Application of work system engineering analysis

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Abstract. Through this research, system engineering will be applied related to the analysis of work systems in hospitals, especially government hospitals where the workload is very high. The object of this research is nurses who work in emergency rooms. The purpose of this study is to apply engineering to the medical world that has been carried out in the manufacturing industry. Similarly, operators who work in the industrial world experience high levels of fatigue such as nurses. This is what underlies this research. Nurses have a high level of fatigue compared to nurses who work in other departments. The high level of fatigue makes it difficult for workers to distillate and focus while working and increases the danger of work fortunes produced by human error and affects the psychological condition of the nurse. Based on the above conditions and impacts, further research needs to be done on a work systems analysis to condense nurses tiredness using the macro ergonomics approach of the System Engineering Initiative for Patient Safety (SEIPS) model in hospitals based on observations and interviews of nurses and hospital management. The expected output is that each nurse does not experience severe fatigue to make maximum patient care.

1. Introduction
Occupational health and safety are the company's main anxiety for the welfare of companies and workers. Industrialization and the development of the service sectors have experienced rapid growth, which is increase in health problems of workplace, one of them is in the hospitals [1]. Human resources needed at the hospital in providing care for patients include nurses. Nurses are the top human resources in terms of numbers in all hospitals. Especially in the inpatient ward nurses, they should make the priority to in their care so that patients really expect the maximum performance of a nurse [2] [3]. In the hospital it is normal for nurses to work in very long shifts. The statistics bureau showed that in 2010 that 75% of shift workers were hospital nurses. The high proportion of work causes a high level of fatigue experienced by nurses so that it cannot provides maximum treatment [4].

Nurses often experience a variety of patient complaints, complex work, and tasks demand to be achieved, repetitive activities, and relationships with co-workers. This vulnerable condition makes nurses easily experience work fatigue. Nurses are important human resources and have a lot of job descriptions so that nurses easily experience fatigue [5]. Work fatigue is a state where there is a reduce in work efficiency, skills are caused by tired feeling or bored to resume movements or work. Fatigue cannot be underrated because it involves the efficacy, productivity, and protection of workers in universal. The high level of assignment causes workers hard to essence and focus when functioning and increases the risk of work accidents caused by human erroneousness [6].

Conditions of fatigue usually result from physical and spiritual activity, stress, and overwork load. That is why fatigue is also defined as the inability to maintain the stamina and energy needed or expected or lack of energy in work capacity. Working with a high level of fatigue can be likened to alcoholism [7][8]. Hospital nurses experience a relatively high mental and physical compared to other hospital staff. Hospital nurses provide all patient care services in terms of simple request to complex workloads. Inadequate number of hospital nurses causes nurses to have overtime potential. Nurses facing non-standard work schedules, long working hours, and night shift adjustments that affect nurses' physical,
mental, and high emotional levels. Hospital nurses experience a high mental and physical burden compared to other hospital staff. Hospital nurses provide all patient care services in terms of simple requests to complex workloads. Inadequate number of hospital nurses causes nurses to have overtime potential. Nurses facing non-standard work schedules, long working hours, and night shift adjustments that affects nurses physical, mental, and high emotional levels [9]. The nursing profession is one of the jobs where staff working in various work shifts. Individuals who work in this night shift with less hours of sleep result in increased fatigue. The consequences of fatigue include memory reduction, reaction time reduction, decrease in speed of information processing, irritability, danger in decision making and affecting nurses emotionally, lack of focus in paying attention to details, concentration decrease, assessment, and motivation. Besides fatigue is associated with serious damage to nursing staff including bones damage, cardiovascular and others. Overall fatigue leads to output reduction, dissatisfaction, absenteeism at work, work leave increase, and high employee turnover [10][11].

There are various kinds of methods, but the method used in analyzing the problem of work fatigue is a macro ergonomic approach. Macro ergonomics deals with factors in the technology subsystem, personnel subsystem, the peripheral environment, and their interactions as an effect on the design of the work system. Optimization of work system design in terms of the characteristics of this sociotechnical system aims to achieve a fully harmonious work system [12]. The macro ergonomic methodology aims to better recognize and overcome the factors that contribute to and/or avoid fatigue in the work system of nurses in hospitals. One of the macro ergonomic approaches is the System Engineering Initiative for Patient Safety (SEIPS) model. The SEIPS model specifically exists and is evolving to address patient and nurse safety. This model illustrates the five components of the work system structure, namely people, organization, task or workload, work environment, as well as equipment and tools and technology to maintain the work system of nurses in hospitals by increasing positive factors if there are negative factors, the factors cannot. accept redesign or systems intervention [13].

The problem of work fatigue has been found in previous studies. one of them is research directed in North Sumatra related to these nurses, explicitly the effect of stress and leadership on the accomplishment of nurses at Pematang Siantar Hospital. The main problems that source stress at work include the lack of balance ratio between nurses and patients, in this case the number of inpatient beds as a comparison, and nurses feeling tired, the long duration of time can be a cause of stress experienced while working to provide services. The results of the regression analysis showed that the coefficient of determination (R2) was 0.429, meaning that the independent variables (stress and leadership) had an effect of 42.9% on the nurse's performance while the remaining 57.1% was affected by other variables which were not examined [14]. Another study on the problem of fatigue was also carried out by Shucisnigdha, et al. This study was conducted using a fatigue alarm approach to improve operator performance. This study focused on one Intensive Care Unit (ICU) with a second unit attendant and monitoring patients from another medical floor. Physiological measures can be used in conjunction with mental workload and affect to produce a complementary definition of fatigue alarm [15] [16].

Based on research has been done before, this conclusion using a macro ergonomic based on SEIPS approach in analyzing nurses fatigue factors in the Intensive Care Unit (ICU).

2. Methodology

This research was led in a hospital in Medan where the entity in this study was the nurse's work system at the hospital. The study began with explanations to observe and see the company condition directly. From the observations, determine the problem formulation based on real condition occur in the company and research objectives can be applied. The research objectives specified are solutions to existing problems. Furthermore, data collection as the input in conducting this research. The data needed is in the form of questionnaire attribute data based on the Systems Engineering Initiative for Patient Safety (SEIPS) assessment. The SEIPS model integrates human factors and health care models to propose a systems engineering model to understand the care process by representing all elements of the work system, this model provides a representation of the complexities of health care [17]. The SEIPS
assessment including some aspects are organization aspect, workload aspect, personal aspect, work environment aspect and tools and technology aspect. The first stage of the study is determination the number of samples. Next is making of questionnaire based on selected attributes. The selected questionnaire attributes were tested for validity and reliability. The next stage is the correlation test between nurses and hospital data. The last stage is to do a regression test based on organization aspect, workload aspect, work environment aspect and tools and technology aspect.

3. Result and Discussion

3.1. Determination of Samples Number

Data used as the samples were obtained from nurses at the Hospital of North Sumatra, Medan with a population of 83 people. The method used to determine the number of samples is a nonprobability sampling method with a sampling technique is saturation sampling, saturation sampling is a sample determination technique with all population used to be a sample of 83 nurses and 7 respondents from the hospital.

3.2. Determination of Questionnaire Attributes

Nurse questionnaire data collection in personal (person) aspect consisting of 15 attributes. 15 personal attributes of the questionnaire data can be seen in Table 1.

| No  | Attribute                          | Category                   |
|-----|------------------------------------|----------------------------|
| 1.  | Age                                | 18-22 years old            |
| 2.  | Gender                             | Female                     |
| 3.  | Education                          | Senior High School         |
| 4.  | Main Work Description              | Nurse                      |
| 5.  | Level of Clinical Expertise        | Competent                  |
| 6.  | Working Time as a Nurse            | 1-3 years                  |
| 7.  | Main Shift Work                    | Morning                    |
| 8.  | Average Working Time per Shift     | 12-13 hours                |
| 9.  | Average Working Time per Week      | 40-44 hours                |
| 10. | Status                             | Not married                |
| 11. | Dependent at Home or in a Care     | 0 person                   |
| 12. | Transportation                     | Motorcycle                 |
| 13. | Distance of Round Trip in Working  | 0.5-1 km                   |
| 14. | Severity of Patients Treated       | Moderate                   |
| 15. | Care Intensity in Patients         | Light                      |

3.3. Correlation Test of Nurses and Hospitals

Correlation test aims to determine the presence/absence of the relationship and the direction of the relationship between the independent and dependent variables in this case are the nurse's work system variables and nurses fatigue variables.
Table 2. Recapitulation of Nurse and Hospital Data Correlation Test

| No  | Attribute Data | r Value (Correlation) | Significant Value | Description       |
|-----|----------------|-----------------------|-------------------|-------------------|
| 1   | Attribute 1    | 0.489                 | 0.000             | Moderate Correl.  |
| 2   | Attribute 2    | 0.420                 | 0.000             | Moderate Correl.  |
| 3   | Attribute 3    | 0.638                 | 0.000             | High Correl.      |
| 4   | Attribute 4    | 0.582                 | 0.000             | Moderate Correl.  |
| 5   | Attribute 5    | 0.346                 | 0.001             | Low Correl.       |
| 6   | Attribute 6    | 0.278                 | 0.011             | Low Correl.       |
| 7   | Attribute 7    | 0.247                 | 0.024             | Low Correl.       |
| 8   | Attribute 8    | 0.256                 | 0.020             | Low Correl.       |
| 9   | Attribute 9    | 0.272                 | 0.013             | Low Correl.       |
| 10  | Attribute 10   | 0.301                 | 0.006             | Low Correl.       |
| 11  | Attribute 11   | 0.298                 | 0.006             | Low Correl.       |
| 12  | Attribute 12   | 0.221                 | 0.045             | Low Correl.       |
| 13  | Attribute 13   | 0.296                 | 0.007             | Low Correl.       |
| 14  | Attribute 14   | 0.330                 | 0.002             | Low Correl.       |
| 15  | Attribute 15   | 0.286                 | 0.009             | Low Correl.       |

Created on the table directly above shows that the attribute has a high correlation level to nurse fatigue is Attribute 3.

3.4. Test of Nurse Regression
Regression analysis is a technique to find the connection between one variable with alternative variable expressed in the form of mathematical equations in a functional connection. Regression analysis conducted based on the assessment of SEIPS aspects namely organizational aspects, workload aspects, work environment aspects and tool and technology aspects of questionnaire attributes. The recapitulation of the regression test on the SEIPS four aspects can be seen in Table 3.

Table 3. Recap of Nurse Regression Test Based on SEIPS Assessment

| Aspect                      | Regression Coefficient |
|-----------------------------|------------------------|
| Organizational Aspect       | 0.615                  |
| Workload Aspect             | 0.638                  |
| Work Environment Aspect     | 0.258                  |
| Tool and Technology Aspect  | 0.264                  |

Built on the table above, it can be understood that all four aspects have a relationship with questionnaire attributes.

4. Conclusion
Macro ergonomics has been recognized as an ergonomic subdiscipline linked to human relations, organization and technology. This research was accompanied in one hospital in Medan using 83 respondents from nurses and 7 respondents from hospitals to find out the factors that stimulus nurse fatigue. Work system assessment to condense nurse fatigue with a macro ergonomic approach from the System Engineering Initiative for Patient Safety (SEIPS) model in hospitals based on observations and interviews of nurses and hospital management. Aspects that stimulus the nurse's work system in hospitals are known based on organization aspect, workload aspect, work environment aspect, tools and technology aspect used. Statistical calculations with the correlation test and regression test show that personal aspects, organizational aspects, workload aspects, work environment aspects, tools and technology aspects influence the level of nurse fatigue.
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