

## Multicenter historical cohort study of the relationship between shift work and blood pressure

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### Original Article

#### Abstract

**BACKGROUND:** Regarding the relationship between blood pressure (BP) and shift work (SW), previous studies have reported contradictory results. In the present study, we used Bayesian multilevel modeling to evaluate the association of SW and BP after controlling some confounding factors.

**METHODS:** Data of this multicenter historical study were extracted from annual observations of the male workers of Isfahan's Mobarakeh Steel Company (IMSC) and Polyacryl Iran Corporation (PIC) in Isfahan, Iran, between 2003 and 2011. In this research, we assessed the effect of SW on systolic BP (SBP) and diastolic BP (DPB) with controlling body mass index, age, work experience, marriage, and education status.

**RESULTS:** A total of 8613 (IMSC, n = 5314 and PIC, n = 3299) workers participated in this study with a mean [standard deviation (SD)] age of 41.60 (8.30) and mean (SD) work experience of 16.17 (7.89) years. In this study, after controlling confounding factors, we found no significant relationship between SW and SBP and DBP.

**CONCLUSION:** In general, the results of this multicenter cohort study did not support a relationship between SW and BP. We suggest prospective studies with controlling more confounding factors in this area.

**Keywords:** Blood Pressure, Multilevel Analyses, Bayesian Method, Iran

*Date of submission:* 11 Dec 2013, *Date of acceptance:* 23 Aug 2014

#### Introduction

Shift work (SW) is an employment pattern designed to make use of, or provide service across, all 24 h of the clock each day of the week.<sup>1</sup>

“Disruption of circadian rhythms (leading to sleep/wake disturbances, desynchronization of internal processes, and increased susceptibility to disease); disturbed socio-temporal patterns (resulting from atypical work hours leading to family problems, reduced social support, and stress); and unfavorable changes in health behaviors (increased smoking, poor diet, and irregular meals). Moreover, there is evidence that biomarkers, such as cholesterol and other lipids, plasminogen, blood pressure (BP) and cardiac activity show changes

related to SW, and may act as mediators of disease processes.”<sup>2</sup>

Nowadays many workers work on SW; for example, more than 3.5 million people are shift workers in England.<sup>3</sup> Numerous studies have shown the association of SW with cardiovascular disease,<sup>4</sup> hypertension,<sup>5</sup> atherosclerosis, Type II diabetes, metabolic syndrome,<sup>6</sup> weight gain,<sup>7</sup> etc. but the relationship of SW on BP. Positive,<sup>8-12</sup> negative<sup>13,14</sup> and no association<sup>15,16</sup> between SW and BP were seen in previous studies. Therefore, considering the inconsistency of the available research in this area, we conducted this multicenter cohort study for the first time in Iran to evaluate the relationship between SW and BP.

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### Materials and Methods

Inclusion criteria were official employment between 2003 and 2011 with at least 2 years of work experience; exclusion criteria were retirement, death or dismissal. The Medical Ethics Committee of the School of Medical Sciences, Tarbiat Modares University, Tehran, Iran, approved the study (code number: 5271065, Date: 2011/11/05).

In this study, BP of both arms was measured in the sitting position after 5 min rest using a calibrated mercury sphygmomanometer considering BHS-IV guidelines.<sup>17</sup> Furthermore, weight and height were measured by a doctor using calibrated equipment by the mean time interval 1.5 years.

The routine rotating and weekly rotating shifts were scheduled with a clockwise rotation plan (2 morning shifts, 2 evening shifts, 2 night shifts and 2 days off for routine rotating and 3 morning shifts, 3 evening shifts, and 1 day off every 2 weeks, Fridays always off for weekly rotating shifts).

The morning, evening, and night shifts began at 7 AM, 3 PM, and 11 PM, respectively. Day workers worked from 7 AM to 3 PM on weekdays and had Thursdays and Fridays off.

Data were analyzed with SPSS for Windows (version 18.0, SPSS Inc., Chicago, IL, USA) and OpenBUGS (version 3.2.2, OpenBUGS Foundation, Helsinki, Finland) Continuous variables are presented as the mean ± standard deviation, whereas categorical data are presented as frequency and percentages. A Kolmogorov–Smirnov test is used to find out if the recorded data are normally distributed. Chi-square test,

NOVA, Kruskal–Wallis test and Bayesian multilevel modeling with skew t-distribution is used to find out any relationship between SW and BP adjusted for age, work experience, marital status and education. Prior distributions and statistical methodology were discussed in works Gholami et al.<sup>18</sup> in this paper,  $P < 0.05$  were considered statistically significant.

### Results

This study was performed on 8613 male workers of IMSC (n = 5314) and PIC (n = 3299). The average repetition and time interval of each subject were approximately 6.7 and 2 respectively. Table 1 shows a summary of different characteristics of the workers by shift schedule.

According to this table 1, age and work experience were significantly higher in weekly rotating shifts in comparison with routine rotating shifts and day workers. The percentage of workers with academic education was significantly higher in day workers as compared to routine rotating and weekly rotating shift workers.

Table 2 shows the mean changes of systolic BP (SBP), diastolic BP (DPB) and body mass index (BMI) of the employees. According to table 2, no significant difference in mean change was noted according to shift schedule.

Table 3 shows a summary of beta, their standard errors and statistical significance using Bayesian multilevel modeling for the relationship between SW and BP after controlling age, work experience, BMI, marital status and education level.

**Table 1.** Comparison of the baseline characteristics of the workers at their first health examination, continues variable described as mean and standard deviation (SD) and categorical variable described as frequency and percent

Continues variable	Shift schedule								P	
	Routine rotating shift workers (n = 4050)		Weekly rotating shift workers (n = 597)		Day workers (n = 3966)		Total			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
SBP (mm Hg)	118.47	9.82	118.83	10.07	118.22	9.22	118.38	9.57	0.245	
DBP (mm Hg)	76.78	6.75	76.62	6.55	76.66	6.41	76.72	6.58	0.665	
BMI (kg/m <sup>2</sup> )	26.12	3.49	25.79	3.35	26.15	3.57	26.11	3.52	0.064	
Age (year)	41.62	8.38	43.31	7.27	41.33	8.33	41.60	8.30	< 0.001	
Work experience (year)	16.33	7.68	18.22	6.79	15.70	8.20	16.17	7.89	< 0.001	
Follow-up time (year)	5.18	2.95	5.66	2.97	4.94	2.69	5.10	2.84	< 0.001	
Categorical variable										
Marital status (married) [n (%)]	3565	89.20	537	91.80	3415.00	88.40	7517.00	89.00	0.051	
Education (upper diploma) [n (%)]	632.00	15.60	113	19.00	964.00	24.40	1709.00	19.90	< 0.001	

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; BMI: Body mass index; SD: Standard deviation; Categorical data were analyzed using the chi-square test; Continuous data were analyzed using ANOVA

**Table 2.** Comparison of the mean changes of blood pressure and body mass index (BMI) in three shift schedules

Variables	Shift schedule								P
	Routine rotating shift workers		Weekly rotating shift workers		Day workers		Total		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Mean SBP change (mm Hg)	0.01	0.1	0.02	0.1	0.02	0.1	0.02	0.1	0.051
Mean DBP change (mm Hg)	-0.03	0.11	-0.03	0.11	-0.02	0.12	-0.03	0.11	0.617
Mean BMI change, (kg/m <sup>2</sup> )	-0.03	0.06	-0.03	0.06	-0.03	0.06	-0.03	0.06	0.238

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; BMI: Body mass index; SD: Standard deviation; Categorical data analyzed using chi-square test; Continuous data analyzed using Kruskal-Wallis Test

**Table 3.** Bayesian multilevel regression results for assessing the effect of shift work on blood pressure (BP) with controlling confounding factor

Response	Predictors	Estimate	SD	95% CI		P
				Lower	Upper	
SBP	Shift schedule					0.755
	Weekly rotating shift/day worker	0.10	0.16	-0.22	0.41	0.543
	Routine rotating shift/day worker	0.19	0.32	-0.43	0.82	0.549
	Age (year)	0.19	0.03	0.14	0.24	< 0.001
	Work experience (year)	0.01	0.03	-0.04	0.07	0.652
	BMI (kg/m <sup>2</sup> )	0.65	0.02	0.60	0.70	< 0.001
	Marital status (married/single)	0.29	0.32	-0.34	0.93	0.367
	Education (upper diploma/lower diploma)	-0.45	0.19	-0.82	-0.08	0.016
DBP	Shift schedule					0.254
	Weekly rotating shift/day worker	0.19	0.12	-0.04	0.42	0.111
	Routine rotating shift/day worker	0.03	0.22	-0.40	0.45	0.904
	Age (year)	0.12	0.02	0.09	0.15	< 0.001
	Work experience (year)	0.10	0.02	0.07	0.14	< 0.001
	BMI (kg/m <sup>2</sup> )	0.58	0.02	0.55	0.62	< 0.001
	Marital status (married/single)	3.04	0.24	2.56	3.51	< 0.001
	Education (upper diploma/lower diploma)	-1.05	0.14	-1.32	-0.77	< 0.001

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; BMI: Body mass index; SD: Standard deviation; CI: Confidence interval

As table 3 shows, no significant difference was noted in the SBP, and DPB according to shift schedule. For significant beta, like BMI, it means that each 1 unit increase in BMI elevated SBP and DPB by 0.65 and 0.58 mmHg, respectively.

## Discussion

This multicenter cohort study was designed and conducted to evaluate the effect of SW on BP in all the workers of IMSC and PIC. Regarding the Bayesian modeling approach, our results did not support a relationship between shift-work and SBP ( $P = 0.755$ ) and DPB ( $P = 0.245$ ). This finding was consistent with the reports of Yadegarfar et al.,<sup>19</sup> Murata et al.,<sup>20</sup> Virkkunen et al.,<sup>21</sup> Merijanti et al.,<sup>22</sup> Puttonen et al.,<sup>23</sup> Hublin et al.,<sup>12</sup> Gholami-Fesharaki et al.<sup>24</sup> and Sfreddo et al.<sup>25</sup> but inconsistent with some other reports.<sup>8-11,26-29</sup> This lack of association can be attributed to the fact that healthier

individuals are usually recruited as shift workers while weaker ones are hired as day workers.<sup>30</sup> Moreover, most of the day workers have administrative jobs and are, therefore, less active, leading to gaining weight (a risk factor of BP elevation). Gholami Fesharaki et al.<sup>31</sup> found a significant increase in BMI (around 0.78 kg/m<sup>2</sup>) among day workers compared with weekly rotating shift workers.

On the other hand, since the effect of SW on the worker also depends on the type of work, personal characteristics, workplace environment and shift schedule,<sup>32</sup> the lack of association can also be attributed to other reasons such as better income, and more off-duty days of shift workers when compared with day workers. Although we could not measure workers' income individually in this study because of the confidentiality of financial information, according to the overall data from Division Human Resource

Management, the salary of a shift worker is 10-40% more when compared with the day workers. Hofelmann et al.<sup>33</sup> identified a negative association between SBP and the contextual income.

The strong points of this study were its multicenter pattern, utilizing a complicated and powerful statistical modeling approach for analyzing the data, appropriate sample size, homogeneity of the study population, and calculation of BMI and measurement of BP in the clinic by a physician. Some weak points of the study were non-evaluation of the family history of BP, and inability to evaluate the experience at previous jobs, sleep, income, stress, and job satisfaction as possible confounding factors.

In general, the results of our multicenter cohort study did not support a relationship between SW and BP. To assess the association between SW and BP, we suggest more accurate prospective studies with controlling confounding factors such as family history, occupational history, and psychological factors such as job satisfaction and occupational stress.

### Acknowledgments

The authors would like to thank all the personnel of IMSC and PIC, especially the staff of Industrial Medicine Department of the two companies, for their cooperation throughout the study. Furthermore, this study was supported by a grant from the Tarbiat Modares University

### Conflict of Interests

Authors have no conflict of interests.

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**How to cite this article:** Gholami-Fesharaki M, Kazemnejad A, Zayeri F, Rowzati M, Sanati J, Akbari H. **Multicenter historical cohort study of the relationship between shift work and blood pressure.** *ARYA Atheroscler* 2014; 10(6): 287-91.