

# Blood Pressure Modifications during Shift Work among Workers in Isfahan City, Iran

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Received 2015 May 19; Revised 2015 July 11; Accepted 2015 September 05.

## Abstract

**Background:** Several factors affect the emergence of high blood pressure, among which include environmental and occupational factors. Shift work is currently a commonly used program at workplaces.

**Objectives:** The purpose of this study was to determine the impact of shift work on blood pressure changes.

**Patients and Methods:** The data used in this retrospective cohort study was collected using annual observations conducted in the Diseases Follow-up Unit, Industrial Medicine Unit of the Occupational Health Center of the Mobarakeh Steel company from 2007 to 2010. In this study, the effect of shift work on systolic and diastolic blood pressure changes were analyzed by controlling for the body mass index (BMI), age, and educational levels using multilevel models.

**Results:** This study included 5,351 people (45.2% on the day shift, 6% on the weekly rotation shift, and 48.8% on a normal rotation shift). By controlling the confounding factors, shift work showed a significant relationship with systolic blood pressure ( $P = 0.01$ ) but failed to show any significant relationships with diastolic blood pressure ( $P = 0.08$ ).

**Conclusions:** According to the results of this study, it seems that shift work can be considered a risk factor for high blood pressure changes. It is recommended that workers who are working in shifts are more at risk and need more supervision.

**Keywords:** Longitudinal Study, Shift Work, Blood Pressure

## 1. Background

High blood pressure is a major public health challenge worldwide. In 2000, about 26.4% of adults had high blood pressure, and it is predicted that by 2025 this figure will reach 29.2% (1). High blood pressure is a risk factor for many diseases including cardiovascular, vascular, and renal diseases (2, 3). Different factors influence the emergence of high blood pressure including environmental and occupational factors such as noise, stress, temperature, exposure to certain substances, and shift work (4). Although working on the night shift is one of the inevitable consequences of technology and is a part of the 24-hour society worldwide, this phenomenon is currently regarded as an occupational risk factor and a threat to health (5). Among the factors influencing blood pressure, shift work can be cited. But, what is shift work? A general definition of shift work is an unusual working pattern compared to those who work daytime shifts; this definition includes types of shifts that involve fixed shift work, rotation shift, forward rotation shift, and backward rotation shift (6). Studies performed on the effect of shift work on blood pres-

sure have revealed different results and therefore, a consensus has not been reached in this field (7-9). Some studies suggest that blood pressure among shift workers is higher than day workers (10-12), and shift work is a risk factor for high blood pressure attacks (13). In contrast, one study has suggested that blood pressure among day workers is higher (14). However, in some studies, no significant relationships were found between shift work and blood pressure (15-18). A retrospective 24-year cohort study demonstrated no statistically significant relationship between shift work and high blood pressure (19). Also, in a study on 493 nurses selected by random sampling from a large hospital, no significant relationship was found between either day shift work or night shift work and the appearance of the high blood pressure (20). In a meta-analysis performed based on temporary studies with a small sample size, the evidence tends more to increases in blood pressure of shift workers compared to day workers (21). Suwazono et al. performed a 14-year cohort study between 1991 and 2005 on day workers and rotational shift workers of a steel factory to examine the effect of shift work on the blood pressure

of Japanese men. The results of their study showed that rotational shift work is an independent risk factor for high blood pressure (12). In a 6-year retrospective longitudinal study, a significant correlation was revealed between the risk of high blood pressure and shift work (22). A retrospective cohort study conducted by Gholami Fesharaki et al. from 2007 to 2009 studied the relationship between shift work and blood pressure and reported no significant relationship between these two (23).

## 2. Objectives

Given the contradictions in previous studies, our study aimed to investigate the relationship between shift work and blood pressure changes in the Esfahan Mobarakeh Steel company.

## 3. Patients and Methods

The data used in this study was collected based on a cohort study using annual observations conducted in the diseases follow-up unit, industrial medicine unit of the occupational health center of the Mobarakeh Steel company during 2007 to 2010 (Esfahan, Iran). The number of employees in the Mobarakeh Steel company was 5,351 people. Two years of service, official or permanent employment, and being healthy without any common diseases during the study were considered as inclusion criteria. Retirement, more than 40% of the medical data missing, and an unwillingness to participate were considered exclusion criteria.

Response variables in this study were defined as differences between systolic blood pressure (SBP) and diastolic blood pressure (DBP) from their respective baseline values.

Data for this study were modeled using multilevel modeling, a novel approach to modeling hierarchical and nested data (24). In our analysis, the workers and the number of repetitions were considered as levels two and one, respectively.

The shift work in Mobarakeh Steel company is divided into three main categories (rotation shift, weekly rotation shift, and day worker). In rotation shift, workers work two mornings, two evenings, two nights, and they are off for two days. In weekly rotation, workers work three mornings and three evenings and are off every two weeks intermittently they have one day off. Workers in the weekly rotation are always off on Fridays and day workers work from Saturday to Wednesday from morning to afternoon and are off on Thursdays and Fridays.

The study protocol was approved by the ethical committee of the medical school of Tarbiat Modares University.

### 3.1. Statistical Analysis

Data were analyzed by MLwiN version 2.1 and SPSS version 17 (SPSS Inc., Chicago, IL, USA). Continuous variables are presented as the mean  $\pm$  standard deviation (SD) and categorical data are presented as frequencies and percentages. Analyses of variance (ANOVA) or Kruskal-Wallis tests were used for continuous variables and chi-square tests for categorical variables (Table 1). In Tables 2 and 3, we used multilevel modeling. The best model (the model with a random intercept and random BMI and age slopes) was chosen with lower Akaike information criterion (AIC). The efficacy of the multilevel model rather than the regression model was also studied using an inter class correlation (ICC). Models with large and significant ICCs have higher efficacy (24). In this study, probability values of 0.05 or less ( $P \leq 0.05$ ) were considered significant.

## 4. Results

This study was conducted with a sample size 5,351. Among the employees, 45.2% worked day shift, 6% were on the weekly rotation shift, and 48.8% were in the normal rotation shift.

The baseline demographic variables according to shift work are reported in Table 1. As shown in Table 1, the weekly rotation shift workers were older, had lower educational levels, and had higher BMI and SBP levels compared with the normal rotation and day workers. In Tables 2 and 3, a summary of the data from the fit of the multilevel model for SBP and DBP changes is presented. The ICCs for SBP and DBP were 0.79 ( $P < 0.001$ ) and 0.68 ( $P < 0.001$ ), respectively, which suggests a higher efficacy of multilevel modeling rather than a simple linear regression model.

Tables 2 and 3 also show that BMI had a positive relationship with SBP and DBP with a one-unit increase in BMI values associated with an average increase of 5.5 and 3.3 units, respectively in SBP and DPB changes.

## 5. Discussion

High blood pressure is one of the major factors threatening human health, particularly in developing countries, including Iran, and currently it is one of the most common chronic diseases (7). Since the disease remains asymptomatic until the onset of complications, it is called the silent killer. High blood pressure is the most common chronic disease in the United States and more than 85 million Americans are diagnosed with high blood pressure and are taking blood pressure lowering drugs was composed and it is an important factor for stroke, chronic renal failure, and myocardial infarction if no control is considered (23). Besides the enormous costs allocated for the

**Table 1.** Baseline Mean and Standard Deviation of SBP and DBP According to Shift Work<sup>a, b</sup>

Shift	SBP, mmHg	DBP, mmHg	BMI, kg/m <sup>2</sup>	Age, y	Education		
					L1	L2	L3
Normal Rotation	113.44 (11.33)	75.61 (8.28)	25.72 (3.31)	38.25 (12.98)	4.12	89.03	6.85
Weekly Rotation	113.44 (11.72)	75.46 (8.46)	25.84 (3.22)	27.84 (13.02)	4.93	95.06	1.00
Day worker	113.53 (11.85)	75.85 (8.31)	25.81 (3.42)	33.91 (13.42)	40.10	43.60	16.30
P Value	0.01	0.30	< 0.001	0.2	0.99	0.01	0.20

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; Education, L1, lower diploma or diploma, L2, Associate and BA, L3, MA or Ph.D.; SBP, systolic blood pressure.

<sup>a</sup>P values are based on chi square and ANOVA or Kruskal-Wallis tests.

<sup>b</sup>Values are expressed as Mean  $\pm$  SD or %.

**Table 2.** Factors Affecting SBP Changes

Parameter	Estimation	Standard Error	P Value
Intercept	3.326	1.813	0.06
BMI, kg/m <sup>2</sup>	0.553	0.062	< 0.001
Age, y	-0.053	0.042	0.2
Normal Rotation	-1.773	0.705	0.01
Weekly Rotation	-0.672	1.115	0.54
Day Worker	Reference Category		
Master or PhD	0.18	2.355	0.99
Associate and BA	-1.977	0.846	0.01
Lower Diploma or Diploma	Reference Category		

Abbreviation: BMI, body mass index

**Table 3.** Factors Affecting DBP Changes

Parameter	Estimation	Standard Error	P Value
Intercept	1.917	1.298	0.13
BMI, kg/m <sup>2</sup>	0.334	0.046	< 0.001
Age, y	-0.038	0.030	0.20
Normal Rotation	-0.872	0.514	0.08
Weekly Rotation	-0.750	0.812	0.35
Day Worker	Reference Category		
Master or Ph.D.	1.289	1.754	0.46
Associate and BA	-0.401	0.619	0.51
Lower Diploma or Diploma	Reference Category		

Abbreviation: BMI, body mass index

and strokes increase seven times in people with high blood pressure. Moreover, the complications from high blood pressure lead to a loss of abundant workforce and economic costs (24). Shift work is one of the social phenomena that has existed from ancient times and today it exists because of economic reasons and modern technology. Shift work patterns in service and manufacturing organizations vary and cause disharmony in the cycles with a period of one day (25). Therefore, due to the importance of shift work, we studied the effect of working in shifts on alterations in blood pressure with a longitudinal study. In this study, the conventional rotation shift showed significant differences in systolic blood pressure, while no relationship was detected between diastolic blood pressure and shift work. This lack of an association can be attributed primarily to the fact that healthier people work on shifts and weaker employees work during the day. Furthermore, since most day workers work in offices, an important feature of this type of work is a lack of movement, and thus, an associated increase in obesity levels. Increased levels of obesity are a factor associated with increases in blood pressure. However, the effect of increasing obesity becomes neutral with the work increasing effects in shift work. The effects of shift work on people mainly depend on the job, their personality, the social and institutional environment, and the shift work characteristics (26). Thus, the lack of correlation can be attributed to other reasons, such as diversity of working times, higher incomes, and more leisure time compared to day workers. Alternatively, in studies finding a relationship between shift work and increases in blood pressure, the samples did not have the same working environments (27). There was also no consistent definition of shift work in the studies (28) and the type of the shift rotation was different in various jobs. Finally, confounding variables (e.g., lifestyle, physical activity, smoking, etc.) that affect blood pressure were not controlled equally. Contradicting relationships have been reported

treatment of high blood pressure, the risk of cardiovascular disease doubles, heart failure increases four times,

between blood pressure and shift work in previous studies. As we mentioned in the introduction, in most studies, there have been significant relationships between blood pressure and shift work (29-31), but some studies (32) have shown no significant relationship between blood pressure and shift work. The findings of the present study showed that there was a significant relationship between blood pressure changes and shift work. A study was done in a nuclear energy company in Japan to investigate the relationship between blood pressure and shift work among 27 rotational shift workers and 26 male day workers, and a strong correlation was found between systolic blood pressure and shift work (30). Blumenthal et al. (33) and Tsutsumi et al. reported similar findings as well (34). Furthermore, no significant relationships were observed between DBP changes and shifts that this significance and direction is consistent with the relationship obtained from other studies (4). Considering the relationships between the variables of this study and blood pressure, as can be seen in Table 2, BMI and education had a significant correlation with blood pressure changes. Furthermore, according to Table 3, only BMI showed a significant correlation with DBP changes.

Limitations of this study include a lack of access to the general health, management leadership behavior (6), obtaining a close family history of hypertension, and an inability to evaluate the amounts of rest and sleep, income, stress, job satisfaction, and smoking as confounding factors. Advantages of this study include its longitudinal design, using multilevel modeling for fitness, and the calculation of BMI and blood pressure indices by clinical experts.

The effect of shift work on blood pressure changes in Mobarakeh Steel company personnel was investigated in the present study. The results of this study showed that shift work influences the changes in SBP, but no significant relationship was observed between shift work and DBP. The main reasons for the lack of observing this relationship may be due to the probability of healthier shifts workers, as well as the flexibility of working time, more income, and more time of weekly shift workers compared to day workers. Moreover, the average BMI was significantly related to changes in SBP and DBP.

### Acknowledgments

This study was part of a MSc thesis at Tarbiat Modares University. The authors would like to thank the personnel of the Mobarakeh Steel company for their full cooperation during the study.

### Footnote

**Authors Contribution:** Elahe Ghazanfari: analysis, review, writing, and consulting; Anoshirvan Kazemnejad:

spenser, analysis, review, writing, and consulting; Mohammad Gholami Fesharaki: analysis, writing, and consulting; Mohsen Rowzati: medical consulting; and Farid Zayeri: consulting.

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