Improving the work system with management engineering methods

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Abstract. Management engineering is often done in the industrial world, especially factories and manufacturing companies. In this research, management engineering will be applied in hospitals, especially in the emergency department, because in previous studies data collection has been carried out and it is concluded that nurses in this department have a high degree of flexibility, so can cause errors while working. Almost the same as the application of fatigue in the manufacturing industry that the level of fatigue on the operator can reduce work productivity. This research will apply a macro ergonomic approach, in which the model used is the System Engineering Initiative for Patient Safety (SEIPS) model at the Hospital. This approach uses interview and observation techniques. Through this approach the causal factors will be seen and, in the future, seen how the solution to overcome this fatigue factor. This method uses a survey system that involves a large state-owned hospital in the city of Medan by using 83 nurse respondents and 7 respondents from the hospital.

1. Introduction

Occupational health is a public health application in a place (company, factory, office, etc) and being a patient in public health is workers and the community around the company [1][15]. From an ergonomic point of view, each workload received by a person must be appropriate or balanced of the physical, cognitive and limitations of human ability to accept the workload [2]. Any work of any kind job requires muscle strength or thought is a workload for all the people do the work. Due to workloads are too heavy or weak physical abilities, it can result in a worker suffering from work-related disorders or diseases. All postures are not natural in working, such as attitudes to reach goods exceed the hand reach must be avoided. Symptoms of fatigue are experienced by employees when working is monotonous and repetitive. Occupational fatigue is often interpreted as a process of decreasing efficiency and reduced physical strength or endurance to continue the activities must be done [3].

Occupational fatigue is a condition which a decrease in work efficiency, skills and resulted by feelings of fatigue or boredom to continue activities or work. Fatigue cannot be underestimated because it affects the effectiveness, productivity, and safety of workers in general. High levels of workload cause workers to concentrate and focus when working and increase the risk of workplace accidents caused by human error[4].
Fatigue condition usually results from physical and spiritual disorders, stress, and overworks. That is why fatigue is also explained as the inability to maintain and preserve the required or expected stamina and energy or the lack of energy in the working capacity. Working with fatigue is even equated to alcoholism [5] [6]. One profession that has a high level of fatigue is a nurse at the hospital. Hospital nurses who provide patient care service often experience temporal demand and heavier workload due to the shortage of staff and potential overtime. Nurses encounter nonstandard work schedules, long works hours and circadian adjustment to night shift which is physically, mentally and emotionally strenuous [7]. The nursing profession is one of the jobs that often uses work shifts, this is because working hours are relatively solid. Individuals who do night shift work in circulation will be exposed to fatigue which causes sleep deprivation. The results of fatigue include reduced memory, reduced reaction time, decreased speed of information processing, irritability, endangered problem solving and critical thinking, slipped in attention to details, decreased concentration, judgment, and motivation. Also, regarding the point that fatigue is associated with serious damage to nursing staff including muscle and cardiovascular damage, etc. Overall fatigue can cause a decrease in output, dissatisfaction, absence from work, increased sick leave, and high personnel turnover. So it is necessary to take the decision to leave work [8].

One method used in analyzing work fatigue problems due to fatigue is the macro ergonomic approach. Macro ergonomic is concerned with factors in the technological subsystem, subsystem personnel, external environment, and their interactions as their impact on work system design. The goal of work system design optimization in terms of its sociotechnical system characteristics is to obtain harmonized work systems fully [9]. The macro ergonomics approach aims to better understand and overcome the factors contribute to and/or prevent fatigue in the work system of nurses in hospitals. One of the macro ergonomics approaches is the Systems Engineering Initiative for Patient Safety (SEIPS) model. The SEIPS model was specifically developed to deal with patient and nurse safety. This model explains five components for the structure of work systems, namely person (person), organization, task or workload, work environment, and equipment and technology to pursue balance in the work system of hospital nurses by increasing positive factors when there are several negative factors cannot accept redesign or system intervention [10].

Work fatigue problems have been solved in previous studies. The research has been conducted in North Sumatra relates to these nurses, namely the influence of stress and leadership on the nurses performance in the general hospital in Pematang Siantar. Problems cause stress in work include the absence of a balance between nurses and patients in this case the quantity of beds as a comparison, and nurses feel exhausted, the long duration can be the cause of the emergence of stress experienced at work. The results of regression analysis indicates that the coefficient of determination (R2) is equal to 0,429, means that the independent variables (stress and leadership) together have an influence of 42,9% on nurse performance when the remaining 57,1% is influenced by other variables not examined [11]. Other studies on fatigue problems were also carried out by Shucisnigdha, et al. The study was conducted using fatigue alarms to improve operator performance. This study aims to look at the working conditions in one Intensive Care Unit (ICU) with the presence of a second unit officer and monitor for patients from other medical floors. Physiological steps can be used together with mental workloads and affect to produce a complementary definition of alarm fatigue [12][13].

Based on the research that has been done before, this study uses a macro approach in analyzing the fatigue factors of nurses at Accident and Emergency Department.

2. Methodology

This study is conducted at one of the hospitals in the Medan city where the object examined in this study is the work system of nurses in hospitals. The study begins with observations to observe and see the condition of the company directly. From the results of observations, it is determined the formulation of the problem in accordance with the conditions occur in the company and the research objectives can be applied. The research objectives determined are a solution to existing problems. Furthermore, the data collection as the input in conducting this research. The data needed is in the form of questionnaires
The questionnaire is a quantity of written questions are used to obtain information from the respondent in the sense of reports about the person, or things. In research, the use of questionnaires is a very important thing in data collection. The main purpose of making a questionnaire is to obtain information is relevant to the goal by fillment in the question by the researcher towards the chosen respondents. Carayon (2001) has set five stages to develop a questionnaire survey, namely:

1. Conceptualization
   Determine what concepts will be measured between the elements of the work system that will be evaluated and the output elements that will be evaluated.

2. Operationalization
   Determine the goals to be achieved from the survey and how to match between the concepts used and the objectives to be achieved.

3. Source of Questionnaire
   Determine the type of survey questionnaire that is used as a reference for research.

4. Making of Questionnaire
   Reviewing the form of questionnaires, the rating scale of measurement and the question items determination, how to fill out questionnaires and etc.

5. Initial testing of the questionnaire who is the respondent will participate in this initial test, and determine the objectives of the initial testing (checking the clarity of the question items, the format and duration of questionnaire fillment).

The questionnaire are distributed to nurses and hospital management. The nurse is the operator with the highest level of fatigue. The management provides a work description. The scale used in the assessment of the questionnaire is the Likert scale. This study uses a Likert scale, Likert scale is a psychometric scale used in questionnaire-based research, and is a scale that is frequently cast-off in research in the method of surveys. When responding to queries on a Likert scale, respondents control their level of agreement with the declaration by choosing one of the obtainable options. Likert scale is used to portion attitudes, opinions and perceptions of a person or group of people about community phenomena.

| Preference | Preference | Preference |
|------------|------------|------------|
| 1 Very agree | 1 Agree | 1 Very Positive |
| 2 Agree | 2 Often | 2 Positive |
| 3 Doubt | 3 Sometimes | 3 Neutral |
| 4 Disagree | 4 Almost Never | 4 Negative |
| 5 Very disagree | 5 Never | 5 Very Negative |

For the determinations of quantitative analysis, the answer is given a notch, for example: very agree / agree / very positive given a score of 5, then agree / often / positively given a score of 4 and so on [14].

The Systems Engineering Initiative for Patient Safety (SEIPS) macro ergonomic approach carried out after questionnaires are distributed. Some of the things discussed in macro ergonomics are organizational structures, interactions among people in the organization and aspects of workers inspiration. In other words, micro ergonomics only look at the level of work but macro ergonomics look at the level of work and also the level of the organization. Macro ergonomics has been known as a subdiscipline of ergonomics related to human, organizational and technological relations. Macro ergonomics is something that is integrated because it includes information, approaches, and equipment from socio-engineering systems, industrial psychology, systems engineering, physical ergonomics, and ergonomics theory. In its implementation, macro ergonomics presents a valuable niche that none of these areas has ignored. As a science, macro ergonomics directs to progress an empathetic of work systems, behavior, or personnel that interact with hardware or software in an internal physical environment, external environment, and organizational structure and processes to make it better.
3. Result and Discussion

3.1. Stages of Ergonomic Approach Using Systems Engineering Initiative for Patient Safety (SEIPS)

In macro ergonomics application there are several stages, namely:

1. Stage of Information Collection
   Information collection needed for making questionnaires about the work system and information about who the respondents will be involved in conducting direct observation in the hospital and conducting interviews with 7 respondents from the hospital management and 83 nurse respondents.

2. Stage of Objective Determination
   Determine the goals to be achieved in the study and the benefits will be obtained for the company. The goal to be achieved is to determine the factors affect the nurse mistakes and how to overcome them.

3. Stage of Implementation
   Determine when the survey will be conducted, the procedure to be used and the survey data collection method used by conducting an open questionnaire distribution based on a Likert scale.

4. Stage of Analysis and Interpretation
   Data processing is done with statistical software to process, analyze and draw conclusions from survey data, then connect with the objectives to be achieved.

5. Stage of Result Deliver
   Making reports on the results of the research conducted.

6. Stage of follow-up action is the final stage of a research to make the next activity plan / action, for example the making of a recommendation work system improvement or implementation of the results of the research conducted.

3.2. Approach of Work System Design

Each work system contains several or all work components, each interacting with each other. Ergonomics as both science and technology is always concerned with interfaces and interactions between operators and work components, and concentrates on the influence of interactions on work system performance. In a relationship table or interaction between operators and work components can be seen in Table 1.

**Table 2. Components of Work System**

| Component   | Design Area                                      | Consideration                                                                 |
|-------------|--------------------------------------------------|-------------------------------------------------------------------------------|
| Hardware    | Design and layout of components                  | Process, equipment, access                                                   |
| Operator    | Physical Characteristics of Skills               | Body characteristics, strength, work capacity, posture, fatigue, and endurance. |
|             | Recipient of information and process             | The five senses (vision, hearing, etc.), attention, memory, etc.              |
|             | Individual and social characteristics             | Age, gender, cultural background, ethnicity, skills, training, motivation, job satisfaction, and interest, saturation, behavior, etc. |
| Organization| Personnel / production organization               | Work-rest time, work rotation, rotating work, interest, satisfaction, responsibility, social interaction, and others. |

From the table above it can be concluded that the factors that influence nurse fatigue are physical work environmental aspect, responsibilities and duties of workers aspect, equipment and technology used aspect, company organization aspect and personal nurses’ aspect.
4. Conclusion
Macro ergonomics has been known as a subdiscipline of ergonomics related to human, organizational and technological relations. This research was conducted at one hospital in Medan City by using 83 respondents from the nurses and 7 respondents from the hospital to determine the factors that influence nurse fatigue. Analysis of work systems to reduce nurse fatigue with the macro ergonomic method of the Systems Engineering Initiative for Patient Safety (SEIPS) model in hospitals created on the consequences of explanations and consultations of nurses and hospital management. The factors that influence the work system of nurses in hospitals are identified both physical work environment aspect, responsibilities and duties of workers aspect, equipment and technology used aspect, company organization aspect and personal nurses’ aspect.

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