Effect of Implementing Sepsis Care Bundle on Clinical Outcomes of Critically Ill Patients

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Abstract

Background: Sepsis is a severe healthcare problem that affects millions of people worldwide every year, and it requires prompt management to reduce mortality. So, early detection and appropriate sepsis management during the first few hours improve outcomes. **Aim**: To evaluate the effect of implementing sepsis care bundle on clinical outcomes of critically ill patients. **Subjects and Method**: **Study design**: A quasi-experimental research design was utilized in this study. **Setting**: This study was conducted at the Anesthesia Intensive Care Unit (ICU) in Tanta Main University Hospitals and the surgical ICU in an International Educational Hospital affiliated to Tanta University Hospitals. **Subjects**: A purposive sample of 80 patients met the criteria for systemic inflammatory response syndrome was selected. **Tools**: **Tool (I)**: Critically Ill Patient Assessment Sheet. **Tool II:** Critically Ill Patient's Clinical Outcomes Assessment. **Results**: the study indicated statistically significant improvements in physiological parameters and decreased the occurrence of septic shock, severe sepsis, and multiple organ failure syndrome with **P<0**.05. **Conclusion**: Implementing the sepsis care bundle for all critically ill sepsis cases can enhance their clinical outcomes and reduce complications, particularly multiple organ failure syndrome. **Recommendations**: The study should be replicated using large probability samples in different settings to generalize the results.

Keywords: Clinical outcomes, Critically ill patient, Sepsis care bundle.

Introduction

Sepsis represents a significant global healthcare challenge, with over 30 million people affected annually, leading to approximately 5.3 million deaths each year. In the intensive care unit (ICU), sepsis is a major concern, affecting around 30% of critically ill patients. However, with timely identification and appropriate treatment, sepsis-related mortality can be reduced by as much as 80%. This highlights the importance of early recognition and effective management of sepsis to improve patient outcomes and reduce the associated burden on healthcare systems worldwide. **(Rudd et al., 2020)**.

Sepsis is a severe microbial infection characterized by symptoms such as tachycardia, fever or hypothermia, tachypnea, and abnormal blood leukocyte counts. It is now understood as an abnormal immune response and dysregulated systemic inflammation triggered by microbial invasion, which leads to organ dysfunction. When sepsis is accompanied by hypotension and hyperlactatemia, and requires vasopressor therapy, it is classified as septic shock. Septic shock is associated with high mortality rates, ranging from 30% to 50% in hospitalized patients, underscoring the critical need for early recognition and management. (**Fleischmann, Mellhammar & Rose., 2020)**.

Sepsis is commonly triggered by fungal, bacterial, or viral infections, with pneumonia, abdominal, and renal infections being the most frequent causes of sepsis progression. It is characterized by a complex inflammatory response that disrupts tissue integrity and causes hemodynamic disturbances, leading to impaired perfusion of vital organs. As sepsis advances, it can progress to septic shock and multi-organ failure due to worsening circulatory insufficiency. This stage is marked by hypovolemia, increased metabolic demands, cardiac depression, and vasoregulatory abnormalities that impair tissue perfusion, contributing to severe organ dysfunction. **(Bullock & Benham, 2023)**.

According to the American Hospital Association, septic shock is the top cause of hospitalization and death among critically ill cases. In the United States, septic shock is the leading death cause, with mortality rates continuously exceeding 25% for severe sepsis and up to 70% for septic shock. Additionally, the death rate for sepsis patients is less than 50% with malfunction of up to four organs, more than 50% with five to seven organs, and reaches 100% with failure of seven or more organs. These statistics encouraged the World Health Organization to classify sepsis as a global health priority **(Guarino et al., 2023**).

Sepsis is a condition that is time-sensitive. Therefore, the early identification and response by health team members and critical care nurses can promote reducing sepsis morbidity, rapid treatment progression, fatality rates, patient deterioration, and ICU length of stay. These outcomes are dependent on

early recognition and ongoing sepsis treatment. Consequently, a sepsis care bundle is introduced to enhance patient outcomes **(Harley et al., 2021)**. Care bundles are a minimal evidence-based therapy collection that, when implemented in conjunction, yield significantly superior results compared to their individual implementations. These therapies are tailored to a specific patient segment or population and care setting (**Gilhooly et al., 2024**).

The utilization of innovative nursing care protocols, such as sepsis care bundles, is one of the most critical nursing interventions. These protocols categorize resuscitation care, including the collection of specific tests (cultures, lactate), oxygen supply, blood glucose monitoring, and vasopressors in addition to intravenous fluids **(Teles et al., 2020)**. Therefore, the implementation of sepsis guideline bundles with greater fidelity has led to superior outcomes, such as reduced ICU admissions, shortened hospital stays, and a reduction in mortality (**Chua et al., 2023**).

Significance of the study

Sepsis is a life-threatening organ failure induced by an abnormal host response to infection, and it is leading to mortality and morbidity worldwide. It is a huge concern for global healthcare systems since it consumes a considerable amount of healthcare resources. In septic shock, tissue perfusion is severely decreased; many rapid organs failures involving the kidneys, lungs, and liver can occur **(Paoli et al., 2024)**.

Epidemiological data on sepsis in critically ill patients in developed countries has been collected in numerous studies, which suggest that the prevalence is on the rise and that the mortality rate is diminishing. Nevertheless, there is a scarcity of information regarding sepsis in Egypt's intensive care facilities (**Fleis, 2023)**. In 2021, the average patient's number with sepsis and septic shock in Tanta University Hospital's Anesthesia ICU is about 60 patients in the general ICU and about 50 in the surgical ICU in the International Educational Hospital affiliated with Tanta University Hospitals (**Tanta University hospital intensive care unit statistical records, 2019)**.

According to the researcher's and ICU staff's experience, the number of patients with septic shock and sepsis increases each year. This alarming increase in incidence can be linked to a variety of variables, including the advanced average age of patients, the increased number of invasive procedures, the widespread usage of chemotherapy, immunosuppressive medications and antibiotic resistance. In spite of significant advances in therapeutic management, the appropriateness and speed of a sepsis care bundle protocol implemented early are expected to improve patient outcomes and reduce complications, particularly multiple organ dysfunction syndrome **(Khan & Divatia, 2020)**. Hence, the aim of the present study is to evaluate the effect of implementing sepsis care bundle on clinical outcomes of critically ill patients.

Aim of the study

It is to evaluate the effect of implementing sepsis care bundle on clinical outcomes of critically ill patients.

Research hypothesis:

Critically ill patients who will be exposed to the sepsis care bundle are expected to have an improvement in their clinical outcomes than the control group.

Operational definition:

Clinical outcomes: encompass maintaining a mean arterial pressure (MAP) of ≥ 65 mmHg, central venous pressure (CVP) between 8-12 mmHg, and central venous oxygen saturation (ScvO2) of ≥ 70%. Additional goals include achieving a urine output of ≥ 0.5 ml/kg/h, ensuring peripheral warmth, reducing skin mottling, and minimizing the incidence of septic shock, severe sepsis, and multiple organ failure syndrome.

Subjects and method

Research design:

A quasi-experimental research design was performed.

Setting:

This study was performed at the Anesthesia ICU in Tanta Main University Hospitals and the surgical ICU in an International Educational Hospital affiliated to Tanta University Hospitals.

Subjects:

A purposive sample of 80 critically ill patients meeting the criteria for systemic inflammatory response syndrome from the previously mentioned setting. The sample size was selected using the Epi Info 7 Statistical Program, and the total number of patients admitted annually according to Tanta University Hospital's statistical health data in 2021 was 110, with the sample size determined as follows:

- Approximately 150 patients are seen annually.
- Confidence level is 99.9%.
- Expected frequency: 50%.
- Accepted error=5%.
- Confidence coefficient=95%.

The subjects were categorized into two groups; each group involved 40 patients. **Control group** received routine ICU care which included constant monitoring of the patient and administration of antibiotics as indicated, whereas the **Study group** received a sepsis care bundle. The subjects of this study were selected based on the following criteria: Patients range in age from 21 to 60 years, both sexes. Patients who meet the criteria for systemic inflammatory response syndrome: **Chakraborty and Burns, (2024)** described SIRS as meeting any two of the following criteria: pulse rate >90 beats/min, body temperature <36ºC or>38ºC, respiratory rate >20 breaths/min or PaCO2 <32mmHg, and white blood cell count > 12,000/µL or <4000/µL.

Exclusion criteria include severe hepatic and renal dysfunction, autoimmune illnesses, co-morbid conditions (diabetes mellitus, pregnancy, or breastfeeding), terminal illness, coagulopathy history, and septic patients.

- These exclusion criteria are because the onset and severity of sepsis-induced organ failure depend on all the previously stated conditions **(Caraballo, & Jaimes, 2019)**.

Tools:

Two tools were used in this study:

Tool (I): Critically Ill Patient Assessment Sheet

This tool was developed by researchers to collect the patient's data. It involved three parts:

Part (1): Patient's Demographic characteristics: for example, code, age and gender**. Part (2): patient's clinical data:** this section was developed by the researcher following an extensive literature review. It includes data on current diagnostic findings, smoking history, past medical history, types of medications, and the presence of invasive devices (such as wound drains, urinary catheters, central venous pressure (CVP) lines, and artificial ventilation devices, including mechanical ventilation, oxygen masks, or tracheostomies). **(Mellhammar et al., 2023)**.

Part (3): Laboratory investigations: involved a complete blood count, serum lactate level and arterial blood gases. Data were compared to normal values **(Yealy et al., 2021)**.

Tool (II): Clinical Outcomes Assessment Tool:

It consisted of three parts:

Part 1: Physiological parameters assessment sheet:

This part was developed by researchers with the critical care physicians and nurses assistance in the ICU for early detection and sepsis management using the most recent sepsis care bundle to detect the sepsis care bundle application on the outcome of a sepsis critically ill patient. It contained CVP 8-12 mmHg, ScvO2 ≥ 70%, MAP > 65 mmHg, urine volume ≥ 0.5 ml/kg/h, and patient's peripheral warm. Skin mottling improved. **(Rhodes et al., 2021; Kleinpell et al., 2019 ; Mikkelsen et al., 2022)**.

Scoring system: Each item was scored as achieved (1) or not achieved (0).

Part 2: Complications of sepsis for critically ill patients: This part was developed by the researchers after an extensive review of literature **(Singer, Deutschman & Seymour, 2016)**. It included:

a- **Severe Sepsis Criteria Assessment**: It is a more sensitive screening test for the early diagnosis of septic patients. It includes sepsis with one or more of the following (signs of organ dysfunction, hypotension, or hypo-perfusion) with systolic blood pressure (SBP) <90, lactic acidosis, or SBP decline ≥ 40 mm Hg of normal.

b- **Septic Shock Criteria Assessment**: it included severe sepsis with hypotension, despite sufficient fluid resuscitation.

c- **Multiple Organ Dysfunction Syndrome Criteria Assessment:** it included evidence of at least two failing organs**.**

Scoring system: Each item was checked as presence yes (1) or no presence (0).

Part 3: The Sequential Organ Failure Assessment Score (SOFA score): It was developed by **Vincent et al., 1996**. It was previously known as the Sepsis-Related Organ Failure Assessment Score. Utilized to monitor a patient's condition through

their stay in an ICU to evaluate the organ function extent or failure rate. The score is composed of six separate scores, one for the hepatic, coagulation, renal, respiratory, cardiovascular, and neurological systems. Each organ function is assigned a score ranging from 0 (normal) to 4 (highest dysfunction), for a maximum total score of 24.

Scoring system:

The total SOFA scoring system was calculated and categorized as the following:

Mild SOFA :< 8, Moderate SOFA: 8-15, Severe SOFA: ≥16.

Method:

Administrative process: Official permission to perform the study was obtained from the directors of Emergency Tanta University Hospital and International Educational Hospital via official letters from the Faculty of Nursing explaining the study aim, and data were collected over a 12-month period, beginning in January 2023 and ending in December 2023.

Ethical consideration:

- Following an explanation of the study's aim, patients and/or first-class relatives provided written informed permission.
- Participants were assured of the privacy and confidentiality of their data.
- Anonymity and the patient's right to withdraw from the study at any time were respected.
- Scientific research ethical committee approval of the Faculty of Nursing Tanta University was obtained with the code number of 150-12-2022.

Tools development:

- **Tool I** (parts 1, 2 & 3) were developed by the researcher after reviewing the relevant literature**. Tool II:** Part (1) and part (2) were developed by the researcher after reviewing the relevant literature. Tool II Part (3) was developed by **Vincent, 1996**.
- All tools' content validity was evaluated by nine experts in emergency and critical care nursing, intensivists, and medical biostatistics.
- **Reliability:** The alpha Cronbach's test was used to examine the reliability of all of the study's tools, and the results were 0.895 and 0.889 for tools I and II, which indicate highly reliable tools.
- **Pilot study:** It was performed on 10% of the cases prior to the actual study, to test the clarity, applicability and feasibility of the different tools items. The data collected from those cases was excluded from the current study.
- Data were collected over 12 months starting from the beginning of January 2023 to the end of December 2023.

The study was conducted in four phases:

1. Assessment phase, upon admission, patients in both groups were evaluated using two tools to collect relevant data throughout the study period.

- The assessment of each patient's sociodemographic and clinical data was conducted using Tool I (Parts 1 and 2), gathering information from the patient, relatives, hospital staff, and ICU records.

- Laboratory investigations, including complete blood count, serum lactate levels, and arterial blood gas measurements, were performed three times: on the 1st, 4th, and 7th days of admission, as outlined in Tool I (Part 3).
- Physiological parameters and sepsis-related complications were evaluated three times for both the study and control groups using Tool II (Parts 1, 2, and 3): on the the 1st, 4th, and 7th days of admission.

2. Planning phase, implementing a sepsis bundle for patients in the anesthesia and surgical ICU was designed based on data from the literature review and assessment phase.

3. Implementation phase, Control group participants received routine ICU care, while study group patients were managed using a sepsis care bundle. This bundle, carried out over 7 days in the anesthesia and surgical ICU, was planned based on data from the assessment phase and literature review and was designed and implemented by the researcher alongside standard hospital care. It included the following components:

A-Use a Sepsis Resuscitation Bundle: which comprises seven elements: - To be done within 3 hours after identifying sepsis:

1- Determine serum lactate level.
2- Collect blood cultures before administering the initial antibiotic.
3- Administer broad-spectrum antibiotics.
4- For hypotension or lactate levels more than 4 mmol/L, administer 30 mL/kg crystalloid.
   - To be performed within 6 hours of the diagnosis of sepsis.
5- If hypotension does not respond to first fluid resuscitation, provide vasopressors to keep the MAP above 65 mmHg.
   - In case of prolonged arterial hypotension despite volume resuscitation (septic shock) or initial lactate > 4 mmol/L (36 mg/dL):
6- Determine the central venous pressure (CVP).
7- Assess the central venous oxygen saturation (ScvO2) via a central venous catheter (CVC).
   - Remeasure lactate if the initial lactate was increased.

B. Adopt Sepsis Management Measures:

(a) Monitor patients' vital signs as follows. Measure the patient's blood pressure (BP) every 15 minutes, rectal temperature every 120 minutes, CVP, arterial pressure, oxygen saturation, and blood glucose level on a regular basis.

(b) Administration of medication as follows:

- Before undergoing pathogen culture and medication susceptibility testing, patients will be treated with broad-spectrum antibiotics as indicated.
- A concentrated red blood cell infusion when the hemoglobin level is less than 7 g/L.
- Pay close attention to the patient's heart rate and BP when using vasoactive medications.

(c) For patients experiencing breathing difficulty or respiratory depression, consider:

- Providing oxygen therapy.

- Suction the secretions from the patient's nose and mouth to enable proper breathing.
- Mechanical ventilation and intubation may be used if essential.

(d) Safety nursing management.

- Proper safety management for agitated patients.
- For individuals with limb tremors, a restraining belt will be utilized to limit movement.
- Handle all tubes properly to avoid bending, twisting, and dropping out.

(e) Nutrition support measures.

- Nasogastric tubes are used to administer enteral nutrition to cases, with strict control over the infusion amount and speed to prevent gastric retention.
- The bed will be elevated to prevent stomach reflux.
- The nutrition temperature was kept at 38-40°C.

(f) Antimicrobial and symptomatic therapy:

- Administer vasoactive drugs to maintain the patient's BP and administer the required medications for the infected lesion.
- Continuous monitoring of vital signs.
- Closely monitor changes in tissue perfusion, such as decreased urine output, altered mental state, and intake/output.

(h) Nursing prevention for complications.

- Patients' catheters and urine bags will be replaced over time.
- Clean their perineum on a daily basis to prevent urinary tract infections.
- Provide suction care to prevent the development of pneumonia.

Evaluation phase: Evaluation was done for both groups three times: after the 1st day of admission, at 4th and 7th days of admission by utilizing tool I part (3), tool II.

Results

Table (1): Illustrates demographic characteristics of the critically ill patients for both studied groups.

It was found that more than half (55%) of control group and half (50 %) of the study groups had ages ranged from (50-60) years old. **Regarding gender**, it was illustrated that more than half (60%) of the control group and about two thirds (70%) of the patients in the study group were male.

Table (2): Shows clinical data of the critically ill patients for both studied groups.

Regarding the current diagnosis, the findings show that more than one third (40%) of the control group and nearly half (45%) of the study group had renal disorders. In relation to past medical history, it was revealed that more than one third (40%) of the control group and half (50%) of the study group had renal disorders. **Concerning the Patient's drug history,** it was found that about more than one third (40%) of the control group and nearly half (45%) of the study group received antihypertensive drugs. **Regarding Smoking history**, the result showed that more than half (55%) of the control group and about more than one third (40%) of the study group were smokers. **In relation to Presence of an invasive device**, all

patients in the control and the study group had urinary catheters.

Table (3): Shows the mean scores of the laboratory investigation domains of the studied critically ill patients throughout periods of intervention. Regarding complete blood count, there was a statistically significant difference in hemoglobin levels between patients in the study group on the 1st, 4th and 7th day at p =0.000. In addition, there was a statistically significant difference in hematocrit between patients in the study group on the 1st, 4th and 7th day (p = 0.003).

Concerning serum lactate level, significant differences were observed among patients in the study group on the 1st, 4th and 7th day at p = (0.000). Regarding Arterial blood gases, there was a significant difference between patients in the study group regarding PH on the 1st, 4th and 7th day at p < 0.05.

Table (4): Shows percentage distribution of the critically ill studied patients regarding their physiological parameters throughout periods of intervention. Statistically significant differences were found in the 1st, 4th and 7th day among the control and the study group regarding MAP, CVP, ScvO2, and urine volume where p <0.05. Significant differences were found in the 1st, 4th and 7th day among study group regarding the patient's peripheral warm, skin mottling turns better as p = 0.002.

Figure (1): Shows distribution of the critically ill studied patients regarding their sepsis complications assessment throughout periods of intervention. This figure shows that (5%, 55% and 90%) of control groups had severe sepsis compared to (5, 25 and 15%) of study groups in the 1st, 4th and 7th day respectively. In addition, (0%, 25% and 50%) of control group had septic shock compared to (0, 15 and 15%) of the study group in the 1st, 4th and 7th day respectively. Also, (40%) of the control group had multiple organ dysfunction syndrome compared to (10%) of the study group on the 7th day.

Table (5): Shows distribution of the critically ill studied patients regarding their sequential organ failure (SOFA) assessment throughout periods of intervention. Statistically significant differences were observed between the control and study groups on the 1st, 4th, and 7th days regarding the Glasgow Coma Scale, MAP (mmHg), coagulation (platelet count), and renal function (creatinine), with p-values of 0.000, 0.013, 0.014, 0.024, 0.002, 0.001, and 0.031, respectively. Additionally, a statistically significant difference was found within the study group for PaO2/FiO2 on the 1st, 4th, and 7th days, with a p-value of 0.013..

Table (6): Represents distribution of the critically ill studied patients regarding their total SOFA level throughout periods of intervention. In relation to total SOFA, the mean and standard deviation of the control group in the 1st, 4th and7th represent 2.45±0.677, 3.90±2.262, and 6.40±3.440 respectively. Concerning study group, it was 1.05±1.300,

1.25±1.629, and 0.80±1.742 in the 1st, 4th and 7th day respectively. A significant difference in total SOFA levels was found between the control group and the study group in the 1st, 4th and 7th day at p = 0.000.

Table (7): Shows the effect of age of the studied critically ill patients on their physiological parameters at 7th day of intervention.

This table reveals that there is no significant difference between the control and study groups regarding their physiological parameters in relation to their age at 7th day of intervention.

Table (8): Shows the effect of gender of the critically ill studied patients on their physiological parameters at 7th day of intervention.

This table demonstrates no significant difference in the control and the study group regarding physiological parameters in relation to their gender. Also, it was detected that physiological parameters achieved high improvement in the study group than the control group in the 7th day of intervention.

Table (1): Demographic characteristics of the critically ill patients for both studied groups

Characteristics	The critically ill studied patients (n=80)				χ^2 P
	Control group (n=40)		Study group (n=40)		
	No	%	No	%	
Age (in years)					
▪ (30-<40)	6	15.0	4	10.0	3.375 0.334
▪ (40-<50)	12	30.0	16	40.0	
▪ (50-60)	22	55.0	20	50.0	
Gender					
▪ Male	24	60.0	28	70.0	FE 0.482
▪ Female	16	40.0	12	30.0	

FE: Fisher' Exact test

Table (2): Clinical data of the critically ill patients for both studied groups

Clinical data	The studied critically ill patients (n=80)				χ^2 P
	Control group (n=40)		Study group (n=40)		
	No	%	No	%	
Current diagnosis					
Respiratory disorders	12	30.0	12	30.0	
CVS disorders	4	10.0	4	10.0	
Postoperative	4	10.0	0	0.0	4.784
Renal disorders	16	40.0	18	45.0	0.443
GIT disorders & Hepatic disorders	4	10.0	6	15.0	
Past medical history					
None	2	5.0	0	0.0	
Respiratory disorders	4	10.0	8	20.0	
CVS disorders	14	35.0	8	20.0	8.081
Neurological disorders	2	5.0	0	0.0	0.152
Renal disorders	16	40.0	20	50.0	
Hepatic disorders	2	5.0	4	10.0	
Drug history					
Antibiotics	10	25.0	8	20.0	
Anti-hypertensive	16	40.0	18	45.0	0.962
Corticosteroids	10	25.0	8	20.0	0.810
Anti-coagulant	4	10.0	6	15.0	
Smoking history					
Smoker	22	55.0	16	40.0	2.414
Non-smoker	14	35.0	16	40.0	0.299
Ex-smoking	4	10.0	8	20.0	
# Presence of invasive device					
wound drainage	2	5.0	10	25.0	
urinary catheter	40	100.0	40	100.0	2.444
CVP line	10	25.0	10	25.0	0.295
mechanical ventilation	6	15.0	4	10.0	
oxygen mask	20	50.0	20	50.0	

More than one answer was chosen

Table (3): Mean scores of the laboratory investigation domains of the studied critically ill patients throughout periods of intervention

Laboratory Investigation	The studied critically ill patients (n=80) Range Mean ± SD							
	Control group (n=40)			F P	Study group (n=40)			F P
	1st day	4th day	7th day		1st day	4th day	7th day	
Complete blood count								
A. WBC ($\times10^3$) ($/mm^3$)	(6.0-11.5) 10.761±18.638	(5.9-12.5) 10.985±30.041	(7.0-16.1) 11.518±15.492	1.450 0.239	(1.1-14.5) 10.286±3.294	(4.67-15.0) 10.816±2.674	(4.6-15.0) 10.765±2.633	0.411 0.664
B. HG (g/dL)	(10.5-14.0) 10.49±0.942	(10.0-14.0) 11.39±1.080	(10.8-14.0) 12.59±0.786	1.440 0.639	(8-14) 10.00±1.459	(9.4-14) 11.00±1.289	(9.8-15) 12.09±1.635	**20.181 0.000***
C. Platelets ($\times10^3$) ($/mm^3$)	(124-305.8) 330.011±47.360	(98-306.1) 274.970±59.869	(97-306.1) 176.585±58.987	0.030 0.975	(49.9-1400) 333.23±433.461	(100.1-1800) 316.185±432.028	(130-270) 171.624±41.845	2.514 0.085
D. Haematocrit (%)	(33-42) 34.35±1.854	(36-41.6) 35.60±1.290	(35-42) 38.57±1.328	0.326 0.723	(29-39) 34.48±3.350	(33-40) 35.78±2.234	(33-40) 36.57±2.342	**6.192 0.003***
Serum lactate measurement	(0.5-3.1) 2.98±0.368	(0.6-2.7) 1.16±0.568	(0.6-3.0) 1.19±0.697	1.643 0.198	(0.5-6.0) 2.53±2.054	(0.4-5.5) 1.56±1.319	(0.2-3.4) 1.07±0.707	**10.317 0.000***
Arterial blood gases								
A. PH	(7.22-7.40) 7.33±0.056	(7.30-7.38) 7.35±0.023	(7.20-7.45) 7.36±0.057	2.518 0.085	(7.10-7.45) 7.28±0.101	(7.20-7.38) 7.33±0.045	(7.20-7.40) 7.34±0.055	**7.521 0.001***
B. PCO_2 (mmHg)	(28-48) 38.39±5.261	(27-50) 38.50±6.214	(25-50) 38.95±7.100	0.091 0.914	(7.4-49) 41.11±9.195	(7.4-50) 40.57±9.115	(7.4-50) 40.11±8.897	0.122 0.885
C. PO_2 (mmHg)	(70-95) 83.80±8.225	(73-96) 84.15±7.970	(72-96) 85.45±8.155	0.459 0.633	(80-93) 87.05±4.466	(79-96) 91.55±4.443	(79-98) 94.30±5.360	**23.496 0.000***
D. HCO_3 (mEq/L)	(16-29) 22.94±3.515	(16-30) 22.91±4.224	(16-33) 22.65±4.881	0.055 0.946	(19-32) 25.11±3.528	(22-30) 25.52±2.484	(20-33) 25.54±3.098	0.251 0.779

* Statistically significant at level P<0.05

Table (4): Physiological parameters of the critically ill studied patients throughout periods of intervention

Indicators	The critically ill studied patients (n=80)												
	Control group (n=40)						χ^2 P	Study group (n=40)						χ^2 P
	1st day		4th day		7th day			1st day		4th day		7th day		
	No	%	No	%	No	%		No	%	No	%	No	%	
1. MAP:														
Achieved	32	80.0	24	60.0	18	45.0	**10.435**	32	80.0	34	85.0	36	90.0	**12.221**
Not achieved	8	20.0	16	40.0	22	55.0	**0.005***	8	20.0	6	15.0	4	10.0	**0.004***
2. CVP														
Achieved	38	95.0	20	50.0	16	40.0	**29.048**	30	75.0	40	100.0	40	100.0	**21.818**
Not achieved:	2	5.0	20	50.0	24	60.0	**0.000***	10	25.0	0	0.0	0	0.0	**0.000***
3. ScvO2														
Achieved	24	60.0	26	65.0	36	90.0	**10.178**	34	85.0	36	90.0	40	100.0	**6.109**
Not achieved	16	40.0	14	35.0	4	10.0	**0.006***	6	15.0	4	10.0	0	0.0	**0.047***
4. Urine volume														
Achieved	38	95.0	26	65.0	16	40.0	**27.300**	38	95.0	34	85.0	40	100.0	**7.500**
Not achieved	2	5.0	14	35.0	24	60.0	**0.000***	2	5.0	6	15.0	0	0.0	**0.024***
5. The patient's peripheral warm, skin mottling turns better.														
Achieved	34	85.0	30	75.0	30	75.0	1.571	34	85.0	40	100.0	40	100.0	**12.632**
Not achieved	6	15.0	10	25.0	10	25.0	0.456	6	15.0	0	0.0	0	0.0	**0.002***

* Statistically significant at level P<0.05

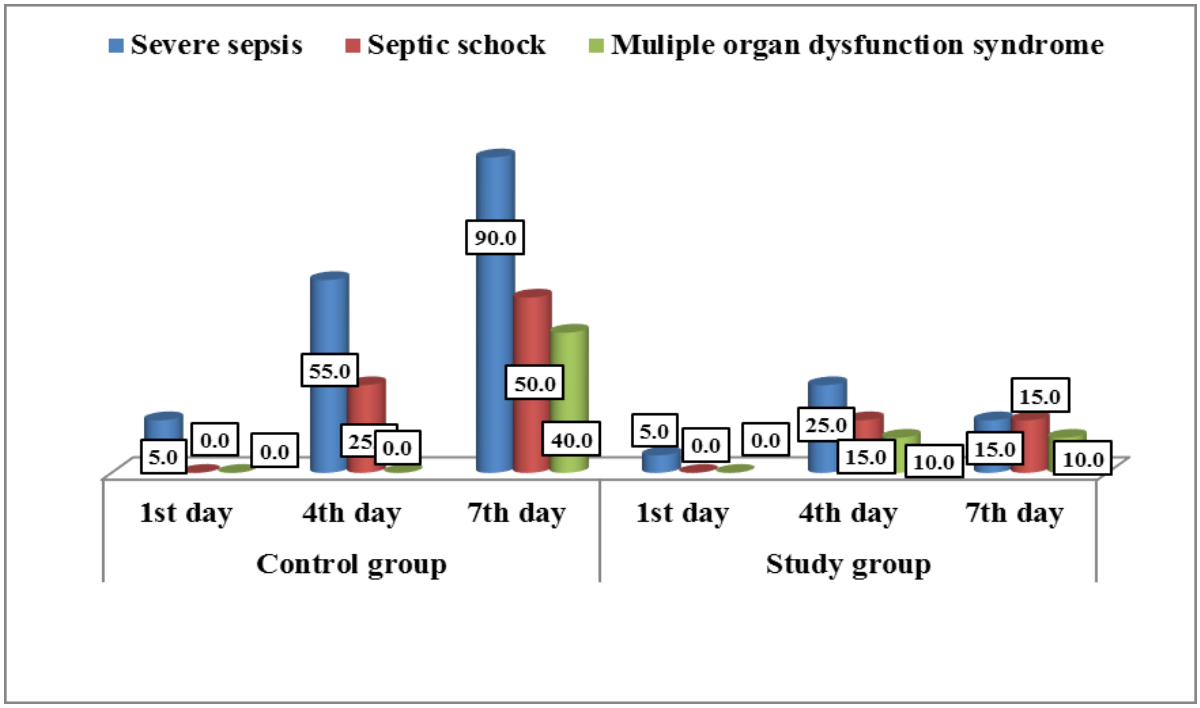

Figure (1): Distribution of the studied critically ill patients regarding their sepsis complications assessment throughout periods of intervention

Table (5): Distribution of critically ill studied patients regarding their sequential organ failure (SOFA) assessment throughout periods of intervention

SOFA Items	The critically ill studied patients (n=80)												
	Control group (n=40)						χ^2 P	Study group (n=40)						χ^2 P
	1st day		4th day		7th day			1st day		4th day		7th day		
	No	%	No	%	No	%		No	%	No	%	No	%	
1. Glasgow coma scale														
▪ 0 (15)	36	90.0	22	55.0	12	30.0		34	85.0	36	90.0	38	95.0	
▪ 1(13-14)	4	10.0	16	40.0	6	15.0	**59.087 0.000***	6	15.0	4	10.0	0	0.0	**18.071 0.013***
▪ 2(10-12)	0	0.0	2	5.0	20	50.0		0	0.0	0	0.0	2	5.0	
▪ 3(6-9)	0	0.0	0	0.0	2	5.0		0	0.0	0	0.0	0	0.0	
2. MAP (mmHg) MAP OR administration of ;vasopressors required														
▪ 0(MAP ≥ 70 mmHg)	30	75	24	60	20	50		28	70.0	32	80.0	34	85.0	
▪ 1(MAP < 70 mmHg)	8	20.0	6	15.0	4	10.0	**16.003 0.014***	10	25.0	6	15.0	6	15.0	**12.073 0.024***
▪ 2(dopamine ≤ 5 µg/kg/min)	2	5.0	10	25.0	14	35.0		2	5.0	2	5.0	0	0.0	
▪ 3(dopamine > 5 µg/kg/min)	0	0.0	0	0.0	2	5.0		0	0.0	0	0.0	0	0.0	
3. PaO2/FiO2														
▪ 0 (≥ 400 (53.3)	22	55.0	22	55.0	22	55.0		26	65.0	34	85.0	36	90.0	
▪ 1(< 400 (53.3)	18	45.0	16	40.0	16	40.0	2.160 0.706	14	35.0	6	15.0	4	10.0	**8.750 0.013***
▪ 2(< 300 (40)	0	0.0	2	5.0	2	5.0		0	0.0	0	0.0	0	0.0	
4. Coagulation (Platelets)														
▪ 0 (≥ 150)	16	40.0	10	25.0	4	10.0		28	70.0	28	70.0	36	90.0	
▪ 1 (< 150)	24	60.0	26	65.0	18	45.0	**35.587 0.000***	12	30.0	8	20.0	0	0.0	**16.591 0.002***
▪ 2 (< 100)	0	0.0	4	10.0	10	25.0		0	0.0	4	10.0	4	10.0	
▪ 3 (< 50)	0	0.0	0	0.0	8	20.0		0	0.0	0	0.0	0	0.0	
5. Liver (Bilirubin)														
▪ 0(< 1.2)	34	85.0	34	85.0	34	85.0		40	100.0	40	100.0	40	100.0	
▪ 1(1.2-1.9)	6	15.0	6	15.0	4	10.0	4.500 0.343	0	0.0	0	0.0	0	0.0	-
▪ 3(6.0–11.9)	0	0.0	0	0.0	2	5.0		0	0.0	0	0.0	0	0.0	
6. Renal function(Creatinine)														
▪ 0(< 1.2)	32	80.0	28	70.0	22	55.0		28	70.0	32	80.0	34	85.0	
▪ 1(1.2-1.9)	8	20.0	4	10.0	2	5.0	**22.354 0.001***	6	15.0	4	10.0	4	10.0	**14.671 0.031***
▪ 2(2.0–3.4)	0	0.0	6	15.0	10	25.0		6	15.0	4	10.0	2	5.0	
▪ 3(3.5–4.9)	0	0.0	2	5.0	6	15.0		0	0.0	0	0.0	0	0.0	

Table (6): Distribution of the critically ill studied patients regarding their total SOFA level throughout periods of intervention

Total SOFA Level	The critically ill studied patients (n=80)													
	Control group (n=40)						χ^2 P	Study group (n=40)						χ^2 P
	1st day		4th day		7th day			1st day		4th day		7th day		
	No	%	No	%	No	%		No	%	No	%	No	%	
▪ Mild	40	100.0	36	90.0	22	55.0	29.833 0.000*	40	100.0	40	100.0	40	100.0	-
▪ Moderate	0	0.0	4	10.0	18	45.0		0	0.0	0	0.0	0	0.0	
Range Mean ± SD	(2-4) 2.45±0.677		(2-9) 3.90±2.262		(2-13) 6.40±3.440		F=27.51 P=0.000*	(0-5) 1.05±1.300		(0-6) 1.25±1.629		(0-7) 0.80±1.742		F=0.827 P=0.440
Control Vs Study t P	36.49 0.000*		36.14 0.000*		84.35 0.000*									

(<8) Mild, (8-15) Moderate, (≥16) Severe

* Statistically significant at level P<0.05

Table (7): Effect of age of the studied critically ill patients on their physiological parameters at 7th day of intervention

Physiological parameters	The studied critically ill patients (n=80) Age (in years)											
	Control group (n=40)						Study group (n=40)					
	(30-<40)		(40-<50)		(50-60)		(30-<40)		(40-<50)		(50-60)	
	No	%	No	%	No	%	No	%	No	%	No	%
1. MAP												
- Achieved	2	5.0	8	20.0	8	20.0	4	10.0	14	35.0	18	45.0
- Not achieved	4	10.0	4	10.0	14	35.0	0	0.0	2	5.0	2	5.0
χ^2 , P	3.295 , 0.192						0.947 , 0.623					
2. CVP												
- Achieved	2	5.0	2	5.0	12	30.0	4	10.0	16	40.0	20	50.0
- Not achieved	4	10.0	10	25.0	10	25.0	0	0.0	0	0.0	0	0.0
χ^2 , P	5.073 , 0.079						-					
3. ScvO2												
- Achieved	6	15.0	10	25.0	20	50.0	4	10.0	16	40.0	20	50.0
- Not achieved	0	0.0	2	5.0	2	5.0	0	0.0	0	0.0	0	0.0
χ^2 , P	1.789 , 0.409						-					
4. Urine volume												
- Achieved	2	5.0	2	5.0	12	30.0	4	10.0	16	40.0	20	50.0

- Not achieved	4	10.0	10	25.0	10	25.0	0	0.0	0	0.0	0	0.0
χ^2 , P	5.073 , 0.079						-					
5. Patient's peripheral warm, skin mottling turns better.	4	10.0	8	20.0	18	45.0	4	10.0	16	40.0	20	50.0
- Achieved	2	5.0	4	10.0	4	10.0	0	0.0	0	0.0	0	0.0
- Not achieved												
χ^2 , P	1.210 , 0.546						-					

Table (8): Effect of gender of the studied critically ill patients on their physiological parameters at 7th day of intervention

Physiological parameters	**The studied critically ill patients (n=80) Gender**							
	Control group (n=40)				**Study group (n=40)**			
	Male		**Female**		**Male**		**Female**	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
1. MAP								
▪ Achieved	10	25.0	8	20.0	24	60.0	12	30.0
▪ Not achieved	14	35.0	8	20.0	4	10.0	0	0.0
FE , P	FE , 0.748				FE , 0.297			
2. CVP								
▪ Achieved	12	30.0	4	10.0	28	70.0	12	30.0
▪ Not achieved	12	30.0	12	30.0	0	0.0	0	0.0
FE , P	FE , 0.188				-			
3. ScvO2								
▪ Achieved	22	55.0	14	35.0	28	70.0	12	30.0
▪ Not achieved	2	5.0	2	5.0	0	0.0	0	0.0
FE , P	FE , 1.00				-			
4. Urine volume								
▪ Achieved	12	30.0	4	10.0	28	70.0	12	30.0
▪ Not achieved	12	30.0	12	30.0	0	0.0	0	0.0
FE , P	FE , 0.188				-			
5. Patient's peripheral warm, skin mottling turns better.	20	50.0	10	25.0	28	70.0	12	30.0
▪ Achieved	4	10.0	6	15.0	0	0.0	0	0.0
▪ Not achieved								
FE , P	FE , 0.159				-			

FE: Fisher' Exact test

Discussion

Sepsis is a major health issue and a leading cause of death among critically ill patients worldwide. Sepsis can lead to organ failure, death, and tissue damage **(Markwart., 2020)**. Sepsis mortality increases by 8% for every hour of treatment delay. Each year, 258,000 people in the United States die from sepsis. Rapid detection and treatment could prevent up to 80% of sepsis deaths **(Sepsis Alliance, 2024)**. So, it requires aggressive treatment and close monitoring for critically ill patients.

Regarding the demographic characteristics of the study subjects, findings indicated that over half of the control group and half of the study group were within the 50-60 age range. This result is attributed to the fact that, as people age, their immune systems may weaken, making them more susceptible to infections that could lead to sepsis. This finding aligns with **Driessen (2022),** who found that over half of the studied group was between 54 and 64 years old. However, it contrasts with the findings of **Sayed et al. (2020),** who reported that the majority of patients studied were aged 18 to less than 38 years.

In terms of sex, more than half of the control group and two-thirds of the study group were male, which may be attributed to the effect of male sex hormones (androgens), as they have been found to reduce cell-mediated immune responses in septic conditions **(Shan et al., 2021)**. This finding aligns with studies by **King et al. (2018) and Lakbar et al. (2022),** who concluded that more than half of their study samples were men.

Regarding the current diagnosis, over one-third of the control group and nearly half of the study group had renal disorders. This may be due to the presence of chronic comorbidities associated with immune dysfunction in sepsis patients, such as chronic renal failure, diabetes mellitus, HIV infection, and alcohol dependence, which increase susceptibility to sepsis **(Jarczak et al., 2021)**. This result is consistent with **Liyanarachi et al. (2024)**, who found that half of the patients had renal diseases, which were significantly associated with a higher risk of sepsis and subsequent mortality. In contrast, the current study's findings differ from those of **Zeng et al. (2021)**, who reported that most ICU patients had respiratory disorders.

Regarding **past medical history,** it was found that more than one-third of the control group and half of the study group had renal disorders. This could be linked to renal disorders, which are recognized as an immunocompromised state characterized by reduced monocyte cytokine production and elevated plasma cytokine levels (**Espi et al., 2020)**. This finding is consistent with **Zarbock et al. (2023),** who reported that more than one-third of critically ill patients in a multicenter observational study on acute kidney injury (AKI) developed sepsis a

median of 5 days after the onset of AKI. However, this result contrasts with the findings of Matthias et al. (2020), who noted that nearly half of their studied group had diabetes mellitus.

Regarding the patient's drug history, the current study found that more than one-third of the control group and nearly half of the study group were receiving antihypertensive medications, which may be attributed to their prior medical history of hypertension. This result aligns with the findings **of Dial et al. (2024),** who determined that more than half of the sepsis patients in their study had a history of hypertension and were on antihypertensive drugs.

Regarding smoking history, the results revealed that more than half of the control group and over one-third of the study group were smokers. This may be attributed to tobacco use, which causes peribronchiolar inflammation and fibrosis, disrupts mucosal permeability, and impairs mucociliary escalator function, thereby increasing susceptibility to infections **(Cha et al., 2023).** This finding is consistent with **Alroumi et al. (2022),** who found that more than half of the patients in their study were former smokers.

Regarding the presence of an invasive device, the current study found that all patients in both groups had urinary catheters. This is crucial, as urinary output and markers for appropriate renal perfusion and cardiac output must be continuously monitored in patients with sepsis. These results align with **Soundaram et al. (2020),** who found that nearly two-thirds of critically ill ICU patients had urinary catheters, leading to over 30 million urine catheter insertions annually.

Concerning laboratory investigations, the study revealed a significant difference among patients in the study group regarding hemoglobin, hematocrit, serum lactate levels, pH, and PaO2 in arterial blood gases on the 1st, 4th, and 7th days. This effect may be attributed to the implementation of the sepsis care bundle. These results were consistent with a study by **Ahmed (2020),** which showed significant differences in laboratory investigations between the study and control groups following the implementation of an evidence-based care bundle, except for total protein and albumin levels.

A significant difference was also observed in the 1^{st}, 4^{th}, and 7^{th} days for all physiological parameters in the study group, including MAP, CVP, ScvO2, urine volume, and improvement in the patient's peripheral warmth and skin mottling. This could be attributed to the sepsis care bundle's impact. The bundle emphasizes a coordinated effort to quickly identify sepsis, conduct essential evaluations, and administer timely therapies, which improve patient outcomes. This is similar to **Liu et al. (2021),** who found that the treatment group had statistically significant improvements compared to the control group after implementing a sepsis bundle clinical nursing pathway for septic shock ($p < 0.05$).

Additionally, the study group showed a lower rate of septic shock, severe sepsis, and multiple organ failure syndrome than the control group, with a significant difference observed on the 1st, 4th, and 7th days. This can be attributed to the effectiveness of the sepsis care bundle in controlling sepsis through regular detection and elimination of risk factors. Critical care nurses played a vital role in identifying patients at risk for sepsis, initiating the care bundle, and reducing the occurrence of septic shock, severe sepsis, and multiple organ failure syndrome **(Rababa et al., 2022).** These findings are in agreement with **Shiramizo et al. (2024),** who reported that implementing a sepsis bundle improved patient outcomes in septic and severe sepsis cases, with the Surviving Sepsis Campaign guidelines significantly reducing complications and mortality. **Miller et al. (2023)** also found that early implementation of bundle elements was associated with decreased rates of severe disease development within the first 24 hours.

The study indicated significant differences between the study and control groups on all SOFA (Sequential Organ Failure Assessment) items except bilirubin across the study periods. Additionally, total mean SOFA scores for the control group increased more significantly, while they decreased in the study group. A significant difference was found in total SOFA scores between the two groups on the 1st, 4th, and 7th days, supporting the hypothesis that adherence to the care bundle is associated with a lower multiple organ failure score. These results align with **Ayoub et al. (2022),** who found that the study group had a significantly lower rate of organ failure than the control group.

However, there were no significant differences between the control and study groups regarding physiological parameters based on age on the 7th day of intervention. This is consistent with the findings of **Ko et al. (2023),** who observed no significant changes in physiological parameters based on age among study patients.

Additionally, there was no significant difference between the two groups in relation to gender. However, it was observed that physiological parameters showed greater improvement in the study group compared to the control group on the 7th day of intervention. This could be attributed to the consistent application of the sepsis care bundle, which may lead to less physiological impairment. These findings were consistent with **Sunden et al. (2020),** who reported no difference in clinical outcomes between genders in sepsis patients.

In conclusion, the findings of this study confirmed that the application of the sepsis care bundle for critically ill patients greatly improved their clinical outcomes.

Conclusion

Adherence to all sepsis care bundle elements brought an improvement in their physiological parameters as well as a significant decrease in the occurrence of septic shock, severe sepsis, and multiple organ failure. By

implementing strategies based on the sepsis care bundle, critical care nurses can improve care for cases with sepsis and contribute to ensuring that critically ill patients with sepsis receive quality nursing care to achieve optimal outcomes.

Recommendations

1. **For clinical practice**, implementing a sepsis care bundle and auditing adherence to each aspect for sepsis patients should be part of standard ICU practices.
2. **Further research** is warranted to support our findings, thereby replicating the study on large probability sampling in different settings.

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