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RESEARCH ARTICLE

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Job strain associated with increases in ambulatory blood and pulse pressure during and after work hours among female hotel room cleaners

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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-h, work hours, and after work hours.

Results: Higher job strain was associated with increased 18-h 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.

KEYWORDS
ambulatory blood pressure, female workers, hypertension, job strain, job stress

1 | INTRODUCTION

Hypertension is one of the most ubiquitous medical conditions in the United States with one in three adults or about 70 million Americans having the condition.[1] High blood pressure and hypertension are major risk factors for cardiovascular diseases (CVD) such as stroke and coronary heart disease and also chronic kidney disease.[1–3] 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.[3] While hypertension is more common among men, almost one in three women will develop the condition.[3]

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,[4–9] but few among low wage and mostly immigrant manual workers such as hotel room cleaners. One such study of hypertension in Haitian immigrant hotel room cleaners reported that individual and organization level factors such as work hours, workload and social support aided in hypertension management among the cleaners.[10] We intended to look at similar factors that may attenuate the association between job strain and ambulatory blood pressure (ABP) in this paper. Previous research with this study population of Las Vegas female hotel room cleaners has linked work-stress to work-related pain,[11] shoulder and neck injury,[12] and poor general health,[13] 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

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

prevalence rates in their country of origin.[14] Moreover, control of hypertension in this population was found to be about 50% lower than in the general U.S. working population.[14] This indicates that these workers are at increased risk for disabling chronic CVD and premature mortality.[14]

To assess why this particular population has such high rates of hypertension, we evaluated potential risk factors. Several risk factors for hypertension like age, gender, socio-economic status (social class), and racial/ethnic disparities have been well-described,[2,3] but the specific psychosocial risk factors like work stress that may be responsible for these disparities have only recently been acknowledged by cardiologists.[15]

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.[16] 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 of 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.[17] 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,[7,8,18,19] some studies report inconclusive results.[20–24] 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.[25–27] 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 | METHODS

2.1 | 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.[12,14,28] In short, participation was voluntary and incentives were not offered. Of the 1276 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,[29] 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. 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 2-h 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 Board of the University of California at Berkeley.

2.2 | 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 h 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-h 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.

2.3 | 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.[12,16] 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.[27] 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.[16,30] The Cronbach's alpha was 0.65 for the decision latitude subscale compared to a range of 0.66-0.72 in the literature.[12,30]

2.4 | 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. Workload items are described in more detail elsewhere.[31]

2.5 | 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 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.

3 | RESULTS

The characteristics of the study sample are summarized in Table 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.[32,33] 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 show the associations between job strain, job control, psychological demands and average ABP and pulse pressure over 18-h 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 to 7.3 P = 0.13) increase in systolic18-h ABP and a 2.3 mmHg increase in 18-h 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 to 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 to 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 to 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).

Table 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 to 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

TABLE 1 Socio-demographic 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 to 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 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-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		mmHg		mmHg		mmHg		mmHg		mmHg		mmHg		mmHg		mmHg	
	95%CI	*P*	95%CI	*P*	95%CI	*P*	95%CI	*P*	95%CI	*P*	95%CI	*P*	95%CI	*P*	95%CI	*P*	95%CI	*P*
Job strain[a]																		
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 to 5.9		−3.0 to 2.5		−0.1 to 4.4		−2.8 to 5.2		−3.1 to 2.5		−0.8 to 3.8		0.4 to 10.7		−2.4 to 4.4		1.8 to 7.9	
Fully adjusted[b]	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 to 7.3		−2.1 to 3.7		0.1 to 4.6		−1.8 to 6.4		−2.1 to 3.7		−0.9 to 3.8		1.9 to 12.6		−2.1 to 5.1		2.9 to 9.2	
Job control[a]																		
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 to 2.2		−1.9 to 3.2		−4.2 to −0.0		−4.6 to 2.8		−1.7 to 3.5		−3.9 to 0.3		−9.0 to 0.4		−4.7 to 1.5		−5.9 to −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 to 2.1		−2.7 to 2.6		−3.7 to 0.5		−4.8 to 2.7		−2.7 to 2.8		−3.3 to 1.0		−9.6 to 0.3		−5.2 to 1.5		−6.1 to −0.3	
Psychological demands[a]																		
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 to 2.0		−2.1 to 1.2		−1.3 to 1.4		−3.2 to 1.8		−2.2 to 1.2		−1.6 to 1.2		−1.9 to 4.4		−2.2 to 1.9		−0.3 to 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 to 3.7		−1.3 to 2.3		−0.7 to 2.1		−1.8 to 3.3		−1.4 to 2.3		−1.2 to 1.8		−0.2 to 6.5		−1.9 to 2.7		0.9 to 4.9	

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

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

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

[b]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.

anti-hypertensive medication, job strain was associated with a significant 7.7 mmHg (95%CI 2.0-13.5, $P = 0.01$) increase in after hours systolic ABP and a 5.2 mmHg (95%CI 2.0-8.4, $P < 0.01$) increase in after hours pulse pressure.

Analyses limited to the 363 Latina hotel room cleaners performed similarly to the total sample (Supplementary Appendix SI).

Supplementary Appendix SII expands findings reported in Table 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.

Supplementary Appendix SIII 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 to 5.6, $P = 0.06$). Total support while mostly inversely associated did not show any clear strong associations with ABP or pulse pressure.

Supplementary Appendix SIV 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 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, $P < 0.01$).

4 | DISCUSSION

4.1 | 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,[4–9] 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.[34,35] 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.[34] However, more recent studies have begun to dispute this phenomenon.[36] 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.[25] 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.[37,38] Both studies identified exaggerated systolic response as a risk factor for future hypertension and cardiovascular disease.[37,38] In general, downstream conditions like coronary heart disease have been reported to be more strongly associated with systolic than diastolic pressure.[39] 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.

4.2 | 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, pulse pressure has been shown in the literature to be associated with increased cardiovascular mortality,[40–43] and it has been cited as the dominant predictor for cardiac events.[44–46] In this study, job strain was most

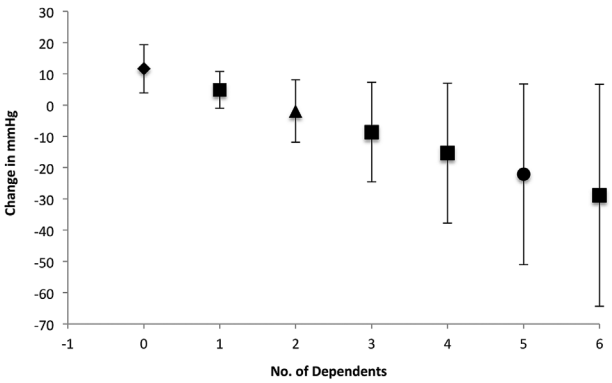

FIGURE 1 Measures of association and confidence intervals for the change in after-work hours SBP due to job strain in mmHg with increasing number of dependents

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[47] that found no differences between people with and without job strain for systolic or diastolic blood pressure, or pulse pressure.[47] 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.

4.3 | Effects of job strain on blood pressure

The observation that job strain increases blood pressure after work hours (eg, at home) more than during the day has been reported by others as well.[48] 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.[48,49] 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.[49] 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.[50] In another study, age and number of children and work-to-family spillover was shown to predict, or increase, work stress.[51]

In our study, the stronger association of job strain with systolic blood pressure and pulse pressure after hours seems to indicate a spillover effect of work stress as seen in other studies,[52,53] 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.[54] A study among nurses found that family structure and specifically dependents were protective against fatigue (work strain) and did promote recovery.[52] 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.[55] 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.

4.4 | 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.[14]

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-h 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,[12,24,56] 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.[10] 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.[57,58]

4.5 | 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.[14] 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.[8,33,59] 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.[59–62] 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.[63]

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 for 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-h 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.[64–66] 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-h 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 s 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 min 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.[27,67] 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,[68] 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.

5 | 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 uncontrolled hypertension in this population, indicates a need for improving blood pressure surveillance and treatment as an 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 supplementing 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.

AUTHORS' CONTRIBUTIONS

Feaster: established the concept and design of the data analysis and interpretation, drafted the papers and completed final manuscript. Krause: 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.

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ETHICS APPROVAL AND INFORMED CONSENT

The study was approved by the Institutional Review Boards of the University of California at Berkeley and San Francisco. Participants gave informed consent.

DISCLOSURE (AUTHORS)

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.

DISCLAIMERS

The funding for the secondary analysis was supported by the CDC. Its contents are solely the responsibility of the authors and do not necessarily represent the official view of CDC.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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