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Risk Analysis in Nurses Who Treat Patients with Infectious Diseases in Indonesia

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ABSTRACT

In this global pandemic of infectious diseases such as coronavirus-19 (COVID-19), Indonesia is one country that has a severe impact. In this situation, medical workers are arguably the most affected as they are the frontline in facing the pandemic. Their dedication and professionalism are put to a tough test; hence, they should stay healthy to provide treatment for the patients. However, in fact, many of them are infected by the coronavirus albeit the use of standard protective equipment and application of health protocols. In this study, a risk analysis on nurses working in inpatient wards for COVID-19 patients in quarantine was carried out. A Method of Human Error Analysis and Reduction Technique (HEART) was employed along with Fault Tree Analysis (FTA). The results indicated that fatigue, comorbid, and boredom were the factors associated with the highest risk of virus infection. These results suggest that management should pay attention to these factors in the work design of medical personnel, especially those who treat patients with infectious diseases such as COVID-19. In conclusion, work design must implement appropriate work shifts, as well as the implementation of strict health protocols.

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1. INTRODUCTION

Until 24 July 2020, there were already 95,418 positive cases of COVID-19 recorded in Indonesia. The confirmed number of deaths and recoveries was 4,665 and 53,945, respectively. According to kompas.com, the rate of positive cases in Jakarta during 13-19 July has reached 5.5%. This rate was higher than the 5% threshold set by WHO. According to PHEOC (Public Health Emergency Operating Center) data from the Ministry of Health of Indonesia, 777,100 people have been tested by 24 July 2020. Therefore, for 95,418 positive cases, the total positive rate in Indonesia would be about 12.3%. This means that in every 100 tests, there would be 12 positive cases found (Mukaromah, 2020).

A health expert from the faculty of public health of Universitas Indonesia stated that the hospital capacity is still adequate nationwide (Manafe, 2020). According to the data from the Ministry of Health (26 July 2020), there were 755 referral hospitals for COVID-19 treatment in the country. Only 20% of COVID-19 cases were in emergency condition and required in-hospital treatment. The remaining 80% should undergo self-isolation either at home or in community facilities. It means that if the average number of positive cases was 1000, only 200 patients required hospital treatment, while the remaining

800 were in self-isolation (Manafe, 2020).

In the early pandemic, when the number of coronavirus cases started to rise and the availability of Personal Protective Equipment (PPE) in some health facilities was limited, a number of doctors and nurses treating COVID-19 patients passed away. The number of infected medical workers continued to increase in the middle of the pandemic. Although the government has committed to distributing the PPE, the association of Indonesian doctors (Ikatan Dokter Indonesia or IDI) reported that there was still a shortage of its supply. Apart from that, issues regarding the quality and manufacture of PPE and the correct way to use it need to be questioned (McCarthy et al., 2020).

For precautions, the access for nurses to the COVID-19 treatment room was already limited to three to four hours, alternating with other nurses. The contagion among these medical staff might have been due to carelessness. Also, they might often just trust that their colleagues were in a healthy, uninfected condition (Anonymous BBC News, 2020).

Although complete PPE has been used, infection among medical workers still occurs. It might be due to fatigue, both physical and psychological, due to the increasing cases. With many of them being infected and forced to leave work, service on COVID-19 treatment has been disrupted since then. These staff members worked in a group. If a member of staff were infected, the entire group should be off, and it would affect the service. There were already 90 workers out of work, but the service for COVID-19 would still be performed since there was a new working group (Lombok Post, 2020). Being infected is one of the known risks of medical workers. According to the director of the regional hospital in NTB province, they have used PPE level II with high standards (Lombok Post, 2020).

COVID-19 is a highly infectious viral disease caused by the SARS-CoV-2 virus. A virus is categorized as a biological hazard for the workplace environment, similar to bacteria and amoebas. In work health and safety, this is a topic related to occupational health and safety or industrial hygiene. A healthy workplace is always a priority for controlling work performance improvement. Besides biological hazards, other hazardous environmental stressors include chemical, physical, and ergonomic threats. All these hazards can affect the health of people working in the environment. Generally, hazardous substances enter the human body through the mouth (ingestion or digestive system), nose (inhalation or respiration system), skin (absorption), and injection (circulatory system).

COVID-19 has an impact not only on healthcare but all other aspects, including economic and social. This outbreak did not originate from industry but from an unhealthy community environment. In a workplace, viruses are spread is carried by humans from outside the workplace. Indifferent than other hazardous substances, it is unseen and can infect through a contaminated medium. A virus can grow in a host, in this case the human body, where the host then becomes the intermediary for the virus to spread. The virus could then weaken the immune system and deliver various symptoms, including cough, flu, and fever. The spread to the environment was through body fluids, specifically droplets released when coughing or sneezing. Surfaces of materials contaminated by these droplets could then infect healthy people. The virus can enter the human body in several ways, including physical contact with infected people or by touching the eyes, nose, or mouth after touching contaminated surfaces.

Based on industrial hygiene, there are four steps of preventive measures toward virus hazard, including anticipation, recognition, evaluation, and control. The first step deals with health protocols set by the government and the WHO to prevent virus infection, such as washing hands, using a mask, physical distancing, and staying at home. The second step relates to the knowledge about virus behavior so that preventive actions can be made. For example, viruses are very dangerous in closed rooms lacking good ventilation and in crowded spaces, and the risk is higher for the elderly and children. Meanwhile, evaluation is about the effectiveness of the preventive actions taken. The last step, control, is about prevention policy with regulations for limiting actions, such as local lockdown, local quarantine, and self-isolation, as well as infection tracking, mapping, and patient data recording.

The coronavirus causing COVID-19 is a microorganism that attacks the respiratory system, causing several effects, from light to severe symptoms, and even death. Considering that this disease spreads massively and globally, it becomes a new threat to all kinds of occupations, both in direct and indirect interaction with the virus. The biggest risk of this virus exposure is experienced by the medical workers, both in hospitals and other health facilities. Several countries, for example, China and Italy, confirmed that 20% of positive cases are from medical workers. In Indonesia, the percentage is about 16%. Hazard of covid-19 exposure on workers can be classified based on type of work (OSHA, 2020), as follows: 1) lower risk (blue): workers working from home or long distance, workers with minimum physical contact with the fellow workers; 2) medium risk (yellow): workers in frequent contact with other people, such is in tourism business, education, and other highly crowded places; 3) high risk (orange): delivery and supporting staffs in hospital facilities, medical transport workers, and morgue workers; 4) very high risk (red): medical workers who regularly take care of infected patients, medical workers working with patients specimens for testing.

Health workers are willing to devote themselves to serving public health and even sacrificing their life and their families in order to tackle the spread of COVID-19. The profession of health workers is a noble profession. This is increasingly manifested in the midst of the Covid-19 pandemic crisis (Hasibuan et.al., 2020). The Central Government and Regional Governments (hospitals) are responsible for the availability of health service facilities and management in order to realize that the degree of health is the highest.

In this study, the infection risk among medical staff working in the hospital's inward department for COVID-19 treatment was investigated, focusing on human errors as the possible cause. According to above mentioned information, a risk analysis is essential to further prevent the infection of COVID-19 among the medical workers, especially in Indonesia. Efforts to protect medical employees from COVID-19 have also been studied by many people, one of which is Ehrlich et al. (2020). He conducted physical and psychological tests on Health Care Worker with the result that the workload of medical employees was increasing due to the large increase in Covid patients. and their co-workers who were infected then made their mental health even worse and they began to feel worried and stressed about themselves and their families and had to isolate themselves away from their families. The long-term effects of stress can result in post-traumatic stress disorder, anxiety, and depression. Thus, it is imperative to employ productive strategies to care for the mental health of our healthcare workers.

In this study, a risk assessment technique will be used to find out to what extent and how human error can occur in a health service job, so that workers can avoid the dangers of being exposed to the COVID-19 virus. To apply this analysis, a HEART method (Human Error Analysis and Reduction Technique) is used. HEART is a method developed from the Human Error Assessment and Reduction technique used in the field of human reliability assessment, for the purpose of evaluating the probability of a human error occurring throughout the completion of a specific task.

From such analyses, measures can then be taken to reduce the likelihood of errors occurring within a system and therefore lead to an improvement in the overall level of safety. Several researchers have used HEART to reduce the risk of existing accidents, such as Hasibuan et al. (2020) and Bowo et al. (2017). The use of the HEART method in high-risk workplaces such as the Nuclear Power Plant has been carried out by Hassan et al. (2020).

2. METHODS

In this study, the method used is a qualitative research type with the method of literature study. The type of data used is secondary data in the form of scientific articles. The articles that have been obtained are then analyzed using content analysis techniques to analyze and understand the text of the article. The articles that describe relevant data with the research are used as a basic reference in determining the probability and likelihood that an event will occur. There are 11 local journal articles that are used as reference material in this study, which contain the information needed as secondary data, besides references from newspapers.

Risk analysis was applied to investigate the risk of coronavirus exposure among medical workers, especially inpatient nurses, considering their important role and duty in the high-risk zone. Although strict safety protocols have been set for anticipation, the threat can still be present due to human error. In this study, the Human Error Analysis and Reduction Technique (HEART) method was carried out on inpatient workers in referral hospitals for COVID-19. The output was Human Error Probabilistic (HEP) values obtained from each potential factor of failure or risk represented through a Fault Tree Analysis (FTA) diagram. This method was proposed by William (1986) and developed by Kirwan (1994). The steps of the HEART method are depicted in Figure 1, and the task hierarchy for COVID-19 treatment in the hospital can be seen in Table 1.

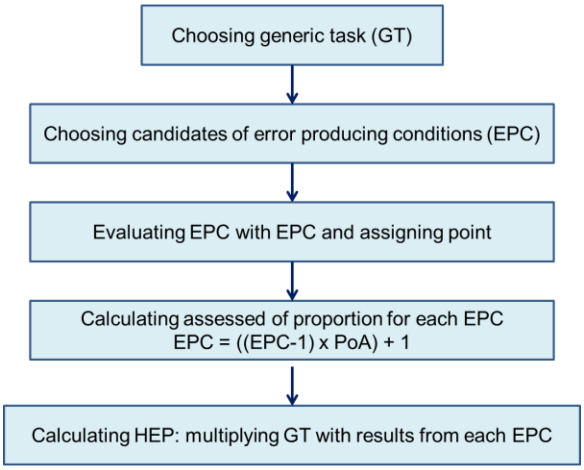

Figure 1. Steps for obtaining HEP

The generic task in Table 1 lists tasks where workers are prone to hazardous exposure. The exposure of inpatient workers to the coronavirus can be caused by many factors; hence, several assumptions were made for simplification. They can be grouped into two classifications based on internal and external factors (Figure 2). Factors related to PPE availability, health protocols, work experience as inpatient workers, and bed availability were assumed as already fulfilled and had no significant effect. The factors investigated were focused on inconsistencies in performing routine tasks and accidental changes. The risk of failure in this case is depicted in the FTA diagram (Figure 2).

The FTA in Figure 2 shows that the risk is attributed to both external and internal factors. Also, like the principle of accidents in general that accidents can occur due to internal and external factors. Internal factors such as behavior, psychological factors, individual innate factors (derivatives), ability factors, and so on. While external factors, such as environmental conditions, facility factors, management factors, other people's factors, and so on. Related to internal factors in this study, human error could be caused by working physiology and psychology, as well as other factors, including individual physical weaknesses such as hypertension, diabetes, heart disease, or allergies.

The external factors were related to poor hospital management, inadequate or improper PPE, poor control and maintenance of the hospital environment and equipment, or less cooperative COVID-19 patients.

The internal factors could trigger human errors, such as carelessness and lack of focus, which further lead to accidents. The external factors were the outside factors affecting a condition, ranging from hazardous to less hazardous and from risky to less risky. For example, poor management would cause scheduling with a busy working shift. Consequently, workers might work too long and gain excessive exposure to high-risk conditions. This could result in a higher risk of infection. Errors can also

Table 1. Generic task: the hierarchical task of inward covid-19 patient treatment in hospital

Before patient treatment	During patient treatment	After treating patient
1. Wearing PPE following the standard. 1.1. Wearing mask 1.2. Wearing cap 1.3. Wearing medical gown 1.4. Wearing protective shoes 1.5. Wearing gloves 1.6. Wearing eye protector 2. Checking COVID-19 symptoms. 2.1. Checking body temperature 2.2. Checking pulses 2.3. Checking blood pressure 2.4. Patient handover approval & administrative checking	1. Checking patient condition 1.1. Checking body temperature 1.2. Checking pulse 1.3. Checking blood pressure 2. Patient cleaning (bathing, clothes changing) 3. Giving meals to patients 4. Collecting and cleaning cutlery used by patients 5. Giving medication to patients	1. Taking off PPE 1.1. Taking off mask 1.2. Taking off cap 1.3. Taking off medical gown 1.4. Taking off protective shoes 1.5. Taking off gloves 1.6. Taking off eye protector 1.7. Taking off face shield 2. Self-cleaning 2.1. Handwashing with soap 2.2. Changing clothes 2.3. Wearing masks 3. Writing report and administrative works, patient handover

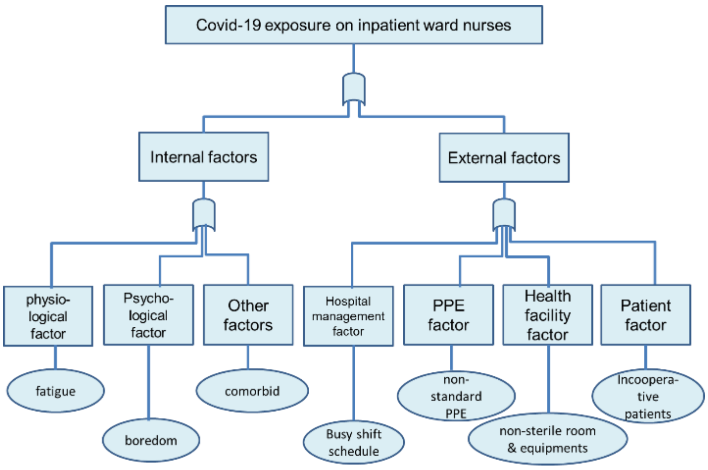

Figure 2. FTA for COVID-19 exposure among the incoming nurses

occur at a higher frequency. Another external factor was related to PPE. Meanwhile, factors related to hospital facilities and equipment were closely related to the lack of environmental control, causing unsterile equipment and facilities. Another external factor was uncooperative patients. Recent studies report that people with isolation and quarantine experience have a significant change in the level of anxiety, anger, confusion, and stress, then becoming uncooperative patients.

Some COVID-19 patients often showed problems (Yulianingtyas et al., 2016) in returning home. This behavior caused disturbance to the medication process and increased infection risk.

3. RESULTS

In terms of determining or completing the EPC and evaluating the EPC events taken from reference sources from several local journal articles are used as judgment in selecting the EPC value in the table.

The HEART technique was developed by Williams (1986) and is based on human performance literature. The human factors analyst must undertake the steps summarized such as in Figure 1.

Step 1, to determine the probability of the Generic task, Table 2 is provided regarding the Generic Unreliability Task, which is a table that classifies the task in terms of its generic human unreliability into one of the 8 generic HEART task types. This table determines the nominal human unreliability probability. Step 2, in terms of determining or completing EPC and evaluating EPC events, reference sources from several local journal articles are taken and used as consideration in selecting the EPC value in Table 3. Table 3 is an Error Producing Condition & Multiplier: Identify relevant error-producing conditions (EPCs) to the scenario/task under analysis, which may negatively influence performance, and obtain the corresponding multiplier. This Maximum predicted nominal amount by which unreliability may increase (Multiplier). Step 3 is to determine the Assessed Proportion of Effect by using Table 4: Estimate the impact of each EPC on the task based on judgment. This

Table 2. Generic unreliability task type (Williams, 1986)

Generic task		*Proposed nominal human unreliability (5th–95th percentile boundaries)*
A	Totally unfamiliar, performed at speed with no real idea of likely consequences	0.55 (0.35–0.97)
B	Shift or restore system to a new or original state on a single attempt without supervision or procedures	0.26 (0.14–0.42)
C	Complex task requiring high level of comprehension and skill	0.16 (0.12–0.28)
D	Fairly simple task performed rapidly or given scant attention	0.09 (0.06–0.13)
E	Routine, highly practised, rapid task involving relatively low level of skill	0.02 (0.007–0.045)
F	Restore or shift a system to original or new state following procedures, with some checking	0.003 (0.0008–0.007)
G	Completely familiar, well-designed, highly practised, routine task occurring several times per hour, performed to highest possible standards by highly motivated, highly trained and experienced person, totally aware of implications of failure, with time to correct potential error, but without the benefit of significant job aids	0.0004 (0.00008–0.009)
H	Respond correctly to system command even when there is an augmented or automated supervisory system providing accurate interpretation of system stage	0.00002 (0.000006–0.00009)
M	Miscellaneous task for which no description can be found. (Nominal 5th to 95th percentile data spreads were chosen on the basis of experience suggesting log-normality)	0.03 (0.008–0.11)

Table 3. Error-producing conditions (EPCs) (Williams, 1986)

	Error-producing condition	*Maximum predicted nominal amount by which unreliability might change going from 'good' conditions to 'bad'*
1.	Unfamiliarity with a situation which is potentially important but which only occurs infrequently or which is novel	× 17
2.	A shortage of time available for error detection and correction	× 11
3.	A low signal-to-noise ratio	× 10
4.	A means of suppressing or overriding information or features which is too easily accessible	× 9
5.	No means of conveying spatial and functional information to operators in a form which they can readily assimilate	× 8
6.	A mismatch between an operator's model of the world and that imagined by the designer	× 8
7.	No obvious means of reversing an unintended action	× 8
8.	A channel capacity overload, particularly one caused by simultaneous presentation of non-redundant information	× 6
9.	A need to unlearn a technique and apply one which requires the application of an opposing philosophy	× 6
10.	The need to transfer specific knowledge from task to task without loss	× 5.5
11.	Ambiguity in the required performance standards	× 5
12.	A mismatch between perceived and real risk	× 4
13.	Poor, ambiguous or ill-matched system feedback	× 4
14.	No clear direct and timely confirmation of an intended action from the portion of the system over which control is to be exerted	× 3
15.	Operator inexperienced (e.g. a newly qualified tradesman, but not an 'expert')	× 3
16.	An impoverished quality of information conveyed by procedures and person–person interaction	× 3
17.	Little or no independent checking or testing of output	× 3
18.	A conflict between immediate and long-term objectives.	× 2.5
19.	No diversity of information input for veracity checks	× 2.5
20.	A mismatch between the educational achievement level of an individual and the requirements of the task	× 2
21.	An incentive to use other more dangerous procedures	× 2
22.	Little opportunity to exercise mind and body outside the immediate confines of the job	× 1.8
23.	Unreliable instrumentation (enough that it is noticed)	× 1.6
24.	A need for absolute judgements which are beyond the capabilities or experience of an operator	× 1.6
25.	Unclear allocation of function and responsibility	× 1.6
26.	No obvious way to keep track of progress during an activity	× 1.4
27.	A danger that finite physical capabilities will be exceeded	× 1.4
28.	Little or no intrinsic meaning in a task	× 1.4
29.	High-level emotional stress	× 1.3
30.	Evidence of ill-health amongst operatives, especially fever	× 1.2
31.	Low workforce morale	× 1.2
32.	Inconsistency of meaning of displays and procedures	× 1.2
33.	A poor or hostile environment (below 75% of health or life-threatening severity)	× 1.15
34.	Prolonged inactivity or highly repetitious cycling of low mental workload tasks	× 1.1 for first half-hour × 1.05 for each hour thereafter
35.	Disruption of normal work-sleep cycles	× 1.1
36.	Task pacing caused by the intervention of others	× 1.06
37.	Additional team members over and above those necessary to perform task normally and satisfactorily	× 1.03 per additional man
38.	Age of personnel performing perceptual tasks	× 1.02

Proportion of the effect value is between 0 and 1.

For assigning HEP value using the HEART method, the generic unreliability task Table 2, error-producing conditions (EPC) Table 3, and assessed proportion effect (APE) Table 4 proposed by William (1986) were used.

The first step is the determination of the generic unreliability task type (Table 2). The next step is the calculation of assessed effect based on the EPC table (Table 3) and the APE table (Table 4), using the following equation:

$$AE = [p_i\,(f_i - 1) + 1] \quad (1)$$

where AE = assessed effect; p_i = assessed proportion of effect; f_i = total HEART effect.

The HEP can then be calculated using the following equation:

$$HEP = [rx \prod_i p(f_i - 1) + 1] \quad (2)$$

where r = nominal human unrealibility; p = assesed proportion; fi = HEART effect.

3.1. Determine HEP for the fatigue factor

Fatigue is a variety of conditions accompanied by decreased efficiency and endurance in work. This is according to the condition's unreliability of A (Table 2). It is a protection mechanism of the human body to avoid

Table 4. Assessed Proportion Effect (Williams, 1986)

Error-producing condition	Maximum predicted nominal amount by which unreliability might change going from 'good' conditions to 'bad'
1. Unfamiliarity with a situation which is potentially important but which only occurs infrequently or which is novel	×17
2. A shortage of time available for error detection and correction	×11
3. A low signal-to-noise ratio	×10
4. A means of suppressing or overriding information or features which is too easily accessible	×9
5. No means of conveying spatial and functional information to operators in a form which they can readily assimilate	×8
6. A mismatch between an operator's model of the world and that imagined by the designer	×8
7. No obvious means of reversing an unintended action	×8
8. A channel capacity overload, particularly one caused by simultaneous presentation of non-redundant information	×6
9. A need to unlearn a technique and apply one which requires the application of an opposing philosophy	×6
10. The need to transfer specific knowledge from task to task without loss	×5.5
11. Ambiguity in the required performance standards	×5
12. A mismatch between perceived and real risk	×4
13. Poor, ambiguous or ill-matched system feedback	×4
14. No clear direct and timely confirmation of an intended action from the portion of the system over which control is to be exerted	×3
15. Operator inexperienced (e.g. a newly qualified tradesman, but not an 'expert')	×3
16. An impoverished quality of information conveyed by procedures and person–person interaction	×3
17. Little or no independent checking or testing of output	×3
18. A conflict between immediate and long-term objectives.	×2.5
19. No diversity of information input for veracity checks	×2.5
20. A mismatch between the educational achievement level of an individual and the requirements of the task	×2
21. An incentive to use other more dangerous procedures	×2
22. Little opportunity to exercise mind and body outside the immediate confines of the job	×1.8
23. Unreliable instrumentation (enough that it is noticed)	×1.6
24. A need for absolute judgements which are beyond the capabilities or experience of an operator	×1.6
25. Unclear allocation of function and responsibility	×1.6
26. No obvious way to keep track of progress during an activity	×1.4
27. A danger that finite physical capabilities will be exceeded	×1.4
28. Little or no intrinsic meaning in a task	×1.4
29. High-level emotional stress	×1.3
30. Evidence of ill-health amongst operatives, especially fever	×1.2
31. Low workforce morale	×1.2
32. Inconsistency of meaning of displays and procedures	×1.2
33. A poor or hostile environment (below 75% of health or life-threatening severity)	×1.15
34. Prolonged inactivity or highly repetitious cycling of low mental workload tasks	×1.1 for first half-hour ×1.05 for each hour thereafter
35. Disruption of normal work-sleep cycles	×1.1
36. Task pacing caused by the intervention of others	×1.06
37. Additional team members over and above those necessary to perform task normally and satisfactorily	×1.03 per additional man
38. Age of personnel performing perceptual tasks	×1.02

Table 5. HEP for fatigue factor

HEP	Fatigue		
Generic Task Type (GTT)	A. Totally unfamiliar, performed at speed with no real idea of likely consequences		
Nominal Human Unreliability (r)	0.55		
Error Producing Conditions	Total HEART effect (fi)	APE (pi)	AE
A danger that finite physical capabilities will be exceeded	1.4	0.5	1.2
Little opportunity to exercise mind and body outside the immediate confines of the job	1.8	0.5	1.4
Human Error Probability (HEP)	0.924		

further damage; thus, recovery could take place (Suma'mur, 1984). Nurmianto (2004) stated that fatigue is a condition where the body runs out of energy due to extensive work. Fatigue often occurs in activities where the tasks are monotonous and repeated. Fatigue is also part of the body's mechanism for protecting action in order to avoid more severe damage, and will be able to recover after resting (Yulianingtyas et al., 2016). According to Suma'mur (1984) and Tarwaka (2016), fatigue can be grouped into two groups: related to process (muscle fatigue and general fatigue) and duration (acute and chronic). During the Covid 19 pandemic, all medical staff, especially inpatient nurses, were asked to work overtime because there was a shortage of medical personnel in hospitals (Pesulima & Hetharie, 2020; Amin et al., 2021; Sembiring et al., 2022; Books et al., 2017; Cheng & Cheng, 2017), and this made them tired quickly. As described in Table 2, the nurses might be unable to quickly recover from exhaustion. It is highly possible that their working condition led to fatigue, physical deterioration, and lack of concentration, which led to human errors. Research shows that staff who are fatigued and sleep impaired are at considerably higher risk of making a medical error (Booker, 2024). The errors producing EPC are 27 dan 22 (Table 3). By selecting Table 4 on no.11, assume the EPC impact on the task is medium, then APE is defined as 0.5. Then, by calculating AE, finally, the HEP is 0.924 (Table 5).

3.2. Determine HEP for the boredom factor

Table 6 represents a situation where the nurses face situations causing boredom. Boredom is a state of mind characterized by a lack of interest, stimulation, or

Table 6. HEP for boredom factor

HEP	Boredom		
Generic Task Type (GTT)	A. Totally unfamiliar, performed at speed with no real idea of likely consequences		
Nominal Human Unreliability (r)	0.55		
Error Producing Conditions	Total HEART effect (fi)	APE (pi)	AE
High-level emotional stress	1.3	0.5	1.15
Low workforce morale	1.2	0.5	1.1
Human Error Probability (HEP)		0.696	

Table 7. HEP for comorbid factor

HEP	Comorbid		
Generic Task Type (GTT)	A. Totally unfamiliar, performed at speed with no real idea of likely consequences		
Nominal Human Unreliability (r)	0.55		
Error Producing Conditions	Total HEART effect (fi)	APE (pi)	AE
A danger that finite physical capabilities will be exceeded	1.4	0.5	1.2
High-level emotional stress	1.3	0.5	1.15
Low workforce morale	1.2	0.5	1.10
Human Error Probability (HEP)		0.874	

challenge. It is a subjective experience that can manifest itself in a variety of ways, including restlessness, apathy, and disinterest. Boredom can be caused by a lack of external stimulation or by internal factors such as a lack of motivation or a sense of purpose. It can arise from routine tasks, repetitive activities, or a lack of novelty, which can result in a sense of time dragging or feeling stuck in a monotonous routine. Boredom can also have negative consequences, such as decreased productivity, poor mental health, and even physical health problems. (Ndetei, 2023). The Boredom factor related to Unreliability of A (Table 2). These circumstances increased emotional load, as well as distressed morale and psychological condition. According to Sembiring et al. (2022) and van Hooft & van Hooft (2018), boredom is an emotional condition that could lead to negative outcomes. It is often related to a lack of challenges and can be influenced by several factors, including monotonous and repetitive activities. Numerous adverse effects are commonly associated with boredom, including reduced motivation and effort, poor performance, depression, and frustration. These conditions could further lead to human error with EPC 29 and 31 (Table 3). By selecting Table 4 is on no.11, assume the EPC impact on the task is medium, then APE is defined as 0.5. Then, by calculating AE, finally, the HEP is 0.696 (Table 6).

3.3. Determine HEP for the comorbid factor

Comorbidity is associated with worse health outcomes, more complex clinical management, and increased health care costs (Valderas, 2009). Pre-existing conditions like hypertension, obesity, cardiovascular impairments, diabetes mellitus, and respiratory disorders have become substantially dangerous factors in cases of COVID-19 infection.

Fitero et al. (2022) wrote about the relationship between various comorbid diseases and COVID-19. Table 7 describes comorbid as a potential factor causing human error. This is also related to the Unreliability of A (Table 2). According to the COVID-19.go.id webpage, the most comorbidities in positive patients are hypertension, diabetes mellitus, heart disease, and chronic obstructive lung disease. Other comorbid with lower percentages were renal disease, other breathing problems, asthma, cancer, immunity disorder, tuberculosis, and liver disease. Based on the data, the proportion of the comorbid from 505 positive cases was as follows: hypertension 53.9%, diabetes mellitus 36%, heart disease 21.6%, chronic obstructive lung disease 18.4%, kidney disease 5.9%, other respiratory problem 5.5%, asthma 2.8%, cancer 1.8%, immunity disorder 1.4%, TBC 1.2%, liver disease 1% (Aida, 2020; Nova & Adisasmito, 2021; Hamami & Noorrizki, 2021; Saptorini et al., 2022). The highest percentage of comorbid causing deaths is hypertension, diabetes mellitus, and heart disease. These diseases might cause a decrease in physical ability and unstable emotional conditions, leading to a higher possibility of virus infection among medical staff. The impacts are on EPC 27, 29, and 31 (Table 3). By selecting Table 4 is on no.12, assume the EPC impact on the task is still medium, then APE is defined as 0.5. Then, by calculating AE, finally, the HEP is 0.874 (Table 7).

3.4. Determine HEP for busy shift schedule

The probability of a busy schedule causing human error is presented in Table 8. Shift workers are at greater risk of occupational hazards such as workplace injury, absenteeism, workplace errors, as well as motor vehicle

Table 8. HEP for busy shift schedule

HEP	Busy shift schedule		
Generic Task Type (GTT)	A. Totally unfamiliar, performed at speed with no real idea of likely consequences		
Nominal Human Unreliability (r)	0.55		
Error Producing Conditions	Total HEART effect (fi)	APE (pi)	AE
A danger that finite physical capabilities will be exceeded	1.4	0.5	1.2
High-level emotional stress	1.3	0.5	1.15
Low workforce morale.	1.2	0.5	1.1
Human Error Probability (HEP)	0.759		

Table 9. HEP for incomplete or non-standard PPE

HEP	Incomplete or non-standard PPE		
Generic Task Type (GTT)	H. Miscellaneous task for which no description can be found		
Nominal Human Unreliability (r)	0.03		
Error Producing Conditions	Total HEART effect (fi)	APE (pi)	AE
Unreliable instrumentation (enough that it is noticed)	1.6	0.3	1.18
Low workforce morale.	1.2	0.3	1.06
Human Error Probability (HEP)	0.0375		

accidents (Booker, 2024). This Generic Task is typically related to the Unreliability of A (Table 2). Overtime is defined as working on specific hours outside the regular working hours, which are set by a company to maximize productivity. Night shift work might give advantages to the workers, such as time for miscellaneous activities in the morning and afternoon, taking care of family, or studying. However, according to research, shift work might cause an increase in specific disorders and have negative effects on workers' health (Books et al., 2017; Cheng & Cheng, 2017). This is because the human biological clock design the body to be active during the day and to rest during the night. A packed shift schedule could deteriorate health conditions and prolong the exposure time to hazards, hence the higher possibility of virus infection due to decreased immunity. The resulting EPCs are 27, 29, and 31 (Table 3). By selecting Table 4 on no.08, assume the EPC impact on the task is still medium, then APE is defined as 0.5. Then, by calculating AE, finally, the HEP is 0.759.

3.5. Determine HEP for incomplete or non-standard PPE

One important consideration involves the appropriate use of effective personal protective equipment (PPE), which may reduce a healthcare provider's likelihood of becoming infected while simultaneously minimizing exposure to other patients that they care for. When healthcare providers are caring for patients with confirmed or suspected COVID-19, they must follow rigid protocols that necessitate the use of appropriate PPE. McCarthy et al. (2020) wrote about PPE that PPE must be thought of in accordance with the design, safe, comfortable, and support work. Apart from paying attention to its manufacture, there also needs to be simulation or training in its correct use. The chance of human error related to PPE is presented in Table 9. This is related to the Unreliability of H. There are several types of PPE for protecting workers during their activities, by isolating the body from potential hazards in the workplace. This is essential for medical workers (Pesulima & Hetharie, 2020; Amin et al., 2021; Saptorini et al., 2022). During this COVID-19 pandemic, the number of PPE was still lacking, although the government has already distributed hundreds of thousands of units (Rezkisari 2020). This was due to PPE only being used once while the number of cases and patients increased. IDI requested that the PPE supply should be maintained since its availability continually decreased due to usage. To fulfill the PPE needs, the government has pushed domestic production. The director of the Leather and footwear textile industry from the Ministry of Industry explained that the additional domestic PPE production was supplied by established companies who diversified their products (Rezkisari, 2020). These producers were expected to be able to fulfill PPE production as many as 16-17 million units per month, including 508,800 packs of surgical gowns per month. The errors producing EPC 23 and 31. By selecting Table 4, No. 17, assume the EPC impact on the task is medium to low, then APE is defined as 0.3. Then, by calculating AE, finally, the HEP is 0.0375 (Table 9).

3.6. Determine HEP for non-sterile equipment and room

Health care facilities that generate medical, chemical, or radiologic waste have a moral and legal obligation to dispose of these wastes in a manner that poses minimal

Table 10. HEP for Non-Sterile Equipment and Room

HEP	Non-sterile equipment and room		
Generic Task Type (GTT)	H. Miscellaneous task for which no description can be found		
Nominal Human Unreliability (r)	0.03		
Error Producing Conditions	Total HEART effect (fi)	APE (pi)	AE
Unreliable instrumentation (enough that it is noticed)	1.6	0.5	1.3
Low workforce morale.	1.2	0.5	1.1
Ambiguity in the required performance standards	5	0.5	2.5
Human Error Probability (HEP)		0.107	

Table 11. HEP for uncooperative patients

HEP	Uncooperative patients		
Generic Task Type (GTT)	H. Miscellaneous task for which no description can be found		
Nominal Human Unreliability (r)	0.03		
Error Producing Conditions	Total HEART effect (fi)	APE (pi)	AE
A danger that finite physical capabilities will be exceeded	1.4	0.3	1.12
No obvious way to keep track of progress during an activity	1.4	0.3	1.12
High-level emotional stress	1.3	0.3	1.15
Low workforce morale.	1.2	0.3	1.1
Human Error Probability (HEP)		0.0476	

potential hazard to the environment or public health. Medical waste (or infectious waste) can produce an infectious disease. When properly used, disinfection and sterilization can ensure the safe use of invasive and noninvasive medical devices. However, current disinfection and sterilization guidelines must be strictly followed (Rutala et al., 2023). The non-sterile environment might also lead to human error (Table 10). This is related to the Unreliability of H (Table 2). Sterilization is an effort to remove all microorganisms by means of physical or chemical treatment. Sterilization requirements on medical service rooms (surgical and isolation rooms) are 0-5 cfu/cm^2 of germ density on the floor and wall, free of pathogenic and microorganisms, and gangrene gas. For supporting rooms (inward room, ICU/ICCU room, newborn room, maternity room, burns treatment, and laundry), the germ density limit is 5-10 cfu/cm^2. Sterilization of equipment for patients' physical treatment is by heating at $\pm$ 121 °C for 30 minutes or 134^{O}C for 13 minutes, and it should follow the instructions for equipment sterilization. Environmentally friendly disinfectants should also be used. Any equipment showing physical change after cleaning, sterilization, or disinfecting should not be used anymore (Endradita, 2017). Less sterile equipment and a workplace might lower motivation because of anxiety, as well as prone to virus infection. All medical device facilities and equipment must be maintained for sterilization, and this is the responsibility of hospital management (Pesulima & Hetharie, 2020; Amin et al., 2021; Yulianingtyas et al., 2016). The errors producing EPC are 23, 31, and 11 (Table 3). By selecting Table 4 on no.11, assume the EPC impact on the task is medium, then APE is defined as 0.5. Then, by calculating AE, finally, the HEP is 0.107.

3.7. Determine HEP for Uncooperative Patients

Patients' cooperation also determines the performance of medical staff (Table 11). This is related to the Unreliability of H (Table 2). Willingness to cooperate is important for cutting the growth of COVID-19 cases. Positive patients or hospitalized people with symptoms of COVID-19 should cooperate with medical staff. This is required to decrease the spread of infection. Otherwise, those uncooperative patients could violate the established health protocol system, even spread the disease to the medical workers (Sembiring et al., 2022; Setyarini & Dwianggimawati, 2021; Nova & Adisasmito, 2021). The errors producing EPC are 27, 26, 29, and 31 (Table 3). By selecting Table 4 on no.15, assume the EPC impact on the task is medium to low, then APE is defined as 0.3. Then, by calculating AE, finally, the HEP is 0.0476.

4. DISCUSSIONS

The summary of HEP value is presented in Table 12. The three factors having the highest HEP are fatigue, boredom, and comorbid. It means that these factors brought the highest risk of virus infection among medical staff, especially those working in the inward room for COVID-19 treatment. Consideration regarding these factors should be taken, especially when assigning medical staff for COVID-19-related duties. The management factor also had a high score and ranked

Table 12. Summary of HEP's value of each factor

No	HEP	HEP value
1	fatigue factor	0.9240
2	boredom factor	0.6960
3	comorbid factor	0.8740
4	busy shift schedule	0.7590
5	incomplete or non-standard PPE	0.0375
6	non-sterile equipment and room	0.1070
7	uncooperative patients	0.0476

fourth. This correlated to the three factors might have ranked higher. Fatigue and boredom might be caused by inappropriate working shifts and scheduling, which was the domain of management. The medical background of medical staff should also be checked before allocating them to cases related to COVID-19, as they might have comorbid. Furthermore, the work design should reassure strict implementation of health protocols, including the use of PPE and sterilization.

To prevent the problem of this fatigue factor, good management action is needed to optimize assignment schedules so that employees do not get tired and have enough time to rest. So, the factor of congenital disease will not have an effect if they are not tired; likewise, the problem of boredom will not occur if the factor of fatigue is avoided.

5. CONCLUSIONS

COVID-19 has an enormous impact on almost all of life aspects. Medical staff have important roles in this pandemic situation and even difficult tasks considering the risk of virus exposure. Considering that a high number of medical workers were infected, albeit with the established healthy protocols, a risk analysis was carried out to assess the potential causes. For this, the HEART method was used for evaluation, emphasizing the potential of human error. Using this tool, it was found that the biggest factors related to the infections among medical workers were fatigue, comorbid, and a busy shift schedule. These results suggest that management should pay attention to these factors in the work design of medical personnel, especially those who treat patients with infectious diseases such as COVID-19. Work design must implement appropriate work shifts, as well as the implementation of strict health protocols.

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