

# Health Effects Associated With Shift Work in 12-Hour Shift Schedule Among Iranian Petrochemical Employees

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**Introduction.** The main purposes of this study were to investigate shift-work-related health problems in 12-h shift schedule and to identify major factors associated with these problems. **Materials and methods.** This cross-sectional study was conducted at 8 petrochemical plants. The study population consisted of 1203 workers (549 shift and 654 day workers). Data on personal details, the shift schedule and adverse health outcomes were collected with a self-administered questionnaire. **Results.** The results showed that health problems in shift workers were more prevalent than in day workers; however, the differences were significant only in gastrointestinal and musculoskeletal disorders. Logistic regression analysis revealed that in addition to shift work, other variables such as extended work time, type of employment, second job and job unit were associated with health problems. **Conclusions.** Working shifts is one important variable influencing the health of petrochemical workers. To improve workers' health, interventional program should focus on the shift schedule as well as other significant aspects of working conditions.

shift work    12-hour shift schedule    extended work shift    health problems  
petrochemical industry

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## 1. INTRODUCTION

The adverse health effects of working shifts have been widely studied and documented in the litera-

ture [1]. They include circadian rhythm disorders, gastrointestinal problems, impairment in sleep quality and quantity, psychological disorders, coronary heart disease, certain cancers, metabolic

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syndrome, chronic fatigue, disturbance of social and family life and performance deterioration [1, 2, 3, 4, 5, 6].

Continuous industrial processes need a shift pattern of 24-h operational cover. The increasing demand for provision of 24-h service, together with the increasing use of complex and costly equipment, may cause diverse problems leading to deterioration in health, productivity and safety [2]. As a continuous process, in the petrochemical industry, shift work has always been common. In some Iranian petrochemical plants, particularly of the Asalooeyeh region (southern part of Iran, Bushehr province), extended shift work (12-h) has been implemented for years. In these plants, shift work typically involves an uninterrupted duty period (or tour) of 14 consecutive shifts of 12 h each followed by 7 days of rest. Tours are worked as successive days and nights with a midtour roll-over shift. This kind of shift-work arrangement is implemented in this area because of the numbers of employees that can be accommodated in an installation, transportation cost reduction, extreme climate, lack of local workers as well as required facilities to provide accommodation for workers' families in the area. In this shift pattern, long working hours (i.e., 12-h shifts) impose extra demands on employees.

Studies on extended work shifts have reported both positive and negative outcomes. The major concerns with this type of shift pattern have been reported to be increasing fatigue, performance decrement, error increment, labor turnover, concentration problems and, finally, detrimental impact on the health of individuals [7]. In this situation, solutions should be sought to combat the adverse effects on the workers that have been associated with working shifts.

Therefore, since there have been few studies on shift-work-related problems in Iranian petrochemical industries with 12-h shift schedule, this comprehensive study was carried out at eight petrochemical plants in the Asalooeyeh region with the following objectives:

- determining the prevalence rate of health problems (including gastrointestinal, cardiovascular, musculoskeletal and psychological

disorders) in shift workers compared with their day counterparts;

- identifying major factors associated with health problems among Iranian petrochemical employees.

## 2. MATERIALS AND METHODS

This cross-sectional study was conducted at eight petrochemical plants in the Asalooeyeh region from March 2009 to February 2010, where male employees did all operational jobs.

### 2.1. Subjects

According to official records, 7185 workers were employed in the eight plants studied, 2120 of them were shift workers. To determine the sample size, a pilot study took place in one of the plants; 50 petrochemical employees participated. On the basis of the results of the pilot study, with the confidence level of 95% and study power of 80%, the sample size was calculated to be collectively 1259, including 629 shift and 630 day workers. From the 629 shift workers, 549 individuals returned the questionnaire (response rate: 87.3%). The response rate for day workers was 100%. A limited number of extra questionnaires were completed by day workers in some plants (24 subjects) increasing the total number of daytime subjects to 654. In all, 1203 male subjects completed and returned the questionnaire.

In each plant, samples were randomly selected from the corresponding personnel list such that workers in important jobs and units (i.e., operation; engineering; security; health, safety and environment, and firefighting; maintenance and office work) were included. To have enough samples in each job unit, proportional to size methodology was applied.

### 2.2. Data Gathering Tool

An anonymous self-administered questionnaire was used to collect the required data from each subject. This was developed with the Survey Of Shiftworkers questionnaire developed for research on shift workers and shown to have

satisfactory reliability and validity across various occupational samples and cultures [8]. The 6-page, Persian-language questionnaire consisted of 54 questions in the following areas:

- individual circumstances (age, job tenure, weekly working hours, marital status, type of employment, number of children, second job, overtime work, education and job unit);
- shift schedule details;
- health outcomes including gastrointestinal disorders (appetite disturbance, constipation/diarrhea, digestion difficulties, peptic ulcer, stomachache and heartburn); cardiovascular disorders (hypertension, irregular pulse and chest pain); musculoskeletal disorders (discomfort/pain in different body regions); psychological disorders (loss of concentration, dizziness, nervousness, carelessness, repetitive errors, irritation, depression, headache, worthlessness, inability to overcome difficulties and incapability to make decisions), sleep disturbances; social and domestic disruption and, finally, hypnotic drug use.

This paper focuses on the health outcomes of gastrointestinal, cardiovascular, musculoskeletal and psychological disorders. A separate paper will present other health outcomes.

To estimate the reliability of the questionnaire, a pilot study, as previously mentioned, was carried out on 50 petrochemical workers. Based on the subjects' oral and written feedback, some questions were modified and some were omitted. After these modifications, the internal consistency coefficient estimated with Kuder-Richardson Formula 20 (KR 20) [9] was found to be .81, which was assumed appropriate.

### 2.3. Data Analysis and Statistical Procedures

Statistical analyses were performed with SPSS 11.5 as follows:

- independent sample *t* test was used to assess differences in the means of age, job tenure and weekly working hours between shift and day workers;

- $\chi^2$  test was used to investigate differences in the prevalence of health outcomes, marital status, type of employment, number of children, second job, overtime work and education between the two groups;
- binary logistic regression analysis (forward method) was used for each outcome retaining the variables in the models to adjust for potential confounders. In the regression analysis, if the *p* value of univariate analysis for assessing association between the variables and reported outcomes was  $\leq .250$ , the variable was included in the binary logistic regression analysis [10].

The level of significance was set at .05.

The Shiraz University of Medical Sciences ethics committee reviewed and approved the study protocol.

## 3. RESULTS

Table 1 summarizes the subjects' personal details. The mean age of day workers was significantly higher than that of shift workers. The mean number of weekly working hours of shift workers was significantly higher than that of day workers ( $p = .001$ ). Overtime work was significantly more frequent in shift than in day workers ( $p = .019$ ). The level of education was higher in day than in shift workers ( $p = .001$ ).

Table 2 illustrates the frequency of health problems in shift and day workers. Although all categorized disorders were more frequent in shift workers, only the prevalence rates of gastrointestinal ( $p = .001$ ) and musculoskeletal disorders ( $p = .002$ ) were significantly higher in shift workers than in their day counterparts.

Table 3 presents significant factors associated with gastrointestinal problems in all subjects. The significant factors are the result of a binary logistic regression analysis performed to adjust for potential confounders. Univariate analyses revealed that work schedule (shift/day), weekly working hours, type of employment, second job, overtime work and education had the necessary requirement ( $p \leq .250$ ) to be included in the regression model. Work schedule, weekly

TABLE 1. Individual Data and Demographics of Subjects ( $n = 1203$ )

| Individual Variables      | Shift Workers<br>( $n = 549$ ) | Day Workers<br>( $n = 654$ ) | $p$               |
|---------------------------|--------------------------------|------------------------------|-------------------|
|                           | $M \pm SD$                     |                              |                   |
| Age (years)               | 29.83 $\pm$ 5.74               | 31.20 $\pm$ 7.08             | .001 <sup>a</sup> |
| Job tenure (years)        | 4.63 $\pm$ 3.91                | 4.92 $\pm$ 4.47              | .237 <sup>a</sup> |
| Weekly working hours      | 88.10 $\pm$ 7.73               | 79.44 $\pm$ 13.29            | .001 <sup>a</sup> |
| Shift work tenure (years) | 3.80 $\pm$ 3.65                | N/A                          | N/A               |
|                           | $n$ (%)                        |                              |                   |
| Marital status            |                                |                              |                   |
| single                    | 196 (35.7)                     | 202 (30.9)                   | .085 <sup>b</sup> |
| married                   | 353 (64.3)                     | 452 (69.1)                   |                   |
| Type of employment        |                                |                              |                   |
| formal                    | 312 (56.8)                     | 321 (49.1)                   | .008 <sup>b</sup> |
| contractor                | 237 (43.2)                     | 333 (50.9)                   |                   |
| Number of children        |                                |                              |                   |
| $\leq 3$                  | 541 (98.5)                     | 631 (96.5)                   | .028 <sup>b</sup> |
| $> 3$                     | 8 (1.5)                        | 23 (3.5)                     |                   |
| Second job                |                                |                              |                   |
| yes                       | 10 (1.8)                       | 23 (3.5)                     | .078 <sup>b</sup> |
| no                        | 539 (98.2)                     | 631 (96.5)                   |                   |
| Overtime work             |                                |                              |                   |
| yes                       | 475 (86.5)                     | 533 (81.5)                   | .019 <sup>b</sup> |
| no                        | 74 (13.5)                      | 121 (18.5)                   |                   |
| Education                 |                                |                              |                   |
| high school degree        | 56 (10.2)                      | 117 (17.9)                   | .001 <sup>b</sup> |
| diploma                   | 281 (51.2)                     | 209 (32.0)                   |                   |
| associate's degree        | 67 (12.2)                      | 69 (10.6)                    |                   |
| B.Sc. and higher          | 145 (26.4)                     | 259 (39.6)                   |                   |
| Job unit                  |                                |                              |                   |
| engineering               | 55 (10.0)                      | 16 (2.4)                     | N/A               |
| security                  | 90 (16.4)                      | 241 (36.9)                   |                   |
| office work               | 57 (10.4)                      | 47 (7.2)                     |                   |
| HSE and firefighting      | 218 (39.7)                     | 68 (10.4)                    |                   |
| operation                 | 70 (12.8)                      | 124 (19.0)                   |                   |
| maintenance               | 59 (10.7)                      | 158 (24.2)                   |                   |

Notes. a—*independent sample t* test, b— $\chi^2$  test; N/A—not applicable, B.Sc.—Bachelor of Science, HSE—health, safety and environment.

TABLE 2. Frequency of Health Problems in Shift and Day Workers ( $n = 1203$ )

| Health Problems  | Shift Workers (%)<br>( $n = 549$ ) | Day Workers (%)<br>( $n = 654$ ) | $p^a$ |
|------------------|------------------------------------|----------------------------------|-------|
| Gastrointestinal | 310 (56.5)                         | 283 (43.3)                       | .001  |
| Cardiovascular   | 92 (16.8)                          | 98 (15.0)                        | .428  |
| Musculoskeletal  | 294 (53.6)                         | 290 (44.3)                       | .002  |
| Psychological    | 439 (80.0)                         | 496 (75.8)                       | .095  |

Notes. a— $\chi^2$  analysis of the prevalence of symptoms in the two groups.

working hours and type of employment were identified as the major factors significantly associated with reported gastrointestinal symptoms; they were retained in the regression model. The results of this analysis showed that gastrointestinal disorders were more likely in shift than in day workers (*OR* 1.52, *p* = .001), in workers with >84 than with ≤84 h per week (*OR* 1.35, *p* = .017) and in contractors than in formal employees (*OR* 1.36, *p* = .010).

Table 4 lists significant factors associated with cardiovascular problems in all subjects. Univariate analyses revealed that weekly working hours, type of employment and job unit should be included in the regression model. Weekly working hours and job unit were significantly associated with cardiovascular symptoms; they were retained in the regression model. The results of this analysis showed that cardiovascular disorders were more likely in workers with >84 than

with ≤84 h per week (*OR* 1.02, *p* = .001). They were less likely in operation workers than in workers of other job units, except for security.

Table 5 demonstrates significant factors associated with musculoskeletal problems in all subjects. Univariate analyses revealed that work schedule, age, weekly working hours, type of employment, second job, education and job unit should be included in the regression model. Work schedule, type of employment and second job were significantly associated with reported musculoskeletal symptoms; they were retained in the regression model. The results of this analysis showed that musculoskeletal disorders were more likely in shift than in day workers (*OR* 1.39, *p* = .006), in contractors than in formal employees (*OR* 1.6, *p* = .001) and in workers with a second job than in those with no second job (*OR* 2.3, *p* = .037).

**TABLE 3. Regression Model Indicating Factors With the Strongest Influence on Gastrointestinal Disorders in Subjects (*n* = 1203)**

| Variables Retained in Model | <i>B</i> ( <i>SE</i> ) | <i>OR</i> | 95% CI       | <i>p</i> |
|-----------------------------|------------------------|-----------|--------------|----------|
| Work schedule               |                        |           |              |          |
| day                         |                        | 1.00      |              |          |
| shift                       | 0.421 (0.122)          | 1.52      | [1.20, 1.93] | .001     |
| Weekly working hours        |                        |           |              |          |
| ≤84                         |                        | 1.00      |              |          |
| >84                         | 0.300 (0.126)          | 1.35      | [1.05, 1.73] | .017     |
| Type of employment          |                        |           |              |          |
| formal                      |                        | 1.00      |              |          |
| contractor                  | 0.308 (0.119)          | 1.36      | [1.08, 1.72] | .010     |

Notes. *OR*—odds ratio, *CI*—confidence interval.

**TABLE 4. Regression Model Indicating Factors With the Strongest Influence on Cardiovascular Disorders in Subjects (*n* = 1203)**

| Variables Retained in Model | <i>B</i> ( <i>SE</i> ) | <i>OR</i> | 95% CI       | <i>p</i> |
|-----------------------------|------------------------|-----------|--------------|----------|
| Weekly working hours        |                        |           |              |          |
| ≤84                         |                        | 1.00      |              |          |
| >84                         | 0.012 (0.002)          | 1.02      | [1.01, 1.03] | .001     |
| Job unit                    |                        |           |              |          |
| operation                   |                        | 1.00      |              |          |
| engineering                 | 1.076 (0.245)          | 2.93      | [1.82, 4.74] | .001     |
| security                    | 0.551 (0.343)          | 1.74      | [0.89, 3.40] | .108     |
| office work                 | 0.799 (0.198)          | 2.22      | [1.50, 3.28] | .001     |
| HSE and firefighting        | 0.972 (0.321)          | 2.64      | [1.41, 4.96] | .002     |
| maintenance                 | 0.956 (0.252)          | 2.60      | [1.59, 4.26] | .001     |

Notes. *OR*—odds ratio, *CI*—confidence interval, HSE—health, safety and environment.

**TABLE 5. Regression Model Indicating Factors With the Strongest Influence on Musculoskeletal Disorders in Subjects ( $n = 1203$ )**

| Variables Retained in Model | B (SE)      | OR   | 95% CI       | p    |
|-----------------------------|-------------|------|--------------|------|
| Work schedule               |             |      |              |      |
| day                         |             | 1.00 |              |      |
| shift                       | 0.33 (0.12) | 1.39 | [1.10, 1.75] | .006 |
| Type of employment          |             |      |              |      |
| formal                      |             | 1.00 |              |      |
| contractor                  | 0.47 (0.12) | 1.60 | [1.27, 2.02] | .001 |
| Second job                  |             |      |              |      |
| no                          |             | 1.00 |              |      |
| yes                         | 0.83 (0.40) | 2.30 | [1.05, 5.03] | .037 |

Notes. OR—odds ratio, CI—confidence interval.

**TABLE 6. Regression Model Indicating Factors With the Strongest Influence on Psychological Disorders in Subjects ( $n = 1203$ )**

| Variables Retained in Model | B (SE)        | OR   | 95% CI       | p    |
|-----------------------------|---------------|------|--------------|------|
| Weekly working hours        |               |      |              |      |
| $\leq 84$                   |               | 1.00 |              |      |
| $> 84$                      | 0.335 (0.155) | 1.40 | [1.03, 1.89] | .031 |
| Type of employment          |               |      |              |      |
| formal                      |               | 1.00 |              |      |
| contractor                  | 0.503 (0.152) | 1.65 | [1.23, 2.23] | .001 |
| Job unit                    |               |      |              |      |
| operation                   |               | 1.00 |              |      |
| engineering                 | 0.035 (0.252) | 1.04 | [0.63, 1.70] | .888 |
| security                    | 0.091 (0.356) | 1.10 | [0.55, 2.20] | .799 |
| office work                 | 0.537 (0.220) | 1.71 | [1.11, 2.64] | .015 |
| HSE and firefighting        | 0.400 (0.296) | 1.49 | [0.84, 2.67] | .176 |
| maintenance                 | 0.743 (0.240) | 2.10 | [1.31, 3.37] | .002 |

Notes. OR—odds ratio, CI—confidence interval.

Table 6 displays significant factors associated with psychological problems in all subjects. Univariate analyses revealed that work schedule, age, weekly working hours, type of employment, second job, education and job unit should be included in the regression model. Weekly working hours, type of employment and job unit were significantly associated with reported psychological symptoms; they were retained in the regression model. The results of this analysis showed that psychological disorders were more likely in workers with  $>84$  than with  $\leq 84$  h per week ( $OR$  1.4,  $p = .031$ ), in contractors than in formal employees ( $OR$  1.65,  $p = .001$ ) and in security and maintenance than in operation.

#### 4. DISCUSSION

Except for age, weekly working hours, type of employment, number of children, overtime work and level of education, shift workers and their day time counterparts had similar socioeconomic and demographic characteristics as they were from the same petrochemical plants.

Like in other studies [11, 12, 13, 14], the prevalence rate of health problems in shift workers in this study was higher than in day workers with a significant difference in gastrointestinal and musculoskeletal symptoms.

The prevalence rate of gastrointestinal symptoms in shift workers was significantly higher than in day workers. This finding is in agreement with other studies [3, 15, 16, 17]. Univariate

analyses revealed that this kind of disorder was associated with different variables. However, logistic regression analysis showed that after adjusting for potential confounders, in addition to work schedule, weekly working hours (>84 versus  $\leq 84$  h) and type of employment (contractors versus formal employees) were retained in the model and were, therefore, significantly associated with reported gastrointestinal symptoms. The results of the investigation into working hours are in line with some other studies, in which long working hours were shown to be associated with higher health risks and should, therefore, be restricted [11, 18]. Regarding type of employment, contractors usually have hard physical work, a lower salary and less job security than formal employees. This indicates contractors' exposure to a high level of job-related stress, which has been shown to be associated with various health outcomes [19, 20].

The prevalence rate of cardiovascular symptoms in shift workers was higher than in day workers but the difference was not significant. In contrast to some other studies indicating an association between shift work and cardiovascular disorders [5, 6, 21], the performed analysis showed that shift work was not associated with the symptoms. This modeling demonstrated that long working hours and job unit were independent risk factors for cardiovascular symptoms. Our findings showed that in operation workers, the probability of this disorder was significantly lower than in others (except for security). Differences in the content of the subjects' job tasks could possibly explain this.

The prevalence rate of musculoskeletal symptoms in shift workers was significantly higher than in day workers. While there have been few studies on the relationship between shift work and musculoskeletal disorders, our regression analysis revealed that after adjusting for confounding variables, shift work was a risk factor for musculoskeletal symptoms, increasing their probability by 40%. Additionally, type of employment and second job were also retained in the model, increasing their probability by 60 and 130%, respectively. Although no data are available on the nature of the workers' second job,

one may infer that physical and mental workload imposed on the workers by a second job can be considered as a risk factor for musculoskeletal disorders and a possible explanation for the observed association.

Whereas there is evidence to suggest that shift work is associated with an increasing degree and frequency of psychological complaints [22, 23, 24], this study found no significant association between shift work and psychological problems. Regression analysis indicated that weekly working hours, type of employment and job unit were the only retained factors in the model. Long working hours (>84 h) and contractor type of employment increased the probability of psychological disorders by 40 to 65%, respectively. The probability of psychological problems was lower in operation workers than in office workers and maintenance employees (*OR* 1.71–2.10).

Finally, limitations of this investigation should be considered when drawing conclusions. Conclusions may be limited by the self-selection of subjects and the use of self-reported data; this study relied on subjective measures and no attempt was made to validate these data against objective ones.

## 5. CONCLUSION

The findings of this study collectively indicate that shift work is an important variable influencing the health of petrochemical workers. Long working hours, type of employment, second job and job unit also influenced the occurrence of disorders. To improve workers' health, any interventional program should, therefore, focus on the shift work schedule and on other significant aspects of working conditions.

## REFERENCES

1. Mitchell RJ, Williamson AN. Evaluation of an 8-hour versus a 12-hour shift roster on employees at a power station. *Appl Ergon*. 2000;31(1):83–93.
2. Ognianova VM, Dalbokova DL, Stanchev V. Stress states, alertness and individual differences under 12-hour

- shiftwork. *Int J Ind Ergon.* 1998;21(3–4): 283–91.
3. Colligan MJ, Tepas DI. The stress of hours of work. *Am Ind Hyg Assoc J.* 1986; 47(11):686–95.
  4. Tamagawa R, Lobb B, Booth R. Tolerance of shift work. *Appl Ergon.* 2007;38(5): 635–42.
  5. Knutsson A, Hallquist J, Reuterwall C, Theorell T, Akerstedt T. Shiftwork and myocardial infarction: a case-control study. *Occup Environ Med.* 1999;56(1):46–50. Retrieved June 18, 2012, from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1757657/pdf/v056p00046.pdf>
  6. Boivin DB, Tremblay GM, James FO. Working on atypical schedules. *Sleep Med.* 2007;8(6):578–89.
  7. Milia LD. A longitudinal study of the compressed workweek: comparing sleep on a weekly rotating 8 h system to a faster rotating 12 h system. *Int J Ind Ergon.* 1998;21(3–4):199–207.
  8. Barton J, Spelten E, Totterdell P, Smith LP, Folkard S, Costa G. The Standard Shiftwork Index: a battery of questionnaires for assessing shiftwork-related problems. *Work Stress.* 1995;9(1):4–30.
  9. Downing SM. Reliability: on the reproducibility of assessment data. *Med Educ.* 2004;38(9):1006–12.
  10. Kleinbaum DG, Kupper LL, Morgenstern H. *Epidemiologic research: principles and quantitative methods.* New York, NY, USA: Van Nostrand Reinhold; 1982. p. 529.
  11. Fischer FM. What do petrochemical workers, healthcare workers, and truck drivers have in common? Evaluation of sleep and alertness in Brazilian shiftworkers. *Cad Saúde Pública.* 2004;20(6):1732–8. Retrieved June 18, 2012, from: <http://www.scielo.br/pdf/csp/v20n6/33.pdf>
  12. Fischer FM, Paraguay AIBB, Bruni AC, Moreno CRC, Berwerth A, Riviello C, et al. Working conditions, work organization and consequences for health of Brazilian petrochemical workers. *Int J Ind Ergon.* 1998;21(3–4):209–19.
  13. Karlsson B, Knutsson A, Lindahl B. Is there an association between shift work and having a metabolic syndrome? Results from a population based study of 27 485 people. *Occup Environ Med.* 2001;58(11):747–52. Retrieved June 22, 2012, from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1740071/pdf/v058p00747.pdf>
  14. Knutsson A. Health disorders of shift workers. *Occup Med (Lond).* 2003;53(2):103–08. Retrieved June 18, 2012, from: <http://ocmed.oxfordjournals.org/content/53/2/103.long>
  15. Gordon NP, Cleary PD, Parker CE, Czeisler CA. The prevalence and health impact of shiftwork. *Am J Public Health.* 1986;76(10):1225–8. Retrieved June 18, 2012, from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1646676/pdf/amjph00273-0059.pdf>
  16. Debbabi F, Chatti S, Magroun I, Maalel O, Mahjoub H, Mrizak N. Le travail de nuit: ses répercussions sur la santé du personnel hospitalier [Night shift work and health among hospital workers]. *Archives des Maladies Professionnelles et de l'Environnement.* 2004;65(6):489–92. In French, with an abstract in English.
  17. Costa G. The impact of shift and night work on health. *Appl Ergon.* 1996;27(1): 9–16.
  18. Folkard S, Lombardi DA, Tucker PT. Shiftwork: safety, sleepiness and sleep. *Ind Health.* 2005;43(1):20–3.
  19. Levi L, Bartley M, Marmot M, Karasek R, Theorell T, Siegrist J, et al. Stressors at the workplace: theoretical models. *Occup Med.* 2000;15(1):69–106.
  20. Cheng Y, Luh WM, Guo YL. Reliability and validity of the Chinese version of the Job Content Questionnaire in Taiwanese workers. *Int J Behav Med.* 2003;10(1): 15–30.
  21. Ha M, Park J. Shiftwork and metabolic risk factors of cardiovascular disease. *J Occup Health.* 2005;47(2):89–95.
  22. Munakata M, Ichi S, Nunokawa T, Saito Y, Ito N, Fukudo S, et al. Influence of night shift work on psychologic state and cardiovascular and neuroendocrine



- responses in healthy nurses. *Hypertens Res.* 2001;24(1):25–31.
23. Smith L, Folkard S, Tucker P, Macdonald I. Work shift duration: a review comparing eight hour and 12 hour shift systems. *Occup Environ Med.* 1998;55(4):217–29. Retrieved June 18, 2012, from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1757571/pdf/v055p00217.pdf>
24. Horwitz IB, McCall BP. The impact of shift work on the risk and severity of injuries for hospital employees: an analysis using Oregon workers' compensation data. *Occup Med (Lond).* 2004;54(8):556–63. Retrieved June 18, 2012, from: <http://occmed.oxfordjournals.org/content/54/8/556.long>