

Analysis of Physical and Mental Workload on Emergency Department (ED) Nurses with Subjective Workload Assessment Technique (SWAT) and Cardiovascular Load (CVL) Methods (Case Study of Sidoarjo City Hospital)

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ABSTRACT

This research was conducted to reveal the amount of mental and physical workloads of nurses, determine the SWAT and CVL indicators which contribute the most impact on the occurrence of workloads, and advise on possible improvements to minimize this workload. The study was carried out in the Emergency Department of RSUD Sidoarjo from May 2023 until the required data is complete. The result of this analysis revealed that the most impactful SWAT indicator on nurses' mental workloads is Time, Shift 1 62.34%, Shift 2 59.13%, and Shift 3 57.19%. Meanwhile, the result of the examination on physical workload using the CVL method with a percentage of 30% states that the highest CVL average percentage is 33%. Based on the results of both indicators, Sidoarjo Regional Hospital is advised to add one more nurse so that the workload of nurses overall can be reduced.

Keywords: CVL; ergonomics; hospital; SWAT; workload.

INTRODUCTION

A nurse is someone who works in an effort to handle patient care or care for patients with varying work demands. Nurses have the knowledge and authority to provide nursing care to others. The task of nurses is to serve the community, nurses are obliged to provide services that are useful for the community by treating, helping and providing support to their patients so that they remain strong and do not easily despair in the face of their illness. Nurses are one of the medical personnel who provide medical services to the community to support the health and recovery of patients, every hospital always needs a nurse and they have a high responsibility for the tasks they do and are able to show good work performance to the relevant agencies, nurses must also always maintain their attitude in front of patients, above and with fellow nurses as well as the relationship that is carried out runs with what is desired.

In addition, nurses also have to do a lot of work in the hospital with busy working hours so that there are some nurses who experience stress seeing this very much work, starting from their service to patients to their responsibilities regarding patient safety. Job-related tasks nurses must pay attention to patients based on the needs of patients, patients' families and others. In carrying out their daily duties, a nurse will more easily experience stress. This is because nurses are often faced with a very large rescue effort for someone's life. Nurses are also always faced with monotonous and routine things, crowded and cramped workspaces, in handling equipment in the emergency room, surgery and so on. From an ergonomic point of view, every workload received by a person must be appropriate or balanced both to the physical abilities, cognitive abilities and limitations of the human being who receives the load. According to Suma'mur (1984) "that the work ability of a worker is the level of skill, physical fitness, nutritional state, gender, age and body size of the worker concerned". According to Iridiastadi (2014: 100) excessive workload can also have a negative impact on work quality and performance. That physiologically excessive workload will have an impact on health and work productivity. In the context of ergonomics, the goal to be achieved is to ensure that the work system is designed in such a way as to obtain the best productivity and quality of work, which can be achieved if the load is within the limits of physical ability.

This study examines nurses who handle Emergency Department (IGD) patients at Sidoarjo City Hospital. Based on interviews with nurses at Sidoarjo City Hospital, they explained that they have a lot of work to do, so that nurses feel burdened with the existing work. For the duration of working time nurses are in accordance with what has been set by the Sidoarjo City Hospital, but as the

number of patients in the Emergency Department (IGD) increases, and the lack of nurses on duty in the IGD room, making nurses feel exhausted with their work. The number of nurses who work in one shift at the Sidoarjo Regional Hospital Emergency Room is 7 people / shift for permanent nurses who are in the Emergency Room (IGD) of Sidoarjo City Hospital and for the average patient from morning to night at least 15 patients who enter, ranging from road accidents, work accidents to other diseases such as heart disease, stroke, diabetes and others. The first shift for nurses starts from 08.00 - 16.00 and for the second shift from 16.00 - 22.00. The method used to measure physical and mental workload is SWAT (*Subjective Workload Assessment Technique*) because this method was developed based on the emergence of the need for subjective measurements that can be used in the actual environment and CVL (*Cardiovascular Load*) cardiovascular strain can be assessed using the work pulse measurement method. Oximeter is one of the tools used to measure pulse rate.

Literature Review

In this section, it will be explained regarding the literature review that will be used in the research and discuss the theory that needs to be understood to be used as a reference or foundation for this research.

Previous Research

1. Pengukuran Beban Kerja Mental Sopir Bus Menggunakan Metode SWAT (Studi Kasus PO. XYZ) (Alfian, 2019).
2. Pengukuran Beban Kerja Karyawan dengan Menggunakan SWAT (Subjective Workload Assesment Technique) dan Work Sampling pada PT. XYZ (Sabrini, 2013).
3. Mental Workload Analysis Of Naval Cadet Academy Using SWAT (Subjective Workload Assessment Technique) Methods (Elisabeth, 2020).

Ergonomics

Ergonomics can be defined as a discipline that studies the limitations, advantages, and characteristics of humans, and utilizes this information in designing products, machines, facilities, environments, and even work systems, with the main objective of achieving the best quality of work without neglecting aspects of health, safety, and comfort of human users (Pratama, 2019). The definition and understanding of ergonomics are as follows: (a) ergonomics is the study of the interaction between humans and machines, and the factors that affect them. The goal is to improve overall system performance (Bridger, 2019); and (b) Jastrzebowski, in 1857 became a pioneer in the use of the word ergonomics, which in Greek *ergos* means "work" while *nomos* means "study" or "laws". According to ergonomics, task demands and work capacity must always be in balance to achieve high work performance. The task demands given should not be too low (*underload*) which can cause *understress*, boredom and boredom. Furthermore, it should not be too excessive (*overload*) which can cause *overstress*, fatigue, work accidents, injuries, and illness.

1. Scope of Ergonomics. Ergonomics based on its understanding can be divided into 4 (Hutabarat, 2017): (a) cognitive ergonomics has to do with human mental processes such as perception, memory and reaction as a result of human interaction with the use of system elements.
 - a. Physical Ergonomics is related to the anatomy of the human body, anthropometry, physiology and biomechanics related to physical activities.
 - b. Organizational Ergonomics is concerned with the optimization of sociotechnical systems, including organizational structures, policies and processes.
 - c. Environmental Ergonomics has to do with lighting, temperature, noise and vibration.
2. Application of Ergonomics. Ergonomics can be applied to work systems to regulate the course of a work process (Pramita, 2019): (a) work position, ergonomics regulates work positions from sitting to standing; (b) work process, ergonomics uses anthropometric rules to facilitate the process of completing work; (c) workplace layout, ergonomics regulates the layout or design of the workplace so that the work process is optimized; and (d) lifting weights, ergonomics regulates the correct position when lifting weights and the portion of the load lifted according to the worker's ability.

Cardiovascular Load (CVL)

The degree of workload depends not only on the amount of calories consumed, but also on the number of muscles involved in static muscle loading. A certain amount of energy consumption will be heavier if only supported by a small number of muscles relative to a large number of muscles. Pulse rate is the number of times the arteries (clean blood vessels) expand and contract in one minute in response to the heartbeat. The number of pulse beats is equal to the number of heartbeats. This is because the contraction of the heart causes an increase in blood pressure and pulse rate in the arteries. Pulse rate and heart rate per minute can be used to calculate energy expenditure (Retno, 2003). More broadly, it can be said that heart rate and respiratory rate are influenced by physiological pressure, pressure by the environment, or pressure due to hard work, where all three factors have an equal influence. Heart rate measurement can be done in various ways, feeling the heart rate on the radial artery and wrist and using a stethoscope. In determining energy consumption, the relationship between energy and heart rate is usually used using the quadratic regression equation as follows: $E = 1.80411 - 0.0229038 X + 4.71733 \times 10^{-4} X^2$

Description: E = Energy (Kcal/m); X = Heart rate/pulse rate (beats/m); K = $E_t - E_i$; Description: K = Energy Consumption (Kikocalories/m); E_t = Energy expenditure at a given work time (kcalories/m); E_i = Energy expenditure at the time before work

Table 1
Classification of Workload is Based on an Increase in Working Heart Rate Compared to The Maximum Heart Rate Due to Cardiovascular Loads

Category	Age (year)			
	< 30	30 - 39	40 - 49	> 50
Very bad	< 25.0	< 25.0	< 25.0	-
Bad	25.0 - 33.7	25.0 - 30.1	25.0 - 26.4	25.0
Regular	33.8 - 42.5	30.2 - 39.1	26.5 - 35.4	25.0 - 33.7
Good	42.6 - 51.5	39.2 - 48.0	35.5 - 45.5	33.8 - 43.0
Very good	> 51.6	> 48.1	> 45.1	> 43.1

source: processed data

Furthermore, the determination of workload classification is based on the increase in work pulse rate compared to the maximum pulse rate due to cardiovascular load (Cardiovascular Load or %CVL) (Manuaba and Vanwongerghem, 1996). Where the maximum pulse rate is 220 minus age for men and 200 minus age for women. According to Tarwaka (2015), cardiovascular (*Cardiovascular = %CVL*) can be calculated with the following formula:

$$\%CVL = \frac{100x (\text{denyut nadi kerja} - \text{denyut nadi istirahat})}{\text{denyut nadi maksimum} - \text{denyut nadi istirahat}}$$

Table 2
%CVL calculation

% CVL	Classification %CVL
<30%	No errors occurred
30% - 60%	Improvement required
60% - 80%	Work in a short time
80% - 100%	Immediate action required
>100%	No activities allowed

source: processed data

Subjective Assessment Technique (SWAT)

The *Subjective Workload Assessment Technique* (SWAT) method was first developed by Gary Reid of the *Human Engineering* Division at Armstrong Laboratory, Ohio USA used to analyze the workload faced by a person who must perform activities that are both physical and mental workloads

that vary and arise due to the increasing need for subjective measurements that can be used in a *real world* environment.

Application of Subjective Workload Assessment Technique

In the application of SWAT, it provides a simple and easy subjective scale to quantify the workload of the activities that must be performed by workers. SWAT will describe the work system as a multidimensional model of workload, which consists of three factors namely, time load (*Time Load*), mental load (*Effort Load*), and psychological load (*Psychological Stress Load*). The use of the *Subjective Workload Assessment Technique* (SWAT) model has 2 stages that must be carried out including:

1. Scale Development Stage. In scale development, the subject (the person whose workload level will be measured) is asked to sort 27 (twenty seven) combination cards of the three description variables (T, E and S) starting from the lowest to the highest. Furthermore, the following analysis is carried out:
 - a. Prototyping and Kendall's Coefficient of Concordance Analysis. *Prototyping* is the process of stratifying respondents into homogeneous groups based on the perceived relative importance of the three main dimensions in SWAT, namely *time load*, *mental effort load*, *psychological stress load*.
 - b. Axiom Test. *The Axiom Test* is used to test the additive model and the consistency of card sorting. The *axiom* test will test three basic properties of the additive model, namely independence, multiple failures, and joint independence.
2. Event Scoring Stage. Then in the *scoring event*, the subject is asked to comment on his work scale SWAT Rating (scale 1 to 3) for each variable T, E, and S of each *task* (each work element or in the completion of a job), then the SWAT *rating* is matched with the results of card sorting from the SWAT program results in the computer to determine the *workload score* of each combination.

Workload

Workload or can also be called *workload* is the effort that must be spent by a worker to meet the demand or *demand* needed to complete the job. Based on facts in the field, it shows that human physical and psychological factors mutually influence the effort expended to complete a job, so measuring workload is needed by a company to monitor human physical and psychological factors at work, so that severe things do not occur and decrease work motivation (Silvia, 2018). Every workload that a person receives must be appropriate and balanced against the physical and mental abilities of the worker who receives the workload so that fatigue does not occur. Work fatigue will reduce performance and increase the level of work errors. Increased work errors will provide opportunities for work accidents. (Amri, 2017).

1. Workload Levels. As explained, achieving a normal workload in the sense of a volume of work that matches work ability is quite difficult. So that there is always an imbalance even though the deviation is small. (Hernanta, 2017). Workload has 3 levels, namely: (1) underload, below normal workload means that the time used to complete the work is less than the available working hours, the value of below normal workload is, 0-40; (2) normal workload, normal workload means that the time used to complete the work is equal to the available working hours, the normal workload range is, 41-60; and (3) overload, above normal workload means that the time used to complete work is greater than the available working hours, the value of workload above normal is 61-100.
2. Classification of Workload Factors, Workload is influenced by two factors, external and internal. Below is an explanation of each factor: (a) external factors, external factors of workload are loads that come from outside the worker's body. including the external workload is the *task (task)* itself, the organization, and the work environment, these three aspects are often referred to as *stressors* or causes of *stress*; and (b) internal factors. internal workload factors are factors that come from within the body itself as a result of reactions from external workloads. the body's reaction is known as *strain*. the severity of *strain* can be assessed both objectively and subjectively. objective assessment, namely through changes in physiological reactions. meanwhile, subjective assessment can be done subjectively, which is closely related to expectations, desires, and satisfaction.

3. Impact of Work Overload. Too high workload has a negative impact on workers, (Hakim, 2018). The impacts are as follows: (a) Work performance is not maximized. The workload given to workers without considering the ability or capacity of workers can cause less than optimal work performance due to fatigue and decreased concentration; (b) Consumer complaints. Consumer complaints are caused by services provided that are less than optimal so that consumers do not feel satisfied; and (c) High absenteeism. High workload is linear with high worker absenteeism as well because workers often experience fatigue and fall ill.
4. Workload Type. Workload is classified into two types, namely, mental workload and physical workload. The following is an explanation of each type of workload: (1) Mental workload. Mental workload is an assessment of workers in terms of *attentional* load between motivational capacity and the demands of the task to be completed. Mental work includes brain work and information processing, (Dewi, 2020); and (b) Physical workload. Physical workload is a workload that requires the muscles and physique of workers as a source of energy to complete the assigned tasks.

Hospital

Hospitals are places where sick people seek and receive medical services and where clinical education for medical students, nurses and various other health professionals is organized. A hospital is a center where public health services, medical education and research are organized according to the *Association of Hospital Care* (Azwar 1996)

1. Hospital Characteristics: (1) most of the workforce are professionals; (2) the head of the hospital has special authority; (c) have more professional group duties than managerial group duties; (d) there are no rules for workload; (e) have a diverse amount and nature of work; (f) all activities are important; (g) service is personal, fast and precise; (h) the service runs 24 hours; and (i) hospital services are highly individualized.
2. Hospital Classification. Hospitals in Indonesia based on their service capabilities can be divided into 5, (Azwar, 1996). (1) type a hospital. the hospital provides a wide range of specialized and subspecialized medical services. it is a *top referral hospital* or central hospital; (b) type b hospital. these hospitals provide broad specialist and limited subspecialist medical services. it is established in each provincial capital (*propincial hospital*) that accommodates referral services from district hospitals; (c) type c hospital. these hospitals provide limited specialist medical services. this hospital is established in each district capital (*regency hospital*) which accommodates referral services from puskesmas; (d) type d hospital. this hospital is transitional as it is planned to be upgraded to a class c hospital. the hospital provides general medicine and dentistry services and accommodates referral services from puskesmas; and (e) type e hospital. these hospitals are *special hospitals* that only provide one type of medical service, including leprosy hospitals, paramedic hospitals, heart hospitals, mother and child hospitals, dental and oral hospitals.

METHODS

This section will explain the methodology in the research as follows. The methodology diagram illustrates the flow of work from *input, process, and output*. The research was conducted at the Sidoarjo City Regional General Hospital (RSUD) located on Jl. Mojopahit No.667, Sidowayah, Celep, Kec. Sidoarjo, Sidoarjo Regency in March 2023 until the data needed in the study could be fulfilled. In the research, it is necessary to identify the research variables that will affect the workload of nurses at Sidoarjo City Hospital. The dependent variable is the variable that is affected or that is the result of the independent variable. The dependent variable in this study is the physical and mental workload of nurses who handle emergency room patients at Sidoarjo City Hospital. Independent variables are variables that affect the dependent variable where the independent variable will be the decision variable to be sought. The following are the independent variables of this study, namely *Time Load, Mental Effort, Psychological Stress, Work Pulse* and *Rest Pulse*.

RESULTS

This section will explain the implementation carried out to complete this research.

Data Collection

1. Work Shift. Sidoarjo Regional General Hospital (RSUD) conducts the process of handling emergency room patients with a duration of 24 hours/day. Each work shift has 3 nurses working to handle patients.
2. Job Description. Nurses in carrying out the process of handling emergency room patients at Sidoarjo Hospital apply several *job desks* consisting of installing IVs and oxygen, giving food and medicine, assisting patients in *personal hygiene*, implementing medical programs (checking blood pressure, checking blood sugar, injecting insulin, etc.), motivating patients, making daily reports on patient progress.
3. Compilation of 27 SWAT Cards. Respondents were asked to rank the 27 SWAT cards in order of low workload to high workload from the perspective of each nurse.
4. Workload Assessment Questionnaire. *Event Scoring* is carried out to assess each nurse's condition at the time of carrying out responsibilities. The data needed in the *Event Scoring* stage is a workload assessment of the workload consisting of time burden (T), mental effort burden (E), and psychological pressure burden (S) according to the activities they perform.
5. CVL Method Data Collection. The data that has been collected will be analyzed to get the desired results.

Data Processing

1. Scale Development Stage. The process of sorting 27 SWAT cards that have been carried out there are three pairs of comparisons of the dimensions used in SWAT. The data that has been obtained is then inputted into the SWAT *software* which is run using DOSBox 0.74 as an emulator. The first step is to calculate the Kendall Coefficient value. If the coefficient value ≥ 0.75 , it can be said that the agreement index in the preparation of cards among respondents is relatively the same and homogeneous.
2. Event Scoring Stage. In the *Event Scoring* stage using *Group Scalling Solution* which is used for all workload assessment data because it has an *endall* coefficient test value of 0.9276 or greater than 0.75 which states that the SWAT card sorting data is homogeneous, the results of calculating the average value of workload per-shift, namely, nurse A's morning shift has a value of 54.1 (medium), nurse B's morning shift has a value of 52.3 (medium), and nurse C's morning shift has a value of 49.1 (medium). Nurse A's afternoon shift has a value of 47.2 (medium), Nurse B's afternoon shift has a value of 52.6 (medium), and Nurse C's afternoon shift has a value of 62.5 (high). Nurse A's night shift has a value of 62.2 (high), Nurse B's night shift has a value of 51.4 (medium), and Nurse C's night shift has a value of 61.9 (high).
3. Calculating the Maximal Pulse Rate. Calculating the maximum pulse rate is done by using the maximum pulse formula and one of the determining variables is the age of the nurse who is the object of measurement. (Maximum pulse rate = 220 - Age).

Table 3
Calculating the Maximal Pulse Rate

Name	Age (Year)	Maximal Pulse Rate
Rahmawati	30	190
Princess	30	190
Rika	25	195
Hartati	32	188
Goddess	26	194
Nur	26	194
Risma	24	196
Rida	29	191
Evi	26	194

source: processed data

Analysis and Discussion

Prototype and Kendall Coefficient Analysis

Based on the results of data processing to measure mental workload using the SWAT method, at the first stage, namely *Scale Development*, the Kendall coefficient value (*W*) for shift I is 0.9247, the Kendall coefficient value (*W*) for shift II is 0.8999, and the Kendall coefficient value (*W*) for shift III is 0.9276. All Kendall's coefficient values (*W*) for shift I, shift II, and shift III > 0.75 indicate that the agreement index in the preparation of cards among respondents is relatively the same and homogeneous and is processed on a group scale. So data processing at the *Event Scoring* stage uses the *Scalling Solution* results for all research respondents or called *Group Scalling Solution*.

Event Scoring Analysis

Event Scoring is the stage of assessing the state of research respondents when carrying out their responsibilities as nurses who handle emergency room patients. In SWAT, this situation assessment still uses T, E, S to be used as indicators. Table 4 shows a comparison of the results of mental workload measurements between shift I, shift II, and shift III.

Table 4
Mental Workload Measurements Between Shift I, Shift II, And Shift III.

Workload Measurement	Category	Percentage Total Mental Workload		
		Shift I	Shift II	Shift III
Work Activities	Low	22%	22%	6%
	Medium	50%	45%	55%
	High	28%	33%	39%

source: processed data

Looking at the duration of working hours between shift I, shift II, and shift III is the same with a duration of 8 hours/shift, the condition that distinguishes shift I, shift II, and shift III is working time. Working time in the first shift is 07.00-15.00, the second shift is 15.00-23.00 at this time is the ideal time to work, while in the third shift is 23.00-07.00, working conditions at night will require more focus because at night is a normal condition for humans to rest and sleep.

CONCLUSION

The conclusion of this study is based on the results of the analysis of the mental and physical workload of nurses who handle Emergency Department patients at Sidoarjo Regional Hospital using the SWAT and CVL methods, the following results were obtained:

1. SWAT Method. The value of mental workload in emergency room nurses at Sidoarjo Regional Hospital is 9 activities categorized as low (17%), 27 activities categorized as medium (50%), and 18 activities categorized as high (33%). The dimension that most influences the mental workload value of nurses who handle emergency room patients at Sidoarjo Hospital is the Time dimension (60%). Recommendations for improvement in minimizing the mental workload of nurses who handle emergency room patients at Sidoarjo Hospital are to increase the workforce of nurses in the third shift, because the percentage of high category workload in the third shift is the largest when compared to the first shift and second shift, and working conditions at night will require more focus because at night is a normal condition for humans to rest and sleep.
2. CVL Method. The measurement results show the highest result of resting pulse is with a pulse rate of 80/minute, while the lowest result of resting pulse is with a pulse rate of 66/minute which shows that the nurse has a low fitness level. The highest workload according to the *Cardiovascular Load (CVL)* method is found in nurse number 7 on behalf of Risma with a percentage of 33. This research produces improvement proposals that can help companies in overcoming employee workload, namely: (1) Improving break times by implementing a short break system (white collar) for 15 minutes before the main break at around 09.45 WIB and 15 minutes before the end of working time at 15.00 WIB to reduce the impact of workload characterized by an increased pulse rate and reduce the impact of employee fatigue; and (2) Provide additional intake during short

breaks such as snacks, milk, eggs and others, with adequate intake having an impact on employee fitness so that it can help reduce the potential for fatigue in employees.

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