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RESEARCH ARTICLE

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Effort-reward imbalance and ambulatory blood pressure among female Las Vegas hotel room cleaners

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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-hour systolic ABP and 18-hour 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-hour systolic blood pressure (SBP) and a 0.7 mmHg (95% CI, −1.1-2.5) increase in 18-hour 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-hour and work hours diastolic ABP, respectively, compared to a 0 mmHg change in 18-hour and work hours diastolic ABP in younger women. 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 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.

KEYWORDS

ambulatory blood pressure, effort-reward imbalance (ERI), female workers, hypertension, job stress

1 | 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.[1] Such a chronic state of stress can cause both physical and mental harm.[1] 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

Institution at which the work was performed: University of California, Los Angeles

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 (eg, 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.[3] 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 isostrain, were found to be positively associated with ABP in this population.[4] Previous research in this population of predominantly female, Mexican American, immigrant workers linked ERI to shoulder and neck injury,[5] general health,[6] and health disparities[7,8] including an increased prevalence of hypertension among the Latina immigrant hotel workers that exceeded prevalence rates in their country of origin.[7]

Risk factors for hypertension like age, gender, smoking, socioeconomic status (social class), and racial/ethnic disparities have been well-described,[9,10] but the potential detrimental effects of ERI on the cardiovascular system appears to be less consistent for women than for men.[11–16] A year 2014 review by Gilbert-Ouimet et al[17] 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.[17] 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 systolic blood pressure (SBP)[16] and hypertension,[15] but observations were limited to white collar female workers[16] 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.[18] In this current study, we will address this study 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 confounding by physical workload and other ergonomic factors.

2 | METHODS

2.1 | 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.[5–7] Of the eligible 1276 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,[19] 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 two-page questionnaire on demographics, history of hypertension diagnosis and treatment, and current workload. Of the 589 in the ABP study, 442 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.

2.2 | 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 were 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.[20,21] 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 daytime 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 (99%) with ERI information had at least four ABP measurements during work hours, and 380 (93%) 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.[22,23]

2.3 | ERI and other psychosocial stressors

Psychosocial work factors were measured by three standard constructs (job strain, isostrain, and ERI) and their respective subscales.[5,6] ERI was assessed using the questionnaire developed by Siegrist and Peter.[3] Extrinsic effort was measured with six 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.[3,24] 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.[25] 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.[25] ERI scores, and the individual effort and rewards subscales, were regressed as continuous measurements standardized to a range from zero to two for comparison purposes.

2.4 | Job strain

In this article, job strain is included only for comparison of work-stress models. Detailed information on assessment and study results have been published separately.[4] In short, job strain was assessed by questions from Karasek's[26] Job Content Questionnaire.[5] Job strain ratios were calculated as the psychological demands score divided by the decision latitude score.

2.5 | Covariates

Sociodemographic factors including age, race/ethnicity, years of education, and place of birth (US vs 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.[5,27]

2.6 | 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 ERI, 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 sociodemographic, 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, TX) for all data analyses.

3 | RESULTS

The characteristics of the study population are presented in Table 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 antihypertensive medication (n = 48) or fulfilling both

TABLE 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						
US Born	50	12.4%		11	13.3%	39	12.2%
Born outside the US	354	87.6%		72	86.8%	282	87.9%
Smoking Status	405						
Smoker	52	12.8%		10	12.1%	42	13.0%
Nonsmoker	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							
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%

Abbreviations: BMI: body mass index; ERI: effort-reward Imbalance.

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

[a]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 subscale).

[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.

criteria (n = 86), per published guidelines for ambulatory daytime blood pressure.[22,23] More than 62% reported relatively low rewards for their efforts (ie, ERI > 1).

Table 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 shows the associations of ERI and ABP stratified by age group. 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 Appendix I (see Supplemental Material), workers with an ERI ratio above 1 were compared to those with an ERI ratio 1 or 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, $P = 0.08$).

Appendix II (see Supplemental Material) and Figure 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 ($P < 0.20$) 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 1 shows the decrease in point effect estimates with increasing numbers of dependents.

4 | DISCUSSION

4.1 | 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.

4.2 | Effects of ERI 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,[14,16,17,28–30] 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.[17] Physiological studies have suggested that ERI can have biological effects on the cardiovascular system in women,[29,31] but possibly more consistent in men.[32] The deleterious effects of ERI with common cardiovascular health outcomes such as hypertension,[11–16] CVD, coronary heart disease (CHD), and IHD,[33–36] are documented but appear to be more consistent in men than women as well. In a 2014 meta-analysis of 11 cross-sectional studies on ERI and blood pressure, only six studies presented results separately for men and women, and of those only one found a positive association between ERI and BP.[17] In a separate meta-analysis of ERI and CHD outcomes, Kivimäki et al[37] reported on

TABLE 2 Associations between ERI ratio, effort and reward subscales, and ambulatory blood pressure by time of day among female Las Vegas hotel room cleaners (n = 407)

	18-h 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*
ERI*																		
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	

Abbreviations: CI: confidence interval; ERI: effort-Reward Imbalance.
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 1.

TABLE 3 Associations between effort ERI and ambulatory blood pressure by age groups and time of day among female Las Vegas hotel room cleaners (n = 407)

	18-h 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
	95% CI		95% CI		95% CI		95% CI		95% CI		95% CI		95% CI		95% CI		95% CI	
Ages < 45, y (n = 259)																		
Fully adjusted	1.0	0.59	0.0	0.98	1.0	0.32	1.2	0.53	0.0	1.00	1.2	0.28	−0.3	0.89	−0.9	0.58	0.7	0.63
	−2.7, 4.7		−2.6, 2.5		−1.0, 3.1		−2.5, 4.9		−2.6, 2.6		−1.0, 3.4		−4.9, 4.3		−4.2, 2.4		−2.1, 3.4	
Ages > 45, y (n = 148)																		
Fully adjusted	0.9	0.78	2.1	0.32	−1.2	0.48	0.4	0.89	2.2	0.31	−1.7	0.35	0.8	0.85	0.4	0.88	0.4	0.87
	−5.3, 7.0		−2.0, 6.3		−4.7, 2.2		−5.7, 6.6		−2.1, 6.4		−5.4, 1.9		−7.5, 9.1		−4.6, 5.4		−4.3, 5.0	

Abbreviations: CI: confidence interval; ERI: effort-reward imbalance.

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 1.

the lack of female samples to test gender differences in ERI. A 2012 meta-analysis of work-related stress also concluded that the association between job stress and cardiovascular diseases in women was not clear.[14,37] One of the eleven reviewed cohort studies that included women used data from the Nurses Health Study that enrolled 35 000 female nurses and this study found women in high strain jobs did not have an increased risk of CHD.[38]

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[29] and cortisol secretion[31] in both genders but some studies found the response to be stronger among men than women.[32] Fewer female study subjects and inconsistencies due to use of casual instead of ambulatory blood pressure have been cited as other possible explanations.[12,17,39] Our study was restricted to female subjects and used ambulatory measurements and identified positive associations of ERI and inverse associations of rewards with SBP, however, effects were relatively small and mostly not statistically significant.

It could also be gender differences, not associated with physiological responses to stress. In our population BP was more strongly associated with job strain than ERI.[4] For example, differences in the magnitude of association between job strain versus ERI on ABP were 1.5 to 6 mmHg for after-hours BP (Appendix III, see Supplemental Material). This was observed for 18-hr SBP and pulse pressure as well. Relatively weak effects of ERI have been documented in other studies among female workers. In a study including 74 female call handler operators in Italy, similar weak or null associations with ERI's respective subscales were also reported.[40] These contrasting findings indicate that job strain and ERI may capture different aspects of job stress in different populations. As a consequence, 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.[3] It could be that the low wage immigrant workers in our study reported higher rewards given that their relative stable unionized jobs provided 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 at all. 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 demonstrated the validity of the ERI tool among a mostly female, all Latinx group,[41] the predominant ethnic group in our study

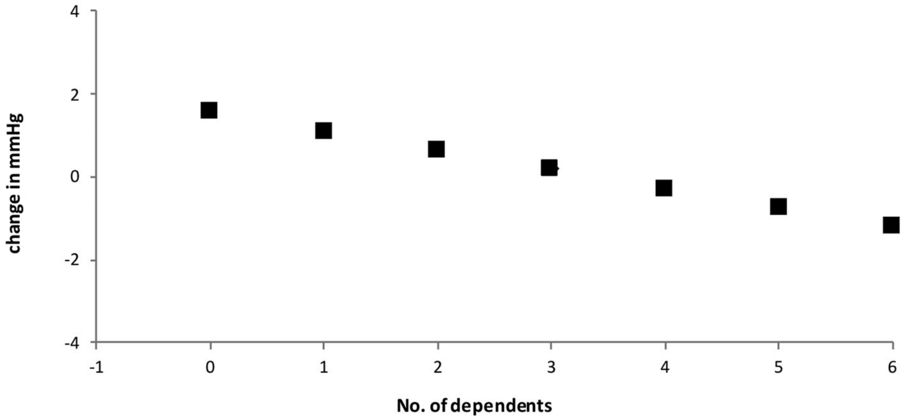

FIGURE 1 Association of after-work hours SBP in mmHg with increasing number of dependents

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 considered an indicator for such influences of cultural and contextual factors.[4]

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.[42] 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.[42] Therefore, we 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.

4.3 | Effect modification by age

We observed a tendency for stronger associations of ERI 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,[30] 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.[7] In any case, researchers should consider effect modification by age when evaluating the effects of work stress on blood pressure.

4.4 | 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.[7] 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.[23,43,44] 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.[43,45–47] Other research suggests that workers in a high strain environment—similar to hotel room cleaners' work environment—exhibit a higher prevalence of the white-coat effect[48]; 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% and 30% in the general population.[17,49–52]

In addition, this study simultaneously assessed both the psychosocial and physical work environment. 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 independent effects of work stress on blood pressure.

Although both measures of stress used standard validated questionnaire instruments, they relied on self-report of job stress. 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.[39,42] A recent article by Bell et al[53] discussed the overall content validity of work stress models including the ERI tool. 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. Although the Job Content 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 significantly associated with ERI in our population (B = 0.04, $P < 0.01$). Because physical workload was significantly associated with ERI, by controlling for physical workload we may have overcontrolled for some of the effects of effort in the ERI scales and that 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.[4] 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 findings 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 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% 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 (Appendix IV, see Supplemental Material). 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.[54,55] Further, in line with a recent guideline by a consortium of influential journal editors and recognized by causal inference researchers,[56] we focused on interpreting the overall effect and confidence interval estimates in terms of magnitude, direction, and precision.[57,58] For the purposes of this study, we interpreted the point estimates[56] accordingly and did not dismiss results with 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)[58] 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.[44] Despite this limitation, the observed positive associations between ERI and ABP and between job strain and ABP lend additional support to existing evidence of 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 population-based cohort studies have shown that an 1 mmHg change in SBP alone could increase incidence of CHD by 9 to 14 cases per 100,000 and heart failure incidence by 13 to 20 cases per 100 000 at the general population level.[59]

5 | 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.[59,60]

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,[5,61–64] 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.[65,66] Collective bargaining language that reduces physical workloads[19] 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,[7] 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.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

Paul Landsbergis declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHORS' CONTRIBUTIONS

MF established the concept and design of the data analysis and interpretation, drafted the papers, and completed the final manuscript. NK led the primary data collection and cleaning used for this analysis, provided feedback on the conception and design of the analysis, and edited and approved manuscripts for publication. Both accept responsibility for the accountability of the work and the integrity and accuracy therein. OAA assessed the design of analysis and provided feedback on the interpretation and implication of results and revised manuscripts.

ETHICS APPROVAL AND INFORMED CONSENT

The research was approved by the Committee on Human Subjects at the University of California at Berkeley.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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