

Conference Paper

Impact of Work-related and Non-work-related Factors on Fatigue in Production/Shift Workers

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Abstract

This research analysed the impact of work-related factors (work period, work shift, overtime work, material weight and noise) and non-work-related factors (age, history of disease, marital status, sleep quality, nutritional status and commute time of fatigue in production shift workers. The present study was conducted during the period March 2017–May 2017 with 105 stamping section workers in PT. X. The research was designed as a cross-sectional study that used questionnaires and the checklist individual strength (CIS) for fatigue variables. The data were analysed via the chi-square method to determine any correlations between fatigue and the independent variables, and multivariate logistic regression was used to determine which variables cause or contribute to worker fatigue. The research demonstrated that 52.4 percent of the evaluated workers experienced fatigue. In addition, the study revealed no significant relationships between work-related factors and fatigue. In contrast, the study concluded that two non-work-related factors, sleep quality and commute time, do contribute to fatigue. The factor that most affected the occurrence of fatigue was the workers' sleep quality ($p = 0.002$), OR = 3.0917, indicating that workers who experience poor sleep quality are three times more at risk of fatigue than workers with good sleep quality (CI 95%: 1.617 – 9.179).

Keywords: fatigue, sleep quality, commute time, checklist individual strength (CIS), questionnaire, production worker

1. Introduction

Fatigue has become the main complaint of 25 percent of workers in the Netherlands [1], and in the United States, 20 percent of the working population experiences work fatigue, which causes a loss of \$136.4 million annually [2]. A survey conducted by Better Work Indonesia in 42 factories and involving 918 workers in Jakarta revealed

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that approximately 42.1 percent of the workers experienced fatigue [3]. In another study, 46.5 percent of the workers in automotive component companies in the city of Bogor experienced fatigue [4].

A number of previous studies have indicated that fatigue is one of the most significant factors that contribute to accidents on the job: people who are tired often fail to take safety precautions. A comprehensive study of accidents showed that 58 percent of commercial vehicle crash were caused by fatigued workers in the workplace [5]. Catastrophic accidents during the past few decades (e.g., Three Mile Island, Bhopal, Chernobil, Exxon Valdez and the Baltic ferry, *Estonia*) occurred at dawn, when workers were experiencing high levels of fatigue [6].

PT. X is a North Jakarta manufacturing company that produces automotive components, especially those for four-wheeled trucks. Because of price increases for raw materials and energy, wages are not in alignment with the increased demand for automotive components, including those manufactured by PT. X. Hence, these companies require optimum efficiency in all production lines, and one of the ways they achieve this is to reduce manpower. As of January 2017, PT. X employed 640 workers, a number down 51 percent from 2012. The imbalance between the number of workers and the demand volume causes employees to frequently work overtime, both on weekdays and weekends, especially in the company's stamping section. The average number of overtime work hours in the stamping section reached 16.25 hours/week per employee, exceeding the overtime work standard of 14 hours/week, which was established by the Indonesian government in Labor law number 13 (2003). An excess of overtime hours could potentially be the most significant factor that causes worker fatigue.

This research aimed to analyse the impact of work-related factors (work period, work shift, overtime work, material weight and noise) and non-work-related factors (age, history of disease, marital status, sleep quality, nutritional status and commute time) on fatigue in production/shift workers.

2. Methods

This study used a cross-sectional design to analyse the relationships between dependent variables comprising work-related factors (work period, work shift, overtime work, material weight and noise) and non-work-related factors (age, history of disease, marital status, sleep quality, nutritional status and commute time) with the independent variable, fatigue. The study was conducted in PT. X, an auto components

factory located in North Jakarta, from March 2017–May 2017. The population in this study comprised all 105 workers (classes I–III) in the company’s stamping section.

Two research instruments were used in this study: the checklist individual strength (CIS) and the Pittsburgh Sleep Quality Index (PSQI). The CIS consists of 20 questions used to evaluate four important aspects of fatigue: subjective feeling of fatigue, lack of motivation, lack of physical activities and lack of concentration [7]. The PSQI assesses sleep quality and sleep disruptions over a one-month duration [8]. The work environments’ noise levels were measured with a sound level meter. The data were analysed via three different methods: univariate analysis (frequency distribution table), bivariate analysis (chi-square) and multivariate analysis (logistic regression) using SPSS statistics 17.0 software.

3. Results

The univariate results of the dependent variable are presented in Table 1. The study found that 55 of the respondents (52.4%) experienced fatigue, while the remaining 50 respondents (47.6%) did not experience fatigue. In this study, the researcher was not able to measure the respondents’ levels of fatigue because of limitation of resources and tools.

Based on the statistical analysis that used chi-square method, the relationship between work-related factors/non-work-related factors and fatigue experienced by workers in the PT.X stamping section is shown in Table 2.

As seen in Table 2, there is no relationship between the occurrence of worker fatigue and the work period, work shift, material weight, noise, age, history of disease, marital status and/or nutritional status. On the other hand, sleep quality ($p = 0.001$) and commute time ($p = 0.027$) showed significant correlations with fatigue among the stamping section workers. Based on the analysis results, the researcher observed an OR value = 4.044 (CI 95% = 1.769 – 9.244), demonstrating that the workers with poor sleep quality had a risk of fatigue that was 4 times higher than that of workers with good sleep quality. Regarding the commute time, the researcher obtained an OR value = 2.617 (CI 95% = 1.187 – 5.766), indicating that the employees whose work commute was more than 30 minutes had a risk of fatigue that was 2.6 times higher than that of the workers whose commute time was less than 30 minutes.

Based on multivariate analysis, the lowest p -value was sleep quality ($p = 0.002$). It can be concluded that the variable which most significantly influences the risk of fatigue among workers in the PT. X stamping section is sleep quality. In addition, based

TABLE 1: Frequency characteristic distribution of production workers.

Characteristic	Amount (people)	Percentage (%)	
Working period	≤ 1 year	55	52.4
	1 – 5 years	0	0
	> 5 years	50	47.6
Shift work	First Shift (afternoon)	58	55.2
	Third Shift (night)	47	44.8
Overtime work	≤ 14 hours	27	25.7
	>14 hours	78	74.3
Material weight	0 kg	22	21
	0.1 – 5 kg	45	42.9
	> 5 kg	38	36.2
Noise	≤ 85 dBA	33	31.4
	> 85 dBA	72	68.6
Age	≤ 25 years old	56	53.3
	> 25 years old	49	46.7
History of disease	There is no history of disease	97	92.4
	There is history of disease	8	7.6
Marital status	Not marriage	54	51.4
	Marriage	50	47.6
	Widow	1	1
Sleeping quality	Good	43	41
	Poor	62	59
Nutritional status	Normal	79	75.2
	Under weight	12	11.4
	Over weight	11	10.5
	Obese	3	2.9
Commute Time	≤ 30 minutes	48	45.7
	> 30 minutes	57	54.3
Fatigue	Fatigue	55	52.4
	Not fatigue	50	47.6
Total		105	100

on the analysis, the researcher found an OR value for sleep quality = 3.917 and CI 95% = 1.671 – 9.179, which is nearly identical to the results of the bivariate analysis.

4. Discussion

A large number of workers in the PT. X production section experience fatigue caused by work activities that involve some physical activities or manual handling, such as lifting, pushing, carrying and moving material. The main activity in the stamping section is moulding the material by pressing it into the steel with a press machine. Workers must continuously lift and move the steel sheets from the workbench into the machine by applying a target 200–400 strokes per hour with materials of varying weights ranging from 1–100 kg. Workers perform this activity 8–11 hours per day while maintaining a standing position and experience physical fatigue due to continuous muscle contraction: a muscle's working ability decreases when it is given a continuous load that reduces the strength and speed of a person's motion [9]. This finding is in accordance with previous research indicating that 83.3 percent of production workers experience fatigue [10]; it is also consistent with a study by Penny which revealed that 46.5 percent of production workers experience fatigue [4].

TABLE 2: The relationship between work-related factors and non-work-related factors with the occurrence of fatigue among production workers.

Variables	Fatigue		Not fatigue		Total		P-Value	OR	CI 95%
	N	%	N	%	N	%			
Working period									
> 5 Year	30	60	20	40	50	100	0.195	1.81	0.829–3.910
< 1 Year	25	45.5	30	54.5	55	100		1	–
Shift of work									
Shift 3 (Night)	27	57.4	20	42.6	47	100	0.460	1.446	0.667–3.138
Shift 1 (Afternoon)	28	48.3	30	51.7	58	100		1	–
Overtime work									
> 14 Hours	41	52.6	37	47.4	78	100	1	1.029	0.428–2.471
≤ 14 Hours	14	51.9	13	48.1	27	100		1	–
Material weight									
> 5 Kg	17	44.7	21	55.3	38	100		0.675	0.232–1.938
0.1–5 Kg	26	57.8	19	42.2	45	100	0.482	0.592	0.248–1.414
0 Kg	12	54.5	10	45.5	22	100		1	–
Noise									
> 85 Db	37	51.4	35	48.6	72	100	0.928	0.881	0.385–2.013
≤ 85 Db	18	54.5	15	45.5	33	100		1	–
Age									
> 25 Years	29	59.2	20	40.8	49	100	0.267	1.673	0.771–3.631

≤ 25 Years	26	46.4	30	53.6	56	100		1	—
History of disease									
There is history of disease	5	62.5	3	37.5	8	100	0.718	1,567	0.355–6.922
Not sick	50	51.5	47	48.5	97	100		1	—
Marital status									
Marriage	28	56	22	44	50	100		0.786	0.363–1.701
Widower	0	0	1	100	1	100	0.393	1	—
Not married	27	50	27	50	54	100		1	—
Sleeping quality									
Poor	41	66.1	21	33.9	62	100	0.001*	4.044	1.769–9.244
Good	14	32.6	29	67.4	43	100		1	—
Nutrition status									
<i>Obese</i>	1	33.3	2	66.7	3	100	0.846	0.5	0.035–7.104
<i>Underweight</i>	6	50	6	50	12	100		0.6	0.041–8.732
<i>Overweight</i>	5	45.5	6	54.5	11	100		0.419	0.036–4.807
Normal	43	54.4	36	45.6	79	100		1	—
Commute Time									
> 30 minutes	36	63.2	21	36.8	57	100	0.027*	2.617	1.187–5.766
≤ 30 minutes	19	39.6	29	60.4	48	100		1	—
Note: * = significant correlation.									

TABLE 3: Result of multivariate analysis.

Variable	B	P-Value	Odd Ratio	CI 95%
Working period	0.209	0.346	1.232	0.789–1.904
Sleeping quality	1.365	0.002	3.917	1.671–9.179
Commute time	0.764	0.084	2.147	0.902–5.111

Based on the statistical analyses in this study, there is no relationship between work-related factors (work period, work shift, overtime hours, material weight and noise) and fatigue. This is probably due to the work system implemented in PT. X, where operator-level workers are non-permanent workers with one-year contracts plus one-year extensions. Upon completion of the extension, each worker’s performance is evaluated to determine whether or not their employment can be changed to a permanent work status. One of the requirements for prospective workers to become contract employees is a maximum age of 25 years. In this study, therefore, the variables of work and age influence each other. Workers who have worked for a period of < 1 year are generally workers in the age group < 25 years, 98.2 percent of

whom are physically younger and whose muscular systems have reached maximum development.

In addition, 96.3 percent of the respondents are unmarried and therefore do not have a role as head of the family, along with the associated responsibilities. Respondents who have < 1 year of experience are contract workers who desire to be appointed permanent employees of PT. X. As a result, they are enthusiastic and highly motivated to work diligently in order to get a good evaluation at the end of their contract terms. On the other hand, the workers who have already worked > 5 years in the stamping section, 68 percent of whom have already worked for 10 years with minimum job rotation, are easily bored.

PT. X implemented a system comprising three work shifts with different work hours: first shift, 7:30–16:15; second shift, 16:15–24:00 and third shift, 00:00–7:30, with five work days (Monday–Friday); shift rotation can be done once a week. The work shift affects fatigue indirectly through changes in sleep patterns and the workers' breaks; workers adjust their bedtimes based on their work times, which causes normal sleep hours to be disordered and irregular [11, 12]. PT. X's overtime policy requires employees to work an extra 3–4 hours per day. As a result, the workers have an 11–12 hour workday rather than the standard 7–8 hour workday. This policy is due to the disparity between the number of employees and the production volumes. The company established this policy to reduce production costs, particularly worker salaries, which are increasing annually.

However, no relationship between fatigue and number of overtime hours was found. Workers whose overtime hours \leq 14 hours a week had weekend breaks, during which they benefit from optimal recovery periods. In addition, workers whose total hours of overtime > 14 hours usually get an allowance in addition to their wages, so overtime is not viewed as a burden, because workers are motivated by the prospect of earning wages that are higher than their standard annual incomes. This finding is consistent with a previous study which found that workers who are happy with their work and have a medium amount of overtime (3 hours a day) usually do not feel tired [13]. However, excessive and continuous amounts of overtime without adequate rest periods can lead to fatigue despite the reward of great compensation [14].

Since work in the stamping section tends to be homogeneous, there is no relationship between material weight and fatigue. Generally, the stamping role consists of taking the material from the table, putting it in the machine, pushing the pressing machine button, taking the processed material and placing it into the pallet. This process requires around 200–300 movements per hour to produce approximately 100

products. In order to reduce the risk of muscle fatigue and muscle injury, the work should be approached ergonomically. For instance, items weighing ≤ 5 kg should be moved from the table to the machine from the same height and be within reach of the worker's arm, whereas items weighing > 5 kg can be moved by using a cutter so that the workers need only to push the goods. In addition, the worker's posture should be considered in the design of work tools and work-area layouts.

The company also recommends 15-minute breaks every 2 hours and 45-minute breaks after 4 hours of work to provide employees time for lunch. In addition, a 30-minute break after 4 hours of work is also important for third-shift workers. Break time is necessary for the body/muscles to go through a recovery process and thus reduce fatigue. Moreover, regular short breaks have a positive impact by preventing the development of muscle fatigue in the neck and shoulders [15].

Our statistical analyses revealed no relationship between noise and fatigue. In general, the workers who are exposed to noise > 85 dBA are those who operate press machines. The noise itself is generated from the stroke of the press machine to a material that fluctuates between 85 dBA and 94 dBA during the process. To reduce exposure to noise, the company provides the workers with ear plugs, resulting in a noise-reduction rate of 26 dBA. Therefore, if the workers use the earplugs properly, there is no difference between the noise-exposure level in an environment that exposes PT. X workers to > 85 dBA noise and that which exposes workers to ≤ 85 dBA.

This study suggests that there is a relationship between the commute time and fatigue among stamping workers. PT. X is located in the capital city, which forces workers to begin their commutes to work at an earlier time to avoid heavy traffic jam. This finding is consistent with research that showed long commuting time resulting fatigue on workers in the city of Tokyo [16]. It is mean public transportation act as a role to reduce the risk of mental fatigue for workers.

According to research conducted in England, one's happiness and life satisfaction, as well as feeling that one's activities are meaningful, decrease during every minute that is spent traveling to work. The worst effects were found in workers whose commutes were 61–90 minutes when compared to workers whose commutes were only 15 minutes [17]. In addition, a longer commute to the workplace results in higher employee absenteeism rates [18].

Aside from fatigue, longer commute times can also cause road accidents. Previous research has found that in terms of driving, shift workers are at a higher risk than non-shift workers; this is due to changes in sleep patterns, travel time to the workplace and the duration of rest before work. Moreover, there is some evidence which shows

that on weekdays, shift workers are more likely to be involved in road accidents than non-shift workers [19].

There was a relationship between sleep quality and fatigue among the stamping section workers: workers who experienced poor sleep quality tended to be 4 times more at risk of fatigue than the workers with good sleep quality. The multivariate analysis resulted in the same finding. Several variables, such as work period, work shift, overtime hours, and family, were found to indirectly affect fatigue. For instance, work shifts affect fatigue by altering sleep patterns and workers' break times. The family affects fatigue because of activities that the worker undertakes at home after work, in accordance with his or her role in the family. The quality of sleep affects the incidence of fatigue directly because sleep is the body's recovery mechanism when awake: if the recovery process is good, the individual will be more prepared and alert. The person will be more focussed and active after having a good night's sleep [20].

As mentioned earlier, workers are sometimes required to work on weekends, resulting in a seven-day work week. The time available for workers to rest before starting their shift is therefore less than 24 hours. This is the main reason for the poor sleep quality experienced by some PT. X workers. Based on the result of this study, each respondent averaged 6 hours of sleep per 24-hour period, while individuals aged 17–64 years are recommended to sleep 7–9 hours per 24-hour period [21]. Based on the data, respondents who worked third shift had 6 hours of sleep, while the respondents who worked first shift had 7 hours. In addition, longer commutes to the workplace caused workers to leave their homes earlier in the morning, thereby further reducing their sleep duration.

The sleep duration of night-shift workers tends to be shorter than that of afternoon shift workers. Another reason why sleep time may be insufficient: Muslim workers are required to pray five times during the day. In addition, the workers' neighbourhoods are usually noisier because the majority of families and neighbours are still engaged in their activities.

According to a previous study [22], workers who have 5–7 hours of sleep during the night usually experience a decrease in physical and mental performance, while workers who sleep only 3 hours a night will show a sustained and unstable physical and mental performance within a few days. In another study, workers who slept less than 4 hours per night showed an increase in performance errors and a decrease in accuracy when performing tasks. Conversely, workers who slept more than 7 hours a night were able to maintain their normal performance levels up to 14 consecutive days [23].

A person with sleep deprivation will experience issues such as drowsiness, decreased cognitive abilities, spirit and quality of life, emotional distress and attendance problems (e.g., absences and tardiness). In addition, lack of sleep can lead to some serious health problems, such as cardiovascular disorders, increased blood pressure, obesity and diabetes due to metabolic disorders and increased blood sugar, growth problems caused by the poor release of endocrine hormones and a reduced immune system that causes increased susceptibility to diseases [20].

5. Conclusions

This study of 105 stamping section workers demonstrated that 55 workers (52.4%) experienced fatigue, and 50 workers (47.6%) did not experience fatigue. There was no significant relationship between work-related factors (work period, shift work, overtime work, material weight and noise) and the occurrence of fatigue on stamping section workers in PT. X. The researcher found six non-work-related factors that significantly contributed to fatigue, such as sleep quality and commute time. The other four factors (i.e., age, history of disease, marital status and nutritional status) were not related to the occurrence of fatigue among the study participants. Based on multivariate statistical analysis, the factor that mostly significantly affected the fatigue rate of the PT. X stamping section workers was sleep quality.

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