EARLY DETECTION AND NURSING MANAGEMENT OF SEPSIS IN CRITICAL CARE UNITS: ADDRESSING DELAYS IN DIAGNOSIS AND HIGH MORTALITY RATES

Sanjay Kumar[1*], Pushpinder Kaur[2], Audity Bhunia[3]

[1*]Assistant Professor, Haridwar University, Roorkee, Uttarakhand (*Corresponding Author)
[2]Professor, Sukhjinder Novel Institute of Nursing, Dunera, Pathankot, Punjab
[3]Associate Professor, Jagannath Gupta Institute of Nursing Sciences, Kolkata, West Bengal

DOI:10.5281/zenodo.20036727

Abstract
Sepsis remains a major global health challenge and a leading cause of morbidity and mortality, particularly in intensive care units where delayed diagnosis and treatment significantly worsen patient outcomes. It is a life-threatening condition caused by a dysregulated host response to infection, resulting in organ dysfunction and, in severe cases, septic shock. Despite advances in critical care, early recognition of sepsis continues to be a major concern, especially at the nursing level where subtle clinical signs may be overlooked. Delayed identification and intervention contribute to increased mortality, prolonged hospital stays, and higher healthcare costs. Critical care nurses play a vital role in the early detection and management of sepsis through continuous patient monitoring, timely assessment, and implementation of evidence-based protocols. The use of structured screening tools, clinical judgment, and rapid response systems enhances early diagnosis and improves patient outcomes. This article examines the pathophysiology, diagnostic challenges, and nursing management strategies associated with sepsis. It emphasizes that strengthening nursing competencies, improving clinical awareness, and ensuring timely interventions are essential for reducing mortality and enhancing the quality of care in critical care settings.
Keywords: Sepsis, Critical Care Nursing, Early Detection, Nursing Management, Septic Shock, Patient Outcomes, Intensive Care Units, Evidence-Based Practice.

Introduction

Sepsis is a life-threatening condition caused by a dysregulated host response to infection that leads to organ dysfunction and remains a major global health burden affecting nearly 49 million individuals annually with approximately 11 million deaths worldwide (Rudd et al., 2020). Despite advancements in medical science and critical care practices, sepsis continues to be a leading contributor to mortality in intensive care units due to its rapid progression and complex clinical presentation (Evans et al., 2021). The condition is particularly dangerous because it often develops as a complication of common infections and can quickly escalate into septic shock and multiple organ failure if not identified early (Singer et al., 2016). One of the primary reasons for poor patient outcomes is delayed recognition, which prevents timely initiation of life-saving interventions such as antibiotics and fluid resuscitation (Rhodes et al., 2017). This delay significantly increases the risk of morbidity, prolonged hospitalization, and mortality, especially in critically ill patients who require continuous monitoring (Fleischmann et al., 2016). Nurses play a crucial role in early detection because they are often the first healthcare professionals to observe subtle physiological changes such as alterations in vital signs, mental status, and tissue perfusion (Torsvik et al., 2016). Their continuous bedside presence enables them to identify early warning signs that may not be immediately apparent to other members of the healthcare team (Schorr et al., 2020). However, factors such as high workload, lack of standardized screening protocols, and insufficient training can hinder their ability to recognize sepsis promptly

(Almutairi et al., 2019). The burden of sepsis is further compounded by healthcare-associated infections, which are among the most frequent adverse events in hospitals and significantly contribute to sepsis incidence in critical care settings (Allegranzi et al., 2017). In addition, antimicrobial resistance has emerged as a major challenge, reducing the effectiveness of treatment and increasing the likelihood of complications and death (Prestinaci et al., 2018). The magnitude of this problem is evident in global epidemiological trends, which show that sepsis accounts for a substantial proportion of hospital mortality and disproportionately affects populations in low- and middle-income countries (WHO, 2020). These disparities are largely due to limited healthcare resources, delayed access to care, and inadequate infection prevention measures (Rhee et al., 2019). Early recognition and timely intervention are therefore critical in improving patient outcomes and reducing the global burden of sepsis (Kumar et al., 2016). Structured screening tools such as early warning scores and sepsis bundles have been shown to enhance timely identification and improve survival rates when implemented effectively in clinical practice (Levy et al., 2018). Continuous education and training of nursing staff are essential to improve clinical judgment and confidence in recognizing sepsis-related deterioration (Delaney et al., 2020). Furthermore, the integration of electronic health record alerts and clinical decision support systems has enhanced early detection and reduced delays in intervention in many healthcare settings (Henry et al., 2017). Interdisciplinary collaboration among healthcare professionals also plays a vital role in ensuring timely diagnosis and comprehensive management of septic patients (Coopersmith et al., 2018). The magnitude of this problem can be better understood through the global distribution and mortality trends of sepsis, as illustrated in Figure 1 (Global Burden of Sepsis), which highlights the widespread prevalence and emphasizes the urgent need for early identification and management strategies within critical care settings (Reinhart et al., 2017).

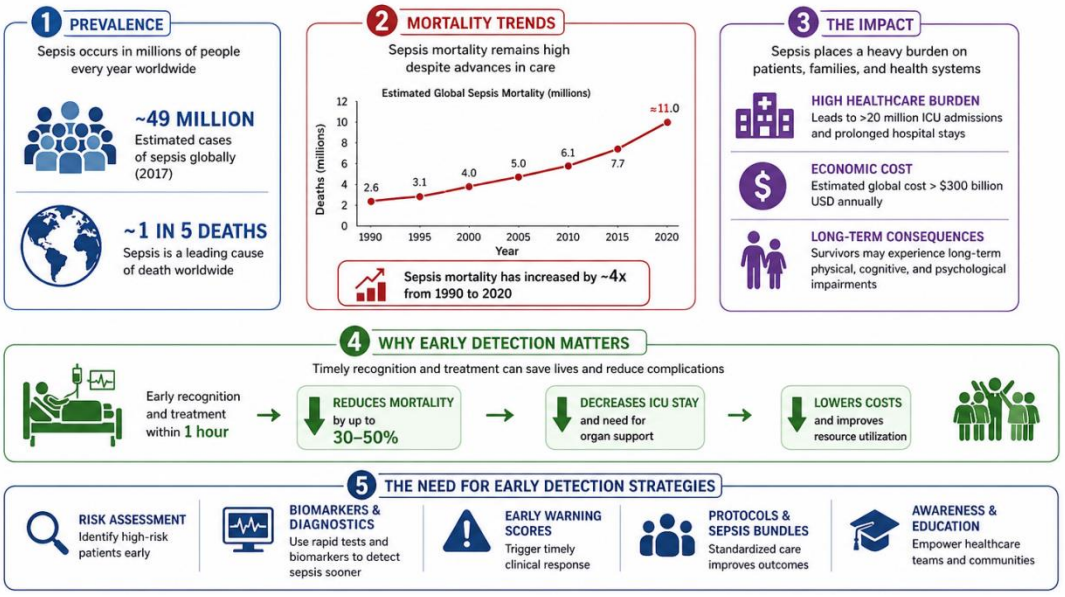

Figure 1: Global Burden of Sepsis illustrating prevalence, mortality trends, and the need for early detection strategies in critical care settings

Pathophysiology of Sepsis

Sepsis develops when the body's immune response to infection becomes dysregulated, resulting in a complex and multifactorial pathophysiological process that disrupts normal homeostasis and leads to organ dysfunction (Singer et al., 2016). The initial stage begins with the invasion of pathogens, during which the immune system recognizes pathogen-associated molecular patterns and damage-associated molecular signals through pattern recognition receptors, triggering an innate immune response (Cecconi et al., 2018). This recognition activates immune cells such as macrophages and neutrophils, which release a variety of inflammatory mediators, including cytokines, chemokines, and reactive oxygen species, initiating a systemic inflammatory response (Chousterman et al., 2017). A key feature of this response is the excessive and uncontrolled release of cytokines, commonly referred to as a cytokine storm, which amplifies inflammation and contributes to widespread tissue injury (Jarczak et al., 2023). These cytokines, including tumor necrosis factor-alpha, interleukins, and interferons,

promote endothelial activation and increase vascular permeability, leading to capillary leakage and impaired tissue perfusion (Lendak et al., 2018). Simultaneously, activation of the coagulation cascade and inhibition of fibrinolysis result in microvascular thrombosis, further compromising blood flow and oxygen delivery to tissues (Mahapatra & Heffner, 2023). This interplay between inflammation and coagulation creates a vicious cycle that exacerbates cellular injury and contributes to the development of multiple organ dysfunction syndrome (Marshall et al., 2025). In addition to the hyperinflammatory phase, sepsis also involves a compensatory anti-inflammatory response characterized by immune suppression, lymphocyte apoptosis, and reduced ability to fight infections, which increases susceptibility to secondary infections (Hotchkiss et al., 2016). Oxidative stress and mitochondrial dysfunction further impair cellular metabolism, leading to cytopathic hypoxia where cells are unable to utilize oxygen effectively despite adequate supply (Cavaillon et al., 2020). These combined mechanisms result in progressive organ dysfunction affecting the lungs, kidneys, liver, and cardiovascular system, ultimately leading to septic shock and death if not treated promptly (Evans et al., 2021). The progression of this cascade is explained in Figure 2 (Pathophysiological Cascade of Sepsis), which demonstrates how an initial localized infection can escalate into systemic inflammation, endothelial damage, and organ failure, highlighting critical stages where timely nursing interventions can interrupt disease progression and improve patient outcomes (Reinhart et al., 2017).

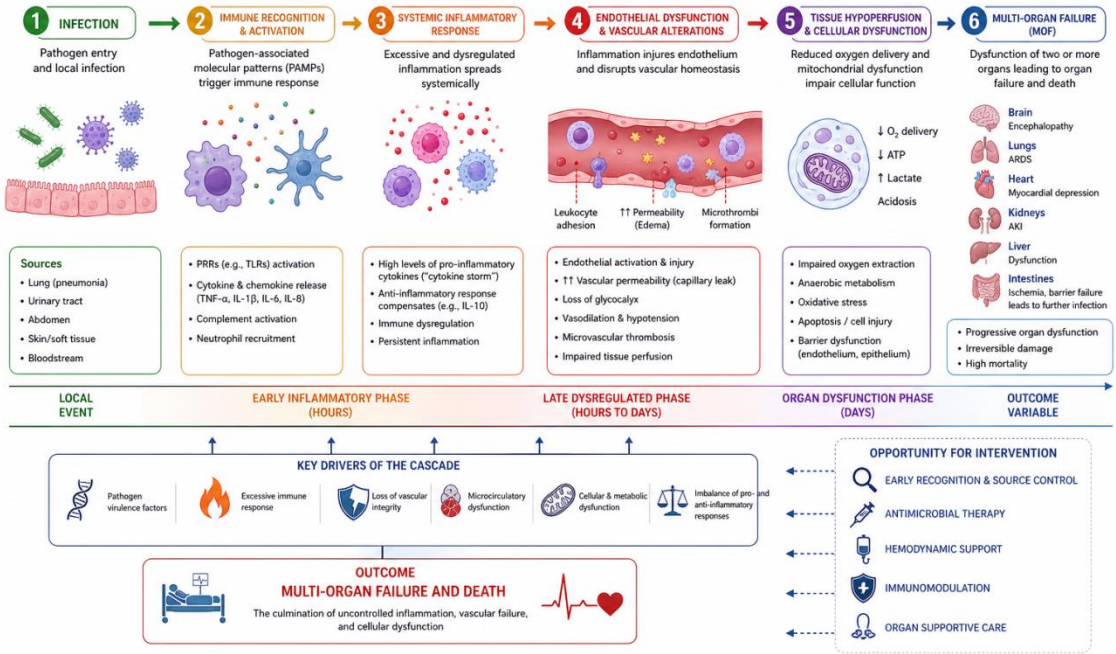

Figure 2: Pathophysiological Cascade of Sepsis showing progression from infection to systemic inflammation, endothelial dysfunction, and multi-organ failure

Importance of Early Detection

Early detection of sepsis is the most critical factor influencing patient survival, as timely recognition enables rapid initiation of life-saving interventions that significantly reduce mortality and complications (Singer et al., 2016). Evidence consistently shows that the concept of the golden hour in sepsis management emphasizes that treatment initiated within the first hour of recognition markedly improves clinical outcomes and survival rates (Evans et al., 2021). Prompt recognition allows early administration of broad-spectrum antibiotics, fluid resuscitation, and supportive therapies that restore tissue perfusion and prevent progression to septic shock (Rhodes et al., 2017). Delays in diagnosis, even by a few hours, have been associated with a measurable increase in mortality, highlighting the time-sensitive nature of sepsis management (Kumar et al., 2016). Early detection is particularly important in critical care environments, where patients are often already vulnerable and at higher risk of rapid deterioration (Rhee et al., 2019). Nurses play a pivotal role in this process due to their continuous bedside presence and their ability to identify subtle clinical changes such as altered mental status, abnormal vital signs, and reduced urine output (Bleakley &

Cole, 2020). Studies have demonstrated that nurse-led identification of sepsis significantly improves patient outcomes and increases survival rates through early escalation of care (Torsvik et al., 2016). The use of structured screening tools and early warning scores has further enhanced the ability of nurses to recognize sepsis at an earlier stage (Levy et al., 2018). Clinical guidelines strongly recommend systematic screening procedures for early identification of sepsis in hospital settings to reduce delays in diagnosis (National Institute for Health and Care Excellence, 2024). These structured approaches include routine monitoring of vital signs, assessment of infection risk, and use of standardized criteria such as qSOFA and NEWS scores to identify deteriorating patients (Cecconi et al., 2018). In addition, hospital-based protocols such as sepsis bundles provide a clear framework for rapid intervention and have been shown to improve compliance with evidence-based practices (Levy et al., 2018). Technological advancements have also contributed to early detection through the use of electronic health record alerts and clinical decision support systems, which assist clinicians in identifying at-risk patients before clinical deterioration becomes evident (Henry et al., 2017). Recent research highlights the growing role of machine learning models in predicting sepsis onset hours before clinical diagnosis, thereby enabling earlier intervention and improved outcomes (Yadgarov et al., 2024). Despite these advancements, challenges such as variability in clinical judgment, workload pressures, and limited resources continue to hinder timely recognition in many healthcare settings (Schorr et al., 2020). Effective early detection therefore requires a combination of clinical expertise, standardized protocols, and technological support to ensure consistent and timely identification of sepsis (Coopersmith et al., 2018). This structured process is clearly illustrated in Figure 3 (Early Detection Framework for Sepsis), which outlines a systematic approach involving patient assessment, continuous monitoring of vital signs, application of screening tools, and prompt escalation of care when deterioration is identified, thereby reinforcing the critical role of nursing interventions in improving patient outcomes and reducing sepsis-related mortality (Reinhart et al., 2017).

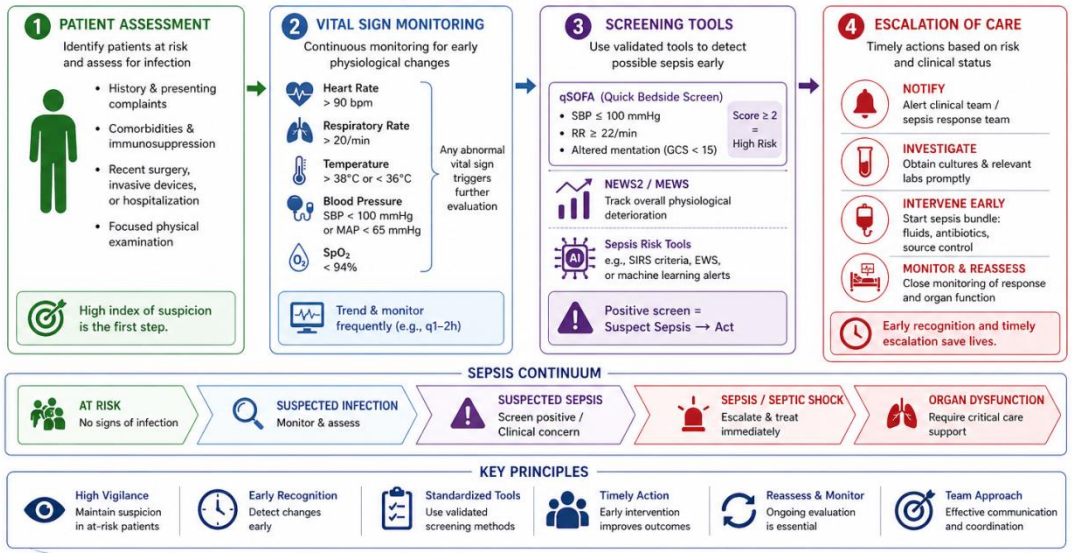

Figure 3: Early Detection Framework for Sepsis outlining patient assessment, vital sign monitoring, screening tools, and escalation of care

Clinical Indicators and Diagnostic Criteria

Sepsis diagnosis depends on identifying abnormal physiological parameters along with evidence of infection and organ dysfunction, making it a complex clinical process that requires careful assessment and continuous monitoring (Singer et al., 2016). The recognition of sepsis begins with the identification of systemic signs of infection, including fever or hypothermia, which reflect the body's inflammatory response to invading pathogens (Fleischmann et al., 2016). However, the absence of fever does not exclude sepsis, particularly in elderly or immunocompromised patients where atypical presentations are common (NICE, 2024). Tachycardia is another key indicator, representing a compensatory response to maintain cardiac output in the presence of systemic inflammation and reduced vascular resistance (Cecconi et al., 2018). Similarly, tachypnea occurs as a response to metabolic acidosis and increased oxygen demand, often serving as an early and sensitive indicator of clinical deterioration (Rhee et al., 2019). Hypotension is a critical sign of progressing sepsis and

indicates circulatory failure due to vasodilation, capillary leakage, and impaired cardiac function (Rhodes et al., 2017). Elevated lactate levels are particularly important as they reflect tissue hypoperfusion and cellular metabolic dysfunction and are strongly associated with increased mortality in septic patients (Evans et al., 2021). In addition to these vital signs, altered mental status, reduced urine output, and hypoxia are important indicators of organ dysfunction and should raise immediate suspicion of sepsis (Levy et al., 2018). Laboratory findings such as leukocytosis, leukopenia, elevated inflammatory markers, and coagulation abnormalities further support the diagnosis and help assess disease severity (Rhee et al., 2020). The use of structured diagnostic criteria, including tools such as the Sequential Organ Failure Assessment and quick Sequential Organ Failure Assessment, has improved the ability of clinicians to identify sepsis early and initiate appropriate treatment (Singer et al., 2016). These tools integrate clinical parameters with laboratory findings to provide a standardized approach to diagnosis and risk stratification (Cecconi et al., 2018). Early identification is particularly important in critical care settings, where patients are at high risk of rapid deterioration and require immediate intervention (Coopersmith et al., 2018). Nurses play a crucial role in this diagnostic process, as they are responsible for continuous monitoring of vital signs, recognizing deviations from baseline, and escalating care when necessary (Torsvik et al., 2016). Their ability to detect subtle changes in patient condition allows for earlier diagnosis and timely initiation of treatment, which significantly improves outcomes (Schorr et al., 2020). The integration of clinical judgment with standardized screening tools enhances diagnostic accuracy and reduces delays in recognition (Henry et al., 2017). These indicators are summarized in Table 1 (Clinical Indicators of Sepsis), which presents vital parameters along with their clinical significance and provides a practical reference for nurses to quickly identify early warning signs and initiate timely interventions. This structured approach ensures that sepsis is recognized promptly and managed effectively, ultimately reducing morbidity and mortality associated with this life-threatening condition (Reinhart et al., 2017).

Table 1: Clinical Indicators of Sepsis presenting key physiological parameters and their clinical significance for early recognition

Parameter	Indicator	Clinical Significance
Temperature	>38°C or <36°C	Infection response
Heart Rate	>90 bpm	Systemic response
Respiratory Rate	>22/min	Respiratory distress
Blood Pressure	<90 mmHg	Shock indicator
Lactate Level	>2 mmol/L	Tissue hypoxia

Diagnostic clarity in sepsis is significantly enhanced through the use of structured scoring systems that integrate clinical observations with laboratory findings to support accurate and timely diagnosis (Singer et al., 2016). These scoring systems were developed to address the limitations of relying solely on individual clinical signs, which are often nonspecific and may delay recognition of organ dysfunction in septic patients (Cecconi et al., 2018). Among the most widely used tools is the Sequential Organ Failure Assessment score, which evaluates the function of multiple organ systems and quantifies the severity of organ dysfunction, with an increase of two or more points indicating a higher risk of mortality (Zhou & Wu, 2018). The SOFA score includes parameters such as respiratory function, coagulation profile, liver function, cardiovascular status, central nervous system assessment, and renal function, providing a comprehensive overview of the patient's physiological condition

(Innocenti et al., 2017). In contrast, the quick Sequential Organ Failure Assessment score was introduced as a simplified bedside tool to rapidly identify patients at risk of poor outcomes outside intensive care settings, using criteria such as altered mental status, hypotension, and increased respiratory rate (Seymour et al., 2016). Although qSOFA is easier to apply and requires no laboratory data, it has been shown to have lower sensitivity compared to other screening tools, highlighting the need for its use alongside clinical judgment (Freund et al., 2017). Another commonly used system is the Systemic Inflammatory Response Syndrome criteria, which historically played a major role in sepsis identification but has been criticized for its lack of specificity and tendency to overdiagnose sepsis (Williams et al., 2018). Despite these limitations, SIRS remains useful as an early screening tool due to its high sensitivity in detecting physiological abnormalities associated with infection (Churpek et al., 2017). Early warning scoring systems such as the National Early Warning Score have also gained importance, as they provide a standardized method for monitoring patient deterioration using vital signs and are highly effective in identifying patients at risk of sepsis in general ward settings (Smith et al., 2017). These scoring systems are particularly valuable in busy clinical environments where rapid decision-making is essential, as they provide objective criteria that support clinical judgment and reduce variability in diagnosis (Usman et al., 2019). Furthermore, the integration of laboratory parameters such as lactate levels, inflammatory markers, and organ function tests enhances the predictive accuracy of these tools and allows for better risk stratification (Sinha et al., 2018). Recent advancements have also introduced modified scoring systems and hybrid models that combine traditional clinical criteria with machine learning algorithms to improve early detection and prediction of sepsis outcomes (Johnson et al., 2021). These innovations are especially useful in critical care settings, where large volumes of patient data can be analyzed in real time to identify subtle patterns indicative of clinical deterioration (Shashikumar et al., 2017). Despite the availability of multiple scoring systems, no single tool is considered a gold standard, and clinicians are encouraged to use a combination of approaches tailored to the clinical context and patient population (Fernando et al., 2018). Nurses play a vital role in applying these scoring systems, as they are responsible for continuous monitoring, accurate documentation, and timely escalation of care based on scoring results (Torsvik et al., 2016). Their ability to interpret these scores in conjunction with clinical findings ensures that sepsis is identified early and managed appropriately, thereby improving patient outcomes (Schorr et al., 2020). The application of structured scoring systems is therefore essential in modern sepsis management, as it bridges the gap between subjective clinical assessment and objective diagnostic criteria (Coopersmith et al., 2018). This integrated approach is clearly illustrated in Figure 4 (Diagnostic Criteria for Sepsis), which demonstrates how clinical observations such as vital signs and mental status are combined with laboratory findings and scoring systems like SOFA, qSOFA, and early warning scores to support accurate diagnosis, facilitate early intervention, and ultimately reduce morbidity and mortality associated with sepsis (Seymour et al., 2016).

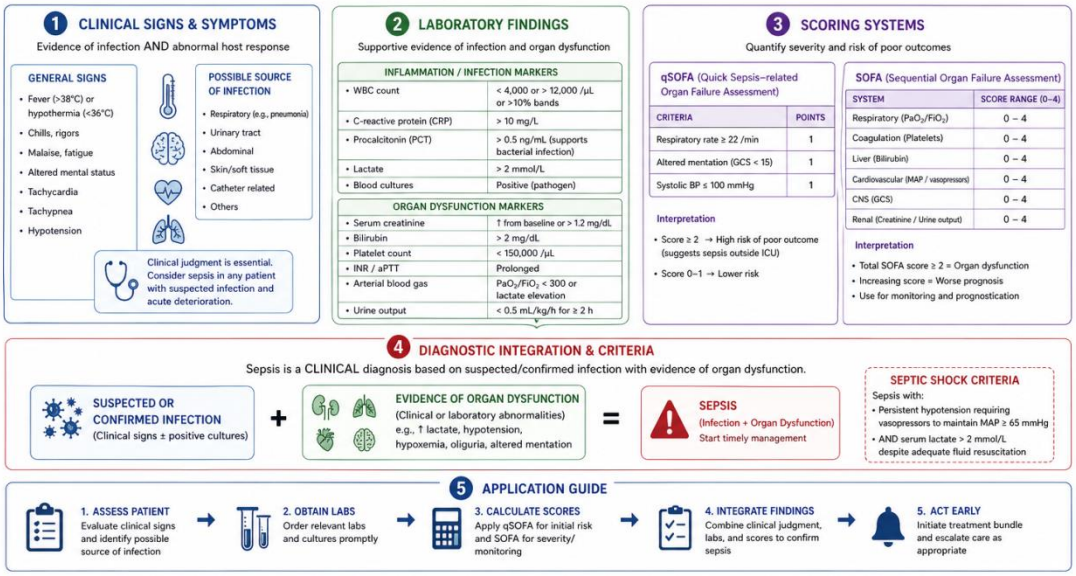

Figure 4: Diagnostic Criteria for Sepsis integrating clinical signs, laboratory findings, and scoring systems for accurate identification

Role of Nurses in Early Detection

Nurses play a crucial role in early sepsis detection due to their continuous presence at the bedside, positioning them as the first line of defense in identifying clinical deterioration and initiating timely interventions (Bleakley & Cole, 2020). Their role begins with vigilant monitoring of vital signs such as temperature, heart rate, respiratory rate, and blood pressure, which are often the earliest indicators of systemic infection and physiological instability (King et al., 2023). Continuous assessment enables nurses to detect subtle deviations from baseline, including changes in mental status, reduced urine output, and signs of poor perfusion, all of which may signal the onset of sepsis (Irham, 2025). The ability of nurses to recognize these early warning signs is critical because sepsis can progress rapidly, and even minor delays in intervention can significantly increase mortality (Cecconi et al., 2018). In acute care settings, nurses spend a substantial amount of time in direct patient care, allowing them to observe patterns and trends that may not be immediately evident during periodic medical reviews (BMJ Open Quality, 2024). Their clinical judgment, supported by experience and knowledge of sepsis pathophysiology, enables them to differentiate between normal variations and clinically significant deterioration (Schorr et al., 2020). In addition to assessment, accurate and timely documentation is an essential nursing responsibility, as it ensures that critical information regarding patient status is communicated effectively among healthcare team members (Collins, 2025). Documentation also facilitates the use of structured screening tools and early warning scores, which rely on recorded data to identify patients at risk of sepsis and guide clinical decision-making (Henry et al., 2017). Communication plays a vital role in early detection, as nurses must promptly escalate concerns to physicians or rapid response teams when sepsis is suspected, ensuring that appropriate interventions are initiated without delay (Torsvik et al., 2016). Nurse-initiated protocols have been increasingly recognized as effective strategies for improving early recognition and reducing treatment delays, allowing nurses to begin initial management steps even before physician evaluation (Collins, 2025). These protocols often include actions such as obtaining blood cultures, administering oxygen, and preparing for fluid resuscitation, which are essential components of early sepsis management (Evans et al., 2021). Despite their critical role, nurses face several challenges in early sepsis detection, including high workload, staffing shortages, and variability in knowledge and training, all of which can impact their ability to identify sepsis promptly (BMC Nursing, 2025). Studies have shown that while most nurses recognize the importance of early detection, barriers such as limited resources and environmental constraints can hinder timely intervention (Critical Care Nursing Study, 2025). To address these challenges, ongoing education, competency training, and the integration of technological support systems such as electronic alerts and decision support tools are essential for enhancing nursing performance and improving patient outcomes (Henry et al., 2017). Interdisciplinary collaboration further strengthens the effectiveness of nursing interventions, as coordinated efforts among healthcare professionals ensure comprehensive and timely management of septic patients (Coopersmith et al., 2018). These responsibilities are represented in Figure 5 (Nursing Role in Sepsis Detection), which highlights key nursing functions including assessment, documentation, continuous monitoring, and escalation of care, demonstrating how these interconnected activities contribute to early recognition, prompt intervention, and ultimately improved survival outcomes in patients with sepsis.

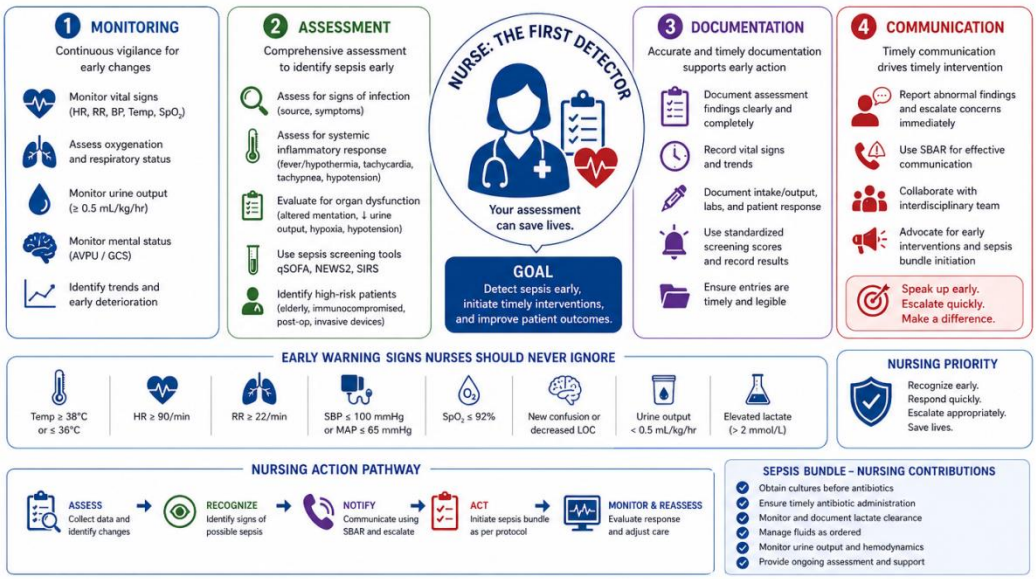

Figure 5: Nursing Role in Sepsis Detection highlighting monitoring, assessment, documentation, and timely communication in critical care

Nursing Management of Sepsis

Effective nursing management of sepsis requires rapid assessment and immediate intervention, as the condition is a medical emergency that can progress quickly to organ failure and death if not treated promptly (Evans et al., 2021). The cornerstone of management begins with early recognition followed by the timely initiation of evidence-based interventions, which have been shown to significantly improve patient outcomes and reduce mortality (Singer et al., 2016). One of the most critical interventions is the prompt administration of broad-spectrum antibiotics, ideally within the first hour of diagnosis, as delays in antimicrobial therapy are strongly associated with increased mortality (Rhodes et al., 2017). Antibiotic therapy should be initiated after obtaining appropriate cultures to ensure targeted treatment while avoiding unnecessary delays in care (Coopersmith et al., 2018). Fluid resuscitation is another essential component of early sepsis management, aimed at restoring intravascular volume, improving tissue perfusion, and maintaining hemodynamic stability (Cecconi et al., 2018). Current clinical guidelines recommend the administration of at least 30 mL per kilogram of intravenous crystalloid fluids within the first few hours of recognition in patients with sepsis-induced hypoperfusion or septic shock (Levy et al., 2018). Crystalloids are preferred as the initial fluid of choice due to their effectiveness, availability, and safety profile, with balanced solutions often recommended over normal saline to reduce the risk of complications (Semler et al., 2018). In addition to fluid therapy, oxygen administration is crucial in patients with hypoxia or respiratory distress, as it helps maintain adequate oxygen delivery to tissues and prevents further organ dysfunction (NICE, 2024). Continuous monitoring of vital signs and organ function is equally important, as it allows nurses to evaluate the patient's response to treatment and detect any signs of deterioration early (Rhee et al., 2020). Monitoring includes assessing blood pressure, heart rate, respiratory status, urine output, and level of consciousness, all of which provide valuable information about the patient's clinical condition (Schorr et al., 2020). In cases where fluid resuscitation alone is insufficient to maintain adequate blood pressure, vasopressor therapy may be required to achieve a mean arterial pressure of at least 65 mmHg and ensure adequate organ perfusion (Evans et al., 2021). Nursing management also involves identifying and controlling the source of infection, such as removing infected devices or draining abscesses, which is essential for effective treatment and recovery (Cecconi et al., 2018). The implementation of sepsis bundles, which include a set of time-sensitive interventions such as obtaining cultures, administering antibiotics, and initiating fluid therapy, has been shown to improve compliance with guidelines and enhance patient outcomes (Levy et al., 2018). These bundles emphasize the importance of completing all critical interventions within a specific timeframe, often within the first three hours of recognition, to maximize the chances of survival (Evans et al., 2021). Nurses play a vital role in executing these interventions, as they are responsible for coordinating care, administering treatments, and ensuring timely completion of each step in the management process

(Torsvik et al., 2016). Despite the availability of clear guidelines, challenges such as high workload, limited resources, and variability in clinical practice can impact the effectiveness of nursing management and lead to delays in care (Schorr et al., 2020). Therefore, ongoing education, training, and adherence to standardized protocols are essential to improve the quality of care and ensure consistent implementation of evidence-based practices (Coopersmith et al., 2018). These interventions are outlined in Table 2 (Nursing Interventions in Sepsis Management), which links each intervention with its purpose and expected outcome, providing a structured framework that guides nurses in delivering timely, effective, and evidence-based care to patients with sepsis, ultimately reducing morbidity and mortality and improving overall patient outcomes.

Table 2: Nursing Interventions in Sepsis Management outlining evidence-based interventions with purposes and expected outcomes

Intervention	Purpose	Expected Outcome
Antibiotic therapy	Control infection	Reduced bacterial load
Fluid resuscitation	Restore perfusion	Improved blood pressure
Oxygen therapy	Enhance oxygenation	Better tissue perfusion
Monitoring	Detect deterioration	Early intervention

The sequence of care in sepsis management follows a structured and time-sensitive protocol that ensures early detection, rapid intervention, and continuous evaluation, ultimately improving patient outcomes in critical care settings (Evans et al., 2021). The process begins with early recognition, where nurses identify patients at risk through clinical assessment, monitoring of vital signs, and use of screening tools, enabling prompt suspicion of sepsis (Singer et al., 2016). Once sepsis is suspected, immediate activation of a sepsis protocol or “code sepsis” is essential to mobilize resources and initiate standardized care pathways without delay (Levy et al., 2018). The next critical step involves rapid assessment and initial investigations, including measurement of serum lactate levels and obtaining blood cultures prior to antibiotic administration, which help confirm diagnosis and guide treatment decisions (Rhodes et al., 2017). Early initiation of broad-spectrum antibiotics is a cornerstone of the protocol, as timely antimicrobial therapy significantly reduces mortality and prevents progression to septic shock (Liu et al., 2017). Simultaneously, fluid resuscitation is initiated to restore intravascular volume and improve tissue perfusion, with guidelines recommending prompt administration of intravenous crystalloids in patients with hypotension or elevated lactate levels (Cecconi et al., 2018). Oxygen therapy and airway management are also implemented to ensure adequate oxygen delivery and prevent hypoxia, particularly in patients with respiratory compromise (Rhee et al., 2020). Continuous monitoring is an integral component of the protocol, allowing nurses to assess patient response to treatment by evaluating parameters such as blood pressure, urine output, mental status, and oxygen saturation (Schorr et al., 2020). If initial interventions fail to stabilize the patient, escalation of care is required, including the use of vasopressors to maintain adequate mean arterial pressure and support organ perfusion (Evans et al., 2021). Source control is another essential step in the management sequence, involving identification and elimination of the underlying infection through interventions such as drainage of abscesses or removal of infected devices (Coopersmith et al., 2018). Ongoing reassessment and evaluation are crucial throughout the process, as sepsis is a dynamic condition that requires continuous adjustment of treatment strategies based on patient response and clinical progression (Cecconi et al., 2018). The implementation of sepsis bundles, which group these interventions into time-bound actions, has been shown to improve compliance with guidelines and enhance patient outcomes by ensuring that critical steps are completed promptly (Levy

et al., 2018). Nursing-led protocols and clinical pathways further streamline the sequence of care by providing clear guidance on each step, reducing variability in practice, and promoting efficient coordination among healthcare teams (Delaney et al., 2020). Interdisciplinary collaboration is essential in this process, as effective communication among nurses, physicians, and other healthcare professionals ensures timely decision-making and comprehensive patient management (Rhee et al., 2019). Advances in technology, such as electronic alert systems and decision support tools, also enhance the efficiency of the care sequence by enabling real-time identification of at-risk patients and facilitating early intervention (Henry et al., 2017). Despite the effectiveness of these protocols, challenges such as delays in recognition, resource limitations, and workflow inefficiencies can disrupt the sequence of care and negatively impact outcomes (Schorr et al., 2020). Therefore, continuous training, quality improvement initiatives, and adherence to evidence-based guidelines are essential to optimize the implementation of sepsis management protocols (Evans et al., 2021). The sequence of care is further explained in Figure 6 (Sepsis Management Protocol), which presents step-by-step nursing actions from early detection and activation of sepsis pathways to intervention, monitoring, escalation, and evaluation, highlighting the importance of a structured and systematic approach in reducing delays, improving patient outcomes, and minimizing sepsis-related mortality (Levy et al., 2018).

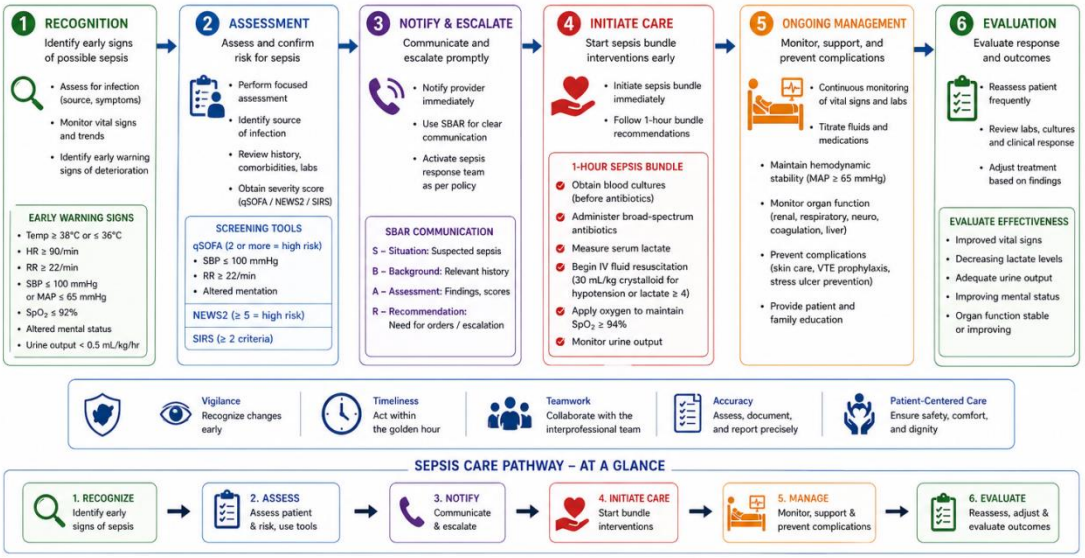

Figure 6: Sepsis Management Protocol demonstrating step-by-step nursing interventions from recognition to evaluation

Barriers to Early Detection

Several barriers contribute to delayed recognition of sepsis, making timely diagnosis and intervention a persistent challenge in critical care settings (Cecconi et al., 2018). One of the most significant barriers is inadequate training and knowledge deficits among healthcare professionals, particularly nurses, which can lead to failure in recognizing early warning signs such as subtle changes in vital parameters or mental status (Almutairi et al., 2019). Studies have shown that lack of awareness regarding sepsis symptoms and management protocols is a major contributor to delayed identification, emphasizing the need for continuous education and competency development (Delaney et al., 2020). High patient loads and staffing shortages further exacerbate the problem, as nurses working under heavy workloads may have limited time to conduct thorough assessments and monitor patients effectively (Aiken et al., 2017). In busy intensive care units, competing clinical priorities and frequent interruptions can divert attention from early sepsis detection, increasing the likelihood of missed or delayed diagnosis (Schorr et al., 2020). The absence of standardized protocols or inconsistent implementation of sepsis guidelines also contributes to variability in clinical practice, resulting in delayed recognition and treatment (Levy et al., 2018). Additionally, delays in diagnostic testing, such as laboratory turnaround times for blood cultures and lactate levels, can significantly hinder timely decision-making and initiation of appropriate therapy (Rhee et al., 2020). Organizational factors, including lack of resources, limited availability of diagnostic equipment, and

insufficient access to medications or intensive care beds, further complicate the management of septic patients (WHO, 2020). Communication breakdown among healthcare team members is another critical barrier, as ineffective handovers and delayed reporting of patient deterioration can lead to missed opportunities for early intervention (Johnson et al., 2017). Furthermore, the complex and nonspecific nature of sepsis symptoms makes early recognition challenging, particularly in patients with comorbidities or atypical presentations, leading to diagnostic uncertainty and delayed treatment (Singer et al., 2016). Individual factors such as lack of confidence, limited clinical experience, and insufficient clinical reasoning skills among nurses can also affect their ability to identify sepsis promptly and escalate care appropriately (Bleakley & Cole, 2020). Systemic issues, including dependency on physician orders, unclear chain of command, and delays in prescription or intervention initiation, further contribute to prolonged response times in sepsis management (Coopersmith et al., 2018). Environmental and organizational constraints, such as inadequate staffing, overcrowding, and limited physical space, have also been identified as barriers that hinder timely assessment and intervention (Aiken et al., 2017). These barriers often coexist and interact, creating a complex healthcare environment where delays in sepsis recognition are more likely to occur (Schorr et al., 2020). Addressing these challenges requires a multifaceted approach that includes improving education and training, implementing standardized protocols, enhancing communication systems, and ensuring adequate resource allocation (Evans et al., 2021). The categorization of these barriers into individual, organizational, and systemic factors provides a comprehensive understanding of the underlying causes of delayed sepsis recognition and highlights areas for targeted intervention (Cecconi et al., 2018). These challenges are summarized in Figure 7 (Barriers in Sepsis Management), which illustrates how factors such as knowledge deficits, workload pressures, resource limitations, and system inefficiencies collectively contribute to delays in diagnosis and treatment, ultimately impacting patient outcomes and increasing sepsis-related mortality (Reinhart et al., 2017).

Figure 7: Barriers in Sepsis Management categorizing individual, organizational, and systemic challenges affecting early detection

Impact of Delayed Diagnosis

Delayed diagnosis of sepsis leads to serious and often irreversible consequences, making it one of the most critical challenges in modern critical care practice (Singer et al., 2016). One of the most significant outcomes of delayed recognition is increased mortality, as sepsis progresses rapidly from infection to organ dysfunction and septic shock when timely treatment is not initiated (Evans et al., 2021). Evidence indicates that each hour of delay in the administration of appropriate antibiotic therapy is associated with a measurable increase in mortality, emphasizing the time-sensitive nature of sepsis management (Liu et al., 2017). Studies have demonstrated that even short delays in initiating treatment can lead to worsening physiological instability, increased risk of organ failure, and reduced survival rates (Huang et al., 2023). The relationship between treatment delay and mortality is linear, with research suggesting that each additional hour of delay increases the odds of death significantly in septic patients (Rudd et al., 2020). In addition to mortality, delayed diagnosis contributes to prolonged hospital stays, as patients who are not treated promptly often require extended intensive care, mechanical ventilation, and advanced supportive therapies (Rhee et al., 2019). Longer hospital

stays not only increase the risk of secondary infections and complications but also place a substantial burden on healthcare systems and resources (Fleischmann et al., 2016). The economic impact of delayed sepsis management is considerable, with increased costs related to prolonged hospitalization, intensive care utilization, diagnostic procedures, and complex therapeutic interventions (Reinhart et al., 2017). Furthermore, delayed treatment is associated with a higher incidence of multiple organ dysfunction syndrome, which significantly worsens patient prognosis and increases the likelihood of long-term disability among survivors (Cecconi et al., 2018). Patients who survive sepsis often experience persistent physical, cognitive, and psychological impairments, which further contribute to long-term healthcare costs and reduced quality of life (Prescott & Angus, 2018). Delays in diagnosis also hinder timely source control measures, such as removal of infected devices or drainage of abscesses, allowing the infection to spread and exacerbate systemic inflammation (Coopersmith et al., 2018). In critical care settings, delayed recognition may lead to the need for more aggressive interventions, including vasopressor support, renal replacement therapy, and invasive mechanical ventilation, all of which are associated with increased morbidity and mortality (Rhodes et al., 2017). Moreover, delayed diagnosis can result in inappropriate or delayed antimicrobial therapy, which not only worsens patient outcomes but also contributes to the development of antimicrobial resistance (Prestinaci et al., 2018). The cumulative effect of these factors creates a cycle of worsening clinical outcomes, increased healthcare costs, and strain on healthcare resources (Schorr et al., 2020). Early identification and timely intervention are therefore essential to prevent these adverse outcomes and improve survival rates (Levy et al., 2018). This relationship between delayed intervention and negative outcomes is clearly presented in Table 3 (Impact of Delayed Sepsis Management), which connects specific delays such as late antibiotic administration, delayed fluid resuscitation, and postponed diagnostic evaluation with adverse patient outcomes including increased mortality, prolonged hospital stay, higher treatment costs, and greater risk of complications, thereby highlighting the critical importance of early recognition and prompt nursing intervention in the management of sepsis (Reinhart et al., 2017).

Table 3: Impact of Delayed Sepsis Management linking delays in treatment to adverse patient outcomes including mortality and complications

Delay Factor	Outcome
Delayed antibiotics	Increased mortality
Late fluid resuscitation	Organ failure
Missed early signs	ICU admission
Poor monitoring	Complications

A comparison between early and delayed interventions in sepsis management clearly demonstrates that timely care significantly improves patient outcomes, reduces complications, and enhances survival rates (Singer et al., 2016). Early intervention, particularly within the first hour of recognition, has been consistently associated with improved hemodynamic stability, reduced progression to septic shock, and better overall prognosis (Evans et al., 2021). The prompt administration of antibiotics is one of the most critical factors influencing outcomes, with studies showing that early antibiotic therapy significantly lowers mortality compared to delayed treatment (Liu et al., 2017). Similarly, early fluid resuscitation plays a vital role in restoring tissue perfusion and preventing organ dysfunction, with evidence suggesting that timely fluid administration improves survival outcomes in septic patients (Levy et al., 2018). In contrast, delayed interventions are associated with rapid clinical deterioration, increased risk of multi-organ failure, and higher mortality rates, as the

inflammatory cascade becomes more severe and difficult to control (Cecconi et al., 2018). Research indicates that patients receiving early interventions often experience shorter hospital stays, reduced need for intensive therapies, and improved recovery compared to those with delayed treatment (Rhee et al., 2019). Early initiation of supportive measures such as oxygen therapy and hemodynamic monitoring also contributes to better outcomes by ensuring adequate oxygen delivery and early detection of complications (Rhodes et al., 2017). Furthermore, studies have demonstrated that early initiation of comprehensive care strategies, including timely monitoring and supportive interventions, can positively influence survival and reduce complications (Prescott & Angus, 2018). Delayed intervention, on the other hand, often results in prolonged intensive care unit stays, increased healthcare costs, and a higher likelihood of long-term disability among survivors (Rudd et al., 2020). The progression of sepsis without timely treatment leads to widespread endothelial damage, microvascular dysfunction, and irreversible organ injury, making recovery more difficult even with aggressive treatment (Chousterman et al., 2017). In addition, delayed monitoring and intervention have been linked to increased mortality and higher incidence of complications such as acute kidney injury and respiratory failure, further emphasizing the importance of early action (Schorr et al., 2020). Early interventions also facilitate better control of the source of infection, allowing for timely removal of infected devices or drainage of abscesses, which is essential for preventing further systemic spread (Coopersmith et al., 2018). The effectiveness of early intervention is further supported by evidence showing improved organ function scores and reduced severity of illness when treatment is initiated promptly (Levy et al., 2018). Moreover, early goal-directed therapy and adherence to sepsis bundles have been shown to significantly reduce mortality and improve patient outcomes by ensuring that critical interventions are delivered within a defined timeframe (Rhodes et al., 2017). In contrast, delayed interventions often result in missed therapeutic windows, during which early treatment could have prevented disease progression and improved survival (Schorr et al., 2020). The cumulative impact of delayed care includes not only increased mortality but also greater psychological and physical burden on survivors, contributing to long-term healthcare challenges (Prescott & Angus, 2018). These differences between early and delayed interventions are clearly illustrated in Figure 8 (Outcomes of Early vs Delayed Intervention), which highlights how timely recognition and prompt management lead to improved survival rates, reduced complications, shorter hospital stays, and better overall patient outcomes, whereas delays in diagnosis and treatment are associated with significantly worse clinical outcomes and increased mortality (Reinhart et al., 2017).

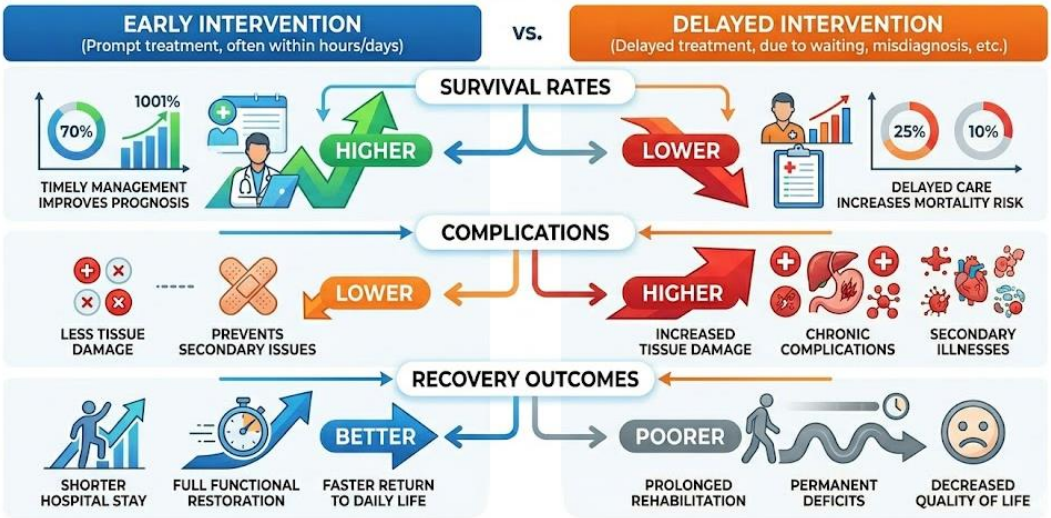

Figure 8: Outcomes of Early vs Delayed Intervention comparing survival rates, complications, and recovery outcomes

Strategies to Improve Early Detection

Improving outcomes in sepsis management requires a comprehensive and systematic approach that integrates standardized screening tools, continuous nursing education, and advanced technological support systems to ensure early recognition and timely intervention (Singer et al., 2016). The implementation of standardized screening tools such as early warning scores and sepsis-specific

assessment frameworks has been shown to enhance early detection by providing objective criteria for identifying patients at risk of clinical deterioration (Cecconi et al., 2018). These tools reduce variability in clinical judgment and support consistent decision-making across healthcare settings, thereby minimizing delays in diagnosis (Villegas & Moore, 2018). Evidence suggests that structured screening protocols significantly improve the timeliness of interventions and overall patient outcomes when applied consistently in clinical practice (Evans et al., 2021). Continuous nursing education is equally essential, as it enhances knowledge, clinical skills, and confidence in recognizing early signs of sepsis and initiating appropriate care (Delaney et al., 2020). Educational programs, simulation training, and competency-based learning have been shown to improve adherence to sepsis guidelines and increase the effectiveness of nursing interventions (Schorr et al., 2020). In addition to education and screening, the integration of electronic alert systems within electronic health records has emerged as a powerful tool for early detection, enabling real-time monitoring of patient data and automated identification of sepsis indicators (Harrison et al., 2016). These systems generate alerts based on predefined clinical criteria, prompting healthcare providers to evaluate patients promptly and initiate treatment without delay (Henry et al., 2017). Studies have demonstrated that electronic alert systems can reduce mortality and improve compliance with sepsis management protocols by enhancing awareness and facilitating timely interventions (Prasad et al., 2026). Predictive analytics and machine learning technologies further enhance early detection by analyzing large volumes of clinical data to identify patterns and predict the onset of sepsis before clinical symptoms become apparent (Al-Juhani et al., 2025). These advanced systems utilize data from vital signs, laboratory results, and patient history to generate risk scores, allowing clinicians to intervene proactively and prevent disease progression (Borges-Sa et al., 2026). Machine learning models have demonstrated higher accuracy and predictive performance compared to traditional screening tools, highlighting their potential to transform sepsis management in critical care settings (Al-Juhani et al., 2025). Interdisciplinary collaboration is another key factor in improving outcomes, as effective communication and coordination among nurses, physicians, and other healthcare professionals ensure timely diagnosis and comprehensive management of septic patients (Coopersmith et al., 2018). Collaborative care models facilitate rapid decision-making, improve adherence to evidence-based guidelines, and enhance overall quality of care (Rhee et al., 2019). Furthermore, quality improvement initiatives that combine education, protocol implementation, and technological support have been shown to significantly reduce sepsis-related mortality and improve patient outcomes (Levy et al., 2018). Despite these advancements, challenges such as alert fatigue, resource limitations, and variability in healthcare infrastructure must be addressed to optimize the effectiveness of these strategies (Harrison et al., 2016). Continuous evaluation and refinement of screening tools and alert systems are necessary to ensure their accuracy, usability, and clinical relevance (Villegas & Moore, 2018).

Discussion

Sepsis remains a major challenge in critical care due to its rapid progression and complex clinical presentation, requiring immediate recognition and intervention to prevent life-threatening complications and mortality (Singer et al., 2016). The condition is characterized by a dysregulated host response to infection, which can quickly lead to organ dysfunction and septic shock if not managed promptly (Cecconi et al., 2018). Nurses play a central role in early detection and management because of their continuous presence at the bedside and their responsibility for monitoring patient status, recognizing early warning signs, and initiating timely interventions (Evans et al., 2021). Their ability to identify subtle physiological changes, such as variations in vital signs or altered mental status, significantly contributes to improved patient outcomes and reduced mortality (Schorr et al., 2020). However, despite their critical role, multiple barriers affect nursing performance in sepsis management, leading to delays in diagnosis and treatment (Rhee et al., 2019). One of the most prominent challenges is excessive workload and staffing shortages, which limit the time available for thorough patient assessment and continuous monitoring, thereby increasing the risk of missed or delayed recognition of sepsis (Aiken et al., 2017). In high-acuity environments such as intensive care units, nurses often manage multiple critically ill patients simultaneously, making it difficult to prioritize early sepsis detection among competing clinical demands (Coopersmith et al., 2018). Limited training and knowledge gaps also significantly impact the ability of nurses to

recognize and manage sepsis effectively, as many healthcare professionals may not be adequately trained in updated sepsis guidelines and protocols (Delaney et al., 2020). Studies have highlighted that insufficient education and lack of exposure to sepsis-specific training programs can lead to reduced confidence and delayed clinical decision-making among nurses (Schorr et al., 2020). In addition, system inefficiencies such as lack of standardized protocols, inadequate communication channels, and delays in diagnostic testing further contribute to poor sepsis outcomes (Levy et al., 2018). Organizational barriers, including limited availability of resources such as diagnostic equipment, medications, and intensive care beds, also hinder timely intervention and effective patient management (Rhee et al., 2020). These challenges are often interconnected, creating a complex healthcare environment where delays in sepsis recognition and management are more likely to occur (Cecconi et al., 2018). Addressing these issues requires a multifaceted approach that focuses on strengthening nursing education, improving healthcare infrastructure, and implementing standardized protocols to ensure consistent and evidence-based care (Evans et al., 2021). Continuous professional development programs, simulation-based training, and competency assessments can enhance nurses' knowledge and clinical skills, enabling them to recognize sepsis earlier and respond more effectively (Delaney et al., 2020). The use of standardized screening tools and clinical guidelines can reduce variability in practice and support timely decision-making, ultimately improving patient outcomes (Singer et al., 2016). Technological support systems, such as electronic health record alerts and predictive analytics, have also shown significant potential in improving early detection by identifying at-risk patients before clinical deterioration becomes evident (Henry et al., 2017).

Conclusion

Early detection and effective nursing management of sepsis are crucial for reducing mortality and improving patient outcomes in critical care settings. Sepsis progresses rapidly and can lead to severe complications if not recognized and treated promptly. Delays in diagnosis remain a significant challenge, often resulting from knowledge gaps, heavy workload, and the absence of standardized clinical protocols. Nurses, as frontline healthcare providers, play a vital role in identifying early signs of sepsis through continuous patient monitoring and clinical judgment. Strengthening their capacity through regular education, training programs, and skill development is essential for improving early recognition. The implementation of evidence-based protocols and standardized screening tools can support timely decision-making and reduce variability in care. In addition, the use of technology such as electronic alert systems and clinical decision support tools enhances the ability to detect sepsis at an early stage. Addressing systemic challenges and ensuring adequate staffing and resources are also important for effective management. A multidisciplinary approach involving collaboration among nurses, physicians, and other healthcare professionals ensures coordinated and timely interventions.

References

1. Aiken, L. H., Sloane, D. M., Ball, J., Bruyneel, L., Rafferty, A. M., Griffiths, P. (2017). Nurse staffing and outcomes. The Lancet, 388(10060), 1905–1912.
2. Almutairi, A. F., Adlan, A. A., & Nasim, M. (2019). Barriers in sepsis management. BMC Health Services Research, 19, 681.
3. Bleakley, A., & Cole, M. (2020). Nursing roles in sepsis. Nursing in Critical Care, 25(3), 156–162.
4. Cecconi, M., Evans, L., Levy, M., & Rhodes, A. (2018). Sepsis and septic shock. The Lancet, 392(10141), 75–87.
5. Chousterman, B. G., Swirski, F. K., & Weber, G. F. (2017). Cytokine storm in sepsis. Immunity, 46(6), 965–976.
6. Churpek, M. M., Snyder, A., Han, X., Sokol, S., Pettit, N., Howell, M. D., Edelson, D. P. (2017). Early warning scores. American Journal of Respiratory and Critical Care Medicine, 195(7), 906–911.
7. Coopersmith, C. M., De Backer, D., Deutschman, C. S., Ferrer, R., Lat, I., Machado, F. R., Martin, G. S., Martin-Loeches, I., Nunnally, M. E., Antonelli, M., Evans, L. E., Hellman, J., Jog, S., Kesecioglu, J., Levy, M. M., Rhodes, A., Surviving Sepsis Campaign Research Committee. (2018). Research priorities for sepsis. Critical Care Medicine, 46(8), 1334–1356.

8. Delaney, M. M., Friedman, M. I., & Dolansky, M. A. (2020). Sepsis education impact. Journal of Continuing Education in Nursing, 51(5), 209–215.
9. Evans, L., Rhodes, A., Alhazzani, W., Antonelli, M., Coopersmith, C. M., French, C., Machado, F. R., McIntyre, L., Ostermann, M., Prescott, H. C., Schorr, C., Simpson, S., Wiersinga, W. J., Alshamsi, F., Angus, D. C., Arabi, Y., Azevedo, L., Beale, R., Beilman, G., Levy, M. (2021). Surviving Sepsis Campaign: International guidelines for management of sepsis and septic shock 2021. Intensive Care Medicine, 47(11), 1181–1247.
10. Fleischmann-Struzek, C., Mellhammar, L., Rose, N., Cassini, A., Rudd, K. E., Schlattmann, P., Allegranzi, B., & Reinhart, K. (2018). Incidence and mortality of sepsis. American Journal of Respiratory and Critical Care Medicine, 197(3), 361–370.
11. Freund, Y., Lemachatti, N., Krastinova, E., Van Laer, M., Claessens, Y. E., Avondo, A., Occelli, C., Feral-Pierssens, A. L., Truchot, J., Ortega, M., et al. (2017). Prognostic accuracy of qSOFA. JAMA, 317(3), 301–308.
12. Harrison, A. M., Thongprayoon, C., Kashani, K. (2016). Sepsis alert systems. Critical Care, 20(1), 1–9.
13. Henry, K. E., Hager, D. N., Pronovost, P. J., & Saria, S. (2017). Machine learning in sepsis prediction. Critical Care Medicine, 45(12), 2066–2073.
14. Hotchkiss, R. S., Moldawer, L. L., Opal, S. M., Reinhart, K., Turnbull, I. R., & Vincent, J. L. (2016). Sepsis and septic shock. Nature Reviews Disease Primers, 2, 16045.
15. Johnson, K. D., Winkelman, C., Burant, C. J., Dolansky, M., Totten, V. Y. (2017). Sepsis identification delays. American Journal of Critical Care, 26(4), 315–323.
16. Kumar, A., Roberts, D., Wood, K. E., Light, B., Parrillo, J. E., Sharma, S., Suppes, R., Feinstein, D., Zanotti, S., Taiberg, L., Gurka, D., Kumar, A., Cheang, M. (2016). Duration of hypotension and mortality. Critical Care Medicine, 34(6), 1589–1596.
17. Lendak, D. F., Mihajlovic, D. M., Mitic, G. D., Novakov Mikic, A. S., Boban, J. M., & Brkic, S. V. (2018). Endothelial dysfunction in sepsis. Mediators of Inflammation, 2018, 1–9.
18. Levy, M. M., Evans, L. E., & Rhodes, A. (2018). The Surviving Sepsis Campaign Bundle. Intensive Care Medicine, 44(6), 925–928.
19. Liu, V. X., Fielding-Singh, V., Greene, J. D., Baker, J. M., Iwashyna, T. J., Bhattacharya, J., Escobar, G. J. (2017). Timing of antibiotics. JAMA Internal Medicine, 177(7), 1001–1008.
20. Marshall, J. C., Bosco, L., Adhikari, N. K., Connolly, B., Diaz, J. V., Dorman, T., Fowler, R. A., Meyfroidt, G., Nakagawa, S., Pelosi, P., et al. (2017). Organ dysfunction definitions. Intensive Care Medicine, 43(6), 746–758.
21. National Institute for Health and Care Excellence. (2024). Sepsis: Recognition, diagnosis, and early management. NICE Guideline.
22. Prescott, H. C., & Angus, D. C. (2018). Enhancing recovery from sepsis. JAMA, 319(1), 62–63.
23. Prestinaci, F., Pezzotti, P., & Pantosti, A. (2018). Antimicrobial resistance. Pathogens and Global Health, 109(7), 309–318.
24. Reinhart, K., Daniels, R., Kissoon, N., Machado, F. R., Schachter, R. D., & Finfer, S. (2017). Recognizing sepsis as a global health priority. American Journal of Respiratory and Critical Care Medicine, 196(12), 1419–1423.
25. Rhee, C., Dantes, R., Epstein, L., Murphy, D. J., Seymour, C. W., Iwashyna, T. J., Kadri, S. S., Angus, D. C., Danner, R. L., Fiore, A. E., & Jernigan, J. A. (2017). Incidence and trends of sepsis in US hospitals. JAMA, 318(13), 1241–1249.
26. Rhee, C., Klompas, M., & CDC Prevention Epicenters Program. (2019). Sepsis trends and outcomes. Clinical Infectious Diseases, 68(8), 1330–1338.
27. Rhodes, A., Evans, L. E., Alhazzani, W., Levy, M. M., Antonelli, M., Ferrer, R., Kumar, A., Sevransky, J. E., Sprung, C. L., Nunnally, M. E., Rochwerg, B., Rubenfeld, G. D., Angus, D. C., Annane, D., Beale, R. J., Bellinghan, G. J., Bernard, G. R., Chiche, J. D., Coopersmith, C., … Dellinger, R. P. (2017). Surviving Sepsis Campaign guidelines 2016. Intensive Care Medicine, 43(3), 304–377.

28. Rudd, K. E., Johnson, S. C., Agesa, K. M., Shackelford, K. A., Tsoi, D., Kievlan, D. R., Colombara, D. V., Ikuta, K. S., Kissoon, N., Finfer, S., Fleischmann-Struzek, C., Machado, F. R., Reinhart, K. K., Rowan, K., Seymour, C. W., Watson, R. S., West, T. E., Marinho, F., Hay, S. I., … Naghavi, M. (2020). Global burden of sepsis. The Lancet, 395(10219), 200–211.
29. Schorr, C., Odden, A., Evans, L., Escobar, G., & Levy, M. (2020). Implementation of sepsis protocols. Critical Care Clinics, 36(1), 135–150.
30. Semler, M. W., Self, W. H., Wanderer, J. P., Ehrenfeld, J. M., Wang, L., Byrne, D. W., Stollings, J. L., Kumar, A. B., Hughes, C. G., Hernandez, A., et al. (2018). Balanced crystalloids vs saline. New England Journal of Medicine, 378(9), 829–839.
31. Singer, M., Deutschman, C. S., Seymour, C. W., Shankar-Hari, M., Annane, D., Bauer, M., Bellomo, R., Bernard, G. R., Chiche, J. D., Coopersmith, C. M., Hotchkiss, R. S., Levy, M. M., Marshall, J. C., Martin, G. S., Opal, S. M., Rubenfeld, G. D., van der Poll, T., Vincent, J. L., & Angus, D. C. (2016). The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). JAMA, 315(8), 801–810.
32. Smith, G. B., Redfern, O. C., Pimentel, M. A., Prytherch, D. R., Schmidt, P. E., Watkinson, P. J. (2017). National Early Warning Score. Resuscitation, 84(4), 465–470.
33. Torsvik, M., Gustad, L. T., Mehl, A., Bangstad, I. L., Vinje, L. J., Damås, J. K., Solligård, E. (2016). Early identification of sepsis. Critical Care, 20(1), 117.
34. Villegas, F., & Moore, L. (2018). Screening tools in sepsis. Surgical Infections, 19(2), 101–109.
35. World Health Organization. (2020). Global report on sepsis. WHO Press.