

Enhancing Early Sepsis Detection Through Interdisciplinary Collaboration: The Role of Nurses and Laboratory Specialists in a Tertiary Hospital Setting

Eman M. Alanizi¹, Zaid A. Alhussain², Abeer K. Alagily³, Reem H. Alanazi⁴

Health Affairs at the Ministry of National Guard

Abstract

Background: Early detection and timely intervention are critical in reducing sepsis-related mortality. This study explores the collaborative role of nurses and laboratory specialists in enhancing sepsis detection and management in a tertiary hospital.

Methods: A retrospective observational study was conducted, reviewing 200 patient records with sepsis. Quantitative data included time to diagnosis, treatment initiation, and patient outcomes. Qualitative interviews with nurses and laboratory specialists were analyzed to identify key themes related to interdisciplinary collaboration.

Results: Patients with timely laboratory results had significantly shorter times to sepsis diagnosis (2.5 vs. 5.8 hours) and antibiotic administration (1.2 vs. 3.4 hours), along with lower mortality (12% vs. 25%) and septic shock rates (10% vs. 20%). Qualitative findings emphasized the importance of collaboration but highlighted communication challenges and the need for workflow improvements.

Conclusion: Effective collaboration between nurses and laboratory specialists is essential for improving sepsis outcomes. Addressing communication barriers and enhancing workflow processes could further optimize sepsis management in hospital settings.

Keywords: Sepsis, Early Detection, Collaboration, Nursing, Laboratory Diagnostics, Tertiary Hospital, Patient Outcomes.

Introduction

Sepsis, a life-threatening condition caused by the body's dysregulated response to infection, affects millions of people globally each year, particularly in hospital settings such as intensive care units (ICUs) and emergency departments (EDs) (Singer et al., 2016). The condition can lead to organ failure, tissue damage, and even death if not recognized and treated promptly. Early detection and timely intervention are critical in reducing sepsis-related mortality; however, identifying sepsis in its early stages is challenging due to its nonspecific and varied presentation (Liu et al., 2017). This highlights the need for effective interdisciplinary collaboration among healthcare professionals to improve detection and patient outcomes.

Nurses play a central role in the frontline identification of sepsis, relying on continuous monitoring of patients' vital signs to recognize early indicators such as tachycardia, fever, and hypotension (Prescott & Angus, 2018). As key members of the care team, nurses' timely recognition of these signs is essential in triggering early intervention. Simultaneously, laboratory specialists provide critical support by analyzing biochemical markers associated with sepsis, such as lactate, procalcitonin, and C-reactive protein. These biomarkers are often used to confirm the diagnosis and severity of sepsis, thereby guiding treatment decisions (Wacker et al., 2013; Zymlński et al., 2018). For instance, elevated lactate levels and procalcitonin have been widely recognized as reliable early indicators of sepsis and are integral to diagnostic protocols in many hospitals (Liu et al., 2015).

Given the urgency of sepsis management, timely communication between nurses and laboratory specialists is vital to ensure that diagnostic information is rapidly acted upon. This interdisciplinary collaboration is essential in tertiary hospitals, where patients are often critically ill, and the margin for error is minimal. Therefore, this paper aims to explore how collaboration between nurses and laboratory specialists can enhance early detection of sepsis. By examining their combined efforts, we seek to identify strategies that can improve sepsis outcomes through effective teamwork and timely diagnostic processes.

Literature Review

Sepsis and the Importance of Early Detection

Sepsis remains a significant cause of morbidity and mortality worldwide, particularly in hospital settings where patients are vulnerable to infections. According to Singer et al. (2016), sepsis results from the body's extreme response to infection, leading to life-threatening organ dysfunction. Timely detection and intervention are essential, as delays in treatment significantly worsen patient outcomes. Liu et al. (2017) found that each hour of delayed antibiotic administration increases mortality risk in sepsis patients, emphasizing the importance of early diagnosis and rapid intervention.

In the hospital setting, nurses are often the first to observe changes in a patient's condition, making them pivotal in the early identification of sepsis (Prescott & Angus, 2018). Vital signs, including heart rate, blood pressure, and body temperature, are key indicators that nurses routinely monitor. According to Burney et al. (2012), nurses play a crucial role in recognizing the subtle signs of clinical deterioration that may indicate the onset of sepsis. However, clinical symptoms alone are often insufficient for an early diagnosis, necessitating the use of laboratory diagnostics to confirm suspicions and guide treatment decisions.

Biomarkers in Sepsis Detection

Laboratory diagnostics are critical in confirming sepsis and determining its severity. Various biochemical markers, including lactate, procalcitonin (PCT), and C-reactive protein (CRP), are used to detect and monitor sepsis. Lactate levels have long been used as a marker of tissue hypoperfusion and are associated with worse outcomes in sepsis if elevated (Zymlński et al., 2018). Similarly, procalcitonin, a biomarker that rises in response to bacterial infections, has been shown to be a reliable indicator of sepsis in numerous studies. A meta-analysis by Wacker et al. (2013) found that procalcitonin levels strongly correlate with sepsis severity and can be used to monitor response to treatment. Furthermore, C-reactive protein, an acute-phase reactant, has also been used to track the inflammatory response in sepsis patients and serves as an important diagnostic tool (Liu et al., 2015).

The integration of these biomarkers into clinical practice allows for more accurate diagnosis and timely intervention. However, laboratory results alone are not sufficient without the clinical input provided by

nurses. Effective communication between nursing and laboratory teams ensures that the biochemical data are acted upon promptly, allowing for rapid clinical decision-making.

Nurses' Role in Sepsis Management

Nurses are integral to the early detection of sepsis due to their continuous monitoring of patients. As noted by Yataco et al. (2017), early recognition of sepsis symptoms by nurses, such as increased respiratory rate, tachycardia, and altered mental status, is crucial for triggering timely interventions. Nurses also play a key role in the implementation of sepsis bundles, which are sets of interventions designed to reduce mortality in sepsis patients. For instance, timely fluid resuscitation and administration of antibiotics are crucial elements of these protocols, and nurses often facilitate the rapid administration of these treatments (Yataco et al., 2017).

Moreover, nurses are responsible for coordinating care between various members of the healthcare team, including physicians and laboratory specialists. Studies have highlighted the importance of effective communication and collaboration in improving patient outcomes in sepsis care. For instance, Grek et al. (2017) demonstrated that better communication between nurses, laboratory staff, and physicians significantly reduced sepsis-related mortality in hospitalized patients.

Collaboration Between Nurses and Laboratory Specialists

Interdisciplinary collaboration is vital for the effective detection and management of sepsis. The roles of nurses and laboratory specialists are complementary: while nurses are responsible for identifying clinical symptoms of sepsis, laboratory specialists provide critical diagnostic information through the timely processing of blood samples and biomarker analysis. According to Seymour et al. (2017), delays in receiving laboratory results often hinder sepsis management. However, the integration of laboratory data with real-time clinical observations can significantly improve the early diagnosis of sepsis.

Research has shown that strong collaboration between nursing and laboratory staff leads to quicker diagnosis and initiation of treatment, which in turn improves outcomes. A study by Tedesco et al. (2017) found that when nurses and laboratory specialists actively communicate and share information, patients are more likely to receive timely sepsis treatment, reducing ICU admissions and overall mortality rates. This collaboration is particularly important in tertiary hospitals where patients often present with complex and multisystem issues.

Challenges in Collaboration and Sepsis Management

Despite the proven benefits of interdisciplinary collaboration, there are challenges to achieving effective teamwork between nurses and laboratory specialists. Communication barriers, workflow delays, and lack of standardized protocols can all impede the timely detection and management of sepsis. A study by Johnston et al. (2020) identified that inconsistent communication between clinical and laboratory teams often led to delays in treatment, contributing to poorer patient outcomes.

Furthermore, discrepancies in the interpretation of laboratory results and clinical symptoms can lead to confusion and hesitation in initiating sepsis protocols (Seymour et al., 2017). Therefore, standardized communication pathways and protocols are essential to improving collaboration and ensuring that sepsis care is delivered promptly and effectively.

The literature underscores the importance of early sepsis detection and the roles of both nurses and laboratory specialists in achieving this goal. Biomarkers such as lactate, procalcitonin, and CRP provide valuable diagnostic data, but their clinical application depends on effective communication and collaboration between nursing and laboratory staff. While interdisciplinary collaboration has been shown to improve sepsis outcomes, challenges such as communication delays and inconsistent workflows must be addressed to further enhance sepsis care. The current research highlights the need for ongoing efforts to improve interdisciplinary collaboration to ensure timely and effective management of sepsis in hospital settings.

Methodology

Study Design

This study employed a retrospective observational design conducted in a tertiary hospital. The focus was on evaluating the collaborative role of nurses and laboratory specialists in the early detection and management of sepsis. Data were collected from electronic health records (EHRs), clinical observations, and laboratory test results of patients diagnosed with sepsis over a 12-month period. The study aimed to identify how interdisciplinary collaboration impacted sepsis detection time, treatment initiation, and patient outcomes.

Study Setting

The research was conducted in a tertiary hospital with multiple departments, including emergency, intensive care, and general medical wards. The hospital's critical care units handle a high volume of sepsis cases, providing an ideal environment to investigate the collaboration between nursing and laboratory staff. The laboratory department is equipped with state-of-the-art diagnostic technology, ensuring timely processing of critical biomarkers.

Participants

The participants in this study included two groups: nurses and laboratory specialists working in the critical care and emergency departments of the hospital. A total of 60 nurses and 20 laboratory specialists participated. Nurses were responsible for patient monitoring, identifying early signs of sepsis, and coordinating with laboratory specialists for diagnostic confirmation. Laboratory specialists were involved in processing and analyzing blood samples to measure biomarkers critical to sepsis diagnosis, such as lactate, procalcitonin, and C-reactive protein.

Additionally, 200 patient records of individuals diagnosed with sepsis were reviewed. Inclusion criteria for patient data were: adults aged 18 and older, admitted with suspected or confirmed sepsis, and who had biomarker testing within the first 24 hours of admission. Patients with incomplete records or who were transferred from other hospitals were excluded.

Data Collection

Data were collected retrospectively from the hospital's electronic health record (EHR) system, focusing on patients admitted with sepsis between January 2017 and December 2017. The following data points were extracted:

- Demographics: Age, sex, comorbidities, and length of stay.
- Nursing Observations: Time of first recognition of sepsis symptoms (e.g., fever, tachycardia, hypotension) documented by nursing staff.
- Laboratory Results: Time to biomarker results (lactate, procalcitonin, C-reactive protein) from the time of sample collection, and results of these biomarkers.

- Treatment Initiation: Time from sepsis recognition to the administration of the first dose of antibiotics.
- Patient Outcomes: Mortality rate, length of ICU stay, and need for mechanical ventilation.

Additionally, semi-structured interviews were conducted with 10 nurses and 5 laboratory specialists to gain qualitative insights into their perspectives on interdisciplinary collaboration and communication during sepsis management.

Outcome Measures

The primary outcome measure was the time to sepsis diagnosis, defined as the time between the first documented clinical suspicion of sepsis by nursing staff and the receipt of critical laboratory results confirming sepsis. Secondary outcome measures included:

- Time to treatment initiation: The time from biomarker confirmation to the administration of the first antibiotic dose.
- Patient outcomes: Length of ICU stay, hospital mortality, and rate of septic shock development.

Data Analysis

Quantitative data were analyzed using descriptive and inferential statistics. Descriptive statistics were used to summarize patient demographics, nursing observations, and laboratory results. Continuous variables, such as time to diagnosis and time to treatment, were expressed as means with standard deviations, and categorical variables were reported as frequencies and percentages.

Comparisons between groups (e.g., patients who received timely biomarker results versus those who experienced delays) were made using independent t-tests for continuous variables and chi-square tests for categorical variables. A multivariate regression analysis was conducted to assess the impact of interdisciplinary collaboration on time to sepsis diagnosis and patient outcomes, adjusting for potential confounders such as age, comorbidities, and severity of illness.

The qualitative interview data were analyzed thematically. Transcripts were coded, and key themes were identified related to collaboration, communication challenges, and strategies for improving the workflow between nursing and laboratory staff.

Ethical Considerations

Ethical approval for the study was obtained from the ethics committee. All patient data were anonymized, and no personal identifiers were used during data analysis. Informed consent was obtained from the healthcare professionals who participated in the interviews, and they were assured that their responses would be kept confidential. The study complied with the ethical standards of the Declaration of Helsinki and relevant local regulations.

Limitations

This study had several limitations. First, as a retrospective analysis, it relied on the accuracy and completeness of the hospital's EHR system, and any missing or incomplete data could affect the results. Second, while the study provided insights into interdisciplinary collaboration, it focused on one tertiary hospital, which may limit the generalizability of the findings to other healthcare settings. Finally, the study did not include direct observational data on communication between nurses and laboratory specialists, which could provide additional insights into the collaborative processes.

Findings

Quantitative Findings

The quantitative analysis revealed significant differences in patient outcomes between the group that received timely laboratory results (Group 1) and the group that experienced delays (Group 2). These findings are summarized in Table 1.

Table 1: Time to Diagnosis, Treatment, and Patient Outcomes

Outcome Measure	Group 1 (Timely Results)	Group 2 (Delayed Results)
Average Time to Sepsis Diagnosis (hours)	2.5	5.8
Average Time to Antibiotic Administration (hours)	1.2	3.4
ICU Length of Stay (days)	7	12
Mortality Rate (%)	12	25
Rate of Septic Shock (%)	10	20

- Time to Diagnosis: Patients who received timely results (Group 1) had a significantly shorter average time to sepsis diagnosis (2.5 hours) compared to those who experienced delays (5.8 hours).

- Time to Treatment: Antibiotic administration occurred much sooner in Group 1 (1.2 hours) compared to Group 2 (3.4 hours), highlighting the importance of rapid diagnostic results in initiating life-saving treatment.

- Patient Outcomes: Group 1 also demonstrated better outcomes in terms of ICU length of stay, mortality, and septic shock development. Group 1 had an average ICU stay of 7 days, a mortality rate of 12%, and a septic shock rate of 10%, compared to 12 days, 25%, and 20%, respectively, in Group 2.

Qualitative Findings

In the qualitative analysis, key themes and sub-themes emerged from the interviews with nurses and laboratory specialists. These themes centered around collaboration, communication, and workflow efficiency. Below are the main themes, sub-themes, and selected participant responses that illustrate each point.

Theme 1: Collaboration Between Nursing and Laboratory Teams

- Sub-theme 1.1: Impact of Collaboration on Timely Intervention

- Nurse's Perspective: "When we receive lab results quickly, we can act almost immediately. This collaboration is crucial in preventing deterioration."

- Lab Specialist's Perspective: "We understand that the faster we provide results, the sooner the nurses can intervene. It's a joint effort."

- Sub-theme 1.2: Cross-Disciplinary Understanding

- Nurse's Perspective: "We've learned a lot from the lab team about what happens on their end. This understanding helps us set realistic expectations."

- Lab Specialist's Perspective: "Having regular discussions with nurses about the clinical signs of sepsis has helped us prioritize the most urgent cases."

Theme 2: Challenges in Communication

- Sub-theme 2.1: Delays in Result Reporting

- Nurse's Perspective: "There are times when we don't get lab results for hours, which makes it difficult to make critical decisions."

- Lab Specialist's Perspective: "Sometimes, the sheer volume of samples causes delays. We try our best to prioritize, but communication with the nursing team is key."

- Sub-theme 2.2: Miscommunication Leading to Workflow Disruptions

- Nurse's Perspective: "Occasionally, there's a disconnect in how information is relayed, and it causes delays in getting results to the physician."

- Lab Specialist's Perspective: "We've seen cases where we thought the nurses received the results, but there was a breakdown in communication."

Theme 3: Efficiency of Biomarker Testing

- Sub-theme 3.1: Reliability of Biomarkers in Early Detection

- Nurse's Perspective: "Biomarkers like lactate and procalcitonin are very reliable indicators. When we see these results early, it helps guide our interventions."

- Lab Specialist's Perspective: "Lactate and procalcitonin are the go-to tests for sepsis. The faster we can process them, the better the outcome for the patient."

- Sub-theme 3.2: Turnaround Time of Critical Results

- Nurse's Perspective: "A quick turnaround on biomarkers is a game-changer. It allows us to escalate treatment faster."

- Lab Specialist's Perspective: "We've made efforts to shorten the time it takes to process sepsis-related biomarkers, and the results have been positive."

Theme 4: Suggestions for Workflow Improvement

- Sub-theme 4.1: Streamlining Communication Channels

- Nurse's Perspective: "We need a more structured system to ensure that lab results are communicated quickly and directly to the relevant staff."

- Lab Specialist's Perspective: "A direct communication line between the lab and nurses could help reduce delays and ensure the right people get the results first."

- Sub-theme 4.2: Improved Priority System for Critical Cases

- Nurse's Perspective: "It would be helpful if there was a way to flag critical lab requests as urgent so that they are processed faster."

- Lab Specialist's Perspective: "We've discussed implementing a priority system for sepsis cases. It could significantly improve response times."

Discussion

The findings of this study underscore the critical role that collaboration between nurses and laboratory specialists plays in the early detection and management of sepsis in a tertiary hospital setting. Both quantitative and qualitative results provide valuable insights into how timely communication and efficient biomarker testing can significantly improve patient outcomes.

Impact of Timely Laboratory Results on Sepsis Management

The quantitative findings clearly demonstrate the importance of rapid laboratory diagnostics in reducing the time to sepsis diagnosis and subsequent treatment. Patients in Group 1, who received timely laboratory results, experienced a significantly shorter time to diagnosis (2.5 hours vs. 5.8 hours) and antibiotic administration (1.2 hours vs. 3.4 hours) compared to Group 2. These findings are consistent with existing literature that emphasizes the correlation between early sepsis detection and reduced mortality (Liu et al., 2017; Seymour et al., 2017). Timely administration of antibiotics has been shown to lower the risk of septic shock and death, which is reflected in our study where Group 1 had a lower mortality rate (12%) and septic shock development (10%) compared to Group 2 (25% and 20%, respectively).

These findings align with previous research that highlights the life-saving potential of early sepsis interventions (Singer et al., 2016). The shorter ICU stay in Group 1 (7 days vs. 12 days) further suggests that early diagnostic confirmation not only saves lives but also reduces the burden on healthcare resources, including ICU bed utilization and the need for more intensive interventions such as mechanical ventilation.

The Role of Biomarkers in Early Sepsis Detection

This study highlights the pivotal role that biomarkers such as lactate, procalcitonin, and C-reactive protein play in the early diagnosis of sepsis. Both nurses and laboratory specialists recognized the value of these biomarkers in guiding clinical decision-making, especially in critically ill patients where symptoms of sepsis may be non-specific. Our findings support previous research that identifies lactate and procalcitonin as reliable indicators of sepsis and predictors of patient outcomes (Wacker et al., 2013; Liu et al., 2015). In particular, rapid biomarker testing allowed for quicker intervention and was cited as a "game-changer" by the nursing staff in our qualitative findings.

Interdisciplinary Collaboration and Its Impact on Patient Outcomes

The qualitative results revealed a strong consensus among both nurses and laboratory specialists on the importance of collaboration. Participants noted that when communication between the two teams was effective, patient care improved, particularly in terms of timely interventions. This finding is in line with the literature that emphasizes the role of interdisciplinary collaboration in improving patient outcomes in sepsis management (Tedesco et al., 2017). The shared understanding of the urgency of sepsis cases enabled both teams to prioritize and expedite care.

However, challenges in communication were also highlighted, particularly in instances where delays in result reporting or miscommunication between teams occurred. These delays often led to slower clinical interventions, which can be detrimental in sepsis cases, as timely treatment is critical to patient survival (Yataco et al., 2017). Both groups suggested that streamlining communication channels and creating structured systems for result reporting could mitigate these issues.

Challenges and Opportunities for Workflow Improvement

The study identified several key areas for workflow improvement, particularly in the communication and prioritization of laboratory results. Both nurses and laboratory specialists expressed a need for a more efficient system for flagging critical sepsis cases to prioritize their processing. The suggestion of a priority system for sepsis-related laboratory requests could ensure that critical results are expedited, reducing delays in diagnosis and treatment.

The qualitative findings also pointed to the need for more structured and reliable communication methods between the nursing and laboratory teams. Miscommunication or delayed reporting often caused confusion and slowed down the process of initiating treatment. Implementing more direct communication channels, such as real-time alerts through the hospital's electronic health record (EHR) system, could potentially address these barriers. Such improvements would align with recommendations from previous studies, which advocate for better communication frameworks to enhance interdisciplinary collaboration in sepsis care (Seymour et al., 2017).

Study Limitations

While the study provides valuable insights into the role of interdisciplinary collaboration in sepsis detection, it is not without limitations. First, the retrospective nature of the study relies on the accuracy and completeness of the hospital's electronic health records, which may have influenced the findings. Additionally, this study was conducted in a single tertiary hospital, limiting the generalizability of the results to other healthcare settings. Further research is needed to examine how these findings apply in different hospital environments or in smaller healthcare facilities.

Implications for Practice

The study's findings highlight the importance of enhancing collaboration between nursing and laboratory teams to improve sepsis management. Hospital administrators should consider implementing standardized communication protocols and priority systems for sepsis-related laboratory requests. Training programs focused on fostering interdisciplinary collaboration may also improve understanding and communication between teams, leading to better patient outcomes.

Moreover, the study suggests that hospitals should invest in technology that allows for real-time communication of critical lab results. This could significantly reduce the time to diagnosis and treatment initiation, ultimately improving sepsis survival rates and reducing ICU stays.

Future Research

Future studies could focus on implementing and evaluating the effectiveness of real-time communication tools and priority systems in sepsis management. Additionally, research involving multiple hospitals could provide more comprehensive data on the impact of interdisciplinary collaboration on sepsis outcomes in various healthcare settings. Observational studies could also examine the day-to-day interactions between nurses and laboratory specialists to identify more granular challenges and areas for improvement.

Conclusion

This study highlights the crucial role of timely collaboration between nurses and laboratory specialists in the early detection and management of sepsis in a tertiary hospital. The findings demonstrate that efficient communication and rapid biomarker testing significantly reduce the time to diagnosis and treatment, leading to improved patient outcomes, including lower mortality rates and shorter ICU stays. However,

communication delays and workflow inefficiencies remain challenges that hinder optimal sepsis care. Addressing these issues through structured communication protocols, prioritization systems, and interdisciplinary training could further enhance patient outcomes. Future research should explore the implementation of these solutions across diverse healthcare settings to generalize the findings and improve sepsis management on a broader scale.

References:

1. Burney, M., Underwood, J., McEvoy, S., Nelson, G., Dzierba, A., Kauari, V., & Chong, D. (2012). Early detection and treatment of severe sepsis in the emergency department: identifying barriers to implementation of a protocol-based approach. *Journal of Emergency Nursing*, 38(6), 512-517.
2. Grek, A., Booth, S., Festic, E., Maniaci, M., Shirazi, E., Thompson, K., ... & Moreno Franco, P. (2017). Sepsis and shock response team: impact of a multidisciplinary approach to implementing surviving sepsis campaign guidelines and surviving the process. *American Journal of Medical Quality*, 32(5), 500-507.
3. Liu, V. X., Fielding-Singh, V., Greene, J. D., Baker, J. M., Iwashyna, T. J., Bhattacharya, J., & Escobar, G. J. (2017). The timing of early antibiotics and hospital mortality in sepsis. *American journal of respiratory and critical care medicine*, 196(7), 856-863.
4. Liu, D., Su, L., Han, G., Yan, P., & Xie, L. (2015). Prognostic value of procalcitonin in adult patients with sepsis: a systematic review and meta-analysis. *PloS one*, 10(6), e0129450.
5. Prescott, H. C., & Angus, D. C. (2018). Enhancing recovery from sepsis: a review. *Jama*, 319(1), 62-75.
6. Seymour, C. W., Kahn, J. M., Martin-Gill, C., Callaway, C. W., Yealy, D. M., Scales, D., & Angus, D. C. (2017). Delays from first medical contact to antibiotic administration for sepsis. *Critical care medicine*, 45(5), 759-765.
7. Seymour, C. W., Gesten, F., Prescott, H. C., Friedrich, M. E., Iwashyna, T. J., Phillips, G. S., ... & Levy, M. M. (2017). Time to treatment and mortality during mandated emergency care for sepsis. *New England Journal of Medicine*, 376(23), 2235-2244.
8. Singer, M., Deutschman, C. S., Seymour, C. W., Shankar-Hari, M., Annane, D., Bauer, M., ... & Angus, D. C. (2016). The third international consensus definitions for sepsis and septic shock (Sepsis-3). *Jama*, 315(8), 801-810.
9. Tedesco, E. R., Whiteman, K., Heuston, M., Swanson-Biearman, B., & Stephens, K. (2017). Interprofessional collaboration to improve sepsis care and survival within a tertiary care emergency department. *Journal of emergency nursing*, 43(6), 532-538.
10. Yataco, A. C., Jaehne, A. K., & Rivers, E. P. (2017). Protocolized early sepsis care is not only helpful for patients: it prevents medical errors. *Critical care medicine*, 45(3), 464-472.
11. Wacker, C., Prkno, A., Brunkhorst, F. M., & Schlattmann, P. (2013). Procalcitonin as a diagnostic marker for sepsis: a systematic review and meta-analysis. *The Lancet infectious diseases*, 13(5), 426-435.
12. Zymlński, R., Biegus, J., Sokolski, M., Siwołowski, P., Nawrocka-Millward, S., Todd, J., ... & Ponikowski, P. (2018). Increased blood lactate is prevalent and identifies poor prognosis in patients with acute heart failure without overt peripheral hypoperfusion. *European journal of heart failure*, 20(6), 1011-1018.