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Research article

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Night shift work and blood pressure: focusing on exposure doses

Trabalho noturno e pressão arterial: um estudo com foco nas doses de exposição

Abstract

Objective: to determine whether levels of night work exposure (current dose; accumulated dose) are associated with hypertension (HBP), systolic blood pressure (SBP) and diastolic blood pressure (DBP). *Methods:* cross-sectional study of 893 nursing personnel. We collected data on sociodemographic, work-related and health behaviour factors and measured blood pressure using a digital monitor. *Results:* after adjusting for sociodemographic variables, working >4 nights per fortnight was associated with increased SBP (4.0 mmHg; 95% CI: 1.01; 6.97) and DBP (2.3 mmHg; 95% CI: 0.24; 4.35). Working more than four nights per fortnight was associated to hypertension (OR 1.57; 95% CI 1.01; 2.43). Individuals who worked at night for >9 years displayed, on average, higher blood pressure levels (SBP of 3.7 mmHg [95% CI: 1.49; 5.92] and DBP of 2.0mmHg [95% CI: 0.46; 3.52]), compared to those who worked at night for ≤9 years. *Conclusion:* these findings suggest that effects of night work begin after a certain exposure dose, *i.e*, after 9 years of night work or when exposed to night work for more than 4 nights per fortnight.

Keywords: shift work; hypertension; blood pressure; nursing; occupational health.

Resumo

Objetivo*: determinar se os níveis de exposição ao trabalho noturno (dose atual; dose acumulada) estão associados com a hipertensão (HAS), a pressão arterial sistólica (PAS) e a pressão arterial diastólica (PAD).* Métodos*: estudo transversal realizado com 893 profissionais de enfermagem. Foram coletados dados sobre aspectos sociodemográficos, relacionados ao trabalho e a comportamentos de saúde. A pressão arterial foi aferida por meio de monitor digital.* Resultados*: após ajuste pelas variáveis sociodemográficas, observou-se que trabalhar mais de 4 noites por quinzena foi associado ao aumento da PAS (4,0 mmHg; intervalo de confiança [IC 95%]: 1,01; 6,97) e PAD (2,3 mmHg; IC 95%: 0,24; 4,35). O trabalho em mais de 4 noites por quinzena foi associado à ocorrência de hipertensão (RC 1,57; IC 95%: 1,01; 2,43). Indivíduos que trabalhavam à noite por mais de 9 anos apresentaram, em média, níveis de pressão arterial mais elevados (PAS de 3,7 mmHg [IC 95%: 1,49; 5,92] e PAD de 2,0 mmHg [IC 95%: 0,46; 3,52]), em comparação com aqueles que trabalharam à noite por 9 ou menos anos.* Conclusão*: esses resultados sugerem que os efeitos do trabalho noturno começam após uma certa dose de exposição, ou seja, após 9 anos de trabalho noturno ou quando exposto ao trabalho noturno por mais de 4 noites por quinzena.*

Palavras-chave: *trabalho em turnos; hipertensão; pressão sanguinea; enfermagem; saúde do trabalhador.*

Introduction

A 2017 estimate indicates that 7.5% of working people in Brazil were night workers, the proportion being higher among men (9.4%) than among women (5.4%)[1]. Several negative health effects are recognized to be related to this working schedule[2-5]. Night work is a risk factor for arterial hypertension (HBP), which must be highlighted not only because HBP prevalence is high and growing, but also because it is an important determinant of other cardiovascular diseases[6].

In recent decades, various studies have evaluated the association between night work and blood pressure[4,7-8]. A recent systematic review and meta-analysis showed statistically significant associations of HBP with rotational shift work, but not with fixed night work[4]. On the other hand, Ferguson et al.[9] suggested that recent exposure (< 12 months) to work in either rotational shifts or fixed night shifts were associated with higher HBP incidence. The study highlighted higher incidence of HBP observed among fixed night workers and argued that it could be explained by circadian mismatch, especially due to the social *jet-lag* experienced by night workers[9]. Based on the average monthly percentage of night shifts in the previous year, they observed that low exposure to night work (0-5%) was associated with a 2.3-fold rate of hypertension while working 95–100% night shifts increased the risk of hypertension by 3.5 times as compared with non-night workers[9].

Such results pose the need for a better understanding of the health effects of exposure to night work, i.e., the frequency and duration of such exposure. From that perspective, a review paper highlighted the association between exposure to shift work and the development of various diseases, including HBP[7]. However, hours of night working do not necessarily reflect frequency of exposure, which depends on the number of nights worked within a certain period. Also, the likelihood of HBP cases is greater in daytime workers with previous night work experience, as compared to those who have never worked nights[10].

Some authors point out that apparently divergent findings may result from different levels of exposure to night work[9-11], highlighting the need for studies to evaluate how different exposure doses of night work affect HBP.

As night work is essential to maintain 24 hours patient care, it is important to study the association between night work exposure dose and HBP, both because these effects need to be better understood and because the findings can assist especially nurse managers and policy makers to define work scheduling strategies. Accordingly, this study aimed to ascertain whether different levels of exposure to night work (current dose: number of nights worked; accumulated dose: years of exposure to night work) are associated with HBP, systolic blood pressure (SBP) and diastolic blood pressure (DBP) in nursing personnel.

Methods

In this cross-sectional study with nursing personnel from a public hospital in Rio de Janeiro, Brazil, all those actively giving care were invited (N = 1332). After refusals (n = 108; 8.1%), the study started with 1224 workers. Of this total, 331 were excluded: 3 failed to answer questions on night work, 5 were prescribed antihypertensive drugs, 21 did not measure blood pressure (n = 21), 93 had worked at night for less than 1 year, and 209 reported working an average of less than one night per week. The final sample comprised 893 night workers (7 p.m. to 7 a.m.) or former night workers, i.e., who worked from 7 a.m. to 7 p.m. at time of data collection but had previously been exposed to night work.

Data were collected in 2013, at the hospital, during working hours, using a questionnaire adapted from other studies[10,12,13] to collect sociodemographic, professional and health information. Participants' anthropometric (weight and height) and blood pressure measurements were taken. These procedures, carried out by previously trained personnel, took about 45 minutes to one hour for each worker.

Exposure variables

Current dose of night work: is the number of nights worked in the previous two weeks. The current dose was computed from responses to the question[12]: *So, let's remember which nights you worked in the last two weeks?* The variable was categorized into: 2 to 4 nights per fortnight and more than 4 nights/fortnight. Although these were fixed night workers (12-hour night shifts followed by 60 hours off), informal shift changes were very common, leading to consecutive working nights.

Accumulated dose of night work: total time of exposure to night work (in years). The variable was created from responses to the questions[12]: *How long have you worked nights?* (to night workers) and *How long did you work nights?* (to former night workers). The variable was categorized into: 1 to 9 years and more than 9 years of night work[12].

Outcome variables

Blood pressure was taken using a validated oscillometric device (Omron HEM 705CPINT). A study evaluating the accuracy of the Omron HEM-705-CP has shown that the device can be used to measure blood pressure in large-scale studies without compromising study validity or precision[14]. Blood pressure was measured in a quiet room, after a 5-minute rest, with the subject seated. Three

measurements were taken at one-minute intervals. The mean of these measurements was used to determine *SBP* and *DBP*[14].

HBP: as given by blood pressure (i) higher than 140 mmHg for SBP or (ii) higher than 90 mmHg for DBP or (iii) use of a medically prescribed anti-hypertensive drug.

Covariables

Data were obtained on sex, age (≤40 years old; >40years old), race/ethnicity (white; black/brown/yellow [Asian]), schooling (upper secondary; university), *per capita* income (in national minimum wages [R$678.00 in 2013]), marital status (single; married; separated/divorced; widowed), professional category (nurse; nursing technician/assistant), physical activity (none; <150minutes/week; ≥150minutes/week), smoking habits (non-smoker; former smoker; current smoker), alcohol consumption (never, moderate; high), insomnia complaint (yes, no), prescription of antihypertensive drugs (yes; no) and Body Mass Index (BMI in kg/m^2, calculated by dividing the participants' weight in kilograms by the square of their height in meters). Weight measurements were taken using a digital scale (Tanita®, model Solar HS-301 which can accurately measure up to 150 kg), and height was measured using a portable stadiometer (Alturexata®), with scale increments of 0.1 cm.

Data analysis

Descriptive analyses were used to characterize the study population. The categorical variables were presented by absolute and relative frequency, and the quantitative variables were described from the medians and interquartile range (IQR = P25-P75), means and standard deviations (SD). Chi-square tests were used for intergroup comparison of categorical variables. The Kolmogorov-Smirnov test was used to check the assumption of normality. The quantitative variables did not exhibit Gaussian distribution, and the Mann-Whitney test was chosen to compare between two independent groups.

Logistic regression analyses were carried out to test the association between night work and the categorical outcome, HBP. Odds ratios (OR) and 95% confidence intervals (95%CI) were estimated.

A gamma regression model with an identity link function was used to test the association between night work and SBP and DBP, as the outcomes are continuous and asymmetrical. The coefficients and 95% confidence intervals (95%CI) were estimated.

Firstly, crude associations between night work (current and accumulated dose of night work*)* and the outcomes (HBP, SBP, DBP) were estimated. The adjusted models were constructed using forward selection of the sociodemographic variables. Based on the literature, age, sex, race/ethnicity, schooling, and professional category were included as confounding variables. We highlight that health behavior variables (physical activity, smoking, alcoholism and insomnia complaints), potentially mediating the relationship between night work and arterial blood pressure, were not included as adjustments to the regression model[8,9]. In a sensitivity analysis, BMI was evaluated as a confounding variable. Goodness of fit was assessed using the Hosmer-Lemeshow test for binary logistic regression, and the Akaike Information Criterion (AIC) and Deviance test for gamma regression. A statistical significance level $\alpha = 0.05$ was adopted. Data were analyzed with the Statistical Package for the Social Sciences (SPSS®) version 20.

All workers were asked the following additional question: "Has a doctor ever prescribed you medication to treat high blood pressure?". Those who answered, "No, never" were considered in additional analyses. This procedure allowed the association between doses of exposure to night work and blood pressure to be tested more reliably than in the total sample.

Ethical considerations

This study was approved by the appropriate ethics committees and officials – Instituto Oswaldo Cruz – IOC/FIOCRUZ, no 635/11, approved on 03/12/2012. The study was briefly explained to participants and they were informed that involvement was voluntary and that they could withdraw at any time with no negative implications. Each participant received a serial number and full names were not recorded. All participants signed consent forms.

Results

The participants were predominantly female (84.0%). The mean age was 43.8 (SD = 11.1) years, the minimum age was 24 years and the maximum 70 years. Most of the participants had a university degree (66.1%) and were married (58.2%). The nursing personnel were divided by occupation, into nursing assistant/technician (64.6%) and nurses (35.4%); 44.4% reported holding 2 or more jobs and 39.6% worked more than 40h/week. Average time working nights was 8 years (54.4% were exposed to night work for 1 to 9 years); the majority (73.9%) worked 2 to 4 nights per fortnight. Most (61%) practiced no physical activity. Mean SBP was 121.03 mmHg (SD = 18.21 mmHg) and DBP was 76.30 mmHg (SD = 11.16 mmHg). Prevalence of HBP was 38.2%. In all, 615 individuals had never been prescribed HBP drugs.

Workers with higher current doses of night work (>4 nights per fortnight) had higher SBP and DBP; this group also included a higher proportion of men than those who worked up to 4 nights per fortnight (**Table 1**).

Table 1 Current dose of night work by sociodemographic, occupational and health factors among nursing personnel at a public hospital in Rio de Janeiro, Brazil, 2013 (N = 552 current night workers)

	Current doses of night work (nights/fortnight)				
	2 - 4 nights (n=410)		*>4 nights (n=142)*		*p*
	n	*%*	*n*	*%*	
Sex					
Female	343	83.7	106	74.6	**0.018**
Male	67	16.3	36	25.4	
Age					
≤40 years	204	49.8	78	54.9	0.288
>40 years	206	50.2	64	45.1	
Race/Ethnicity*					
White	160	39.5	51	35.9	0.449
Black/Brown/Yellow (Asian)	245	60.5	91	64.1	
Schooling					
Upper secondary	128	31.2	49	34.5	0.469
University	282	68.8	93	65.5	
Marital status					
Married	247	60.2	79	55.6	0.192
Separated	56	13.7	14	9.9	
Widowed	10	2.4	3	2.1	
Single	97	23.7	46	32.4	
Professional category					
Nurse	140	34.1	38	26.8	0.105
Nursing technician/assistant	270	65.9	104	73.2	
Physical activity					
None	252	61.5	90	63.4	0.600
<150 min/week	60	14.6	16	11.3	
≥150 min/week	98	23.9	36	25.3	
Smoking					
Non-smoker	314	76.6	106	74.6	0.895
Former smoker	54	13.2	20	14.1	
Current smoker	42	10.2	16	11.3	
Alcohol consumption*					
Never	208	50.9	68	47.9	0.542
Moderate	183	44.9	63	44.4	
High	17	4.2	11	7.7	
Insomnia complaints					
No	298	72.7	96	67.6	0.249
Yes	112	27.3	46	32.4	
Hypertension					
No	277	67.6	86	60.6	0.130
Yes	133	32.4	56	39.4	
Prescribed antihypertensive drugs					
No	301	73.4	107	74.4	0.650
Yes	109	26.6	35	24.6	
	Median; IQR				
Per capita income (minimum wages)#	3.0; 1.9 - 4.0		3.0; 1.8 - 4.0		0.760
Accumulated dose of night work (yrs)#	10.0; 5.0 - 18.0		8.0; 6.0 - 15.0		0.456
Body Mass Index (kg/m^2)#	26.6; 23.9 - 31.3		27.6; 24.6 - 31.3		0.130
Systolic blood pressure (mmHg)#	117.3; 107.3 - 128.2		120.2; 112.7 - 131.0		**0.016**
Diastolic blood pressure (mmHg)#	75.5; 75.0 - 82.7		76.5; 76.5 - 83.8		**0.050**

*Missing data. Interquartile range (IQR = P25-P75). Chi-square tests were used for intergroup comparison of categorical variables. #Mann-Whitney test was used to compare between two independent groups.

As compared with individuals with a low cumulative dose of night work, those with more than 9 years of night work were found to include a higher proportion of men, older people, individuals with upper secondary education, separated/divorced/widowed persons, smokers or former smokers, hypertensives and individuals with a prescription of antihypertensive drugs. Also, higher levels of BMI, SBP and DBP were observed among the workers with higher cumulative doses of night work exposure than among individuals who had worked nights for less time (**Table 2**).

Table 2 Accumulated dose of night work by sociodemographic, occupational and health factors among nursing personnel at a public hospital in Rio de Janeiro, Brazil, 2013 (N = 893 workers currently or previously exposed to nigh shift work)

	Accumulated dose of night work				*p*
	1 - 9 years (n=504)		*>9 years (n=389)*		
	n	*%*	*n*	*%*	
Sex					
Female	445	88.3	305	78.4	**<0.001**
Male	59	11.7	84	21.6	
Age					
≤40 years	306	60.7	92	23.7	**<0.001**
>40 years	198	39.3	297	76.3	
Race/Ethnicity*					
White	197	39.3	145	37.7	0.615
Black/Brown/Yellow (Asian)	304	60.7	240	62.3	
Schooling					
Upper secondary	148	29.4	155	39.8	**0.001**
University	356	70.6	234	60.2	
Marital status					
Married	304	60.3	216	55.5	**0.020**
Separated	59	11.7	70	18.1	
Widowed	9	1.8	13	3.3	
Single	132	26.2	90	23.1	
Professional category					
Nurse	190	37.7	127	32.6	0.118
Nursing technician/assistant	314	62.3	262	67.4	
Physical activity					
None	293	58.1	252	64.8	0.059
<150 min/week	72	14.3	56	14.4	
≥150 min/week	139	27.6	81	20.8	
Smoking					
Non-smoker	411	81.6	258	66.3	**<0.001**
Former smoker	56	11.1	81	20.8	
Current smoker	37	7.3	50	12.9	
Alcohol consumption*					
Never	255	50.6	193	49.9	0.616
Moderate	223	44.2	168	43.4	
High	26	5.2	26	6.7	
Insomnia complaints*					
No	357	70.8	268	69.1	0.569
Yes	147	29.2	120	30.9	
Hypertension					
No	357	70.8	195	50.1	**<0.001**
Yes	147	29.2	194	49.9	
Prescribed of antihypertensive drugs					
No	383	76.0	232	59.6	**<0.001**
Yes	112	24.0	157	40.4	
	Median; IQR				
Per capita income (minimum wages)#	3.0; 2.0 - 4.0		3.0; 1.9 - 4.0		0.172
Body Mass Index (kg/m^2)#	26.1; 23.6 - 29.8		28.6; 25.2 - 32.4		**<0.001**
Systolic blood pressure (mmHg)#	114.7; 106.3 - 123.7		124.0; 112.7 - 135.0		**<0.001**
Diastolic blood pressure (mmHg) #	73.7; 67.3 - 80.7		77.7; 71.3 - 85.3		**<0.001**

*Missing data. Interquartile range (IQR = P25-P75). Chi-square tests were used for intergroup comparison of categorical variables. #Mann-Whitney test was carried out to compare between two independent groups.

Workers classified as hypertensive included a higher proportion of men, individuals who were older, brown/black, had upper secondary education, were separated or widowed, nursing technicians and smokers or former smokers. Note also that 18.5% of individuals classified as hypertensive by blood pressure measurement reported not having been prescribed antihypertensive drugs. Higher levels of BMI, SBP and DBP were observed among hypertensives than among individuals classified as normotensives (**Table 3**).

Table 3 Hypertension by sociodemographic, occupational and health factors among nursing personnel at a public hospital in Rio de Janeiro, Brazil, 2013 (N = 893 workers currently or previously exposed to nigh shift work)

	Hypertension				*p*
	No (n= 552)		*Yes (n=341)*		
	n	%	*n*	%	
Sex					
Female	474	85.9	276	80.9	**0.032**
Male	78	14.1	65	19.1	
Age					
≤40 years	315	57.1	83	24.3	**<0.001**
>40 years	237	42.9	258	75.7	
Race/Ethnicity*					
White	231	42.1	111	32.9	**0.007**
Black/Brown/Yellow (Asian)	318	57.9	226	67.1	
Schooling					
Upper secondary	153	27.7	150	44.0	**<0.001**
University	399	72.3	191	56.0	
Marital status					
Married	330	59.8	190	55.7	
Separated	67	12.1	62	18.2	**0.001**
Widowed	6	1.1	16	4.7	
Single	149	27.0	73	21.4	
Professional category					
Nurse	215	38.9	102	29.9	0.006
Nursing technician/assistant	337	61.1	239	70.1	
Smoking					
Non-smoker	431	78.1	238	69.8	
Former smoker	72	13.0	65	19.1	0.018
Current smoker	49	8.9	38	11.1	
Alcohol consumption*					
Never	281	51.1	167	49.0	
Moderate	238	43.3	153	44.9	0.815
High	31	5.6	21	6.1	
Insomnia complaints*					
No	386	70.1	239	70.1	0.992
Yes	165	29.9	102	29.9	
Physical activity					
None	149	27.0	71	20.8	
<150 min/week	71	12.9	57	16.7	0.060
≥150 min/week	332	60.1	213	62.5	
Prescribed antihypertensive drugs					
No	552	100	63	18.5	-
Yes	0.0	0.0	278	81.5	
			Median; IQR		
Per capita income (minimum wages) #	3.0; 2.0 - 4.4		2.4; 1.8 - 3.7		0.020
Body Mass Index (kg/m^2)#	25.7; 23.3 - 28.9		29.9; 26.5 - 33.0		**<0.001**
Systolic blood pressure (mmHg)#	112.6; 105.4 - 120.7		129.9; 119.2 - 144.7		**<0.001**
Diastolic blood pressure (mmHg)#	72.3; 66.3 - 78.0		82.0; 74.3 - 91.2		**<0.001**

*Missing data. Interquartile range (IQR = P25-P75). Chi-square tests were used for intergroup comparison of categorical variables. #Mann-Whitney test was carried out to compare between two independent groups.

Considering the regression models adjusted for sociodemographic variables, the highest dose of current night work (>4 nights per fortnight) was associated with increased SBP and DBP, on average, 4.0 mmHg (95%CI: 1.01; 6.97) and 2.30 mmHg (95%CI: 0.24; 4.35), respectively, compared to the reference group. Also, working more than 4 nights per fortnight was associated with HBP (OR 1.57; 95%CI: 1.01; 2.43). In relation to the accumulated dose of night work, individuals who worked at night for more than 9 years displayed, on average, higher blood pressure levels (SBP of 3.7 mmHg (95%CI: 1.49; 5.92) and DBP of 2.0 mmHg (95%CI: 0.46; 3.52)) than those who worked at night for ≤9 years. The association between HBP and cumulative dose of night work was borderline (**Table 4**).

Supplementary analyses adjusted by sociodemographic variables plus BMI returned similar results. The highest dose of current night work (>4 nights/fortnight) was associated with increased SBP and DBP, on average, of 3.6 mmHg (95%CI: 0.73; 6.41) and 1.94 (95%CI: 0.49; 3.84) mmHg, respectively, as compared to the reference group. A borderline association was observed between HBP and current dose of night work (OR = 1.51; 95%CI: 0.95; 2.41). In relation to the accumulated dose of night work, individuals who worked at night for more than 9 years displayed, on average, higher SBP levels (2.4 mmHg; 95%CI: 0.22; 4.53). DBP (0.88 mmHg; 95%CI: -0.57; 2.33) and HBP (OR = 1.07; 95%CI: 0.76; 1.50) did not return statistically significant associations with cumulative dose of night.

Table 5 shows additional results for to individuals who had never been prescribed anti-hypertensive drugs. In this group, adjusted regression models showed that the highest cumulative dose of night work was associated with increased SBP and DBP, on average, of 4.0 mmHg (95%CI: 1.62; 6.38) and 2.1 mmHg, respectively. There was also a statistically significant association between higher cumulative dose of night work and HBP (OR 1.88; 95CI% 1.04; 3.42). Those who worked more nights displayed higher SBP (4.7 mmHg;95%CI: 1.73; 7.68) and DBP (2.9 mmHg;95%CI: 0.61; 5.13) than the group who worked fewer nights/fortnight. A higher dose of night work was also strongly associated with hypertension (OR 3.06; 95%CI 1.54; 6.05).

Table 4 Association between night work exposure doses and blood pressure among nursing personnel at a public hospital in Rio de Janeiro, Brazil, 2013

	Systolic blood pressure		*Diastolic blood pressure*		*Hypertension*	
	Crude model	*Adjusted model*	*Crude model*	*Adjusted model*	*Crude model*	*Adjusted model*
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	OR (95% CI)	OR (95% CI)
	Current dose of night work (N=552)					
2 - 4 nights/fortnight	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
>4 nights/fortnight	4.1 (0.69; 7.43)*	4.0 (1.01; 6.97)*	2.3 (0.14; 4.41)*	2.3 (0.24; 4.35)*	1.37 (0.93; 2.01)	1.57 (1.01; 2.43)*
	Accumulated dose of night work (N=893)					
1 - 9 years	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
>9 years	9.5 (7.22; 11.70)*	3.7 (1.49; 5.92)*	4.0 (2.52; 5.41)*	2.0 (0.46; 3.52)*	2.39 (1.81; 3.16)*	1.33 (0.97; 1.82)

Models adjusted for sex, age, race/ethnicity, schooling and professional category. β-value: difference between groups, coefficients derived from the gamma regression models. OR: Odds Ratio from logistic regression models. 95% CI: 95% confidence interval. Ref.: Reference category. *Association statistically significant.

Table 5 Association between night work exposure doses and blood pressure among nursing personnel not prescribed antihypertensive drugs at a public hospital in Rio de Janeiro, Brazil, 2013

	Systolic blood pressure		*Diastolic blood pressure*		*Hypertension*	
	Crude model	*Adjusted model*	*Crude model*	*Adjusted model*	*Crude model*	*Adjusted model*
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	OR (95% CI)	OR (95% CI)
			Current dose of night work (n=408)			
2 - 4 nights/fortnight	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
>4 nights/fortnight	4.8 (1.47; 8.09)*	4.7 (1.73; 7.68)*	2.8 (0.52; 5.16)*	2.9 (0.61; 5.13)*	2.80 (1.48; 5.27)*	3.06 (1.54; 6.05)*
			Accumulated dose of night work (n=615)			
1 - 9 years	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
>9 years	7.8 (5.48; 10.18)*	4.0 (1.62; 6.38)*	3.8 (2.14; 5.52)*	2.1 (0.32; 3.94)*	2.60 (1.53; 4.43)*	1.88 (1.04; 3.42)*

Models adjusted for sex, age, race/ethnicity, schooling and professional category. β-value: Difference between groups, coefficients from the gamma regression models. OR: Odds Ratio from logistic regression models. 95% CI: 95% Confidence interval. Ref.: Reference category. *Association statistically significant.

Discussion

The statistically significant associations found between higher cumulative night work dose and higher levels of blood pressure (SBP and DBP) and higher odds of HBP, as compared with lower cumulative dose of night work, are consistent with studies that have shown significant associations between longer durations of night work and higher blood pressure levels and higher odds of HBP[15,16].

Wang et al.[15], who compared characteristics of women who worked at night and during the day, observed that the longer the duration of night work (in years), the higher the probability of high blood pressure, obesity and smoking. Significant associations were found with these cardiovascular risk factors, especially in female workers with long exposure to night work (more than 20 years), as compared with those who worked during the day[15]. In a prospective cohort study with registered nurses, longer duration of rotating night shift work was associated with a higher risk of coronary heart disease[17]. These results corroborate our hypothesis that higher cumulative doses of night work are associated with higher blood pressure levels and HBP. On the other hand, a meta-analysis showed a significant association between rotating shift work (but not among fixed night workers) and HBP. However, it did not explore the effects of doses of night work exposure[4].

Regarding the detailing of exposure to night work by investigating the current dose of work, our data suggest that, among nursing personnel, higher frequency of working nights is associated with high blood pressure levels and higher odds of HBP. A recent cohort study showed that both night and rotating shift work was associated with greater risk of incident hypertension. In line with our findings, that study found that, in a period of one year, the greater the frequency of night work, the greater the risk of hypertension[9]. Studies with other outcomes have shown similar results. Peplonska et al.[18] used several measures to evaluate exposure to night work, including hours of work, nights worked and accumulated years of night work, in studying their association with obesity in female nurses and midwives. They observed an association between higher frequency of nights worked (>8 nights/month) and obesity, as compared with lower frequency of night work (2 - 7 nights/month). Women who worked at night more often (fixed night shift) displayed higher risk of obesity than women who worked in rotating shifts[19].

Park et al.[20] used the accumulation of night work, computed by multiplying nights by months of work, to show that a high accumulation of night work was significantly associated with high risk of cardiovascular diseases, as compared with never working nights[20]. Their methodological contribution reinforces the importance of using the dose of night work in order to evaluate the outcome of interest. As in the studies above, the authors of this study sought to refine the work variable by duration of exposure and frequency of night work (i.e., accumulated dose and current dose, respectively), enabling us to contribute to the field of knowledge and strengthening the study.

The doses of night work considered in this study yielded convergent results in relation to the outcomes evaluated here (SBP, DPB and HBP). However, the exposure variables are conceptually different and refer to different work characteristics. Current dose relates to work characteristics and their acute consequences, while cumulative dose reflects the worker's life over the years, to consider the chronic effects of such working hours. The duration of night work does not explain the frequency of night work, which may be substantially different among subjects depending on the number of nights worked[18]. Note that, in this study, the accumulated dose of night work also considers past night work by those currently working days. Previous studies of our group have shown the effects of previous in night work (among daytime workers), as compared with those who never worked nights[10,12,21].

The impacts of exposure to night work have not been completely described. The possible mechanisms by which night work may heighten risk of cardiovascular disease (including hypertension) stem from the circadian desynchronization related to behavioral, psychosocial and biological changes[22]. It has to be considered that circadian rhythms govern the biological variables, among them the blood pressure[23]. The relation between night work and HBP may involve biological mechanisms that influence workers' sleeping patterns, inducing more intense sympathetic activity during sleep[24], altered circadian blood pressure rhythm, with consequent absence of night dip[25], reduced autonomic cardiac regulation[8], shorter sleep duration and increased sleepiness[26]. Inflammatory processes[27] and alteration in hormone regulation[28] may also be involved. In addition, unhealthy behavior habits are considered to be mediators in the development of HBP in night workers; these range from high-fat foods, irregular meals and snacks during work shifts[29], little involvement in leisure activities[30] and higher prevalence of smokers than among day workers[31]. All these factors are interlinked due to circadian desynchronization and are considered cardiovascular health stressing conditions[22]. Although the present study did not focus on evaluating the relationship night work dose and BP regardless of the role of mediating variables, it is interesting to note that even with additional adjustment for BMI, associations between current dose of night work and increased BP levels remained statistically significant, although with lesser magnitudes, as expected.

In view of the known changes in circadian rhythm resulting from night work[22,28], it is appropriate to consider the possible effects of hypertensive drugs in night workers. Night shift work may interfere in the dose-response patterns of many drugs. Hermida et al.[23] investigated the effect of administering hypertensive drugs while respecting circadian blood pressure variation among hypertensive individuals. They found that using the drugs at night was more efficient in controlling blood pressure, diminishing the prevalence of non-dippers and reducing morbid-mortality from cardiovascular diseases than in the group whose drug occurred at the traditional time, *i.e*, on waking[23]. So, given the effects that night work may cause on circadian blood pressure rhythm, with consequent alterations in response to hypertensive drugs, the analysis offered here, considering the possible interference of drug prescription, also showed relevant results.

Note, in this connection, that in the subsample that had never been prescribed antihypertensive drugs, on spot measurement, a not insignificant proportion of individuals (18%) showed blood pressure levels compatible with hypertension. These individuals were mostly younger (under 40 years old) than the total sample (data not presented). This data deserves attention as it concerns a group that possibly hypertensive, but unaware of the disease, despite being health personnel with ample knowledge of the subject and dealing frequently with blood pressure.

This study is notable in that it evaluates night work exposure dose in real world conditions and using blood pressure measurements. Although the mercury sphygmomanometer is the gold standard for blood pressure measurement, automatic devices for measuring blood pressure are sufficiently accurate to result in little bias in estimates of the effect of risk factors relating to blood pressure and hypertension. They can therefore be used for measuring blood pressure and detecting hypertension in large epidemiological studies[14]. Nonetheless, note that workers were classified as hypertensive based on three spot arterial pressure measurements at 1-minute intervals. Further on blood pressure measurement, it is not known at what time the measurements were taken. As this field research was conducted during working hours, BP of for current night workers was measured between 9 pm and 11 pm; and of former night workers, between 9 am and 18 pm. Timing of assessment is a potential confounder, since a circadian variation is expected in for blood pressure[32]. However, even given, it was possible to capture the associations. Certainly, the ideal situation would be to adjust the analyses by time of measurement, were this data available.

One strength of this study is that it investigated previous night workers. However, no information was available as to the time elapsed since ending night work, which may have led to heterogeneity in the group. Despite that, it was possible to observe the adverse effects of the duration of night work, which were stronger among current night workers than

among former night workers (data not shown). The study design contributes to the literature on night work exposure doses and increased blood pressure, a relationship that has not yet been fully clarified. Despite the cross-sectional approach, in which the temporality of events cannot be assured, there is little likelihood that hypertension leads workers to high doses of night shift work, in turn, reinforcing the potential of this study. Given that the sample comprised mostly women, it would be relevant to adjust the analyses for menopausal status, but unfortunately this factor was not measured, which needs to be taken into account in interpreting the results. The study included nursing personnel who work 12 hours consecutively, with 60 hours off, which allows them more than one employment, as is common practice in nursing teams[13]. Accordingly, the findings should be generalizing to other work arrangements with caution.

Conclusion

The study's detailed approach to night work, using the more refined optics of duration and frequency, incorporated new dimensions into the analyses, thus contributing greater substance to the findings in the literature. It is possible that aspects of night work exposure dose may contribute to controversies identified in the literature. Being a cross-sectional study, the findings point to causal relations, but do suggest the possibility that the effects of night work begin after certain exposure doses (more than four nights per fortnight or longer than 9 years). Although HBP is multifactorial in origin, this study took a fresh lens to understanding HBP in workers' health. In this respect, findings may return measures to minimize the number of nights worked by hospital nursing teams in order to reduce the harm done by night work.

In summary, the results underline the need for attention to night workers, who face biological and psychosocial harm from this work regime. Effective health improvement strategies for these workers must be expanded, taking into account chronobiological criteria in the interventions, in order to promote workers' health and well-being, as well as effective patient care.

Authors' contribution

Silva-Costa A, Braz BP, Griep RH and Rotenberg L contributed substantially to the study design, data collection and analysis, manuscript writing, revisions and final version approval, and assume full responsibility for the study and the published content.

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