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Fatigue and Psychological Distress: A Case Study Among Shift Workers of an Iranian Petrochemical Plant, During 2013, in Bushehr

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Abstract

Background: Shift work is a well-recognized occupational health hazard in both industrialized and industrially developing countries. Prolonged working time, day/night shift rotation, circadian rhythm and sleep disorders, family and social problems are the most important features of shift working, which have serious complications.

Objectives: The present study evaluated the fatigue and psychological distress and their relationship among shift workers, in a petrochemical plant (Southern Pars gas field) in Southwest Iran.

Materials and Methods: In this cross-sectional field study, 400 shift workers from a plant were involved, with participation rate of 72.5% (290 persons). The multidimensional fatigue inventory (MFI-20) and general health questionnaire (GHQ-28) were used to evaluate the level of fatigue and psychological distress, respectively.

Results: The results showed that the fatigue and psychological distress (particularly social dysfunction, anxiety and insomnia) are frequent among 12-hour shift workers (the total MFI and total GHQ scores were 42.68 ± 17.88 and 34.66 ± 18.56). A relatively strong positive correlation was found between fatigue and psychological distress (r = 0.62). The results of the stepwise regression model indicated that the psychological distress was significantly related only to general fatigue, mental fatigue and reduced motivation, whereas it was not to the physical fatigue and reduced activity.

Conclusions: The study findings highlight the importance of the mental aspect of fatigue in this working group. These results have possible implications for workers' health and well-being and for the design of shift work systems, for industrial workers.

Keywords: Fatigue, Occupational Health, Mental Disorders, Sleep Disorders, Circadian Rhythm

1. Background

Due to continuous material processing and 24 hours activity, shift work is common in many occupations. Consequently, 15 - 30% of the working population in industrialized countries is involved in various types of permanent night and rotating shift work, although this percentage is higher in developing countries, due to lack of job organization, irregular work hours and night working (1-3). The term 'shift working' refers to a job, which is performed in unusual and unconventional times, and is one of the factors affecting workers' health in many workplaces and industries. On the other hand, shift work is a well-recognized occupational health hazard in both industrialized and industrially developing countries (4, 5). Day/night shift rotation is one of the most important features of shift working, which has serious complications in terms of circadian rhythm and sleep disorders (6-8). In addition to several health problems, such as cardiovascular, gastrointestinal diseases and mental disorders, shift working has been shown to be associated with fatigue (9, 10). Sleeplessness and exhaustion, caused by fatigue during shift working, can lead to decreased alertness and performance and to increased failure or incident rates, and this may have serious constraints for workers, their families and the society (11-13).

Fatigue, as a common symptom, can be defined as a mental sense of weakness, energy defect and burn out, which disrupts any physical and cognitive activity (13-15). Fatigue is also one of the most important symptoms of distress, which is a common experience, caused by insufficient rest or sleep, heavy physical or mental activity and lack of motivation to begin any activity (16). Evidence suggests that fatigue is a frequent complaint among different working groups (17, 18). The findings from a study, conducted among the working population of 15 European countries, indicated that 5 - 56% of workers experienced fatigue (18). This is important, because the link between fatigue and accidents, in different occupational groups, has been well established (13).

Psychological distress is another important issue, which should be considered in shift work related studies. Several previous studies have evaluated fatigue and psychological distress, among shift workers (19-21). In a study

among industrial workers, fatigue was conceptualized as a decrease in energy and motivation, which was more likely to be experienced by night shift workers, compared to those working in other shifts (21). The authors noted that longer reaction times were associated with increased ratings of mental aspects of fatigue. Studies conducted among other working groups, such as anesthesiologists, have also reported a significant relationship between fatigue and psychological distress (17, 22). There are also studies, which reported no relationship between psychological distress and shift working (19, 20), and, therefore, this is an area that needs further investigation.

Petrochemical industries are one of 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. A review of the literature shows that there are limited studies conducted among industrial shift workers, about the relationship between fatigue and psychological distress, particularly in petrochemical industries. Moreover, very little is known about the prevalence of fatigue and psychological distress of 12-hour shift workers, in this industry. A systematic review study showed the fatigue and safety, as the main concerns of 12-hour shift working (23). Several case studies, in the petrochemical industry, in North America, investigated the health problems among shift workers (24).

2. Objectives

In an attempt to address this issue, the present study was conducted to evaluate the prevalence of fatigue and psychological distress and their relationship in 12-hour rotating shift workers, in a petrochemical plant.

3. Materials and Methods

3.1. Study Design and Setting

This cross-sectional field study was conducted between September and December 2013, in a governmental petrochemical plant (Southern Pars gas field), in Southwest Iran. Due to the relatively hot and humid climate, there is a special working condition in this region. The research sites included operational, maintenance, engineering, security and health, safety and environment (HSE) departments, as well as administrative offices. A questionnaire was administered to collect data about fatigue and status of psychological distress. The company, as a non-referral field, had approximately 400 rotating male shift workers, at the time of study, and all of these workers were asked to participate in the study. The shift work used here refers to a job, which is performed in unusual and unconventional times. The work schedule time duration was from 7.00 am to 19.00 pm and from 19.00 pm to 7.00 am, and the shift schedule followed a 7 days - 7 nights - seven rests pattern, in a forward rotating program. The ethical review committee of the Tabriz University of Medical Sciences, Tabriz, Iran, reviewed and approved the study protocol.

3.2. Participants

All the 400 male shift workers of the petrochemical plant were included in this study, as a census method. Work experience of less than one year and, also, having physical disabilities or mental diseases were defined as the exclusion criteria. No worker was found to correspond with these criteria. Of the 400 subjects, 290 declared their agreement, by completing the questionnaires. This represented a response rate of 72.5%. All workers were familiarised with the study procedure and any questions were answered, by the investigator. The participation was strictly on a voluntary basis and the workers were under no obligation to complete the study. A written informed consent form was signed by each shift-worker, before participation in the study.

3.3. Data Collection

A questionnaire, consisting of three sections, including demographic characteristics, multidimensional fatigue and psychological distress status, was used for data collection. Demographic details included: age, weight, height, educational level, marital status, shift work tenure and job title. The whole questionnaire took about 20 minutes to complete.

The multidimensional fatigue inventory (MFI–20) (25) was used to evaluate the fatigue, in this study. The MFI-20 is a reliable and validated tool, which is widely used for evaluating fatigue in both patients and healthy individuals (26-28). The MFI-20 is a 20 item self-report assessment tool, which assesses five dimensions of fatigue, including general fatigue, physical fatigue, reduced motivation, mental fatigue and reduced activity. Each dimension consists of four items: two indicative for fatigue, where a high score indicates a high fatigue level, and two contraindicative, where a high score indicates low fatigue level. The respondents to the MFI-20 are asked to specify the extent to which the particular statements relate to them, on a 5-point scale. The total possible score, for each subscale, ranges from 4 to 20, with higher scores indicating a higher level of fatigue. The English version of MFI-20 has been translated and revised into the Persian language (Farsi) and has an established validity and reliability (29). This revised version was used in this study.

The 28 item general health questionnaire (GHQ-28) is generally used as a self-report assessment tool, to evaluate the status of psychological distress (30), and is a well-tried and tested technique (31). The brevity, intelligibility, and psychometric properties of the GHQ-28 are the most important reasons for using this tool (31). The GHQ-28 has four subscales: somatic symptoms (questions 1 to 7), anxiety and insomnia (questions 8 to 14), social dysfunction (questions 15 to 21) and severe depression (questions 22 to 28). Each item is accompanied by four possible responses, ranging from "never true" to "always true", and scoring from 0 to 3. The total possible score for each subscale ranges from 0 to 21, and for the GHQ-28 ranges from 0 to 84, with higher scores indicating

more severe mental problems (30). The Persian version of GHQ-28, which has an established validity and reliability (32), was used in this study. Moreover, a cut-off point of 27.38 was used for the GHQ-28 (e.g. those scoring 27.38 or above were designated as poor psychological distress) in this study, which was based on the Noorbala et al.'s study (32).

3.4. Statistical Analysis

Analysis of the data was performed, using SPSS version 11.5 (SPSS Inc., Chicago, IL, USA). To compare the two questionnaires (e.g. GHQ-28 and MFI-20), the range of all scores obtained form both questionnaires were transformed into 0 - 100 domain. Therefore, the cut-off point of GHQ–28 was changed from 23 to 27.38, in the modified domain. The internal consistency of questionnaires was evaluated using Cronbach's alpha. Normality was tested using QQ plots and all discriptive values were expressed as Mean ± SD. Stepwise regression analysis was performed, to evaluate the relationship between the fatigue and psychological distress status. The R square and Pearson's correlation coefficients were also calculated, for these variables. In addition, Errorbar was used to show the relationship between the mean scores. A $P < 0.05$ was considered statistically significant.

4. Results

4.1. Demographic Data

The mean age and shift work experience of the participants were 31.5 (range = 21 - 59; SD = 5.11) years and 5.83 (range = 1 - 28; SD = 2.89) years, respectively. Most of the participants were married (77.2%) and their educational level ranged from primary school (4.1%) to master's degree (4.4%). Overall, in this study, a relatively weak impact of demographic characteristics was found on fatigue and psychological distress.

4.2. Fatigue

As shown in Table 1, the total fatigue score of the MFI–20, for the study population, was 42.68 (range = 0 - 100; SD = 17.88). The general fatigue (Mean = 69.40; SD = 18.22) and reduced motivation (Mean = 30.90; SD = 18.73) were the subscales with the highest and lowest mean scores, respectively. The Pearson's correlation test showed a moderate positive correlation between the MFI–20 subscales, with r values ranging from 0.41 to 0.67 (as shown in Table 2). The general fatigue and mental fatigue subscales had a strong positive correlation (r = 0.67), while there was a weak positive correlation (r = 0.41), between the general fatigue and reduced activity subscales. The correlation coefficients for the total MFI and its subscales ranged from 0.71 to 0.86. The Cronbach's α for the MFI subscales were, as follows: general fatigue (0.72), physical fatigue (0.68), reduced activity (0.70), reduced motivation (0.52) and mental fatigue (0.77). The Cronbach's α for the total MFI was 0.89. These values suggest good internal consistency for the scale, as a whole, and for the subscales, individually.

4.3. Psychological distress

The scores of the GHQ and its subscales are presented in Table 3. The proportions in this sample above the cut-point were: total (59.7%), social dysfunction (86.2%), anxiety and insomnia (71.7%), somatic symptoms (57.9%) and severe depression (26.2%). The total mean GHQ score was 34.66 (range = 0 - 100; SD = 18.56). The mean scores of the GHQ subscales were: social dysfunction, 43.0 (SD = 18.05); anxiety and insomnia, 42.17 (SD = 24.52); somatic symptoms, 35.25 (SD = 21.80); and severe depression, 18.19 (SD = 20.44). A moderate to high positive correlation was found between the GHQ subscales, with r values, ranging from 0.61 to 0.80 (as shown in Table 4). A strong correlation was also found between the total GHQ and its subscales (Pearson's coefficients, ranging from 0.82 to 0.92). Cronbach's α for the GHQ subscales were as follows: somatic symptoms (0.88), anxiety and insomnia (0.93), social dysfunction (0.86), severe depression (0.89). The Cronbach's α for the total GHQ was 0.95. These values indicate good internal consistency for the scale, as a whole, and for the individual subscales.

4.4. Relationship Between Fatigue and Psychological Distress

The results of stepwise regression analysis, which evaluated the relationship between psychological distress (GHQ total score) and fatigue (MFI subscales scores), indicated that only general fatigue, mental fatigue and reduced motivation remained in the model ($P < 0.05$) (as shown in Table 5). Therefore, the model was as follows:

$$\text{GHQ} = -3.59 + 0.351\,(\text{General fatigue}) + 0.177\,(\text{Mental fatigue}) + 0.263\,(\text{Reduced motivation}) \quad (1)$$

In addition, to diagnose the relationship between the GHQ and MFI, a linear regression test was performed with R square = 0.626 and Adjusted R square = 0.390, which means that, per each unit score of MFI, 0.651 is added to the GHQ score. Therefore, the final model was as follows: GHQ = 6.89 + 0.651 (MFI). The results of Pearson's correlation test between the GHQ and MFI subscales, presented in Table 2, indicated that the most positive correlations were found between the total GHQ with general fatigue (r = 0.61) and mental fatigue (r = 0.59), while a weak positive correlation was found for reduced activity (r = 0.30).

Finally, the Pearson's correlation test showed a relatively high positive correlation, between the total GHQ and MFI (r = 0.62) (Table 2). The scores of GHQ subscales were significantly higher for workers with moderate to high level of total fatigue (3 - 5 on the 5-point scale) than those with a low level of total fatigue (1 - 2 on the 5-point scale) (Figure 1). Similarly, the scores of the MFI subscales were significantly higher in those workers with the total GHQ score ≥ 27.38 than in those with a lower score (total GHQ score < 27.38) (Figure 2).

Table 1. Scores of the Multidimensional Fatigue Inventory Questionnaire[a]

MFI scale	Mean ± SD	Min - Max
General fatigue	69.40 ± 18.22	0 - 100
Reduced activity	35.26 ± 21.63	0 - 100
Physical fatigue	42.41 ± 23.84	0 - 100
Reduced motivation	30.90 ± 18.73	0 - 100
Mental fatigue	43.06 ± 24.35	0 - 100
Total MFI	42.68 ± 17.88	0 - 100

[a]Abbreviations: MFI, multidimensional fatigue inventory; SD, standard deviation.

Table 2. Pearson's Correlation Coefficients Between the Subscales and the Total Scores of the Multidimensional Fatigue Inventory and General Health Questionnaire[a]

Subscale	General Fatigue	Physical Fatigue	Reduced Activity	Reduced Motivation	Mental Fatigue	Total MFI
General fatigue	-	-	-	-	-	-
Physical fatigue	0.59	-	-	-	-	-
Reduced activity	0.41	0.49	-	-	-	-
Reduced motivation	0.53	0.61	0.47	-	-	-
Mental fatigue	0.67	0.62	0.49	0.62	-	-
Total MFI	0.81	0.83	0.71	0.79	0.86	-
Total GHQ	0.61	0.46	0.30	0.53	0.59	0.62

[a]Abbreviations: GHQ, general health questionnaire; MFI, multidimensional fatigue inventory.

Table 3. Scores on the General Health Questionnaire[a]

GHQ scale	Mean ± SD	Min - Max	0 - 27.38 [b]	27.38 – 100 [b]
Somatic symptoms	35.25 ± 21.80	0 – 100	122 (42.1)	168 (57.9)
Anxiety and insomnia	42.17 ± 24.52	0 – 100	82 (28.3)	208 (71.7)
Social dysfunction	43.00 ± 18.05	0 – 100	40 (13.8)	250 (86.2)
Severe depression	18.19 ± 20.44	0 – 100	214 (73.8)	76 (26.2)
Total GHQ	34.66 ± 18.56	0 – 100	117 (40.3)	173 (59.7)

[a]Abrreviation: GHQ, general health questionnaire.
[b]Values are reported as No. (%).

Table 4. Pearson's Correlation Coefficients of the Subscales of General Health Questionnaire (n = 290)[a,b]

GHQ Scale	Somatic Symptoms	Anxiety and Insomnia	Social Dysfunction	Severe Depression
Somatic symptoms	-	-	-	-
Anxiety and insomnia	0.80	-	-	-
Social dysfunction	0.62	0.68	-	-
Severe depression	0.64	0.69	0.61	-
Total GHQ	0.88	0.92	0.82	0.84

[a]Levels of significance: r = 0.11, 0.13, 0.17 corresponds for P = 0.05, 0.01, 0.001, respectively.
[b]Abbreviations: GHQ, general health questionnaire.

Table 5. Regression Relationship Between Psychological Distress (General Health Questionnaire Total Score) and Fatigue (Multidimensional Fatigue Inventory Subscales Scores)[a]

Variable	Beta ± SE	Standard Beta	P Value
General fatigue	0.351 ± 0.061	0.344	0.000
Mental fatigue	0.177 ± 0.050	0.232	0.000
Reduced motivation	0.263 ± 0.057	0.205	0.000
Constant	-3.59 ± 3.29	–	0.278

[a]R square = 0.676, adjusted R square = 0.451.

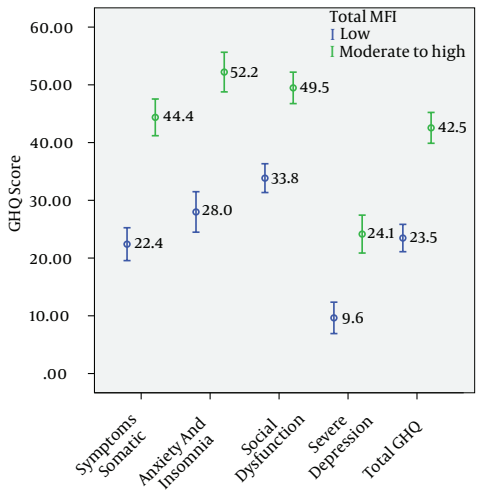

Figure 1. Relationship between the total fatigue score of the multidimensional fatigue inventory and general health questionnaire subscales scores.

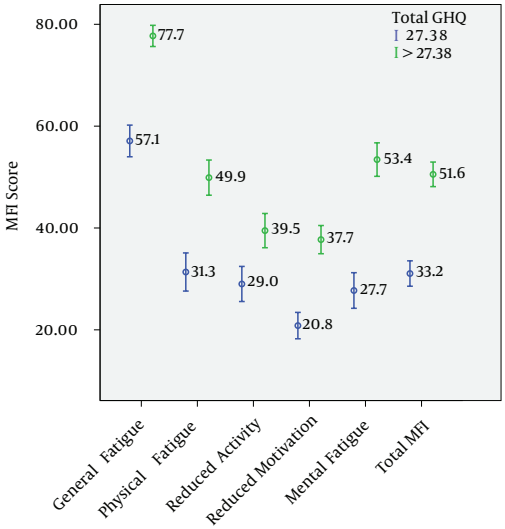

Figure 2. relationship between the total general health questionnaire score and multidimensional fatigue inventory subscales scores.

5. Discussion

The findings of the present study provide an insight into the fatigue and psychological distress and their relationship among petrochemical workers, involved in rotating 12-hour shift work schedules. The results confirm that the fatigue (particularly general fatigue) and poor psychological distress (especially social dysfunction and anxiety and insomnia) are frequent among 12-hour shift workers, which might reflect the working condition, nature of work and workload of this working group. These findings suggest that 12-hour shift schedules should be appropriately managed to ensure that the health and safety so that the employees would not be compromised. As a corollary of this study, a relatively weak impact of demographic characteristics was found on fatigue and psychological distress (33).

One of the main findings of the study was that the total mean GHQ score was relatively high, indicating distress among the study population. It was also shown that the total mean GHQ score was above the cut-point, for more than half of the study population, which highlights the high prevalence of poor psychological distress, in this group. Interestingly, the scores of the GHQ subscales indicated that social dysfunction, anxiety and insomnia were more problematic than somatic symptoms and depression among 12-hour shift workers. Although there is limited research to compare this result with, there is a certain amount of indirect evidence that this may be the case for shift workers in other industrial settings. In a study among machine operator shift workers, it was found that work/non-work conflict was positively related to psychological health (34), and not to physical health. Other studies have also shown a positive association between poor sleep and shift work (4, 35). This can possibly be explained by prolonged working hours, high workload and insufficient off the job social interactions, of this working group. This is, also, in part consistent with the findings of a previous study, among general working population (36). The proportion of the sample with the total GHQ and social dysfunction scores above the cut-point in this study is also much higher than those reported among the Iranian general population (37).

The results also provide further evidence that fatigue is a frequent complaint among shift workers, which is in line with findings from previous research (4). The scores of the MFI subscales indicated that the general fatigue is more problematic than other dimensions of fatigue, in these workers. The mean score for subscale measuring general fatigue among the study participants was relatively high. This was followed by the mean scores of mental fatigue and physical fatigue subscales, respectively. It is also interesting to note that the mean score for the reduced motivation subscale was very low, among the respondents. Although there is no other similar study reported in the literature, with which to compare the results, these findings are not consistent with previous reports among general population, in other communities (28, 38, 39). For example, the mean score of 69.4 for general fatigue subscale, in our study, is much higher than those reported among the American (27.6), Danish (28.0) and Colombian (30.0) population, which highlights the working condition of 12-hour industrial shift workers, compared to general population. On the other hand, the mean scores of all fatigue subscales in our study population are much lower than those reported for patient groups (40). These findings provide additional evidence that, in addition to the tools and methods used in differ-

ent studies, several factors, such as sample community, cultural status and racial-ethnic differences can also affect the various aspects of fatigue, and, therefore, this can results in the contradictory findings.

As shown in this study, there was a relatively high positive correlation between fatigue and psychological distress, so that those participants, with poor mental health condition, experienced a higher level of fatigue. This is in agreement with the findings of Pawlikowska et al. (17), who found a fairly positive correlation between fatigue and psychological distress among British general population. According to the stepwise regression model, the psychological distress was only significantly related to general fatigue, mental fatigue and reduced motivation, while it did not relate to the physical fatigue and reduced activity. This is of particular interest, since it highlights the importance of mental aspect of fatigue (rather than physical aspect), in this working population. This can possibly be attributed to the arrangement of shift work schedules, in the study region. Additionally, the poor psychological distress condition, in those in the group with moderate to high level of total fatigue (Figure 1), and a high level of fatigue, in those in the group with the total GHQ score $\geq$ 27.38 (Figure 2), indicated a two-way relationship between the fatigue and psychological distress condition of this sample. These findings may have significant implications for shift workers' health and well-being and for the design of shift work systems, in industrial settings.

In this study, the rate of fatigue and psychological distress and their relationship were investigated in a petrochemical plant, with 12-hour shift system. Therefore, it was not the purpose of this study to investigate the causal effect of 12-hour shift on fatigue or psychological distress, because it can be influenced by various factors. In order to control the confounding factors, such as chemical, physical and other ergonomic risk factors, another study was designed and implemented in a second petrochemical plant, with 8-hour shift, which have relatively same chemical, physical and ergonomic exposure pattern. The findings of the current study (12-hour) will be discussed compared with 8-hour shift work study, as another article.

This study has limitations that need to be taken into account, when considering the implications of the findings. The present study was cross-sectional in design, and, therefore, no causal inferences can be drawn. The study was conducted in a workplace with special environmental conditions (e.g. relatively high temperature and humidity), and, therefore, further research in other settings is required to have a better understanding and knowledge in this regard. Due to limited access to various petrochemical plants, with different shift rotating systems, the relationship between shift rotating system and workers health status was not considered in the current study design. Lastly, as the MFI-20 has not been used for evaluation of fatigue, among industrial workers, it was difficult to compare the results with other studies. However, the findings of this study confirm that MFI-20 is an instrument, on which the researchers can rely on, to assess fatigue in industrial workers. It is therefore recommended that MFI-20, which has been mainly used for non-industrial populations so far, can be used in other industrial and occupational groups.

Taken together, the results of the present study suggest that the prevalence of fatigue and poor psychological distress are relatively high among the workers, with 12-hour shift system. The relatively high mean GHQ score, particularly in the form of social dysfunction, anxiety and insomnia, indicates distress among this working group. The results also highlight that the mental aspect of fatigue is more problematic than the physical aspect, in this working group. These findings emphasize the need for ergonomic interventions for improving the working conditions of 12-hour industrial shift workers. The results also indicated that there is a relatively strong positive correlation between fatigue and psychological distress status of the study population, which may have possible implications for industrial workers' health and well-being, and for the design of shift-work systems.

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Footnotes

Authors' Contributions: This manuscript was extracted from the thesis written by Ahmad Bazazan, MSc student of ergonomics. Yahya Rasoulzadeh: study design and supervision, manuscript edition; Ahmad Bazazan: Data collection, manuscript drafting; Iman Dianat: consultation during study design and implementation, manuscript edition; Abdolrasoul Safaiyan: statistical data analysis.

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