at home. All but five of the 407 participants (98.8%) had at least four ABP measurements during work hours, and 380 (93.3%) had at least one ABP measurement after work hours. Participants did not take blood pressure measurements during sleep because the device required manual initiation of any recording. Pulse pressure was calculated as the individual difference of systolic and diastolic ABP measurements and averaged for each time period.

Research staff recorded resting blood pressure (RBP) using the same technology and techniques as the ambulatory blood pressure measurements. Resting blood pressure was measured multiple times by study staff during the initial main questionnaire administration, and again measured multiple times during the separate ambulatory blood pressure training. These measurements were averaged together to create a single RBP measurement.

Work Stress Assessment

Job strain were assessed by questions on psychological demands (five items), decision latitude (nine items), coworker support (four items), and supervisor support (three items) from Karasek's Job Content Questionnaire[7,39]. More information on the development of the job strain ratio is mentioned here[85], but in short, total support was the sum of coworker and supervisor support scales. An additional modifier was applied to supervisor support to equally weight supervisor and coworker support scales. Continuous measures of job strain were created following published methods[25]. Job strain ratios were calculated as the psychological demands score divided by the decision latitude score.

ERI was assessed using the questionnaire developed by Siegrist and Peter[84]. Extrinsic effort was measured with 6 items. Reward was measured with 11 items. Overcommitment, an additional construct aimed to assess intrinsic effort, was not measured in this study. More information on the ERI ratio is available here[118], but in short, the ERI ratio was calculated as the efforts score divided by the rewards score. A multiplier was applied to the reward score denominator to equalize the number of items in the subscales.

Covariates

To create a meaningful estimate that can be applied to other studies in work stress and blood pressure, we reviewed the literature for confounders that are consistently included in the assessments. In a meta-analysis published by Gilbert-Ouimet et al[20], the authors noted that in research on the association between work stress and blood pressure the following variables were included as variables for adjustment in the published models: Sociodemographic (age, gender, ethnicity), socioeconomic (education, income, occupation), lifestyle risk factors (smoking, alcohol or caffeine consumption, physical activity, stressful situations, personality traits), biological risk factors (body mass index, waist circumference, known history of cardiovascular disease, diabetes, medication for hypertension, menopausal status, estrogen medication, pregnancy history, sodium intake, cholesterol), and other (marital status, number of children, posture, stress outside work, having eaten a meal, length of time in the current job, and social support at work and outside work) (see Table 4.1).

Among the variables suggested in the literature the final set of confounders for this analysis are listed in Table 4.1. Sociodemographic factors including age, race/ethnicity, years of education, and place of birth (U.S.- versus foreign-born), and number of dependents at home were assessed by questionnaire. Anthropometric variables (body height and weight) were assessed during survey administration using portable scales. Occupation was not included as all members in the study population were hotel rooms cleaners, but income was collected. The final study sample was restricted to females.

Statistical Analysis

We used regression calibration methods from the measurement error literature to approximate the measures of association between work stress and blood pressure[119,120]. Briefly, regression calibration is a statistical method for adjusting point and interval estimates of measures of association obtained from regression models for bias due to measurement error in assessing mismeasured variables[121,122]. The basis of the regression calibration for measurement error analysis is the construction of the calibration model for the generation of the expectation for an unknown variable using data on a measured known variable and selected covariates. Specifically, this study, which had data on both ABP and RBP, aimed to create prediction models of ABP using RBP and other existing covariates that are readily available to other researchers in the literature. Such prediction models can then be used for regression calibration of the potential associations between work stress and measurement-error adjusted RBP (calibrated to mimic ABP). To develop the calibration model, we fitted regression models of the true ABP conditional on RBP and select covariates, and then saved the predicted ABP from these regressions for both systolic and diastolic ABP. We then replaced the observed value RBP in models relating RBP to work stress variables with the predicted ABP from the calibration models to obtain regression calibrated associations between work stress and ABP. In short, in this study, calibration equations were created to provide calibration factors to approximate ABP using RBP measurements (to yield ABP prediction models for use in subsequent regression calibration). The ABP prediction models were based on linear regression analyses with age, race/ethnicity, smoking status body mass index (BMI), self-reported anti-hypertension medication status, and number of years on the job. The measures of job stress, i.e. ERI and job strain, were re-centered and rescaled to a unit range from zero to two for comparison purposes so that a one-unit change represents half the range for each variable. Unstandardized coefficients from the bootstrap models with 100 repetitions are presented as mean differences of blood pressure (e.g., RBP, calibrated RBP and ABP) in mmHg associated with a one-unit difference (half the range) in the ERI and job strain models. We used

Stata statistical software version 14.0 (StataCorp LLC, College Station, Texas) to analyze the study data.

4.4 Results

The demographics for the study are presented in Table 4.2. The majority of the women in this study were below age 44 (86.4%), with the majority between the ages of 35-44 (56.1%). Almost 87% were Hispanic, with the majority (54.2%) being of Mexican American descent and being born outside of the United States (87.1%). Almost 68% had less than a high school education with the average worker ending their education around ninth grade. Finally, most of the women were non-smokers (86.7%) and had a least one dependent at home (55.6%).

Table 4.3 shows coefficients and standard errors from linear regression of ambulatory blood pressure (ABP) and other selected covariates, with resting blood pressure measurements. The fraction of ABP explained by the RBP-calibration 0.60 for systolic and 0.43 for diastolic.

Table 4.4 shows the estimated unstandardized regression coefficients for RBP, RBP with the calibration factor, and ABP measurements. In the fully-adjusted bootstrapped model, a one unit increase in job strain was associated with a 1.9 mmHg increase in systolic RBP (sRBP) (95% CI -2.4, 6.1), a 3.0 mmHg increase calibrated sRBP (95%CI -3.0, 9.1), and a 3.2 mmHg increase in 18-hr systolic ABP (sABP) (95%CI -0.2, 6.7). For diastolic blood pressure, a one unit increase in job strain was associated with a 0.9 increase (95% (CI -2.1, 3.9) in diastolic RBP (dRBP), a 1.3 mmHg increase in calibrated dRBP (95% CI -2.8, 5.4), and a 0.9 increase (95%CI -1.8, 3.5) in 18-hr dABP.

When considering the associations of ERI with RBP and ABP, a one unit increase in ERI was associated with a 1.0 mmHg (95% CI -2.4, 4.3) increase in sRBP, a 1.6 mmHg increase in calibrated sRBP (95% CI -3.8, 6.9), and a 1.6 mmHg (95% CI -1.2, 4.3) increase in 18-hr sABP. For diastolic blood pressure, a one unit increase in ERI was associated with a 1.4 mmHg increase (95% CI -0.8, 3.6) in dRBP, a 2.0 mmHg increase in calibrated dRBP (95%CI -1.2, 5.2), and a 0.3

increase (95%CI -1.5, 2.1) in 18-hr dABP. Calibrated-RBP yielded better approximation for the effects of works stress on ABP for systolic blood pressure, but less so for dRBP.

4.5 Discussion

Summary

In this study, we found that the use of RBP alone underestimates the association between both work stress models and systolic ambulatory blood pressure, but the estimates are less consistent for diastolic blood pressure. We also found that measures of ambulatory blood pressure can be estimated using resting blood pressure by applying regression calibration, and that using the calibrated BP measures replicated the results of the true ABP associations with work stress for the systolic ABP but less so for the diastolic ABP.

Effects of Work Stress on Blood Pressure

Regression calibration provides a valuable approach to strengthening research in work stress and blood pressure. Links between work stress (such as ERI and job strain) and elevated blood pressure levels and hypertension risk have been documented in the literature[17–22], but several inconsistencies have been cited across several papers that lead to inconclusive results. For example, a recent systematic review reported more consistent risks of elevated blood pressure in men than women[20], and a more consistent association among papers that used ABP versus RBP[20,24,25]. This paper looked to evaluate those specific issues.

Ambulatory blood pressure has been lauded over resting blood pressure in work stress literature for a number of reasons. For example, papers have established that ABP is a better predictor than RBP of target organ damage[123,124], and incident cardiovascular disease[125,126], and has a better ability to capture blood pressure variations related to daily activities thereby reducing information bias, especially the so-called "white-coat" and “masked hypertension” effects[27,28,30]. Studies that compared resting/casual (in-clinic) to ambulatory BP measures have found that ambulatory measures are less prone to measurement error and tend to be better predictors of cardiovascular disease outcomes[30,75–77]. Other research suggests that workers in a high strain environment – similar to hotel room cleaners' work environment – exhibit higher prevalence of the white-coat effect[78]; emphasizing the importance of supplementing casual in-clinic with ABP measures among such populations. ABP measures provide better precision by capturing the BP fluctuations within and between work and home or clinic and make it possible to capture "masked" hypertension, defined as elevated ambulatory BP in the presence of normal resting casual BP. The prevalence of masked hypertension has been estimated to be between 8–30% in the general population[20,99–102]. Despite these reported downsides, RBP may still be attractive to researchers for its ease of collection and cost so having estimates to approximate ABP are useful.

Interestingly, among previously published papers in this population, job strain and ERI were more strongly associated with systolic ABP than diastolic ABP[85,118], and this could explain the inconsistency for the underestimate of risk when compared to RBP. In fact, in recent systematic reviews of results among work stress on the effects of blood pressure where the results for diastolic and systolic were presented separately, both reviews reported more consistent and larger increases in systolic BP than diastolic BP[20,28]. Therefore, it is possible that when evaluating the efficacy of the calibration factor, there may be more utility for systolic measurement. This is supported in other studies among women where increases were found either only in systolic blood pressure[22], stronger associations in systolic blood pressure[97,127], or even a reverse association on prevalence of high diastolic blood pressure[128]. Additionally, in a study looking at the effects of gravitational forces in the cardiovascular system and damage in the vascular system that could lead to essential hypertension, the author noted that systolic pressure is an index for the protective elastic resistance of the vascular walls, and increases in systolic pressure indicates an active compensatory response to cardiovascular demand[129]. Further, the author stated that an increase in diastolic pressure alone without an increase in systolic would not indicate additional demand to the cardiovascular system[129]. Though this study designed to evaluate the pathogenesis of hypertension for people who have prolonged sitting – something that would not apply to the active, heavy labor of cleaning hotel rooms – it does point to the physical changes that can develop due to demand to the cardiovascular system and how systolic and diastolic damage can act independently. The increases in systolic blood pressure appear to be more predictive of downstream health effects like coronary heart disease, congestive heart failure, renal failure, and mortality in the literature as well[130,131]. In an important paper from the Framingham heart study, the authors noted that knowing only the systolic blood pressure correctly classified the stage of blood pressure in 99% of adults over age 60 whereas knowing the diastolic blood pressure allowed only 66% to be classified correctly[132]. Finally, our findings of stronger associations among systolic blood pressure, and better estimates for the calibrated sRBP can be more important, despite weaker associations among diastolic blood pressure, and that these estimates can still inform the utility of the calibration factors for resting blood pressure in future studies.

Strengths and Limitations

In this analysis, we used bootstrap regression calibration models that have been shown to preserve efficiency[133], while also accurately developing predictive models using variables collected frequently in work stress studies[20]. Other measurement error correction approaches, including split-sample validations studies, others have been criticized for being inefficient since researchers must by definition only use portions of the data sets lowering the amount of data available for regression analyses[133,134].

In addition to measuring both RBP and ABP and being able to approximate ABP with RBP, this study sample collected a large number of potential confounders in the 29-page questionnaire that allowed us to create a model that was similar to those presented in the literature[20], though we did have to restrict on gender and occupation. Of the 941 participating all were hotel room cleaners, eleven were male and only one of the males had enough data to be included in this analysis. Because of the small sample of males, they were excluded, which could limit the external validity (generalizability) of the calibration factor for systolic RBP measurements. Although we needed to restrict to females, these findings among a large understudied immigrant low wage female working population are increasingly important in an economy where service and labor jobs are increasingly filled by foreign-born and Hispanic residents[135].

Our community-based participatory research approach when developing the questionnaire was instrumental in achieving a high response rate and validation for the covariates. In the original study, 74% of the population participated in the questionnaire component, making initial selection bias by recruitment unlikely[51,52]. Finally, both measures of stress were measured using a validated questionnaire, based on self-report of job stress, and was developed with participant input.

This study was limited to one occupation, hotel room cleaners. In a study by Landsbergis *et al*, the authors state that a limited occupational variance can lead to weaker associations and can reduce the statistical power to detect associations of work stress and blood pressure[28]. Limiting this study to room cleaners, like restricting on gender may affect power. It may also affect generalizability across studies if gender and occupation greatly modify the association. Because we are comparing the effect estimates across blood pressure measurements, we do not believe it would affect the direction of information bias introduced by RBP versus ABP but may affect the magnitude.

We were also unable to evaluate nighttime associations because participants needed to manually initiate the measurement device to start any BP measurements. Night-time BP measures are important for capturing longer spill-over effects from work and detection of any blunted, or non-dipping, nighttime BP pattern that has been previously associated with higher cardiovascular mortality and morbidity compared with normal nighttime BP dips[79–81]. While nighttime BP is important, a study by Boggia *et al* showed that daytime BP alone predicted the 10-year incidence of fatal and non-fatal strokes, cardiac, and coronary events just as well as nighttime BP[136]. Thai said, researchers in work stress and blood pressure should consider capturing 24-hour ABP, but should not discount day time (work hour) measurements.

Conclusions

In this population, ambulatory blood pressure was approximated using RBP using regression calibration methods, and RBP was shown to underestimate the association between work stress and systolic blood pressure when compared with ambulatory blood pressure. Researchers evaluating the effects of work stress who have available resting blood pressure measurements, should consider their results and evaluate if they are an underestimate of the true risk of elevated systolic blood pressure levels.

4.6 Tables and Figures

Table 4.1. Table of covariates for consideration and inclusion in the regression calibration

Category	Presented in the Literature	Final Confounder Set (n=391)
Sociodemographic	**Age, gender*, race/ethnicity**	**Age**, **gender***, **race/ethnicity**
Socioeconomic	**Education, income, occupation**	**Occupation***
Lifestyle	**Smoking**, alcohol or caffeine consumption, leisure time physical activity, stressful situations, personality traits	**Smoking**
Biological	**BMI**, waist circumference, known history of CVD, diabetes, **medication for hypertension**, menopausal status, estrogen medication, pregnancy history, sodium intake, cholesterol	**BMI, medication for hypertension**
Other	Marital status, number of children, posture, stress outside work, having eaten a meal, **length of time in the current job**, and social support at work and outside work	**Number of years on the job**

Bolded variables are included in the final model.
*Sample set is limited to female hotel room cleaners

Table 4.2: Sociodemographic and job characteristics among female hotel room cleaners in Las Vegas (n=391)

Sociodemographic Factors	n	mean/%	range
Age	391	41.3	21, 66
20-34	89	30.3%	
35-44	165	56.1%	
45-59	29	9.9%	
60 or older	11	3.7%	
Race/Ethnicity	391		
White, non-Hispanic	10	2.6%	
Black, non-Hispanic	19	4.9%	
Mexican American	212	54.2%	
Other Hispanic	128	32.7%	
Other	22	5.6%	
Foreign-Born Status	387		
U.S. Born	50	12.9%	
Born Outside the U.S.	337	87.1%	
Socioeconomic Factors			
Years of Education	391	9.1	0, 21
Biological Factors			
BMI (kg/m^2)	391	28.6	17.6, 49.3
Medication for Anti-Hypertension Use	47	12.0%	
Lifestyle and Other Factors			
Smoking Status	391		
Smoker	52	13.3%	
Non-Smoker	339	86.7%	
No. Adults/Household	317	3.0	1, 7
No. Dependents/Household	348	1.1	0, 9
Psychosocial Job Factors			
Job Strain[a]	391	0.7	0.3, 1.8
Demand Subscale	391	56.1	24, 86
Control Subscale	391	36.4	18, 48
Effort-Reward Imbalance (ERI) Ratio Continuous[b]	362	1.5	0.2, 5.0
Effort Subscale	387	21.4	6, 36
Reward Subscale	364	33.4	11, 55
ERI (dichotomous >1)	226	62.4%	
Hotel Sites	407		
Hotel A	106	27.1%	
Hotel B	76	19.4%	
Hotel C	96	24.6%	
Hotel D	56	14.3%	
Hotel E	57	14.6%	

a Job Strain defined as continuous variable (psychological job demand subscale divided by decision latitude)

b Effort Reward Imbalance (ERI) ratio operationalized at the individual level as continuous variable (effort subscale divided by reward subscale) and as dichotomous variable (quotient of effort and reward subscales > 1 yes/no)

Table 4.3. Calibration Equation Coefficients for Resting Blood Pressure and Job Stress measurements[i] given Ambulatory Blood Pressure Measurements and Select Covariates among Female Hotel Room Cleaners (n=391)

	Ambulatory Blood Pressure (ABP)			
	Systolic ABP		Diastolic ABP	
	Coefficient (SE)	R^2	Coefficient (SE)	R^2
Intercept	43.11 (8.48)^		28.23 (5.79)^	
Resting Blood Pressure	0.58 (0.03)^		0.52 (0.04)^	
Age	0.10 (0.05)		0.07 (0.04)	
Race	-0.18 (0.64)			
Black, Non-Hispanic	0.68 (4.88)		-0.49 (3.00)	
Mexican American	0.85 (4.2)		-0.90 (2.90)	
Other Hispanic	-0.19 (4.16)		-0.45 (2.91)	
Other	1.52 (4.65)		0.40 (3.34)	
Body Mass Index (BMI)	0.24 (0.09)^		0.18 (0.06)^	
Non-Smoker	-0.48 (1.20)		0.39 (0.97)	
Medication for HTN	-3.58 (1.86)^		-1.56 (1.02)	
No. of Years Working	0.09 (0.10)		0.08 (5.79)	
Total		0.60		0.43

Abbreviations: ABP, Ambulatory Blood Pressure; No., Number; SE, Standard Error

[i] Independent variables (Job strain and ERI) rescaled to a range of 0 to 2 for comparison. One unit of any rescaled variable equals one half of the full range of this variable as shown in Table I.

^ p = 0.05

Table 4.4. Associations[i] of job strain[ii] and ERI[ii] with resting and ambulatory blood pressures before and after regression calibration analysis of data from female hotel room cleaners in Las Vegas

	Systolic		Diastolic	
	Linear regression coefficient (mean difference)	95% CI	Linear regression coefficient (mean difference)	95% CI
Job Strain (n=391)				
RBP	1.9	(-2.4, 6.1)	0.9	(-2.1, 3.9)
True ABP	3.2	(-0.2, 6.7)	0.9	(-1.8, 3.5)
Predicted ABP (RBP-calibrated)	3.0	(-3.0, 9.1)	1.3	(-2.8, 5.4)
ERI (n=362)				
RBP	1.0	(-2.4, 4.3)	1.4	(-0.8, 3.6)
True ABP	1.6	(-1.2, 4.3)	0.3	(-1.5, 2.1)
Predicted ABP (RBP-calibrated)	1.6	(-3.8, 6.9)	2.0	(-1.2, 5.2)

Abbreviations: ABP, Ambulatory Blood Pressure; CI, Confidence Interval; ERI, Effort-Reward Imbalance; RBP, Resting Blood Pressure

[i] Adjusted for age, race/ethnicity, smoking status, BMI, hypertension medication status, and number of years on the job.

[ii] Exposure variables (Job strain and ERI) rescaled to a range of 0 to 2 for comparison. One unit of any rescaled variable equals one half of the full range of this variable as shown in Table 4.2.

CHAPTER 5: CONCLUSIONS AND PUBLIC HEALTH RELEVANCE

The literature linking job stress with blood pressure and surveys indicating increasing levels of work stress over generations of workers[2] are testaments that work stress and hypertension will continue to be important health issues for years to come. Understanding the underlying risk factors, especially among understudied female working populations, with inclusive measures of job stress and accurate blood pressure measurements are vital for the development of targeted hypertension treatment and prevention programs in these populations. This dissertation provided evidence that work stress does increase blood pressure in this population of female hotel room cleaners, and showed that the use of resting blood pressure does underestimate this risk when compared to ambulatory blood pressure.

This first study showed that job strain increases blood pressure and pulse pressure, especially after work hours. Counter to expectations, the study also showed that social support at work did not attenuate the association, but having dependents needing care at home did. Studies that looked at the effects of work stress and after work hours “spillover effects” typically find domestic commitments exacerbate the effects of work stress. Future studies looking at this effect should consider additional factors like dependents at home and cultural factors that may modify this association. Additionally, in this population it appears that anti-hypertension medication may attenuate the effects of job strain. Altogether, these findings suggest that because work stress can increase blood pressure, work sites can include primary prevention strategies including changes in working conditions, stress management, active ABP surveillance and hypertension management intervention programs.

The second study showed that ERI was associated with higher systolic blood pressure and pulse pressure, and higher rewards were associated with lower blood pressures as expected. In previous studies, age especially among women, was an important modifying factor on the association of ERI and BP. When we stratified on age, we found women over age 45 displayed stronger associations between ERI and ABP. Associations with ABP were stronger for job stress measures based on job strain compared to ERI, which suggests that job stress researchers should consider multiple measures of job stress depending on the work site, the population at risk, and possible cultural differences. Taken together, the first two studies both support the presence of a positive association between job stress and blood pressure among female workers.

In the final study, we found that resting blood pressure did underestimate the association between both work stress models and systolic ambulatory blood pressure and that regression calibration methods can serve as useful research tools in situations where resting blood pressure is readily available. Our study provides an estimate of the magnitude and direction of the bias introduced, and can inform work stress researchers when using RBP in lieu of ABP.

Taken together, these studies contribute to the work stress and blood pressure literature supporting the theory that job strain and ERI increase blood pressure in female workers, including this population of female hotel room cleaners. Additionally, they highlight that certain factors like dependents in the home and age play a role in modifying the effects. Finally, this research provides empirical support for the hypothesis that using resting blood pressure in work stress studies introduces a conservative bias that may underestimate the risk of work stress. Research with understudied working populations using optimal assessment tools will further improve our understanding of the contributions of work to health.

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