Original Article:

Assessing the effect of shift work among petrochemical Industries staff at Mahshahr, Iran

Maryam Kazemi¹, Alireza Abadi²*, Farid Zayeri³, Hormoz Hassanzade⁴

¹Department of Biostatistics, Faculty of Paramedical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran
²Department of Community and Health, Shahid Beheshti University of Medical Sciences, Tehran, Iran
³Associate Professor, Department of Biostatistics, Faculty of Paramedical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran
⁴Occupational Medicine, specialist petroleum industry Health Organization, Mahshahr, Iran

*Corresponding Author: email address: alirezaabadis@gmail.com (A.abadi)

ABSTRACT

This study aims to examine the effect of shift work on overweight and obesity, hypercholesterolemia and GHQ score (GHQ-28) as an indicator of psychological well-being in subjects working in petrochemical industry sited in Mahshahr, west of Iran. In this longitudinal study, population consisted of 2493 (1321 day workers and 1171 shift workers) whose mean ages were 46.18 years for day workers and 45.53 years for shift workers, during a four years period (from 2008 to 2011). All workers were investigated by Persian version of General Health Questionnaire-28 (GHQ-28) as screen tool. The serum cholesterol, height and weight were measured with definitions of hypercholesterolemia as serum total cholesterol ≥ 220 mg/dl, overweight and obesity as body mass index (BMI) ≥ 25 kg/m². A conditional joint random effects models approach was applied to explore the effect of shift working on multivariate responses over this period of time. Shift work was significantly associated with GHQ score and BMI. Results indicated that the shift workers had about 0.65 higher mean scores of GHQ than the day workers and 0.18 higher BMI (95% CI 0.17 to 1.14) and (95% CI 0.05 to 0.27), respectively. Shift work did not show significant relationship with hypercholesterolemia (95% CI -0.27 to 0.009). The results of the present study suggest that shift work may be directly responsible for increased body fatness and is associated with psychological problems.

KeyWords: Shift work; Body Mass Index; (GHQ-28) score; Petrochemical industries staff; Random effects model

INTRODUCTION

Shift work can be defined as work patterns that extend beyond the conventional 8-hours day time. It includes night shift work, rotating work (between the thirds of the 24-hours cycle) or working in unusual hours of daytime [1]. Over the last 50 years, due to the expansion of industrial activities and market needs, shift work has increased considerably in many countries [2]. Proportion of shift workers is estimated to represent more than 20% of the entire working population [3]. An investigation on the effect of shift work on the health of workers is therefore important. Based on previously published literature, the adverse health effects of shift working can comprise circadian rhythm disorders, gastrointestinal problems, psychological distress, coronary heart disease, metabolic syndrome, fatigue, disturbance of social and family life, and impairment in sleep quality [4]. The mechanisms linking shift work to health problems are not clear but sleep problems, stress and lifestyle and behavioral changes can be considered as the main potential mediators [5]. The General Health Questionnaire (GHQ) is used to detect psychiatric disorder in the general population and within community [6]. In the GHQ-28 the respondent is asked to compare his
recent psychological state with his usual state [7]. All items have a 4-point scoring system using Likert scoring (0-1-2-3) [8]. The GHQ-28 score contains 28 items; all items have been divided into four subscales through factor analysis as mentioned above [9]. Several studies have reported that hypercholesterolemia tend to occur more frequently in shift workers than in fixed daytime workers [10, 11]. Hypercholesterolemia is a lifestyle-related disease that is also thought to be related as risk factor for cardiovascular disease [12]. Obesity is a risk factor for chronic disease and a number of studies report that there are significant correlations between shift work and weight gain, overweight and obesity [13, 14]. One of the most commonly used indicators to classify underweight, normal and overweight or obesity in adults is body mass index (BMI) which is calculated through division of weight in kilograms by the square of the height in meters (kg/m²) [15]. However, most of the previous studies were cross-sectional, while here a longitudinal study is carried out on the relationship between alternating shift work and the variation of cholesterol level, BMI and change in level of GHQ. The link between cardiovascular disease, psychiatric illness and shift work is still questioned and an investigation among shift workers versus day workers will provide better understanding of how shiftwork might exert its effect during a four year period in a relatively large sample size of petrochemical industry staff. Petrochemical industries are among the well-known and economically important continuous work areas, in which shift working is unavoidable. It is, therefore, necessary to evaluate the adverse health effects of shift working on workers in these industries.

MATERIALS AND METHODS

Study population and sampling

In this longitudinal research, a total of 2493 petrochemical staff of Mahshahr city, southwest of Iran, who participated in the periodical health examinations were recorded 4 times from 2008 to 2011. All these staff according to a regular annual schedule were referred to occupational center. There, height and weight as a part of the periodic examination were measured by the trained nurse. There are two types of job schedule for staff: first, as day worker and second, as constant rotational shift alternating with periods of four days. This study considered the BMI as an ordinal outcome with categories: <18.5 kg/m² (underweight), 18.5-25 (Normal), and >25 (overweight or obese)[Ha, 2005 #170]. The health examinations, including blood sampling were carried out randomly between 9:00h and 15:00h throughout the study period. None of the measurements were taken within 30 min after a meal or heavy physical activity. Hypercholesterolemia was classified as a total serum cholesterol of ≥220 mg/dl (5.7 mmol/l)). GHQ-28 was considered as continuous responses and workers who showed high GHQ-28 score were considered as having poor psychological well-being. The multivariate responses consist of GHQ-28 score, cholesterol level (≤200, >200) and BMI.

Data Analysis

We employed conditional joint random effects model, which takes into account the inherent association between the continuous, binary and ordinal outcomes. This study assumes that there are m subjects and n repeated measurement for the ith subjects. At the first stage, interaction effect of time and shift working are both included within the models for multivariate outcomes. Then, the proposed joint modeling approach is applied to analyze the data and concluded that it is not statistically significant. The model parameters were estimated using the Bayesian method and the 95% credible intervals of the estimates were used to evaluate the statistical significance; if a credible interval for a variable includes zero, this means that the effect of this variable is non-significant.
GHQ_{ij} = \beta_{10} + \beta_{11}\text{shift}_{ij} + \beta_{12}\text{time}_{i} + \mathbf{b}_l + \varepsilon_{ij}

(CHO_{ij} = 1) = \phi(\beta_{20} + \beta_{21}\text{shift}_{ij} + \beta_{22}\text{time}_{i} + \mathbf{b}_l)

(BMI_{ij} \leq K) = \phi(\alpha_k - \beta_{30} - \beta_{31}\text{shift}_{ij} - \beta_{32}\text{time}_{i} - \mathbf{b}_l)

\mathbf{\varepsilon}_i = \begin{pmatrix}
\varepsilon_{i1} \\
\vdots \\
\varepsilon_{in_i}
\end{pmatrix} \overset{iid}{\sim} \mathcal{N}(0, \mathbf{\Sigma}_\varepsilon)

\mathbf{b}_i = \begin{pmatrix}
\mathbf{b}_{1i} \\
\mathbf{b}_{2i} \\
\mathbf{b}_{3i}
\end{pmatrix} \overset{iid}{\sim} \mathcal{N}(0, \mathbf{G})

GHQ_{ij}, CHOL_{ij} and BMI_{ij} are the continuous, binary and ordinal responses, respectively and \(\beta = (\beta_1, \beta_2, \beta_3)\) are unknown regression coefficients and \(\mathbf{b}_i\)'s are random effects, which are independent of the within-subject random errors \(\varepsilon_i\). It is noted that the covariance matrix \(\mathbf{G}\) of the random effects \(\mathbf{b}_i = (\mathbf{b}_{1i}, \mathbf{b}_{2i}, \mathbf{b}_{3i})\) actually reflects the inherent association between the longitudinal continuous, binary and ordinal outcomes. Data were analyzed with SPSS (version 22) and R (version 3.3.3), continuous variable are presented as the mean \pm standard deviation, whereas categorical data are presented as frequency and percentages. Chi-square test, and ANOVA are used to find out any relationships between shift working and BMI, cholesterol level and GHQ-28 score.

RESULTS

This study was performed on 2493 male workers of Petrochemical industries in Mahshahr city. Among these participants, 1172 (56.2\%) subjects were shift workers and 1321 (43.8\%) subjects were day workers. The mean (SD) age of these staf was 44.58 (8.42\%) years, ranging from 24 to 66 years. The mean (SD) age of the shift and day workers was 46.18 (9.14\%) years old and 42.53 (6.87\%) years old, respectively. There was no statistically significant result in the mean age between two groups. (45.53\% \pm 6.87 for day worker and 46.18\% \pm 9.14 for shift worker, p=0.001).

Error! Reference source not found. shows the results of conditional joint random effects modeling. In this study, it seems that ‘shift work’ did not show significant relationship with hypercholesterolemia; despite the borderline difference of cholesterol between shift workers and day workers, it was not statistically significant (95\% CI -0.27 to 0.009).

The shift work has a positive relationship with BMI and the mean GHQ score, indicating that rotating shift work causes obesity and psychiatric diseases. For the GHQ variable, the estimated parameter of 0.65 shows that the shift workers had about 0.65 higher mean scores of GHQ than workers in four times of measurement. Regarding GHQ, two groups revealed the same trend in the first year, but at the end of the last year, the difference between two groups was 1.4. For BMI variable, the proportion of shift workers with normal BMI showed a higher decrease in comparison with day workers. No obvious trend was observed for cholesterol, unless 6.5\% difference in the first year between shift and day workers decreased to 3.5\% at the end of the second year. Mean percentages of overweight and obese workers for each group are shown in figure 1. For BMI variable, during the 4 years, shift workers had a worse situation compared to day worker. (Shift workers had higher BMI than day workers). On hypercholesterolemia variable, the %65 initial difference between the two groups reduced to %3.1 in year 4 and the comparison of the mean of GHQ-28 score in figure 3 revealed that day workers had more psychological problem than shift workers.
the day workers (95% CI 0.17 to 1.14). In addition, for the categorical BMI variable, the estimated odds of OR 1.18 showed that odds of being overweight or obese in shift workers was about 18 percent higher than the day workers (95% CI 0.05 to 0.27).

Table 1. Descriptive statistics for BMI, cholesterol level and GHQ-28 scores of the personnel at different time points

<table>
<thead>
<tr>
<th>Response</th>
<th>Category</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Day workers</td>
<td>Shift workers</td>
<td>Day workers</td>
<td>Shift workers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>192(31.7%)</td>
<td>318(38.2%)</td>
<td>201(31.7%)</td>
<td>262(32.6%)</td>
</tr>
<tr>
<td>CHOL</td>
<td>&lt;=200</td>
<td>201(31.7%)</td>
<td>262(32.6%)</td>
<td>166(25.9%)</td>
<td>231(28.9%)</td>
</tr>
<tr>
<td></td>
<td>&gt;200</td>
<td>414(68.3%)</td>
<td>515(61.8%)</td>
<td>434(68.3%)</td>
<td>542(67.4%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>474(74.1%)</td>
<td>568(71.1%)</td>
<td>296(66.2%)</td>
<td>342(63.1%)</td>
</tr>
<tr>
<td>BMI</td>
<td>Underweight</td>
<td>72(11.9%)</td>
<td>63(7.5%)</td>
<td>68(10.7%)</td>
<td>74(9.2%)</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>182(30.0%)</td>
<td>247(29.7%)</td>
<td>218(34.3%)</td>
<td>253(31.5%)</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>352(58.1%)</td>
<td>523(62.8%)</td>
<td>349(55.0%)</td>
<td>477(59.3%)</td>
</tr>
<tr>
<td>GHQ score</td>
<td></td>
<td>11.97±6.7</td>
<td>11.62±6.1</td>
<td>12.24±6.8</td>
<td>11.48±6.2</td>
</tr>
</tbody>
</table>

Table 2. Joint modeling results for assessing the effect of shift working on GHQ, cholesterol level and BMI

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>Est</th>
<th>SD</th>
<th>2.5% CI*</th>
<th>97.5% CI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHQ-28 Score</td>
<td>Intercept</td>
<td>11.06</td>
<td>0.2413</td>
<td>10.5821</td>
<td>11.5303</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>0.30</td>
<td>0.0713</td>
<td>0.1680</td>
<td>0.4454</td>
</tr>
<tr>
<td>CHOL</td>
<td>Intercept</td>
<td>-0.5725</td>
<td>0.0725</td>
<td>-0.7139</td>
<td>-0.4251</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>-0.01259</td>
<td>0.0753</td>
<td>-0.2759</td>
<td>0.0099</td>
</tr>
<tr>
<td>BMI</td>
<td>Intercept (Underweight/Normal)</td>
<td>2.9311</td>
<td>0.0762</td>
<td>2.7850</td>
<td>3.0806</td>
</tr>
<tr>
<td></td>
<td>Shift (Day/Shift)</td>
<td>0.1634</td>
<td>0.0572</td>
<td>0.0538</td>
<td>0.2758</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>-0.0172</td>
<td>0.0182</td>
<td>-0.0525</td>
<td>0.0190</td>
</tr>
<tr>
<td></td>
<td>Intercept (Overweight/Normal)</td>
<td>2.4611</td>
<td>0.0448</td>
<td>2.2976</td>
<td>2.4664</td>
</tr>
</tbody>
</table>

*Credible interval

Figure 1. Comparison of the two groups of participants with hypercholesterolemia

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DISCUSSION

The present study used a random effects model to assess the effect of shift work on GHQ-28 score, hypercholesterolemia and overweight or obesity. At the best of our knowledge, this is the first study performed in Iran which evaluates the simultaneous effect of shift work on BMI, Cholesterol level and GHQ-28 score. The results showed that shift working was significantly associated with lower GHQ scores and higher percentage of overweight and obese cases in the studied staff.

One of the main findings of the study was that the mean GHQ-28 score in shift workers was significantly higher than the day workers. This means that the general health status of the shift workers was poorer than the day workers. Our findings revealed that two groups had rather similar scores in the first year, but at the end of the last year, the mean difference between two groups was about 1.4. The present study did not evaluate the scores of the GHQ subscales but many studies indicated that social dysfunction, anxiety and insomnia were more problematic than...
somatic symptoms and depression among shift workers [8, 16, and 17]. For instance, a study by Virtanen et al investigated the association between shift work and the onset of mental disorder such as insomnia and depression for 14 months. In this study, the researchers showed that shift work significantly increases the risk of depression and sleep disorders [18]. In another cohort study on 295 male Japanese electrical manufacturers no significant differences were found among shift workers and day workers as for the scores for the total GHQ-28 score and its four subscales [19]. Various mechanisms may be involved in the health effects of shift work; one of them is social infraction which makes it difficult for shift workers to stay with their families. This mechanism could be due to stress, as previous study have shown stress causes irregular sleep, anxiety and weight gain and other problems [20, 30].

The present study also showed that shift workers had higher BMI compared with day workers: odds of being overweight or obese in shift workers was about 18 percent higher than the day workers. This might be considered as an important finding, because a higher BMI is associated not only with an increased risk for morbidity and mortality, but also with accidents and injuries at work [21, 22]. This result was consistent with the reports of another survey conducted by L Di Lorenzo et al. They showed that obesity was more prevalent in shift workers than in day workers (%20 vs. %9.7) [23]. Furthermore, a Danish cohort study on men aged 40-59 also found an association between shift work and increased body weight [24]. Other studies have revealed that overweight and obesity are more prevalent in day workers than shift workers and reported significant relationship between body weight and shift work [25, 27]. Weight gain in shift workers has been explained by several mechanisms, such as higher calorie intake [28], changes both in dietary habits (such as eating fewer meals and more snacks) and in the circadian distribution of food intake [28, 29], lower physical exercise, and changes in sleeping habits [28].

Hypercholesterolemia is a lifestyle-related disease which is promoted by factors such as sedentary lifestyle, excessive stress and an increase in the consumption of a high-fat diet which are considered to be risk factors for coronary heart disease [30, 31]. Shift workers have behavioral changes including dietary habits and smoking. Lennermas et al reported that 22 shift workers who were eating mostly in the night had higher levels of serum total cholesterol [32]. Previously, a number of cross-sectional and longitudinal studies have been conducted on the relationship between shift work and hypercholesterolemia. Some of the cross-sectional studies concluded that shift work may be a risk factor for the onset of hypercholesterolemia [11, 33, 34] and others reported no significant relationship between them [32, 35, 36]. In a cross-sectional study performed by Nazri et al on 148 Malaysian workers, no significant correlation was found regarding total cholesterol [37]. Another 14-year cohort study on 5510 male workers in a steel company reported no significant association between shift workers and hypercholesterolemia. Using healthy workers in the shift works could be the reason for this finding and may explain the absence of a link between shift work and hypercholesterolemia.

Since a study on the health effects of shift work should take into account the healthy worker effect, cross-sectional studies would not be able to eliminate that effect and thus have less reliability than longitudinal study [38, 39]. In the present study, random effects model was used for assessing the relationship between shift working and GHQ score, BMI and hypercholesterolemia. An advantage of this method is that it allows an evaluation of repeated measurements of work condition and lifestyle. Moreover, the large sample size was another advantage of this research. However, the current study has several limitations that should be mentioned. First, only the staff of petrochemical in Mahshahr, Iran were studied. Therefore, the results can’t be generalizable among all staff of petrochemical in Iran. Second, since a pre-designed questionnaire was used, the researchers could not evaluate the scores of the GHQ subscales. Third, no investigation over other factors such as lifestyle, eating habits and socioeconomic status was used.
CONCLUSION
In summary, our results showed that shift work is related to some aspects of the health in the shift workers. Therefore, the establishment of programs for health promotion of shift work disorders in companies is urgently required. The present literature found that the shift schedule leads to psychiatric disorders and higher incidence of obesity among petrochemical staff. These findings emphasize the need for ergonomic interventions for improving the working conditions of shift workers. Consequently, in order to improve the staff’s health, regular checkups, and efficient health screening should be used in order to control unhealthy lifestyle habits of all workers and particularly shift workers of industrialized countries.

“The authors declare no conflict of interest”

REFERENCES


