A Comparative Study of Nursing Practices and Outcomes of Care for Children with Sepsis Using Systemic Inflammatory Response Syndrome and Thammasat Pediatric Early Warning Scores Criteria and Thammasat University Hospital Pediatric Sepsis Screening Scores

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Extended Abstract:

Sepsis is a life-threatening condition and a leading cause of morbidity and mortality in hospitalized children. Early recognition of sepsis and timely initiation of treatment can reduce complications and mortality. The Thammasat University Hospital pediatric sepsis protocol consists of a sepsis screening tool and pediatric sepsis guidelines based on the Surviving Sepsis Campaign Guidelines for Pediatrics. Clinical tools, such as the Systemic Inflammatory Response Syndrome (SIRS) criteria, combined with the Thammasat Pediatric Early Warning Scores (TPEWS), have long served as standard frameworks in pediatric sepsis screening and care escalation. However, a new version of institution-specific screening tools, the Thammasat University Hospital Pediatric Sepsis Screening Score (TUH pediatric sepsis screening score), has been developed aiming at improving early detection. This retrospective comparative study aimed to evaluate nursing practice and clinical outcome associated with the use of SIRS plus TPEWS criteria versus the TUH pediatric sepsis screening score. The study applied the Donabedian Model of quality assessment, consisting of three components, which include 1) the structure component covering the original and new versions of sepsis screening protocol, 2) the process involving the actual activities, such as assessment of sepsis according to sepsis screening protocol and timely administration of antibiotic within one hour, and 3) the outcome dimension encompassing key clinical indicators, such as incidence of septic shock, sepsis-related mortality, and registered nurse satisfaction with the screening tools used.

Outcome data were collected using the original pediatric sepsis protocol, which included the SIRS criteria and the TPEWS from December 2020 to March 2022, and the new version of the TUH Pediatric Sepsis Screening Score from April 2022 to July 2023. Data were collected from the Electronic Medical Records (EMR) of a sample of pediatric patients at risk for sepsis who were admitted to the pediatric ward at Thammasat University Hospital. The sample was selected through purposive sampling. Inclusion criteria comprised pediatric patients with a fever and a body temperature

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above 38.5 °C. Exclusion criteria were: 1) presentation with septic shock prior to hospital admission, 2) incomplete or missing data, 3) family refusal or termination of treatment, and 4) being transferred to another healthcare facility. The researcher obtained patient medical records that met the inclusion criteria from the Information Technology Office at Thammasat University Hospital. The patient sample was categorized into two groups: 281 pediatric patients who received the original version of the pediatric sepsis protocol, and 514 pediatric patients who received the new version of the protocol. Nurse satisfaction with the pediatric sepsis protocol was assessed from 43 registered nurses. Inclusion criteria for the nurse participants: 1) a minimum of three years of experience in pediatric care, 2) prior experience with nursing practices under both the original and new versions of the pediatric sepsis protocol, and 3) willingness to participate in the study. The researcher collected data using questionnaires enclosed in an envelope and distributed directly to the selected nurse participants for self-completion. The research instruments included: the Pediatric Patient Data Recording Forms, the SIRS and TPEWS Assessment Form, the TUH Pediatric Sepsis Screening Score Assessment Form, the Nursing Care Documentation Forms, the Clinical Outcomes Assessment Form, the Nurse Demographic Data Recording Forms, and the Nurse Satisfaction with the Pediatric Sepsis Protocol Questionnaire. The content validity index (CVI) of all research instruments was equal to 1. The reliability coefficients of the satisfaction of nurses with the original version and the new version of the Pediatric Sepsis Protocol Questionnaire, as measured by Cronbach's alpha, were .95 and .97, respectively. SPSS version 29 was used to analyze the data and determine statistical significance at .05. Data were analyzed using descriptive statistics, chi-square, Fisher's exact test, independent t-tests, and paired t-tests.

The research findings revealed that the sepsis in pediatrics using the TUH pediatric sepsis screening score assessment and the administration of the antibiotic within one hour were significantly greater, but the rate of septic shock was significantly lower than using the SIRS plus TPEWS assessment ($\chi^2 = 10.66$, $p < .05$); the mortality from sepsis was not a significant difference ($p > .05$). Registered nurses reported significantly higher satisfaction both overall and across all dimensions when using the new version of the pediatric sepsis protocol than the original version ($t = -5.50$, $p < .05$). The findings of this study have significant implications for pediatric sepsis management. These results support the use of the TUH Pediatric Sepsis Screening Score as a more effective and user-friendly tool for early identification and management of pediatric sepsis in clinical practice.

Keywords: Mortality, Pediatric sepsis protocol, Pediatric sepsis nursing care, Sepsis, Septic shock

Author contributions:

YS: Conceptualization, method and design, tool development and validation, data collection, analysis and interpretation, drafting, reviewing, and editing the manuscript, and final approval of the submitted version

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การศึกษาเปรียบเทียบการปฏิบัติการพยาบาลและผลลัพธ์การดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือดตามแนวทางการประเมินแบบ Systemic Inflammatory Response Syndrome ร่วมกับ Thammasat Pediatric Early Warning Scores และ Thammasat University Hospital Pediatric Sepsis Screening Scores

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บทคัดย่อขยาย :

ภาวะติดเชื้อในกระแสเลือดเป็นภาวะคุกคามต่อชีวิตและเป็นสาเหตุการเจ็บป่วยและเสียชีวิตที่สำคัญในเด็กที่เข้ารับการรักษาในโรงพยาบาล การค้นหาผู้ป่วยและให้การดูแลอย่างรวดเร็วจะช่วยลดภาวะแทรกซ้อนและการเสียชีวิตได้ แนวทางการดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือดในโรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ ประกอบด้วยเครื่องมือในการคัดกรองภาวะติดเชื้อในกระแสเลือดและแนวทางการดูแลรักษาอ้างอิงจาก Surviving Sepsis Campaign Guidelines เครื่องมือทางคลินิก ได้แก่ เกณฑ์การตอบสนองต่อการอักเสบทั่วร่างกาย (Systemic Inflammatory Response Syndrome: SIRS) ที่ใช้ร่วมกับการประเมินสัญญาณเตือนก่อนเข้าสู่ภาวะวิกฤตในเด็ก (Thammasat Pediatric Early Warning Scores: TPEWS) ที่ใช้เป็นมาตรฐานมาอย่างยาวนานสำหรับคัดกรองภาวะติดเชื้อในกระแสเลือดในเด็กและยกระดับการดูแลรักษา อย่างไรก็ตาม โรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติได้มีการพัฒนาเครื่องมือคัดกรองแบบใหม่ คือ แบบประเมิน Thammasat University Hospital (TUH) Pediatric Sepsis Screening Score มีเป้าหมายเพื่อปรับปรุงประสิทธิภาพในการค้นพบผู้ป่วยในระยะแรก การวิจัยครั้งนี้เป็นการศึกษาเปรียบเทียบย้อนหลังมีวัตถุประสงค์เพื่อประเมินการปฏิบัติการพยาบาลและผลลัพธ์ทางคลินิกที่ใช้การประเมินกลุ่มอาการตอบสนองต่อการอักเสบทั่วร่างกาย (SIRS) ร่วมกับการประเมินสัญญาณเตือนก่อนเข้าสู่ภาวะวิกฤตในเด็ก (TPEWS) เปรียบเทียบกับการประเมิน TUH Pediatric Sepsis Screening Score โดยใช้กรอบแนวคิดการประเมินคุณภาพการดูแลของโดนาบีเดียนเป็นแนวทางการวิจัย ประกอบด้วย 3 องค์ประกอบ ได้แก่ 1) โครงสร้าง คือ แนวทางการคัดกรองภาวะติดเชื้อในกระแสเลือดแบบเดิมและแบบใหม่ 2) กระบวนการ เกี่ยวข้องกับกิจกรรมที่ปฏิบัติจริงในการประเมินภาวะติดเชื้อในกระแสเลือดตามแนวทางการคัดกรองผู้ป่วยและการให้ยาปฏิชีวนะอย่างรวดเร็วภายใน 1 ชั่วโมง และ 3) ผลลัพธ์ ครอบคลุมตัวชี้วัดทางคลินิกที่สำคัญ ได้แก่ การเกิดภาวะช็อค การเสียชีวิตจากการติดเชื้อในกระแสเลือด และความพึงพอใจของพยาบาลวิชาชีพต่อการใช้เครื่องมือคัดกรอง

ในการเก็บรวบรวมข้อมูล ใช้แนวทางการดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือดแบบเดิมที่มีการประเมินกลุ่มอาการตอบสนองต่อการอักเสบทั่วร่างกาย (SIRS) ร่วมกับการประเมินสัญญาณเตือน

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วันที่รับบทความ 5 มีนาคม 2568 วันที่แก้ไขบทความ 22 เมษายน 2568 วันตอบรับบทความ 25 เมษายน 2568

ก่อนเข้าสู่ภาวะวิกฤต (TPEWS) ระหว่างธันวาคม 2563 ถึงมีนาคม 2565 และแนวทางการดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือดแบบใหม่ที่มีการประเมิน TUH pediatric sepsis screening score ระหว่างเดือนเมษายน 2565 ถึงกรกฎาคม 2566 เก็บรวบรวมข้อมูลจากเวชระเบียนอิเล็กทรอนิกส์ของกลุ่มตัวอย่างผู้ป่วยเด็กที่มีความเสี่ยงต่อการเกิดภาวะติดเชื้อในกระแสเลือดและเข้ารับการรักษาในหอผู้ป่วยกุมารเวชกรรม โรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ คัดเลือกกลุ่มตัวอย่างแบบเฉพาะเจาะจง เกณฑ์คัดเข้า คือ ผู้ป่วยเด็กที่มาด้วยอาการไข้ อุณหภูมิร่างกายมากกว่าหรือเท่ากับ 38.5 องศาเซลเซียส เกณฑ์คัดออก คือ 1) ผู้ป่วยที่มีภาวะช็อคตั้งแต่แรกรับเข้ารักษาในโรงพยาบาล 2) เวชระเบียนที่บันทึกข้อมูลไม่สมบูรณ์ 3) ญาติปฏิเสธการรักษาหรือขอยุติการรักษา 4) ผู้ป่วยที่ได้รับการส่งต่อไปโรงพยาบาลอื่น ผู้วิจัยคัดเลือกเวชระเบียนผู้ป่วยที่เป็นไปตามเกณฑ์คัดเข้าจากข้อมูลที่ได้รับจากงานสารสนเทศ กลุ่มตัวอย่างแบ่งออกเป็น 2 กลุ่ม คือ กลุ่มที่ได้รับการดูแลตามแนวทางแบบเดิมจำนวน 281 ราย และกลุ่มที่ได้รับการดูแลตามแนวทางแบบใหม่จำนวน 514 ราย และความพึงพอใจของพยาบาลต่อการปฏิบัติตามแนวทางการดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือด จำนวน 43 ราย เกณฑ์คัดเข้า คือ 1) มีประสบการณ์ทำงานดูแลผู้ป่วยเด็กอย่างน้อย 3 ปี 2) มีประสบการณ์ดูแลผู้ป่วยตามแนวทางการดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือดทั้งแบบเก่าและใหม่ 3) มีความสมัครใจเข้าร่วมการวิจัย ผู้วิจัยเก็บรวบรวมข้อมูลโดยใช้แบบสอบถามซึ่งใส่ซองเอกสารและแจกจ่ายโดยตรงให้กับกลุ่มตัวอย่างพยาบาลเป็นผู้ตอบแบบสอบถามเอง เครื่องมือที่ใช้ในการวิจัยประกอบด้วย แบบบันทึกข้อมูลทั่วไปผู้ป่วย แบบบันทึกการประเมิน SIRS และ TPEWS แบบบันทึกการประเมิน TUH pediatric sepsis screening score แบบบันทึกการดูแลผู้ป่วย แบบประเมินผลลัพธ์การดูแล แบบสอบถามข้อมูลส่วนบุคคลของพยาบาล และแบบสอบถามความพึงพอใจของพยาบาลต่อแนวทางการดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือด เครื่องมือที่ใช้ในการวิจัยทุกชนิดผ่านการตรวจสอบความตรงเชิงเนื้อหา ได้ค่าดัชนีความตรงเชิงเนื้อหา (CVI) เท่ากับ 1 และตรวจสอบความเชื่อมั่น (reliability) ของแบบสอบถามความพึงพอใจของพยาบาลต่อแนวทางการดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือดแบบเดิมและแบบใหม่โดยใช้สัมประสิทธิ์แอลฟาครอนบาค ได้ค่าความเชื่อมั่นเท่ากับ .95 และ .97 ตามลำดับ วิเคราะห์ข้อมูลโดยใช้โปรแกรมสำเร็จรูป SPSS เวอร์ชัน 29 กำหนดระดับนัยสำคัญทางสถิติ เท่ากับ 0.05 สถิติที่ใช้ ได้แก่ สถิติบรรยาย chi-square, Fisher's exact test, independent t-test และ paired t-test

ผลการวิจัยพบว่า การเกิดภาวะติดเชื้อในกระแสเลือดของผู้ป่วยเด็กและการได้รับยาปฏิชีวนะภายใน 1 ชั่วโมงในกลุ่มที่ใช้เกณฑ์การประเมินด้วย TUH pediatric sepsis screening score มากกว่า แต่การเกิดภาวะช็อคจากการติดเชื้อในกระแสเลือดต่ำกว่ากลุ่มที่ใช้เกณฑ์การประเมินด้วย SIRS ร่วมกับ TPEWS อย่างมีนัยสำคัญทางสถิติ (χ^2 = 10.66, $p < .05$) ส่วนอัตราการเสียชีวิตจากภาวะติดเชื้อในกระแสเลือดไม่แตกต่างกัน ($p > .05$) และความพึงพอใจโดยรวมและทุกด้านของพยาบาลต่อการปฏิบัติตามแนวทางการดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือดแบบใหม่มากกว่าแบบเดิมอย่างมีนัยสำคัญทางสถิติ ($t = -5.50$, $p < .05$) ผลการวิจัยครั้งนี้มีความสำคัญต่อการจัดการภาวะติดเชื้อในกระแสเลือดในเด็ก ผลลัพธ์นี้สนับสนุนการใช้แบบประเมิน TUH pediatric sepsis screening score ซึ่งเป็นเครื่องมือที่มีประสิทธิภาพและใช้งานง่ายสำหรับการระบุภาวะติดเชื้อในกระแสเลือดระยะแรกในผู้ป่วยเด็กและการจัดการทางคลินิก

คำสำคัญ : การเสียชีวิต แนวทางการดูแลผู้ป่วยเด็กติดเชื้อในกระแสเลือด การพยาบาลผู้ป่วยเด็กติดเชื้อในกระแสเลือด ภาวะติดเชื้อในกระแสเลือด ภาวะช็อคจากการติดเชื้อ

Introduction

Sepsis is a systemic inflammatory response syndrome (SIRS) caused by exposure to various pathogenic microorganisms that lead to the severity of multiple organ dysfunction syndrome.[1] Sepsis is a life-threatening condition and a major cause of mortality. Moreover, sepsis is the cause of death of as many as one in four people around the world.[2] According to the World Health Organization (WHO), 11 million deaths from sepsis worldwide, accounted for 20% of all deaths in 2020.[3] In children younger than five years old, approximately 2.9 million deaths were found from sepsis. There were approximately 454,000 deaths reported for children and adolescents aged 5-19 years.[4] In Thailand, the Ministry of Public Health determined the target decrease in the rate of deaths caused by severe sepsis should be lower than 26% in 2023,[5] but the performance of the Ministry of Public Health found 35.73% of the rate of deaths caused by sepsis in pediatric and adult patients.[6] Factors associated with sepsis and mortality in patients were gender, age, severity of illness, comorbidity, and access to invasive catheter.[7,8] In addition, delayed antibiotic administration, inadequate fluid resuscitation, and delayed treatment are important factors in severe infection and mortality.[9,10,11]

Mortality caused by sepsis is not dependent on early treatment alone, it is dependent on the timeliness of recognition and treatment, which has led to the successful implementation of care.[12] In 2020, the Surviving Sepsis Campaign Guidelines in pediatrics developed pediatric sepsis and septic shock guidelines that emphasized early recognition. It is an important strategy that increases the survival of patients. Early recognition will help healthcare providers timely identify patients with sepsis and provide early treatment during the early stage of the disease, resulting in rapid cardiovascular system recovery, reduced organ dysfunction, and decreased mortality.[13]

In 2019, Thammasat University Hospital began using pediatric sepsis protocol with SIRS criteria (Systemic Inflammatory Response Syndrome) assessment and abnormal vital signs in the pediatric intensive care unit (PICU) and emergency room. Inpatient pediatric wards were using Thammasat Pediatric Early Warning Scores (TPEWS)[14] to assess all pediatric patients who were admitted to the hospital. It determined the target rate of deaths caused by septic shock in pediatrics should be lower than 5%. According to statistics in 2020 and 2021, the mortality of pediatric patients with septic shock was 11.8% and 7.2%, respectively. A review problem shows that the cause of care in pediatric patients with sepsis dose not achieved; delay recognition leads to delayed resuscitation and severe sepsis.[15]

Later, the Pediatric Thammasat University Critical Care Team developed and improved a new version of the Thammasat University Hospital Pediatric Sepsis Protocol that was used from April 2022 onwards, consisting of the Thammasat University Hospital pediatric sepsis screening score (TUH Pediatric Sepsis Screening Score) assessment form and pediatric sepsis guidelines[16] based on the Surviving Sepsis Campaign Guidelines in Pediatric 2020, which emphasize early recognition to achieve treatment goals.[13] Furthermore, the Surviving Sepsis Campaign Guidelines suggest that antibiotics should

be given within one hour after diagnosis of sepsis to inhibit the body's reaction to pathogens and affect organ dysfunction. Therefore, it can reduce death.[13] The most mortality of pediatric patients with sepsis occurs within 48-72 hours after sepsis recognition. The most common causes of death were refractory shock (34%) and multiple organ dysfunction syndrome (27%).[17] Therefore, if healthcare provider teams can identify patients with sepsis in an early stage in timely and appropriate compliance with sepsis guidelines, their complications of sepsis and mortality can be decreased.[18]

Nurses are key people who closely care for patients and play a role in the assessment and screening of patients. A literature review found sepsis outcomes improved after the implementation of a sepsis screening tool and sepsis care bundles, such as a decrease in septic shock, organ dysfunction, ICU and hospital length of stay, and mortality.[19,20] Early recognition is important in pediatric sepsis management. Delay in diagnosis was associated with prolonged time to treatment of antibiotics, which affected mortality.[21] Nursing practices according to the pediatric sepsis protocol will help provide effective care for patients and improve outcomes. It can increase the quality of health care.[19] According to the Donabedian concept framework,[22] if the nurse is satisfied with the implementation of the pediatric sepsis protocol, it will be used as a tool in practice and will lead to good quality health care.[23] However, there has not been a comparative study of outcomes of the new assessment and care guidelines with the TUH pediatric sepsis screening score and original assessment and care guidelines with SIRS and TPEWS. Therefore, the researcher was interested in a comparative study of the results of nursing practices and outcomes of care according to the pediatric sepsis protocol including the satisfaction of nurses in the implementation of pediatric sepsis protocol. The results of this study can be used to develop and encourage nurses to follow sepsis protocol so that patients are safe, reduce the severity of septic shock, reduce mortality, and develop more effective patient care.

Objectives of the study

1. To compare the sepsis in children between using the SIRS with TPEWS assessment (the original version pediatric sepsis protocol) and the TUH sepsis screening score assessment (the new version pediatric sepsis protocol).

2. To compare the percentage of antibiotics administration within one hour between the original version pediatric sepsis protocol group and the new version pediatric sepsis protocol group.

3. To compare outcomes of care (septic shock and mortality caused by sepsis) between the original version pediatric sepsis protocol group and the new version pediatric sepsis protocol group.

4. To compare the satisfaction of registered nurses between using the original version pediatric sepsis protocol group and the new version pediatric sepsis protocol group.

Conceptual framework

The conceptual framework of this study was based on the Donabedian framework,[22] which

consisted of three interrelated components to assess the quality of care. The three components were as follows: 1) **Structure** refers to providing care within the context of the organization which includes policies and development plans for patient care that are established, 2) **Process** refers to activities that constitute health care, including diagnosis, treatment, rehabilitation, and prevention. These activities are performed by nurses to achieve good outcomes for their patients. 3) **Outcome** refers to changes in individuals as a result of receiving health services, such as change in health status, knowledge of self-care, change in the behavior of patients, and satisfaction with health services.

In this study, the improvement of pediatric sepsis outcomes is a demonstration of the quality of care, which consists of three components based on the Donabedian conceptual framework. The structure refers to the original and new versions of the Thammasat University Hospital Pediatric Sepsis Protocol, which are patient care policies developed by the Pediatric Thammasat University Critical Care Team, consisting of the TUH pediatric sepsis screening score and pediatric sepsis guidelines for early recognition and appropriate treatment on time, leading to decreased mortality. Human resources, such as nurse staff management. Supervision, such as nurses are educated through training sessions. Material resources and facilities, such as Computerized Physician Order Entry (CPOE) for prescription. The factors of nurse staff management, material resources, and prescribing-dispensing systems are administrative structures. Therefore, they are not studied at this time. Process refers to nursing activities according to the pediatric sepsis protocol evaluated by antibiotic administration within one hour. The outcomes of the implementation of the pediatric sepsis protocol were septic shock and mortality caused by sepsis. Moreover, satisfaction with the implementation of the pediatric sepsis protocol was the outcome in terms of nurses. Three components are interrelated. Good structure and implementation of pediatric sepsis protocol in a timely and complete manner result in good outcomes. The conceptual framework of this study is shown in Figure 1.

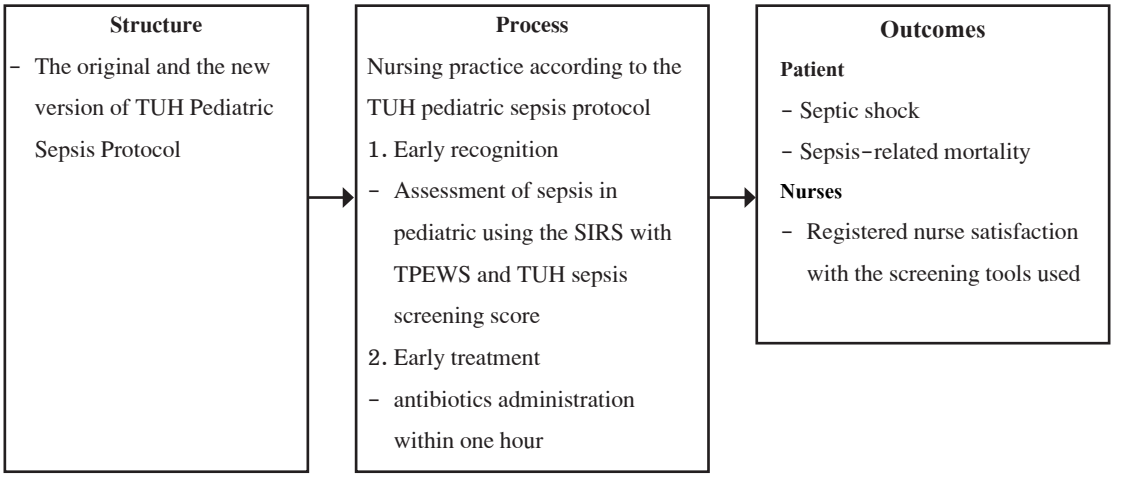

Figure 1 Conceptual framework of this study

Research hypothesis

1. The sepsis in children using TUH sepsis screening score assessment (new version pediatric sepsis protocol) is higher than using SIRS with TPEWS assessment (original version pediatric sepsis protocol).

2. The percentage of antibiotics administration within one hour in the new version pediatric sepsis protocol group is greater than in the original version pediatric sepsis protocol group.

3. The outcomes of care (septic shock and mortality caused by sepsis) in the new version pediatric sepsis protocol group are lower than the original version pediatric sepsis protocol group.

4. The satisfaction of registered nurses using the new version pediatric sepsis protocol group rather than the original version pediatric sepsis protocol group.

Methods

This research was a retrospective study, collecting data from patient medical records to compare nursing practices and care outcomes with survey research to compare the satisfaction of nurses between using an original version pediatric sepsis protocol group and a new version pediatric sepsis protocol group. The samples consisted of pediatric patients and registered nurses. The patient samples were males and females aged 0-15 years who were at risk for sepsis and admitted into the pediatric intensive care unit (PICU), pediatric general ward 1, pediatric general ward 2, and private pediatric ward of Thammasat University Hospital. The samples were recruited using purposive sampling. The inclusion criteria were pediatric patients with a fever and a body temperature above 38.5 °C. The exclusion criteria were as follows: 1) presentation with septic shock prior to hospital admission, 2) missing data, 3) family refusal or termination of treatment, and 4) patients transfer to another hospital. The patient samples were divided into 2 groups; there are 281 samples supervised according to the original version of the pediatric sepsis protocol that uses SIRS and TPEWS assessment (December 2020-March 2022), and 514 samples supervised according to the new version of the pediatric sepsis protocol that uses the TUH pediatric sepsis screening score (April 2022-July 2023). In addition, forty three nurses included in this study were employed in the Pediatric Intensive Care Unit (PICU), pediatric general ward 1, pediatric general ward 2, and private pediatric ward of Thammasat University Hospital. All participants had at least three years of experience in pediatric care; prior experience using both the original and new versions of the pediatric sepsis protocol; and were willing to participate in the study.

Instruments

The research instruments used in this study were divided into two types as follows:

1. Pediatric patient's data recording forms were composed of five parts as follows:

Part 1: Pediatric patient data recording forms consist of 11 items, including gender, age, main diagnosis, comorbidity, number of comorbidities, period of sepsis, diagnosis of sepsis by a physician,

vital signs and physiological changes, invasive catheter insertion over 48 hours, site of infection, and pathogen.

Part 2: SIRS and TPEWS assessment form according to the original version of pediatric sepsis protocol. It consists of 3 items, including SIRS criteria assessment 2 items and TPEWS assessment 1 item. SIRS criteria presence of at least two of the following four criteria, one of which must be abnormal temperature or leukocyte count which indicates that the patient is at risk for sepsis: 1) body temperature of > 38.5 or < 36 degrees Celsius 2) heart rate more than the normal range for age 3) respiratory rate more than the normal range for age and 4) abnormal white blood cell. The TPEWS[14] consists of eight physiological and vital signs parameters: body temperature, respiratory rate, work of breathing, heart rate, systolic blood pressure, pulse pressure, capillary refill time, oxygen saturation, and level of consciousness. Each parameter is scored from 0 to 3, resulting in a total possible score ranging from 0 to 24. A total score of 4 or higher indicates an increased risk of clinical deterioration to a critical condition.

Part 3: The TUH pediatric sepsis screening score assessment form according to the new version of the pediatric sepsis protocol. The TUH pediatric sepsis screening score was developed by the Pediatric Thammasat University Critical Care Team.[16] It consists of two items, including the risk of infection and the TUH pediatric sepsis screening score. For patients at risk for sepsis which one of the following should be assessed using the TUH pediatric sepsis screening score: body temperature of < 36 or ≥ 38.5 degrees Celsius, sign of infection, cancer that has received chemotherapy or radiotherapy and has not finished treatment for more than 6 months with fever, white blood cell < 5,000 or > 15,000 cells/cu.mm. or platelet < 80,000 cells/cu.mm. The TUH pediatric sepsis screening score consists of 7 parameters, including heart rate, respiratory rate, systolic blood pressure, pulse pressure, oxygen saturation, capillary refill, and consciousness. In each parameter range of 0-1 point, except for the systolic blood pressure range of 0-2 points. The total score is between 0-8 points. A cut point ≥ 2 points indicates that the patient is at risk for sepsis.

Part 4: The nursing care documentation form consists of one item, including time to antibiotic administration within one hour.

Part 5: The clinical outcomes assessment form consists of two items, including septic shock and mortality caused by sepsis diagnosed by the physician. Each item response is 'yes' or 'no'.

The content validity of the Pediatric patient data recording forms, SIRS and TPEWS assessment form, TUH pediatric sepsis screening score assessment form, nursing care documentation form, and clinical outcomes assessment form were examined by three experts, and its Content Validity Index (CVI) was equal to 1.0.

2. The satisfaction of nurses with the pediatric sepsis protocol questionnaire. It has two parts consisting of the satisfaction of nurses with the original and the new version of the pediatric sepsis protocol questionnaire. The questionnaire consists of 12 items, with a 5-Likert rating scale (highest, high, moderate, low, and lowest). In each questionnaire, it has the same questions covering content, difficulty of use, and

utilization. A high overall score and high scores in each dimension indicates a high level of satisfaction. The interpretation of the mean scores is classified into five levels as follows: 1) 4.51-5.00 indicates the highest level of satisfaction, 2) 3.51-4.50 indicates a high level of satisfaction, 3) 2.51-3.50 indicates moderate satisfaction, 4) 1.51-2.50 indicates low satisfaction, and 5) 1.00-1.50 indicates the lowest level of satisfaction.[24] The content validity of the questionnaire was examined by three experts, and its content validity index (CVI) was equal to 1. The reliability of Cronbach's alpha coefficient was .95 and .97, respectively.

Human subject protection

This research was approved by the Human Research Ethics Committee, Faculty of Medicine Ramathibodi Hospital, Mahidol University (COA. No. MURA2023/879) and the Human Research Ethics Committee of Thammasat University Hospital (007/2567). The researcher requested permission from the director of Thammasat University Hospital to search for patient medical records and to collect data from nurses before proceeding with data collection. Prior to data collection, the researcher explained the research objectives and procedures to the nurse, the right to participate or withdraw from the research at any time. It was emphasized that all information would be kept confidential, individual names would not be disclosed, and the findings would be reported in aggregate form. Those who agreed to participate were then asked to sign an informed consent form.

Data collection

The researcher collected data after approval from the Institutional Review Board and the research setting's authorities, as follows:

1. The researcher met with the heads of the pediatric intensive care unit, pediatric general ward 1, pediatric general ward 2, and private pediatric ward to explain the research details and seek permission to collect data.

2. Data collection was done in two phases as follows:

Phase I data collection from patient's medical records is as follows:

1) The researcher conducted a letter requesting data for children aged 0-15 years with fever, body temperature more than 38.5 degrees Celsius, and admitted to the pediatric intensive care unit, pediatric general ward 1, pediatric general ward 2, and private pediatric ward from December 1, 2020, to July 31, 2023, from the information database of Thammasat University Hospital.

2) The researcher obtained patient medical records that met the inclusion criteria from the Information Technology Office at Thammasat University Hospital. The patient samples were categorized into two groups: 281 pediatric patients who received the original version of the pediatric sepsis protocol, and 514 pediatric patients who received the new version of the protocol.

3) The researcher collected data from patients' Electronic Medical Record (EMR) using the following forms: the pediatric patient's data recording forms, the SIRS and TPEWS assessment form, the TUH

pediatric sepsis screening score assessment form, the nursing care documentation forms, and the clinical outcomes assessment form. Patients were excluded if their data was incomplete and did not meet inclusion criteria.

Phase II data collection from the nurse sample is as follows:

1) The researcher met with the head of the pediatric intensive care unit, pediatric general ward 1, pediatric general ward 2, and private pediatric ward to request nurse information operating in the ward and select nurses who meet the inclusion criteria from the head nurse of 43 nurses.

2) Before collecting data, the researchers introduced themselves to the nurse sample, and explained the research objectives, how to collect data, and subject protection. After the nurse agreed to participate in the study, the researcher obtained their written informed consent.

3) The researcher collected data using the nurse's data recording forms and the satisfaction of nurses with original and new versions of the pediatric sepsis protocol questionnaire. The questionnaire was enclosed in an envelope and directly distributed to the selected nurse participants for self-completion.

4) The researcher collected the completed questionnaires two weeks after they were distributed to the nurse participants. The head nurse was responsible for collecting all questionnaires, which were sealed in envelopes prior to being returned to the researcher to ensure confidentiality.

3. The researcher examines the completeness of the information before analyzing the data.

Statistical analysis

The SPSS version 29 was used to analyze the data and determine the statistical significance equal to 0.05. The descriptive statistics, including frequency, percentage, mean, and standard deviation were used to describe the pediatric patient's and nurse's data. For analyzing data on pediatric patients, a Chi-square test, Fisher's exact test, and an independent t-test were used to compare groups. The Chi-square test was used to compare the sepsis, antibiotic administration within one hour, and septic shock between the original and new versions of the pediatric sepsis protocol group. The Fisher's Exact Test was used to compare mortality caused by sepsis between the groups because it did not meet the assumption. The paired t-test was used to compare the satisfaction of registered nurses between using the original version pediatric sepsis protocol group and the new version pediatric sepsis protocol group.

Results

A total of 795 pediatric patients, 281 were in the original version of the pediatric sepsis protocol and 514 were in the new version of the pediatric sepsis protocol group. The majority of pediatric patients in both groups were male (56.20% and 53.10%, respectively). The mean age in the original version of the pediatric sepsis protocol group was 36.50 months (SD = 43.90, median = 16, mode = 1) and 39.46 months (SD = 39.40, median = 26, mode = 1) in the new version of pediatric sepsis protocol group. The most common main diagnosis in the original

version of the pediatric sepsis protocol group was gastrointestinal diseases (34.90%), and the new version of the pediatric sepsis protocol group was respiratory diseases (37.70%). The pediatric patients in both groups had one comorbidity, 20.00%, and 22.20%, respectively. The most common comorbidity in the original version of the pediatric sepsis protocol group was hematological diseases (26.60%), while in the new version of the pediatric sepsis protocol group was respiratory diseases (32.40%). In both groups, central venous catheters were found to be the most common invasive catheter insertion over 48 hours (77.80% and 85.70%). In the original version of the pediatric sepsis protocol group, 43.50% of infections were located in the gastrointestinal system, while 52.40% were located in the respiratory system in the new version of the pediatric sepsis protocol group. The most common pathogen in the original version of the pediatric sepsis protocol group was bacteria (77.50%), while in the new version of the pediatric sepsis protocol group was virus (52.50%). The differences in pediatric patient data were not significant between groups ($p > .05$), but the main diagnosis, site infection, and detected pathogens were significant differences ($p < .05$).

In the original versions of the pediatric sepsis protocol group, 47 patients (18.20%) had a TPEWS ≥ 4 and were diagnosed with sepsis, and 14 patients (2.60%) had a TPEWS ≥ 4 but did not have sepsis. In the new versions of the pediatric sepsis protocol group, 82 patients (31.80%) had a TUH pediatric sepsis screening score ≥ 2 and were diagnosed with sepsis, and 26 patients (4.90%) had a TUH pediatric sepsis screening score ≥ 2 but did not have sepsis. The sepsis in children using the TUH pediatric sepsis screening score assessment was significantly greater than using SIRS with TPEWS assessment ($p < .05$). (Table 1)

Table 1 Comparison of sepsis in children between using the SIRS with TPEWS assessment and the TUH sepsis screening score assessment.

sepsis	Original version (n = 281)		New version (n = 514)		X^2	p-value
	SIRS+TPEW < 4 (n = 220)	SIRS+TPEW ≥4 (n = 61)	TUH-PSSS < 2 (n = 406)	TUH-PSSS ≥ 2 (n = 108)		
Sepsis n (%)						
No sepsis	150 (27.90)	14 (2.60)	347 (64.60)	26 (4.90)	207.98	< .001
Sepsis	70 (27.10)	47 (18.20)	59 (22.90)	82 (31.80)		

The SIRS and TPEWS assessments demonstrated a sensitivity of 40.20% and specificity of 91.59%. In comparison, the TUH sepsis screening score showed a higher sensitivity of 58.20% and a specificity of 93.00%. (Tables 2 and 3)

Table 2 Sensitivity and specificity of sepsis using SIRS and TPEWS for screening sepsis. (n = 281)

Assessment	Sepsis		Total
	Sepsis n (%)	No sepsis n (%)	
SIRS+TPEW ≥ 4	47 (40.20)	14 (8.50)	61
SIRS+TPEW < 4	70 (59.80)	150 (91.50)	220
Total	117 (100)	164 (100)	281

Table 3 Sensitivity and specificity of sepsis using TUH Sepsis Screening Score for screening sepsis. (n = 514)

Assessment	Sepsis		Total
	Sepsis n (%)	No sepsis n (%)	
TUH-PSSS ≥ 2	82 (58.20)	26 (7.00)	108
TUH-PSSS < 2	59 (41.80)	347 (93.00)	406
Total	141 (100)	373 (100)	514

Note: TUH-PSSS = Thammasat University Hospital Pediatric Sepsis Screening Score

161 patients were receiving antibiotics in the original versions of the pediatric sepsis protocol group and 281 in the new versions of the pediatric sepsis protocol group. The antibiotic administrations within one hour were 58 patients (36.00%) for the original versions of the pediatric sepsis protocol group, with 161 patients (57.30%) for the new version of the pediatric sepsis protocol group. The percentage of antibiotics administration within one hour in the new version pediatric sepsis protocol group was significantly greater than in the original version pediatric sepsis protocol group ($p < .05$). (Table 4)

Table 4 Comparison of the antibiotic administration time between the original and new version pediatric sepsis protocol groups

Antibiotic administration time	Original version (n = 161)		New version (n = 281)		X^2	p-value
	Number	Percentage	Number	Percentage		
Within 1 hour	58	36.00	161	57.30	17.68	< .001
More than 1 hour	103	64.00	120	42.70		

In the original versions of the pediatric sepsis protocol group, 19 patients (6.80%) were in septic shock and 1 patient (0.40%) died from sepsis. In the new version of the pediatric sepsis protocol group, 10 patients (1.90%) were in septic shock and 1 patient (0.20%) died from sepsis. Septic shock in the new version of the pediatric sepsis protocol group was significantly lower than in the original version of the pediatric sepsis protocol group ($p < .05$). Mortality caused by sepsis in the original and new versions of the pediatric sepsis protocol group was not a significant difference ($p > .05$). (Table 5)

Table 5 Comparison of the outcomes of care between the original and new version pediatric sepsis protocol groups.

Outcomes of care	Original version (n = 281)		New version (n = 514)		X^2	p-value
	Number	Percentage	Number	Percentage		
Septic shock						
No septic shock	262	93.20	504	98.10	10.66[a]	.001
Septic shock	19	6.80	10	1.90		
Sepsis-related mortality						
No death	280	99.60	513	99.80	-[b]	1.000
Death	1	0.40	1	0.20		

a = chi-square, b = Fisher's exact test

There were 43 nurses in this study. All of them were females, with most being between 26-30 years of age (65.10%). The mean age was 30.02 years (SD = 3.40). The majority of nurses (95.30%) have a bachelor's degree. A total of 15 nurses (35.90%) were employed in the private pediatric ward. The majority of participants (48.80%) had between three and five years of professional experience in pediatric care. The average work experience was 6.93 years (SD = 3.69). The majority of nurse (n = 23; 53.50%) had received training on both the original and new versions of the pediatric sepsis protocol. The comparison of the satisfaction of registered nurses between using the original and new versions of the pediatric sepsis protocol groups revealed that the overall and each dimension satisfaction of registered nurses using the new version of the pediatric sepsis protocol was significantly higher than using the original version of the pediatric sepsis protocol ($p < .05$). (Table 6)

Table 6 Comparison of the satisfaction of registered nurses between the original and new version pediatric sepsis protocol groups.

Satisfaction of registered nurses	Original version (n = 43)			New version (n = 43)			t	p-value
	Mean	SD	Level	Mean	SD	Level		
Overall satisfaction dimension of satisfaction	4.07	0.62	high	4.54	0.49	Very high	-5.50	< .001
1. Content of the tools used in the assessment and pediatric sepsis protocol	4.09	0.58	high	4.50	0.53	high	-4.55	< .001
2. Difficulty in using the assessment tool and practices	3.90	0.79	high	4.52	0.58	Very high	-5.59	< .001
3. Utilization	4.12	0.68	high	4.57	0.51	Very high	-4.72	< .001

Discussion

The research findings indicate that the identification of sepsis in children using the TUH pediatric sepsis screening score assessment was significantly higher compared to the use of the SIRS combined with TPEWS assessment ($p < .05$), supporting the established hypothesis. This result may be attributed to the structure of the TUH pediatric sepsis screening score, which incorporates criteria based on abnormal vital signs and physiological indicators similar to those used in TPEWS but applies them specifically in the context of suspected infection. As a result, the TUH pediatric sepsis screening score allows for more accurate and timely identification of pediatric patients at risk for sepsis. According to the research findings, the TUH pediatric sepsis screening score can be used to screen for pediatric patients who may have sepsis (TUH-PSSS ≥ 2 points) for care more than the TPEWS assessment (TPEW ≥ 4 points) with two abnormal SIRS criteria. However, the final diagnosis showed that the patient has sepsis was 31.80% and no sepsis was 4.90%. It shows that the TUH pediatric sepsis screening score can increase sepsis alert and increase the chances of finding patients with sepsis. Moreover, the TUH pediatric sepsis screening score has a sensitivity of 58.20% and a specificity of 93.00% in screening for sepsis more accurate than the TPEWS assessment with two abnormal SIRS criteria, which has a sensitivity of 40.20% and a specificity of 91.50%. Based on standard indices, sensitivity or specificity ranges of 80-89% are considered acceptable. Consequently, further development of the tool is necessary.[25] Early recognition of TPEWS and TUH pediatric sepsis screening scores is the key to achieving the best clinical outcomes. According to international studies, a sepsis alert tool for pediatric patients was developed. It was found that after using the tool, the error rate in identifying patients with sepsis decreased from 17.3% to 3.8%.[19] Similarly, the study by Eisenberg et al. and Alturki et al. found that using an electronic alert system for sepsis screening resulted in patients being more identified and receiving faster treatment.[26,27] In addition, the original and new versions of the pediatric sepsis protocol that use SIRS and TPEWS assessment and TUH pediatric sepsis screening score with pediatric sepsis guidelines are consistent with the Surviving Sepsis Campaign Guidelines that focus on the early recognition and provide care based on the sepsis bundle.[13]

The rate of antibiotic administration within one hour was significantly higher in the group using the new version pediatric sepsis protocol compared to the original protocol group ($p < .05$), which is consistent with the established hypothesis. It can be described that nurses can follow new sepsis guidelines for more efficient sepsis screening, notify doctors when sepsis is detected, and quickly implement a medical treatment, which enables patients to receive antibiotics within one hour because these guidelines are designed to be clearer and easier for nurses to follow. Furthermore, the resources necessary to provide health services for antibiotic dispensing are affected by structured factors, which affect the administration of antibiotics within one hour. During the original version of the pediatric sepsis protocol, the medication dispensing system required submitting a treatment

order form with an urgent medication form, which was delivered to the pharmacy by ward staff. This process was time-consuming. But, during the new version of the pediatric sepsis protocol, the hospital began using the Computerized Physician Order Entry (CPOE) system. This allowed the medication orders from doctors to be instantly sent to pharmacists. In the case of urgent antibiotic requests, pharmacists would immediately prepare the medication, enabling nurses to administer the medication to patients promptly. Consistent with previous studies, it was found that implementation of the sepsis protocol significantly decreased the time to antibiotic administration to within 60 minutes ($p < .05$).[27,28] The results of this study showed that the patients in the new version of the pediatric protocol group were more likely to receive antibiotics within one hour. This is following the Surviving Sepsis Campaign Guidelines that suggest antibiotics should be given within one hour after diagnosis.[13]

Septic shock in the new version of the pediatric sepsis protocol group was significantly lower than in the original version of the pediatric sepsis protocol group ($p < .05$), which is consistent with the established hypothesis. It can be described that pediatric patients at risk of sepsis are supervised according to pediatric sepsis protocol, which includes tools for early recognition. This allows nurses to quickly screen and identify sepsis, leading to the timely initiation of treatment. The study showed that patients with the new version of the pediatric sepsis protocol group received antibiotics within one hour more than those supervised according to the original version of the pediatric sepsis protocol group. Antibiotics can prevent the body from reacting to pathogens and affecting organ dysfunction, which can help reduce septic shock. According to the study of Medeiros et al. studied the effect of pediatric sepsis protocol in the emergency room. The study found that following these guidelines significantly reduced the incidence of septic shock ($p < 0.001$).[29] The analysis showed no significant difference in sepsis-related mortality between the original and new pediatric sepsis protocol groups ($p > .05$), which does not support the initial hypothesis. It can be discussed that there may be several factors related to the mortality rate of patients with sepsis, including age, comorbidities, the severity of the disease, and delays in the care process.[7,10] The analysis of the overall data for both groups of patients who died from sepsis revealed that the patients were between one and six years old and had one comorbidity. The patients in the original version of the protocol group had genetic abnormalities, while the patients in the new version of the protocol group were leukemia patients undergoing chemotherapy, which reduced the number of white blood cells in the body. This led to a lower immune response. When sepsis occurred, the severity of the disease progressed easily, resulting in abnormal hemodynamics, leading to septic shock and higher mortality rates.[30] Although the patients were evaluated for sepsis and received rapid treatment according to the pediatric sepsis protocol, including administering antibiotics within one hour, it could still result in subsequent death. Consistent with the study by Kortz et al., it was found that the mortality rate of pediatric patients with sepsis before and after following the Surviving Sepsis Campaign Guidelines did not differ significantly.[31]

The analysis found that overall satisfaction and each dimension was significantly higher among registered nurses using the new version of the pediatric sepsis protocol compared to those using the original version ($p < .05$), which is consistent with the established hypothesis. It can be described that the new version of pediatric sepsis protocol includes a clear patient care procedure, enabling nurses to understand the care process and assist in decision-making systematically. In addition, the guidelines are shared between doctors and nurses, ensuring that patient care follows the same direction and promoting communication within the multidisciplinary team. This enhances the speed and efficiency of patient care. According to this study, most nurses are between the ages of 26 - 30 years, have 3-5 years of work experience, and have previously participated in original and new versions of pediatric sepsis protocol. This shows that the sample of nurses, who are young and less experienced, actively engage in self-study and training to develop knowledge in patient care that is constantly changing. This ongoing development allows them to have a good understanding of patient management, which in turn leads to higher satisfaction with the new version of pediatric sepsis protocol, which has been developed following current patient care standards, compared to the traditional guidelines. Consistent with the study found that age and work experience have a negative correlation, while training has a positive correlation with knowledge in managing patients with septic shock.[32] If the nurses have knowledge and understanding of patient care, they will be satisfied with following the pediatric sepsis protocol. In addition, this study found that nurses believe the new version of pediatric sepsis protocol includes clear patient assessment tools and straightforward care procedures, making them easier to follow. They also recognize the benefits of using these guidelines for quickly screening pediatric patients, allowing timely treatment and leading to better outcomes for patients. It can be seen from the results of a study of nursing satisfaction with the implementation of the new version of the pediatric sepsis protocol that the difficulty of using the assessment tool and practices and utilization is at the highest level when compared to the satisfaction of the implementation of the original version of the pediatric sepsis protocol that is at a high level.

Recommendations for Nursing Practice

1. There should be continuous study and development of pediatric sepsis protocol according to the Surviving Sepsis Campaign Guidelines to update and appropriate care for current situations.

2. Nurses should be regularly trained on pediatric sepsis protocol to ensure effective nursing practices and good outcomes for patients.

3. The Artificial Intelligence (AI) program should be developed to assist nurses in scoring patient assessments using the TUH pediatric sepsis screening score with greater convenience and speed.

Recommendations for Future Study

There should be a study on the effects of nursing practices according to the pediatric sepsis protocol in pediatric patients with septic shock and process

outcomes, such as obtaining blood collection within five minutes, fluid resuscitation within one hour, and vasopressor administration within one hour according to care standards. Including care outcomes such as acquiring from shock within six hours, organ dysfunction, and hospital length of stay.

Limitation of the Study

This research is a retrospective study, collecting data from pediatric patient medical records as a result of limitations on data collection. Furthermore, this study was conducted in a tertiary care hospital that has specialized personnel and adequate medical resources for pediatric care. Therefore, the implementation of the sepsis protocol may not be generalizable to settings with limited resources.

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