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Integrating Human Reliability Assessment into Health Promotion Strategies to Reduce Patient Mortality and Preventive to Legal Issue

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ABSTRACT

Introduction: Human error is one of the leading factors in medical negligence cases worldwide. These errors may include a range of actions such as misdiagnosis, medication errors, and procedural mistakes. Based on studies and reports from several major hospitals in Indonesia, as well as reports from the Hospital Patient Safety Committee (Komite Keselamatan Pasien Rumah Sakit – KKPRS), incidents related to patient safety in the ICU remain considerably high. Human Reliability Analysis (HRA) is a method used to prevent human error by analysing and assessing the likelihood of human mistakes within a work system and by developing mitigation strategies to minimise such errors. The HRA method involves several techniques and approaches that can be applied in healthcare settings to enhance patient safety and prevent medical negligence.

Methods: This qualitative descriptive-exploratory study was conducted in the ICU of Dr. Wahidin Sudirohusodo General Hospital from January to March 2025. Thirty ICU healthcare workers were recruited through total sampling. Mortality data were reported only for contextual description, not as a direct outcome of HRA, in order to avoid conflating qualitative error mapping with quantitative outcomes.

Results: ICU nurses demonstrated a higher potential for human error compared to anesthesiology residents. The ICU mortality rate was 45%, with chronic kidney disease, malignancies, and cardiovascular disorders identified as the leading causes of death. These figures are presented descriptively and not interpreted as effects of HRA

Conclusion: The SHERPA approach provided insight into potential errors, their impact, and contributing factors, enabling recommendations to strengthen ICU safety systems. These findings underline the urgent need for medical audits and suggest potential implications of SHERPA in reducing medico-legal risks, rather than establishing causal effects on mortality reduction.

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INTRODUCTION

With the advancement of time, healthcare services have also improved. The improvement of the healthcare system through the use of more modern science, techniques and technology has given hope for a longer life, making it easier for doctors to make more accurate diagnoses and perform more accurate medical procedures on patients.

The provision of medical services gives rise to a contractual relationship between a doctor as the provider of medical services and a patient as the recipient of medical services, which in turn gives rise to an agreement. Both doctors and patients have the right to freely enter into agreements that give rise to rights and obligations that must be fulfilled. This agreement is legally referred to as a therapeutic contract or therapeutic transaction (1). A therapeutic transaction is legally defined as a legal relationship between a doctor and a patient in professional medical services based on competence in accordance with specific expertise and skills in the field of medicine (2).

Human error is one of the main factors in medical negligence cases worldwide. These errors can take many forms, ranging from misdiagnosis and medication errors to procedural errors. Cases of medical negligence due to human error are a global problem that affects many healthcare systems around the world. Below is some of the latest data and information on medical negligence caused by human error in various countries (3).

The Institute of Medicine (IOM) in its report "To Err is Human" (1999) estimated that approximately 98,000 deaths occur in US hospitals each year due to preventable medical errors. Johns Hopkins Medicine in a 2016 study stated that medical errors are the third leading cause of death in the US, with an estimated 250,000 deaths per year (4,5).

Indonesia has seen an increase in medical malpractice or negligence cases year after year. The medical profession in Indonesia is highly sought after by the public. High academic standards, professional attitudes and characteristics, and work related to human lives make this profession highly regarded by the public. As a result, the medical profession is currently more vulnerable to criticism and attacks than other professions. The medical profession in Indonesia is currently in the public spotlight due to issues of medical negligence, which are identified with the failure of doctors to treat patients (6,7).

Graph 1. Trend of increase in the number of reported and completed medical negligence cases from 2018 to 2022

Based on research and reports from a number of large hospitals in Indonesia as well as reports from the Hospital Patient Safety Committee (KKPRS), incidents related to patient safety in the ICU are still relatively high, especially those related to nosocomial infections and medication errors. A study conducted in several referral hospitals in Indonesia showed that nosocomial infections in ICUs can reach 30-50% of the total ICU patients. One of the most common infections is ventilator-associated pneumonia (VAP), which is caused by prolonged use of a ventilator. In addition, medication errors are reported to occur in about 20% of ICU patients, including dosage errors and inappropriate drug interactions. Reports from the Ministry of Health and various other studies also mention that catheter-related bloodstream infections and catheter-related urinary tract infections are often problems in ICUs (6–8).

Human Reliability Analysis (HRA) is a method used to prevent human error by analysing and assessing the possibility of human error in work systems, as well as developing mitigation measures to minimise such errors. The HRA method includes several techniques and approaches that can be used in the context of healthcare to improve patient safety and prevent medical negligence (9,10). Analysing the potential for human error is a critical step in preventing medical negligence. Human error potential analysis enables early identification of critical points where human error is likely to occur. By identifying high-risk areas, mitigation measures can be implemented to reduce the likelihood of errors. For example, Bates et al. (1998) found that the use of systems such as Computerised Physician Order Entry (CPOE) can significantly reduce medication errors (11).

Analysing potential human error is a critical step in preventing medical negligence. Analysing potential human error enables early identification of critical points where human error is likely to occur. By identifying high-risk areas, mitigation measures can be implemented to reduce the likelihood of errors. For example, Bates et al. (1998) found that the use of systems such as Computerised Physician Order Entry (CPOE) can significantly reduce medication errors.

METHOD

This study employs a clear and systematic approach to ensure the reliability and validity of the findings. Below are the components of the methodology:

Research Type

The type of research conducted in this study was qualitative research with a descriptive exploratory approach. This research method aims to understand phenomena in depth by describing (descriptive) and exploring (exploratory) various aspects of these phenomena. In this study, researchers collected qualitative data from various sources such as interviews, observations, and documents to gain a holistic understanding of a particular problem or situation.

Population and Sample/Informants

Population refers to the generalization area consisting of objects or subjects that possess specific qualities and characteristics determined by the researcher to be studied and subsequently drawn conclusions from. The population in this study comprises all healthcare personnel working in the ICU at Dr. Wahidin Sudirohusodo General Hospital, including anesthesiology specialists, anesthesiology residents, and ICU nurses. A sample is a subset of the population that represents the characteristics of the population to be studied. According to Arikunto, "A sample is a representative of the entire population that serves as the object of research." To determine the sampling method, the researcher refers to Suharsimi Arikunto's guidelines: "If the population consists of fewer than 100 individuals, it is preferable to include all of them, making the study a population study. If the population is larger, a sample of 10–15% or 20–25% may be taken." Based on these provisions, this study employed total sampling, as the population consisted of fewer than 100 individuals. Thus, the sample comprised all 30 medical personnel working in the ICU with inclusion criteria Personnel officially assigned to the ICU, Having more than one year of experience working in the ICU, Possessing complete official documents, such as a Medical Practice License (STR) or Professional Practice Permit (SIP), Personnel directly involved in patient care in the ICU and Personnel willing to complete the questionnaire provided by the researcher. Than exclusion Personnel currently on leave or inactive, Personnel unable to communicate effectively and Personnel with medical or psychological conditions that could hinder participation in the study.

Research Location

This research will be conducted in the intensive care unit (ICU) of Dr. Wahidin Sudirohusodo Central General Hospital.

Instrumentation or Tools

The instruments used in this study include: The Human Reliability Assessment (HRA) questionnaire was used to identify and measure the potential for human error in medical procedures. Medical records were used to collect data on patient mortality rates in the ICU.

Data Collection Procedures

The data used in this study are: Primary data collected from data on potential human error through direct observation and questionnaires using HRA instruments that have been adapted to working conditions in the ICU. Secondary data collected from mortality figures taken from hospital medical records that recorded deaths in the ICU during 2024. Conducting direct observations in the ICU to collect data on potential human error, as well as recording mortality rates from medical records.

Data Analysis

Data will be analysed using the Human Reliability Assessment (HRA) method to identify human error factors and using Pearson's correlation analysis to examine the relationship between mortality rates and potential human error.

Ethical Approval

This research has been approved by the Health Research Ethics Committee (KEPK), Faculty of Medicine, Hasanuddin University, Makassar (Approval Letter No: 20/UN4.6.4.5.31/PP36/2025). The confidentiality of all participants is strictly maintained throughout the research process.

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RESULTS

Identification of medical personnel tasks in the ICU through Hierarchical Task Analysis (HTA)

HTA shows the tasks that must be performed by operators to produce a product. From this HTA, human errors that may occur when operators perform their work can be predicted. In this study, researchers grouped the tasks of medical personnel in the ICU based on three factors, namely cognitive, physical, and environmental factors.

HTA from Cognitive Factors

Based on the results of interviews and literature studies, the researchers determined several tasks that are at risk of causing human error based on the existence of cognitive risk factors using HTA as follows:

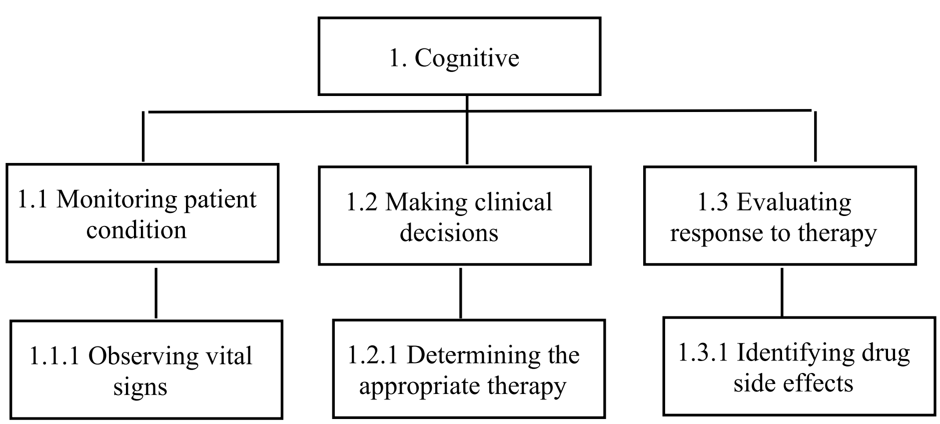

Figure 1. Cognitive HTA in the ICU

HTA of Physical Factors

Medical personnel in the ICU face a high physical workload due to the intensive, risky nature of their work, which requires rapid responses. This physical load includes activities such as lifting patients, standing for long periods, reaching for equipment, and high mobility between care rooms. Hierarchical Task Analysis (HTA) is used to identify the structure of these tasks so that their physical load can be analysed and ergonomic solutions found.

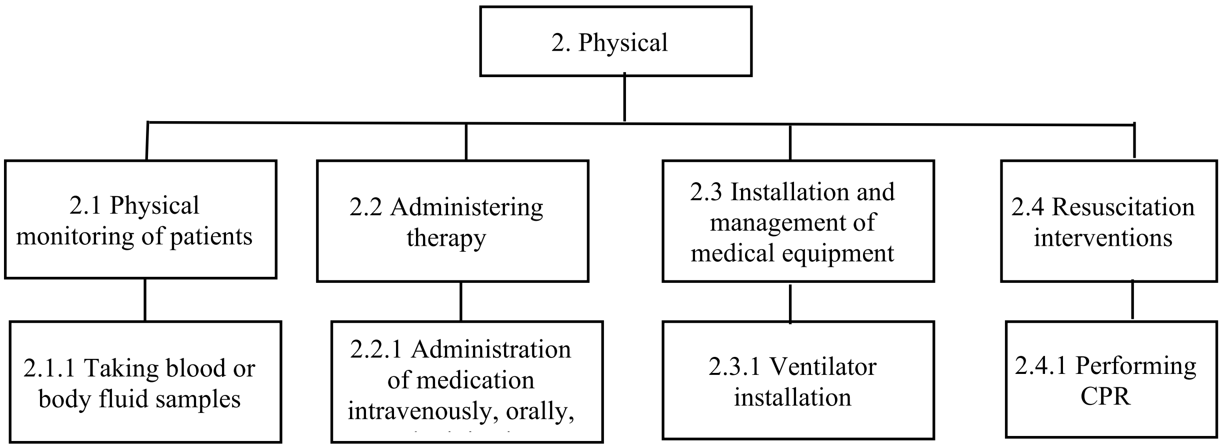

Figure 2. Physical HTA in the ICU

HTA from Environmental Factors

The Intensive Care Unit (ICU) is a high-intensity work environment filled with medical equipment, staff traffic, and critically ill patients who require continuous attention. Environmental factors such as lighting, noise, temperature, space for movement, layout, and room cleanliness greatly affect the performance, safety, and concentration of medical personnel and contribute to human error.

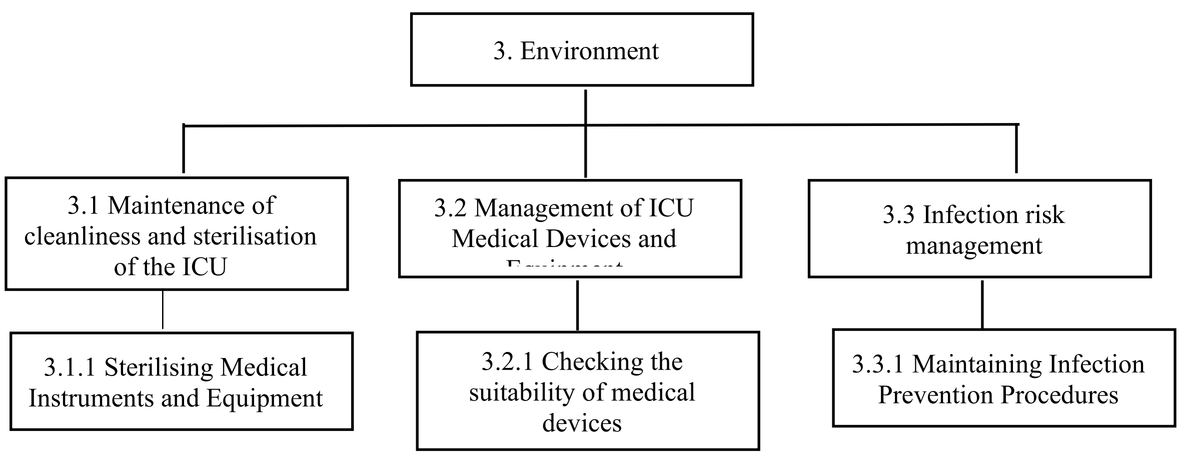

Figure 3. Environmental HTA in the ICU

Predicting Human Error Using the SHERPA Method (Systematic Human Error Reduction and Prediction Approach)

Human Error Identification (HEI)

Human Error Identification (HEI) is a systematic process for recognising, analysing, and classifying potential human errors in the execution of a task or work system, before or after the error occurs. The main objective of HEI is to anticipate the types of errors that may be made by individuals (such as medical personnel, operators, or technicians), so that systems, procedures, and the work environment can be redesigned or adjusted to prevent such errors from occurring.

The following are the results of human error identification from the Hierarchy Task Analysis (HTA) that has been presented previously:

Table 1: Results of Human Error Identification (HEI) Analysis

No. Task	Error Mode	Error Description
1.1.1	A10	Improper storage of tools and documentation
1.2.1	S2	Incorrect identification of treatment options
1.3.1	C2	Incorrect observation of patient symptoms
2.1.1	S2	Incorrect selection of sampling location
2.2.1	S2	Incorrect identification and determination of follow-up actions
2.3.1	A5	Incorrectly monitoring and evaluating patients
2.4.1	A1	Incorrectly performing rapid assessment
3.1.1	A5	Incorrect preparation prior to sterilisation
3.2.1	A5	Incorrect preparation prior to sterilisation
3.3.1	A5	Incorrect use of PPE

Consequence Analysis

Consequence analysis in the SHERPA (Systematic Human Error Reduction and Prediction Approach) method in the ICU is an important process for assessing the potential impact of human error on patient safety, hospital operations, and the medical staff themselves. In the critical and complex ICU environment, where time and precision of action are vital, small errors can lead to major consequences, such as disability, serious complications, or even patient death.

Table 2. Analysis of Error Consequences in the ICU

No. Task	Error Description	Impact of Error
1.1.1	Incorrect storage of equipment and documentation	Minimal
1.2.1	Incorrect identification of treatment options	Minimum
1.3.1	Incorrect observation of patient symptoms	Moderate
2.1.1	Incorrect selection of sampling location	Minimal
2.2.1	Incorrect identification and determination of follow-up actions	Moderate
2.3.1	Incorrectly monitoring and evaluating patients	Moderate
2.4.1	Incorrectly performing a rapid assessment	Serious
3.1.1	Incorrect preparation prior to sterilisation	Minimal
3.2.1	Incorrect preparation prior to sterilisation	Minimum
3.3.1	Incorrect use of PPE	Minimum

Ordinal Probability Analysis

Ordinal Probability Analysis is a process of assessing the likelihood of a human error occurring, using a qualitative or ordinal scale rather than exact numbers. This approach is often used in conjunction with SHERPA or other risk management methods in clinical settings, including in the ICU.

Table 3. Risk Matrix with Ordinal Probability Scale

No. Task	Error Description	Number of medical personnel	Probability Level
1.1.1	Incorrect storage of equipment and documentation		
	MPPDS Anaesthesia	5	Very Low
		12	Low
		1	High
	ICU Nurse	2	Very Low
		9	Low

		2	Medium
		1	High
1.2.1	Incorrect identification of treatment options		
	MPPDS Anaesthesia	2	Very low
		16	Low
	ICU Nurse	3	Very low
		9	Low
		1	Medium
		1	High
1.3.1	Incorrect observation of patient symptoms		
	MPPDS Anaesthesia	3	Very low
		13	Low
		2	Medium
	ICU nurse	4	Very low
		9	Low
		1	Medium
2.1.1	Incorrect choice of extraction site		
	MPPDS Anaesthesia	4	Very low
		13	Low
		1	Medium
	ICU nurse	3	Very Low
		9	Low
		1	Medium
		1	High
2.2.1	Incorrect identification and determination of follow-up actions		
	MPPDS Anaesthesia	7	Very low
		11	Low
	Anaesthesia Nurse	7	Very low
		5	low
		2	High
2.3.1	Incorrect monitoring and evaluation of patients		
	MPPDS Anaesthesia	3	Very low
		12	Low
		3	Medium
	ICU nurse	2	Very low
		8	Low
		2	High
2.4.1	Incorrectly performing a rapid assessment		
	MPPDS Anaesthesia	7	Very low
		10	Low
		1	Medium
	ICU nurse	6	Very low
		6	Low
		2	High
3.1.1	Incorrect preparation prior to sterilisation		
	MPPDS Anaesthesia	8	Very low
		7	Low
		3	Medium
	ICU nurse	7	Very low
		6	Low
		1	Medium
3.2.1	Incorrect preparation prior to sterilisation		
	MPPDS Anaesthesia	5	Very low

		10	Low
		3	Medium
	ICU Nurse	6	Very low
		7	Low
		1	Medium
3.3.1	Incorrect use of PPE		
	MPPDS Anaesthesia	3	Very low
		13	Low
		1	Medium
		1	High
	ICU Nurse	1	Very low
		12	Low
		1	Medium

Strategy Analysis

Strategy analysis in SHERPA bridges the gap between identifying errors and taking concrete action. This is an important step in transforming analysis into systemic improvement, so that errors are not only recognised, but prevented and managed with a practical, evidence-based approach.

Table 4. Improvement Strategy Analysis

No. Task	Error Description	Causal Factors	Improvement Solution
1.1.1	Improper storage of tools and documentation	Excessive task complexity	Reorganisation of layout, new SOPs, clear division of tasks, EMR digitisation system
1.2.1	Incorrect identification of treatment options	Excessive task complexity	Clinical pathway, CDSS, therapy checklist
1.3.1	Incorrect observation of patient symptoms	Excessive task complexity	EWS/NEWS, observation checklist, digital alarm system
2.1.1	Incorrect selection of sampling location	Lack of training or experience	Clinical simulation, visual SOPs, direct supervision, case-based training
2.2.1	Incorrect identification and determination of follow-up actions	Excessive task complexity	Implementation of WHO-Patient Safety Solutions-based "ICU Safety Protocols"
2.3.1	Incorrect monitoring and evaluation of patients	Lack of training or experience	Mandatory Intensive Rotation in Emergency & ICU Units and High-Fidelity Medical Simulation Training
2.4.1	Incorrect rapid assessment	Excessive task complexity	Structured Clinical Approach: Use Rapid Assessment Protocols
3.1.1	Incorrect preparation prior to sterilisation	Excessive task complexity	Implementation of the WHO/AAMI Sterilisation Checklist, Efficient and Structured Workflow, Task Rotation and Work Rest System
3.2.1	Incorrect preparation prior to sterilisation	Excessive task complexity	Implementation of the WHO/AAMI Sterilisation Checklist, Efficient and Structured Workflow, Task Rotation and Work Rest System
3.3.1	Incorrect use of PPE	Excessive task complexity	Risk-based PPE usage checklist, standardisation of task flow and activity priorities, supervision and audit of PPE usage

Mortality Rate in the ICU

This study aims to examine the mortality rate in the Intensive Care Unit (ICU) of Wahidin Sudirohusodo Hospital, based on the medical records of patients who died between January and March 2025, as follows:

Table 5. Summary of Mortality Rates in the ICU

No.	Period	Gender		n (%)	Total
		L	P		
1	January	66	69	34	135
2	February	127	109	59	236
3	March	12	14	7	26
	Total	205	192	100	397

The data in the table above shows that the highest number of deaths in the ICU occurred in February, with approximately 236 deaths, and the lowest in March, with approximately 26 deaths. Of these three periods, more male patients died, approximately 205, compared to female patients, approximately 192.

Table 6. Comparison of Death Rates in the ICU with Total Deaths

No.	Period	Number of Deaths in the ICU	Total Death Rate	n (%)
1	January	135	290	46
2	February	236	300	78
3	March	26	310	8
	Total	397	900	44

Source: Primary Medical Record Data

From the table above, it can be seen that the ICU in February contributed approximately 78% to total deaths in the hospital, while this figure decreased to 8% in March. Based on the number of deaths in the ICU during the period January–March 2025 compared to the total number of deaths, the ICU contributed to 44% of deaths at Dr. Wahidin Sudirohusodo Hospital.

Table 7. Recap of Time of Death

No.	Period	Time of Death (hours)		Number
		<48	>48	
1	January	64	71	135
2	February	80	156	236
3	March	6	20	26
	Total	150	247	397

Source: Primary Medical Record Data

The table above shows that the highest number of deaths with a time of death <48 hours occurred in February, with around 80 people, and the lowest in March, with around 6 people. Meanwhile, for time of death >48 hours, it was also in February with a number of approximately 156 people and the lowest in March, approximately 20 people. When totalled, the time of death of patients in the ICU during the 3 periods was approximately 247 people for deaths >48 hours.

Calculation of Mortality Rate

ICU Mortality Rate

$$= \frac{\text{(Number of patients who died in the ICU)}}{\text{(Total number of patients treated in the ICU)}} \times 100$$

$$= \frac{397 \times 100}{875}$$

$$= 0.45 \times 100$$

$$= 45\%$$

Hospital Mortality Rate

$$= \frac{\text{(Number of Deaths in Hospital)}}{\text{(Number of patients admitted to the hospital)}} \times 100$$

$$= \frac{900}{8578} \times 100$$

$$= 10.4\%$$

In the above calculation, we can see that the ICU Mortality Rate (45%) is higher than the Hospital Mortality Rate (10.4%), indicating that patients treated in the ICU have a higher risk of death.

The following are the 10 most common underlying causes of death in the ICU at Dr. Wahidin Sudirohusodo Hospital: In the above calculation, we can see that the ICU Mortality Rate (45%) is higher than the Hospital Mortality Rate (10.4%), indicating that patients treated in the ICU have a higher risk of death.

The following are the 10 most common underlying causes of death in the ICU at Dr. Wahidin Sudirohusodo Hospital:

Table 8. Underlying Causes of Death in January 2025

No.	Underlying Disease	Number (%)
1	Chronic kidney disease (N18.x)	26
2	Malignancy (Cxx.x / Dxx.x)	24
3	Hypertensive heart disease (I11.x)	11
4	Haemorrhagic stroke (I61.9)	8
5	Coronary artery disease (I25.x)	8
6	Congestive heart failure (I50.x)	8
7	Hepatoma (C22.x)	5
8	Meningioma / Brain tumour (D32.x / C71.x / D16.3)	5
9	Tetralogy of Fallot (Q21.3)	3
10	Ventricular septal defect (Q21.0)	3

Source: Primary medical record data

In January 2025, the leading causes of death were Chronic Kidney Disease (N18.x) and Malignancy (Cxx.x/Dxx.x), each accounting for 24%. The third position was occupied by Hypertensive Heart Disease (I11.x) at 11%, followed by other cardiovascular diseases such as Haemorrhagic Stroke, Coronary Artery Disease, and Congestive Heart Failure. In addition, there were also deaths due to congenital diseases such as Tetralogy of Fallot, Ventricular Septal Defect**,** as well as cases of brain and liver tumours.

Table 9. Underlying Causes of Death in February 2025

No.	Underlying Disease	Number %
1	Malignancy (Cxx.x / Dxx.x)	24
2	Chronic kidney disease (N18.x)	14
3	Hypertensive heart disease (I11.x)	12
4	Pneumonia (J18.9)	12
5	Diabetes mellitus (E11.x)	7
6	Tuberculosis (A15.x / A18.x)	7
7	Congestive heart failure (I50.x)	7
8	Coronary artery disease (I25.x)	7
9	Spinal cord injury / tetraplegia (S14.x)	5
10	Trauma (Sxx.x / Txx.x)	5

Source: Primary medical record data

In February 2025, malignancy remained the leading cause of death at 24%, followed by chronic kidney disease at 20% and hypertensive heart disease at 12%. In addition to chronic diseases, there was an increase in cases of infections such as pneumonia (8%) and tuberculosis (5%), as well as metabolic diseases such as diabetes mellitus (6%). Furthermore, cases of trauma (5%) and spinal cord injury (4%) also began to emerge as significant causes of death, albeit in lower numbers.

Table 10. Underlying causes of death in March 2025

No.	Underlying Disease	Number %
1	Chronic kidney disease (N18.x)	23
2	Malignancy (Cxx.x / Dxx.x)	21
3	Pneumonia (J18.9 / J22)	13
4	Sepsis / Septicaemia (A41.x / A40.x)	10
5	Tuberculosis (A15.x)	8
6	Acute myocardial infarction (I21.x)	8
7	Hypertensive heart disease (I10–I13)	6
8	HIV disease (B20.x)	4
9	Traumatic brain injury (S06.x)	4
10	Encephalopathy / Meningoencephalitis (G04 / G93 / G03)	4

Source: Primary medical record data

In March 2025, the leading cause of death was Chronic Kidney Disease (N18.x) at 23%, followed by Malignancy (Cxx.x / Dxx.x) at 21%. This indicates that chronic kidney disease and cancer remain the primary causes of death in healthcare facilities. In third place was Pneumonia (J18.x / J22) at 13%, indicating the significant role of lower respiratory tract infections in patient mortality.

Other causes of death include Sepsis / Septicemia (A41.x / A40.x) at 10%, Tuberculosis (A15.x) at 8%, as well as Acute Myocardial Infarction (I21.x) and Hypertensive Heart Disease (I10–I13), each contributing 8%. In addition, there were deaths due to HIV (B20.x) at 4%, Traumatic Brain Injury (S06.x) at 4%, and Encephalopathy/Meningoencephalitis (G04.x/G03.x) at 4%.

Based on primary medical record data, the underlying causes of patient deaths in January and March 2025 show a fairly consistent trend, with a predominance of chronic and degenerative diseases. In general, the three tables show that malignancies and chronic kidney disease are the leading causes of death in all three months, reflecting the high burden of chronic disease in the patient population.

Cardiovascular disease remains a major contributor to mortality, while cases of infection and trauma increased in February. These findings emphasise the importance of a preventive and long-term management approach to chronic diseases, as well as the need for vigilance against infectious diseases and trauma that can develop into significant causes of death.

DISCUSSION

Implementation of the SHERPA method of Human Reliability Assessment (HRA) in the ICU

The Human Reliability Analysis (HRA) method is an approach used to evaluate the potential for human error in complex systems, such as in the Intensive Care Unit (ICU), which involves many human, technological, and procedural factors. HRA identifies and measures the likelihood of errors made by individuals or teams, as well as their impact on patient safety.

In the medical world, especially in the ICU, human error is a factor that greatly influences the quality of patient care. Human error in the ICU often occurs due to a stressful environment, high cognitive load, and the complexity of medical tasks. Therefore, it is important to use methods that can analyse and identify the possibility of human error in the medical work system in the ICU. One effective method for analysing human error is the SHERPA (Systematic Human Error Reduction and Prediction Approach) method. This method was developed to analyse and reduce human error in complex systems, such as in the ICU, where there are many interactions between humans and technology.

The SHERPA method helps map each task and subtask of medical personnel, then analyses the types of errors that may occur. In this study, it was found that the most common type of error made by healthcare workers in the ICU was Action Error, where 6 out of 10 task items were of this error mode. Action error is defined as an error directly related to the execution of an action, not to decision-making or planning. In the ICU context, action errors can include mistakes in administering medication, incorrectly setting up an infusion, misusing breathing aids, or other physical actions performed incorrectly. These errors often occur due to unintentional mistakes, negligence, limited perception, attention distractions, or fatigue (12).

It is important to identify these action errors because they are often not caused by malicious intent or ignorance, but by limitations in the work system and stressful working conditions. Therefore, SHERPA may not only record errors but also provide potential insights into their severity, detectability, and suggest realistic recommendations for improvement, such as retraining, protocol refinements, or changes in medical device design.

Several previous studies have identified that action errors occur most frequently in ICUs. Catchpole (2008) in the study Human Factors in Intensive Care Units found that there are various types of human errors in ICUs, including action errors such as incorrect device placement and missteps in resuscitation. Although not directly mentioning SHERPA, this approach is in line with the classification of action errors (13). In line with this, research conducted by Wiegmann (2003) used the HFACS (Human Factors Analysis and Classification System) framework, which is similar to SHERPA in categorising errors, including action errors. In ICUs, procedural and direct action errors account for nearly 60% of all critical incidents (14,15).

SHERPA not only identifies errors but also evaluates the likelihood of errors occurring, the consequences of those errors, and the likelihood of them being detected and prevented. This is particularly important in the ICU, as small errors can have fatal consequences. In this study, researchers found that most MPPDS anaesthetists and nurses in the ICU had a low risk of making errors in all types of tasks. Compared to MPPDS anaesthetists, ICU nurses had a higher number of high-risk tasks. Of all tasks, there were only two MPPDS anaesthetists at high risk, while there were five ICU nurses. ICU nurses are at greater risk of human error than anaesthesia residents due to several systemic, psychosocial, and operational factors directly related to workload, exposure to repetitive actions, and extensive administrative and clinical responsibilities.

There are several reasons why nurses are at greater risk of human error than anaesthesia MPPDS, namely:

ICU nurses are consistently involved in various direct actions to patients, such as administering medication, monitoring vital signs, adjusting ventilators, and performing basic life-saving interventions. These actions are often repetitive, urgent, and multitasking, thereby increasing the risk of action errors, such as incorrect dosages, incorrect equipment, or forgotten procedures. According to Haneman (2010), ICU nurses have a significant workload, and 70% of procedural errors stem from nursing tasks (16).

Nurses often work long shifts (12 hours or more), including night shifts, which causes fatigue (physical and mental exhaustion). This reduces alertness, focus, and precise motor responses. In contrast, anaesthesia residents tend to have more controlled shifts and focus on one patient at a time (e.g., during surgery). According to Rogers (2004), the risk of clinical errors increases significantly after nurses have worked more than 12.5 hours (17).

ICU nurses are responsible for several patients at once (usually 2–3 patients in the nurse: patient ratio in the ICU), while anaesthesia residents tend to treat patients one at a time in more focused situations (e.g. during surgery or interventional procedures). This causes nurses to be more frequently distracted, shift focus, and be at risk of interruption-based errors. According to Flynn (1999), the frequency of interruptions is directly proportional to the number of errors made by nurses in administering medication and other procedures (18,19).

In addition to clinical duties, nurses are often burdened with administrative tasks such as medical record-keeping, medication reporting, and other documentation. A high administrative workload reduces the time available for clinical tasks, thereby increasing the risk of negligence in direct practice. According to Ball (2014), a high documentation workload is associated with an increased incidence of errors in direct care(20).

Anaesthesia residents have generally undergone medical education and specialist training, giving them a more in-depth background in clinical decision-making and risk assessment. Meanwhile, although ICU nurses are trained, in some cases they are given complex tasks without in-depth training for specific technical situations (e.g., troubleshooting heavy equipment or responding quickly to haemodynamic changes). According to Reason (2000), the complexity of tasks without adequate training is one of the root causes of errors in medical work systems (21).

Results of ICU Mortality Analysis

The mortality rate in the Intensive Care Unit (ICU) is one of the main indicators in assessing the quality of medical services and the effectiveness of the critical patient care system in hospitals. In this study, an analysis was conducted on a number of patients treated in the ICU at Wahidin Hospital to determine the mortality rate, the distribution based on demographic and clinical variables, and the possible contribution of human error to patient outcomes. The results showed that the ICU mortality rate during the study period was 45% of ICU admissions (397 deaths out of 875 patients). The previous mention of "83%" was a misinterpretation of the ICU's share of hospital-wide deaths in February and has been corrected for consistency**.** When compared to international standards, ICU mortality in developed countries such as the United States ranges from 10–29% depending on case complexity and ICU type (sepsis, trauma, neurology, surgery, etc.) (22). Thus, the 45% mortality rate in this study should be interpreted descriptively and indicates the urgent need for a comprehensive service quality audit in the ICU. The high ICU mortality may be explained by several interacting factors. First, many patients were admitted in a clinically late stage, where organ deterioration was already irreversible. This reflects weaknesses in the referral system, where patients remained too long in primary or secondary facilities without adequate equipment or expertise and only reached the ICU in terminal condition. In such cases, the ICU functions less as a site of recovery and more as a terminal care setting, contributing to the high mortality observed.

Secondly, high mortality rates may also reflect the inefficiency of the ICU system itself, in terms of structure, processes and resources. Research by Valentin et al. (2011) confirms that ICUs with low nurse-to-patient ratios, limited ventilators and no 24-hour intensive care specialists have higher mortality rates (23). Systemic failure in implementing standard protocols such as early goal-directed therapy for sepsis, ventilator-associated pneumonia bundles, or patient safety bundles also increases the likelihood of preventable deaths.

Third, it is possible that the high mortality rate is related to the lack of reporting and management of human error. Many hospitals in developing countries do not have transparent and structured clinical error reporting systems, so that potential errors such as delays in administering antibiotics, medication dosing errors, and medical device usage errors go undetected and uncorrected. According to Reason (2000), in a system that is unresponsive to errors, incidents will continue to recur and accumulate, leading to major system failures, including increased mortality (21).

Patient deaths in the ICU can be distinguished based on the time of death after admission, which is usually divided into two categories: death <48 hours (within less than 48 hours after admission to the ICU) and death >48 hours (more than 48 hours after admission to the ICU). These two categories are closely related to the factors that cause death, including human error that can occur in the care of critically ill patients.

This study found that deaths >48 hours were higher than deaths <48 hours. Deaths after 48 hours were more often associated with long-term complications arising from continuous intensive care. Patients who stayed longer in the ICU were more likely to experience complications such as ventilator-associated pneumonia (VAP), deep vein thrombosis (DVT), nosocomial sepsis, or progressive multiple organ failure.

Potential implications of human error on mortality rates in the ICU based on medico-legal aspects

Human error in the Intensive Care Unit (ICU) has a very significant impact on patient mortality rates. In the ICU, patients are generally in critical condition, where quick and accurate clinical decisions are essential. Human error in the treatment of critically ill patients can be fatal, not only affecting the patient's medical outcome but also giving rise to medico-legal implications that can impact medical personnel, hospitals, and the healthcare system as a whole. This discussion will explore how potential human error in the ICU can contribute to mortality rates and its implications from a medico-legal perspective.

In this study, there were several errors made by both the Anaesthesia MPPDS and ICU nurses, which had varying impacts ranging from minimal to serious. Errors in the ICU often lead to serious consequences for patients, which can result in death or complications that can worsen their condition. Medical errors that occur in the ICU not only affect patient clinical outcomes, but can also have significant legal implications for medical personnel, hospitals, and the healthcare system as a whole. The relationship between the impact of errors and legal implications is very close, as medical errors that are not immediately addressed or repeated errors can form the basis for legal claims such as medical malpractice or medical negligence.

Medical errors that occur in the ICU can lead to lawsuits, especially if the errors cause harm or death to patients. Malpractice is a common problem in ICUs due to human error, whether caused by excessive task complexity, lack of training, or high stress and work pressure. If it is found that the error occurred due to negligence or lack of attention to established medical procedures, the hospital and medical personnel may be subject to legal action.

Legal claims in malpractice cases may include financial compensation for the patient's family, as well as criminal liability for medical personnel who are found guilty. Research by Myers (2021) shows that medical errors that cause death in the ICU often result in lawsuits against hospitals, which not only harm the hospital in the form of financial losses but can also damage the reputation and professional integrity of the medical personnel involved (24).

The SHERPA (Systematic Human Error Reduction and Prediction Approach) method is one approach used to analyse human error in complex systems, such as hospitals or ICUs. This method was first introduced by Stanton et al. (1997) and is very useful in analysing, identifying, and reducing the risk of errors in environments involving many technical, operational, and human factors, such as in cases of medical negligence (25).

In the context of medical negligence cases, the SHERPA method can help identify the source of human error, assess contributing factors, and propose solutions to reduce or eliminate potential errors that could result in medical negligence or errors in treatment procedures. The application of SHERPA in hospitals as a form of legal prevention has many benefits in reducing medical errors and minimising the potential for malpractice lawsuits. By identifying tasks that are prone to errors, assessing the potential for human error, and implementing appropriate solutions, hospitals can improve medical procedures, enhance patient safety, and minimise the legal risks that may arise from medical negligence. SHERPA is not only a tool for improving the quality of medical care, but also a strategy that can help hospitals meet their legal obligations and maintain their reputation.

CONCLUSION

Human Reliability Analysis (HRA) is a method used to analyse the potential for human error in complex systems, such as in the Intensive Care Unit (ICU). HRA aims to understand and reduce human errors that can impact patient safety. In the context of the ICU, HRA analysis can help identify factors that can cause errors in medical procedures, communication errors, or technical errors that could potentially lead to death or other complications. In this study, the use of the SHERPA method as one of the HRA methods can provide an overview of potential errors, their impact and causes, so that hospitals can make improvements to the quality of service, particularly in the ICU and generally in all systems in the hospital.

The mortality rate in the ICU at Dr. Wahidin Sudirohusodo Hospital is very high, requiring a medical audit of all aspects of service in the ICU. Several factors may cause the high mortality rate in the ICU. First, most patients admitted to the ICU are already in a clinically late stage, where organ deterioration is irreversible. Second, the high mortality rate may also reflect the inefficiency of the ICU system itself, in terms of structure, processes, and resources. Third, it is possible that the high mortality rate is related to the lack of reporting and management of human error.

In the context of medical negligence cases, the SHERPA method can help identify sources of human error, assess contributing factors, and propose solutions to reduce or eliminate potential errors that could result in medical negligence or errors in treatment procedures. The application of SHERPA in hospitals as a form of legal prevention has many benefits in reducing medical errors and reducing the potential for malpractice lawsuits.

AUTHOR’S CONTRIBUTION STATEMENT

SZGA, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; SZGA ,SAL, JD, AMM, BJN,AAZ,GSL, led the data collection, advised on the data analysis and interpretation and reviewed the manuscript; SZGA ,SAL, JD, AMM, BJN,AAZ,GSL reviewed the manuscript; SZGA, advised on the data analysis and interpretation and reviewed the manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

I affirm that the integrity, originality, and authenticity of this manuscript are entirely the result of human scholarly effort. I take full responsibility for the accuracy, validity, and ethical compliance of the work submitted.

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