# The relationship between shift work and Framingham risk score: A five-year prospective cohort study

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**Original Article**


## Abstract

**BACKGROUND:** There is a small number of studies that considered the relationship between shift work (SW) and Framingham risk score (FRS). This study prospectively examined the association between SW and FRS among man workers based on the multilevel modeling approach.

**METHODS:** This five-year prospective cohort study was done among workers (using stratified random sampling) who work in Esfahan's Mobarakeh Steel Company (EMSC), Iran, from March 2011 to February 2015.

**RESULTS:** The study sample included 1626 man workers (mean age = 40.0 ± 6.2). Among these subjects, 652 (40.01%), 183 (11.3%) and 791 (48.6%) were day workers, weekly rotating shift workers and routinely rotating, respectively. After controlling unbalanced variables, there was no any significant association between SW and FRS.

**CONCLUSION:** The results of this prospective cohort study did not show a relationship between SW and FRS.



**Keywords:** Multilevel Analysis, Cohort Study, Night Shift Work, Iran

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## Introduction

Shift work (SW) is an unusual working pattern in comparison to the workday. This work pattern is an integral part of the provision of services in many industrial, economic and service activities.[1] Although many studies have reported the relationship of SW to other diseases like type 2 diabetes,[2] overweight or obesity,[3] blood pressure[1] cholesterol and triglycerides,[4] total cholesterol as an indicator of lipid metabolism[5] and cardiovascular disease (CVD),[6] very limited evidence considered the correlation between SW and Framingham risk score (FRS). The FRS is a diagnostic tool that is widely used to estimate the risk of CVD in the next 10 years based on some variables such as age, sex, total cholesterol, high-density cholesterol (HDL), systolic blood pressure (SBP), history of smoking and history of diabetes.[7]

CVDs are one of the most important causes of death and inability in the human communities. Early identification of individuals at risk is the main objectives of public health in many societies.[8] A simple way for this subjects is Framingham algorithm.[9]

The association between SW and risk of CVDs based on the FRS was reported in a previous study.[10] Based on the findings of this study, the prevalence of CVD risk factors among night-shift workers is 67% higher than the workday.[10]

Furthermore, blood flow rate in the coronary arteries of woman nurses was considered in another survey. The results of this study demonstrated the increased risk of disordered coronary blood flow in night-shift nurses.[11] To our knowledge, a small number of studies considered the correlation between SW and FRS. Therefore, in this five-year prospective cohort study, we investigated the relationship between SW and FRS in Esfahan's Mobarakeh Steel Company (EMSC), Iran, from March 2011 to February 2015.

## Materials and Methods

This five-year prospective cohort study was conducted in EMSC from March 2011 to February 2015. The protocol of this research was designed in accommodation with the platform of the Declaration of Helsinki and then approved by the Medical Ethics Committee of Tarbiat Modares University, Tehran, Iran (code number: 52D.3817).


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Individuals were contacted via phone and protocols of the study were thoroughly explained for each person. All subjects were willingly entered into the study and a written consent form signed by them.

In this study, FRS and its components including SBP, cholesterol, and HDL were considered as a dependent variable, while SW was considered as an independent variable. Additionally, factors such as age, work experience, body mass index (BMI), smoking, and education status were considered as control variables. The FRS is a sex-specific method used to estimate the ten-year risk of CVD in individuals.

High score of FRS means the high probable risk of cardiovascular disease within a specified time course, generally ten to thirty years. FRS also shows who is the more prone to get the advantage of prevention.[12] To calculate this score, $X_1$, $X_2$, …, $X_5$ must initially be calculated according to the table 1, and then the FRS can be calculated using the following formula:

$$FRS = \sum_{i=1}^{5} X_i$$

The score ranges between -2 and 36. Higher FRS indicated the increased 10-year CVD risk of a person.

The work area of EMSC was arranged into strata and participants were randomly selected via stratified random sampling.

Inclusion criteria were willing to participate, official employment between March 2011 and February 2015 with at least two years of work experience in March 2011, and not taking antihypertensive and blood lipid-lowering drugs. Patients who met the following criteria were excluded from the study: retirement, death or dismissal (Figure 1). The optimal sample size, which contained 1971 cases, was calculated using the unequal t-test formula considering the effect size = 0.27 and dropout rate of 22% ($\alpha$ = 5%, $\beta$ = 10%) based on a previous study.[1] After remaining in the sitting position for 5 minutes, the SBP of both arms was measured by three general practitioners using a calibrated portable or wall-mounted Baumanometer sphygmomanometer Kompak Model-260 mmHg (WA Baum, Copiague, NY). Laboratory variables were measured using calibrated instruments. In this study, regular smokers were people smoking at least one cigarette daily for at least one year. The scheduled of shift time is presented in Gholami Fesharaki et al.[1] study.

We used R software (version 3.2.1) and package "nlme" for analysis of data. Chi-square test was used to compare categorical variables, while analysis of variance (ANOVA) and Kruskal-Wallis tests were used to compare continuous variables. Intention-to-treat (ITT) analysis using multilevel modeling[1] was used for modeling correlated and longitudinal data and investigating the predictors of longitudinal changes in FRS after controlling for BMI, work experience, as well as educational status. The measurements for each individual were repeated 5 times, and each time interval measurement was one year. In this study, P < 0.050 was considered to be statistically significant.

**Table 1.** Scoring of age, smoking, cholesterol, high-density lipoprotein (HDL) and systolic blood pressure (SBP) for calculating Framingham risk score (FRS)

| Age range | X1 | | X2 | | X3 | | X4 | X5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age | | Smokers | | Cholesterol (mg/dl) A: < 160, 190-199, 200-239, 240-279, ≥ 280 | | HDL (mg/dl) B: < 40, 40-49, 50-59, ≥ 280 | SBP (mmHg) C: < 120, 120-129, 130-139, 140-279, ≥ 280 | | | |
| | M | W | M | W | M | W | M or W | WT | WNT | MT | MNT |
| ≤ 34 | -7 | -9 | 9 | 8 | (0, 4, 7, 9, 11) | (0, 4, 8, 11, 13) | (-1, 0, 1, 2) | (0, 3, 4, 5, 6) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |
| 35-39 | -3 | -4 | 9 | 8 | (0, 4, 7, 9, 11) | (0, 4, 8, 11, 13) | (-1, 0, 1, 2) | (0, 3, 4, 5) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |
| 40-44 | 0 | 0 | 7 | 5 | (0, 3, 5, 6, 8) | (0, 3, 6, 8, 10) | (-1, 0, 1, 2) | (0, 3, 4, 5) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |
| 45-49 | 3 | 3 | 7 | 5 | (0, 3, 5, 6, 8) | (0, 3, 6, 8, 10) | (-1, 0, 1, 2) | (0, 3, 4, 5) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |
| 50-54 | 6 | 6 | 4 | 3 | (0, 2, 3, 4, 5) | (0, 2, 5‹4, 7) | (-1, 0, 1, 2) | (0, 3, 4, 5) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |
| 55-59 | 8 | 8 | 4 | 3 | (0, 2, 3, 4, 5) | (0, 2, 5‹4, 7) | (-1, 0, 1, 2) | (0, 3, 4, 5) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |
| 60-64 | 10 | 10 | 2 | 1 | (0, 1, 1, 2, 3) | (0, 1, 3‹2, 4) | (-1, 0, 1, 2) | (0, 3, 4, 5) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |
| 65-69 | 12 | 11 | 2 | 1 | (0, 1, 1, 2, 3) | (0, 1, 3‹2, 4) | (-1, 0, 1, 2) | (0, 3, 4, 5) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |
| 70-74 | 14 | 12 | 1 | 1 | (0, 0, 0, 1, 1) | (0, 1, 1, 2, 2) | (-1, 0, 1, 2) | (0, 3, 4, 5) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |
| ≥ 75 | 16 | 13 | 1 | 1 | (0, 0, 0, 1, 1) | (0, 1, 1, 2, 2) | (-1, 0, 1, 2) | (0, 3, 4, 5) | (0, 1, 2, 3,4) | (0, 1, 2, 2, 3) | (0, 0, 1, 1, 2) |

Data are shown as frequency

Framingham risk score (FRS) = X_1 + X_2 + X_3 + X_4 + X_5

HDL: High-density lipoprotein; SBP: Systolic blood pressure; M: Man; W: Woman; WT: Woman treated; MT: Man treated; WNT: Woman none treated; MNT: Man non treated

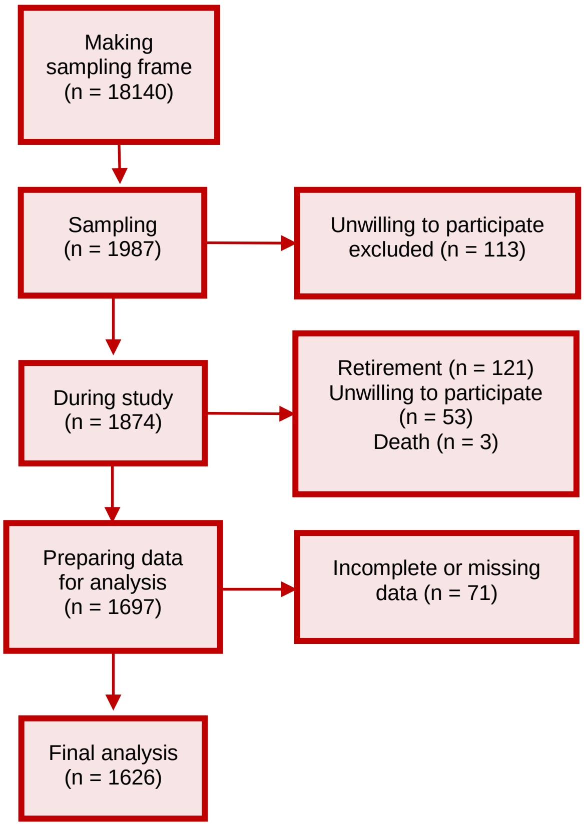


**Figure 1.** Cohort flow diagram

## Results

This study was conducted on 1626 man workers of EMSC. Among these subjects, 652 (40.01%), 183 (11.3%) and 791 (48.6%) were day workers, weekly rotating shift workers and routinely rotating workers, respectively.

Demographical information of workers, presented according to the SW, can be seen in table 2. The mean of age (P < 0.001) and work experience (P < 0.001) and also the percentage of educational levels (P < 0.001) in day workers was significantly higher than routine and weekly rotating shifts.

According to the shift schedule, trends in SBP, HDL, fasting blood sugar (FBS), cholesterol and FRS from 2011 to 2015 are presented in table 3 and figure 2. We found decreasing trend for cholesterol and FBS levels from 2011 to 2015, while an increasing trend was observed for SBP and FRS. Finally, significant fluctuations were found in HDL values. These trends were similar according to the day and shift workers.

Table 4 shows the mean changes of FRS and its constituent variables according to the SW. The non-significant difference was found in shift schedule during the time. Moreover, the relationship of SW to FRS and constituent variables by controlling the baseline and confounder variables is demonstrated in table 5. There was no significant relationship between shift schedule and FRS, SBP, HDL, FBS and cholesterol, after controlling the baseline and confounder variables.

## Discussion

Our results have revealed that changes in FRS and other factors were not significant during the period of 5-year study. Therefore, we conclude that the observed difference in results of multilevel modeling is not because of the SW effect, but this difference is related to the baseline.

Although few number of researches have examined the relationship between SW and FRS, these results have not been consistent with our findings. Our data were inconsistent with the study of Pimenta et al.[10] and Kubo et al.[11] that showed a significant relationship between FRS and SW. None of the FRS sub-items showed any significant change in the SW.

**Table 2.** Demographical characteristics of workers according to the shift Schedule

| Variable | Shift schedule | | | Total | P* |
|---|---|---|---|---|---|
| | Routine rotating shift workers | Weekly rotating shift workers | Day workers | | |
| Sex (Man) | 791 (100) | 183 (100) | 652 (100) | 1626 (100) | P > 0.9999 |
| Smoke (Yes) | 122 (15.4) | 24 (13.1) | 94 (14.4) | 240 (14.7) | 0.694 |
| Education (upper diploma) | 42 (5.5) | 12 (6.8) | 208 (33.1) | 262 (16.1) | < 0.001 |
| Age (year) | 39.3 ± 5.9 | 40.2 ± 5.9 | 40.7 ± 6.5 | 40.0 ± 6.2 | < 0.001 |
| Work experience (year) | 7.0 ± 8.2 | 5.3 ± 7.5 | 8.3 ± 8.7 | 7.4 ± 8.4 | < 0.001 |
| BMI (kg/m2) | 26.2 ± 3.3 | 25.7 ± 3.4 | 26.0 ± 3.5 | 26.0 ± 3.4 | 0.268 |

Data are shown as number (%) or mean ± standard deviation (SD); * Chi-square or analysis of variance (ANOVA) or Kruskal-Wallis tests
BMI: Body mass index

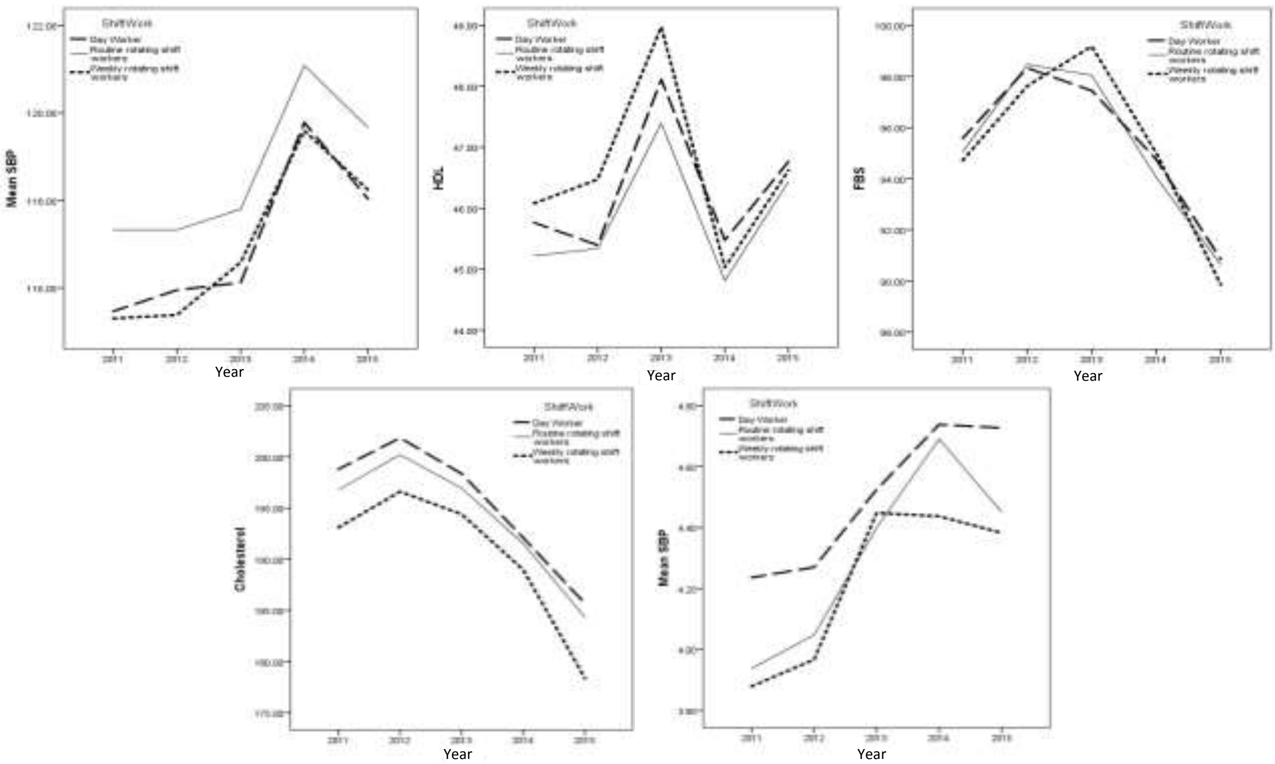


**Figure 2.** Trend plots of systolic blood pressure (SBP), high-density lipoprotein (HDL), fasting blood sugar (FBS), cholesterol and Framingham risk score (FRS) from 2011 to 2015

Such result has been supported in the previous studies like Gholami Fesharaki et al.,[1] Murata et al.,[13] Hublin et al.,[14] Yadegarfar and McNamee,[15] Virkkunen et al.,[16] Sfreddo et al.,[17] Puttonen et al.,[18] and it is not compatible with some other studies[19-26] regarding the blood pressure and it is consistent[4,27,28] and inconsistent[29,30] with other studies regarding the lipid profile.

**Table 3.** Trends in systolic blood pressure (SBP), high-density lipoprotein (HDL), fasting blood sugar (FBS), cholesterol and Framingham risk score (FRS) from 2011 to 2015 according to the shift schedule

| Variable | Shift schedule | Time duration | | | | | P† |
|---|---|---|---|---|---|---|---|
| | | 2011 | 2012 | 2013 | 2014 | 2015 | |
| SBP (mmHg) | DW | 115.5 ± 10.5 | 116.0 ± 12.0 | 116.1 ± 12.2 | 119.8 ± 12.9 | 118.0 ± 11.9 | < 0.001 |
| | RRS | 117.3 ± 12.2 | 117.3 ± 11.8 | 117.8 ± 12.4 | 121.1 ± 13.0 | 119.7 ± 12.8 | < 0.001 |
| | WRS | 115.3 ± 10.4 | 115.4 ± 10.4 | 116.6 ± 11.3 | 119.6 ± 11.5 | 118.2 ± 12.7 | < 0.001 |
| | P* | 0.004 | 0.026 | 0.033 | 0.101 | 0.037 | |
| HDL (mg/dl) | DW | 45.8 ± 7.9 | 45.4 ± 9.2 | 48.1 ± 9.6 | 45.5 ± 9.6 | 46.8 ± 9.5 | < 0.001 |
| | RRS | 45.2 ± 7.3 | 45.3 ± 8.6 | 47.4 ± 10 | 44.8 ± 9.4 | 46.4 ± 8.8 | < 0.001 |
| | WRS | 46.1 ± 7.1 | 46.5 ± 7.9 | 49.0 ± 8.4 | 45.0 ± 8.5 | 46.6 ± 10.4 | < 0.001 |
| | P* | 0.213 | 0.210 | 0.070 | 0.418 | 0.794 | |
| FBS (mg/dl) | DW | 95.6 ± 19.2 | 98.3 ± 21 | 97.5 ± 18.1 | 94.8 ± 20.5 | 90.9 ± 21.0 | < 0.001 |
| | RRS | 95.1 ± 18.0 | 98.5 ± 17.4 | 98.1 ± 17.4 | 94.1 ± 20.9 | 90.6 ± 25.2 | < 0.001 |
| | WRS | 94.7 ± 17.5 | 97.6 ± 21.4 | 99.2 ± 15.6 | 95.0 ± 21.3 | 89.9 ± 18.8 | < 0.001 |
| | P* | 0.798 | 0.883 | 0.436 | 0.758 | 0.829 | 0.798 |
| Cholesterol (mg/dl) | DW | 198.8 ± 35.9 | 201.9 ± 36.3 | 198.3 ± 37.9 | 192.1 ± 36.8 | 185.7 ± 36.3 | < 0.001 |
| | RRS | 196.8 ± 35.0 | 200.2 ± 35.7 | 196.9 ± 37.3 | 191.5 ± 37.8 | 184.3 ± 37.3 | < 0.001 |
| | WRS | 193.1 ± 31.5 | 196.6 ± 33.7 | 194.4 ± 35.0 | 189.0 ± 36.5 | 178.4 ± 33.1 | < 0.001 |
| | P* | 0.109 | 0.186 | 0.407 | 0.590 | 0.035 | |
| FRS | DW | 4.2 ± 2.4 | 4.3 ± 2.4 | 4.5 ± 2.9 | 4.7 ± 2.7 | 4.7 ± 2.8 | < 0.001 |
| | RRS | 3.9 ± 2.4 | 4.1 ± 2.3 | 4.4 ± 2.8 | 4.7 ± 2.9 | 4.5 ± 2.5 | < 0.001 |
| | WRS | 3.9 ± 2.2 | 4.0 ± 1.9 | 4.5 ± 3.2 | 4.4 ± 2.7 | 4.4 ± 2.8 | 0.001 |
| | P* | 0.038 | 0.109 | 0.708 | 0.409 | 0.111 | |

Data are shown as mean ± standard deviation (SD); * Analysis of variance (ANOVA) or Kruskal-Wallis tests; † Multilevel modeling
SBP: Systolic blood pressure; HDL: High-density lipoprotein; FBS: Fasting blood sugar; FRS: Framingham risk score; DW: Day worker; RRS: Routine rotating shift workers; WRS: Weekly rotating shift workers

**Table 4.** The comparison of Framingham risks score and its constituent variables changes during the study time

| Variable | Shift schedule | | | | | | P* |
|---|---|---|---|---|---|---|---|
| | Routine rotating shift workers | | Weekly rotating shift workers | | Day workers | | |
| | Mean | Median (Q1:Q3) | Mean | Median (Q1:Q3) | Mean | Median (Q1:Q3) | |
| SBP (mmHg) | 0.59 | 0 (-10:10) | 0.73 | 0 (-10:10) | 0.64 | 0 (-10:10) | 0.847 |
| HDL (mg/dl) | 0.31 | 0 (-4:5) | 0.14 | 0 (-5:5) | 0.25 | 0 (-5:5) | 0.772 |
| FBS (mg/dl) | -1.11 | -1 (-9:6) | -1.21 | -1 (-8:6) | -1.20 | -1 (-8:6) | 0.598 |
| Cholesterol (mg/dl) | -3.07 | -2 (-20:14) | -3.68 | -4 (-20:14) | -3.28 | -3 (-20:15) | 0.834 |
| FRS | 0.13 | 0 (-1:1) | 0.13 | 0 (-1:1) | 0.12 | 0 (-1:1) | 0.759 |

* Kruskal-Wallis test

For variable Y, at first $D_1 = Y_{2012} - Y_{2011}, D_2 = Y_{2013} - Y_{2012}, D_3 = Y_{2014} - Y_{2013}, D_4 = Y_{2015} - Y_{2014}$ was calculated, then the variable change was calculated using Change $Y = \bar{D}$

SBP: Systolic blood pressure; HDL: High-density lipoprotein; FBS: Fasting blood sugar; FRS: Framingham risk score; Q1: First quartile; Q3: Third quartile

The lack of association between FRS and SW might be due to the fact that younger and healthier people are usually recruited as shift workers because of low education, while weaker and older individuals are hired as day workers because of high education. Additionally, most of the day workers have administrative jobs, therefore less active. It, in turns, leads to weight gain (a risk factor of blood pressure elevation). Gholami Fesharaki et al.[31] found a significant increase in BMI (around 0.78 kg/m$^2$) among day workers compared to weekly rotating shift workers.

The other reason can be related to "stopping hypertension in EMSC" (SHIMSCO) plan for controlling of hypertension in EMSC.[32] SHIMSCO is one of the workplace intervention projects to control hypertension of EMSC workers, where workers received an educational schedule containing healthy lifestyle and self-care suggestions for hypertension management.

## Conclusion

Using powerful statistical modeling method for data analysis, sufficient sample size, homogeneity of the study population, and calculation of lipid profile and blood pressure in the clinic by 3 physicians are the strengths of this prospective cohort study. Nevertheless, lack of proper evaluation of the family history of blood pressure, information on previous work experiences, sleep, incomes, stress, and job satisfaction were considered as weaknesses of this research.

**Table 5.** Multilevel modeling for assessing the effect of shift work (SW) on systolic blood pressure (SBP), high-density lipoprotein (HDL), fasting blood sugar (FBS), cholesterol and Framingham risk score (FRS) by controlling baseline and confounder variables

| Response | Weekly rotating shift/day worker | | | Routine rotating shift/day worker | | | P‡ | ICC (%) |
|---|---|---|---|---|---|---|---|---|
| | β | SE | P* | β | SE | P† | | |
| SBP (mmHg) | -0.143 | 0.696 | 0.838 | 0.664 | 0.447 | 0.138 | 0.273 | 30 |
| HDL (mg/dl) | 0.217 | 0.484 | 0.653 | 0.084 | 0.315 | 0.789 | 0.899 | 36 |
| FBS (mg/dl) | 0.876 | 0.985 | 0.374 | 0.235 | 0.641 | 0.714 | 0.673 | 31 |
| Cholesterol (mg/dl) | -2.374 | 1.863 | 0.202 | -1.631 | 1.211 | 0.178 | 0.288 | 39 |
| FRS | 0.018 | 0.129 | 0.887 | -0.039 | 0.083 | 0.634 | 0.839 | 38 |

* For weekly rotating shift compared to day worker; † For routine rotating shift compared to day worker; ‡ Simultaneous P for weekly rotating and rotating shift compared to day worker

Result controlled for education, age, work experience, baseline body mass index (BMI), baseline SBP (just For SBP), and baseline FRS (just For FRS)

SBP: Systolic blood pressure; HDL: High-density lipoprotein; FBS: Fasting blood sugar; FRS: Framingham risk score; SE: Standard error; ICC: Interclass correlation

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## Conflict of Interests

Authors have no conflict of interests.

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