OBSERVATIONAL STUDY

OPEN

Understanding ICU Nursing Knowledge, Perceived Barriers, and Facilitators of Sepsis Recognition and Management: A Cross-Sectional Study

Katherine A. Kissel, MN, RN[1,2]
Karla D. Krewulak, PhD[1,3]
Thérèse G. Poulin, BSc[3]
Ken Kuljit S. Parhar, MD, MSc[1,3,4,5]
Daniel J. Niven, MD, PhD[1,3]
Vanessa M. Doiron, MScHQ, RN[1]
Kirsten M. Fiest, PhD[1,3,4,6]

IMPORTANCE: Nursing workforce changes, knowledge translation gaps, and environmental/organizational barriers may impact sepsis recognition and management within the ICU.

OBJECTIVES: To: 1) evaluate current ICU nursing knowledge of sepsis recognition and management, 2) explore individual and environmental or organizational factors impacting nursing recognition and management of sepsis using the Theoretical Domains Framework (TDF), and 3) describe perceived barriers and facilitators to nursing recognition and management of patients with sepsis.

DESIGN, SETTING, AND PARTICIPANTS: This cross-sectional survey was administered to nurses working in four general system ICUs between October 24, 2023, and January 30, 2024.

MAIN OUTCOMES AND MEASURES: Quantitative questions (single/multiple choice, true/false, and Likert-based questions eliciting agreement with a statement) were analyzed using descriptive statistics. Open-ended questions exploring barriers and facilitators to sepsis recognition and management were analyzed using qualitative content analysis.

RESULTS: A total of 101 completed survey responses were retained. Most nurses agreed early sepsis detection saves lives ($n = 98$, 97%, TDF domain Beliefs About Consequences) and that nursing care can improve patient outcomes ($n = 97$, 96%, TDF domain Optimism). Fewer nurses agreed it was easy to identify priority sepsis interventions based on order urgency ($n = 53$, 53%, TDF domain Memory, Attention, and Decision Processes). Reoccurring barriers and facilitators to sepsis recognition and management were commonly identified across the TDF domains of Knowledge, Skills, Environmental Context and Resources, and Social Influences, including competency deficit (with facilitators including support from colleagues), workload or staffing, and equipment or resource availability.

CONCLUSION AND RELEVANCE: ICU nursing sepsis recognition and management is impacted by numerous individual, environmental, and organizational factors. Recommendations include enhanced competency development or support, utilization of structured reinforcement measures (involving the interdisciplinary team and imploring the use of integrative technologies), and addressing equipment/resource-related gaps. Future research and improvement initiatives should use a theory-informed approach to overcome the pervasive, complex challenges impeding timely sepsis recognition and management.

KEYWORDS: critical care nursing; intensive care; sepsis; septic shock; theoretical domains framework

DOI: 10.1097/CCE.0000000000001200

Sepsis is a life-threatening clinical condition, characterized by immune dysregulation in response to infection and resulting in organ dysfunction (1). Early recognition and management of sepsis is essential to

KEY POINTS

Question: What individual and environmental/organizational factors, and barriers and facilitators impact current ICU nursing sepsis recognition and management?

Findings: Within this cross-sectional survey of nurses in four general system ICUs, individual and environmental or organizational factors impacting sepsis recognition and management were identified. Barriers and facilitators (e.g., nursing competency, workload/staffing, equipment or resource availability, collegial support) were reoccurring within the Theoretical Domains Framework domains: Knowledge, Skills, Environmental Context and Resources, and Social Influences.

Meaning: This study identifies challenges for local ICU nursing sepsis recognition and management: to address these gaps and optimize adherence to evidence-based recommendations, improvement opportunities must address these complex challenges across numerous system levels.

improve patient outcomes, including the prevention of septic shock and death (2, 3). The Surviving Sepsis Campaign "International Guidelines for Management of Sepsis and Septic Shock" offers global recommendations to guide the management of adult patients with sepsis and septic shock (3). Within inpatient hospital settings, nurses play an integral role in both the early recognition of sepsis and the provision of targeted interventions with known mortality benefits (4). The ability to recognize sepsis and deliver timely intervention is further paramount among ICU nurses, given critically ill patients are at high risk for sepsis (5), and although variable, the burden of sepsis remains high within ICUs globally (6). ICU nurses may additionally respond to deteriorating patients within hospital wards as members of the critical care rapid response team (e.g., locally defined as ICU outreach) (7).

The frequency in which missed or delayed sepsis detection occurs within ICUs and broader care settings is underreported. In one literature review of diagnostic error-related harm within the United States, Newman-Toker et al (8) estimate that delayed or missed sepsis diagnosis varied from 8.2% to 20.8%. In a Canadian retrospective review of medico-legal cases, numerous factors were associated with delayed or missed sepsis diagnosis at the provider, team, and organizational level, including assessment-related concerns, communication breakdown, and resource constraints (9). Within this study, nursing-specific factors included the failure to identify or communicate (to the provider) key findings, such as clinical deterioration or blood culture results (9). Historically, several strategies have been used to aid the early recognition and management of sepsis. Nurse-led bundles targeting early interventions such as the timely obtainment of blood cultures and initiation of antimicrobial therapy in patients with sepsis have been associated with increased bundle compliance in ICUs or emergency departments (10, 11); bundle adherence has been associated with reductions inpatient mortality (12). However, sustained bundle compliance has not always been observed (13–16). In a recent systematic review exploring sepsis assessment and management in adult critically ill patients, Rababa et al (17) reported a lack of nursing confidence or preparation for the effective identification and management of sepsis; in this review, assessment and management were further impacted by numerous barriers at the nurse, patient, and local (unit) or organizational levels. These findings convey that nurse recognition and management of sepsis is not only dependent on individualized knowledge but also on the complex organizational and individual factors that influence these behaviors (18).

Additional challenges may impact an ICU nurse's ability to recognize and manage sepsis. For example, newly graduated nurses are being hired to fill ICU vacancies; historically, these positions required nurses to have advanced acute care experience. Locally, nurse educators have reported this shift in the critical care nursing workforce has led to an increased need for clinical nursing support (from nurse educators and bedside nursing staff), to facilitate nursing skill development and knowledge acquisition at the bedside. The hiring of new graduate nurses across critical care settings may be increasing due to the ongoing nursing shortage (19). ICU nurses working during the COVID-19 pandemic also experienced alterations in the provision of clinical education or support, including the rapid transition of ICU classroom orientation to online platforms to mitigate infection risk (20), and the reassignment of nurse educators to provide direct bedside care during times of capacity strain (21). The extensive "Surviving Sepsis"

guidelines do not identify whom (among the multidisciplinary team) should implement specific recommendations or guide how they should be implemented. Given the current critical care nursing workforce challenges and these knowledge translation gaps, an evaluation of current critical care nursing knowledge of sepsis recognition and management is warranted.

MATERIALS AND METHODS

Objectives

The aims of this study were to: 1) evaluate current ICU nursing knowledge of sepsis recognition and management, 2) explore additional individual and environmental or organizational factors, which may impact nurse recognition and management of sepsis using the Theoretical Domains Framework (TDF) (22), and 3) describe perceived barriers and facilitators to nursing recognition and management of patients with sepsis.

Study Design

This is a cross-sectional study using a survey questionnaire. This study is reported according to the "Strengthening the Reporting of Observational Studies in Epidemiology" statement guidelines for reporting cross-sectional studies (23, 24) and the "Consensus-Based Checklist for Reporting of Survey Studies" (25). Ethical approval was obtained on August 30, 2023, from the University of Calgary Conjoint Health Research Ethics Board (REB23-1122, study title "Understanding ICU Nursing Knowledge, Perceived Barriers, and Facilitators of Sepsis Recognition and Management: A Cross-Sectional Study"). An implied consent script was disseminated with the study invitation. Completion of the surveys implied agreement to participate. Procedures were followed in accordance with the ethical standards of the responsible committee on human experimentation (University of Calgary REB) and with the Helsinki Declaration of 1975.

Setting, Population of Interest

The setting and population of interest included ICU Registered Nurses (RNs) who worked within one of four general system ICUs (located within tertiary academic and community hospitals) within an urban center in Western Canada, during the study period (between October 24, 2023, and January 30, 2024). Within these units, ICU RNs care for similar generalized patient populations, use the same policies and educational resources, and follow the same orientation and specialty skill certification processes.

Survey Design

Theoretical Framework. A theory-based approach is recommended to identify and address the complex behaviors influencing the translation of evidence-based guidelines into practice; without adopting a theory-based approach, interventions may fall short of achieving clinical practice change (26). As a result, evaluations of relevant factors impacting nursing sepsis knowledge and management within this study are situated within the constructs of the TDF, which is specifically designed to comprehensively evaluate implementation challenges and support the translation of evidence into practice (22).

Variables. The survey tool was comprised of four sections (**Additional File 1**, http://links.lww.com/CCX/B450), with questionnaire content development guided by the literature (1, 3, 27–36):

1) Demographics: Participant age, gender, years of experience (as an RN in total, and number of years working in adult ICU), and certification as an ICU outreach (rapid response) team member (yes/no);
2) Sepsis Knowledge Assessment Tool: comprised of single/multiple choice and true/false questions;
3) Factors Pertaining to Sepsis Recognition and Management: explored within the constructs of the TDF (22), to further identify individual, environmental/organizational, and social factors which impact sepsis recognition (identification) and management and using a five-point Likert-based response to determine agreement with a statement (from strongly disagree to strongly agree), and;
4) Open-ended questions exploring barriers and facilitators of sepsis recognition and management.

The survey tool was developed iteratively and reviewed for face and content validity (37) by team members with ICU nursing (K.A.K., V.M.D.) and medical expertise (D.J.N., K.K.S.P.), and with experience using the TDF (D.J.N., K.D.K., K.M.F., K.K.S.P.). Further end-user testing and review was provided by a local nurse educator not involved with the research study and

who has experience in quiz/questionnaire design, and frontline general system ICU RNs in another city who share the same local policy/resource and orientation processes as prospective study participants.

Recruitment and Study Size

The anonymized survey was administered using Qualtrics (Provo, UT) (38). To mitigate the risk of respondent bias (e.g., RNs with increased confidence or experience recognizing and treating patients with sepsis could be more likely to respond), members of the research team reviewed survey results as they were received, to ensure a variety of demographic responses (years of adult ICU experience) were received. Invitation to participate was disseminated to pre-existing ICU email distribution lists by an administrative assistant with no study involvement, and nurse educators not involved in the project provided in-person reminders. A goal sample size of 100 respondents (approximately 20% of the eligible sample) was determined, based on other studies imploring similar methodology to elicit frontline ICU RN feedback (21, 39).

Data Analysis

Quantitative survey responses were collated and analyzed using descriptive statistics (means, medians, and proportions as appropriate) within Stata (40). The open-ended questions underwent deductive qualitative content analysis, coded according to respective TDF domains (22) to systematically capture RN insights, and guide the development of actional recommendations that are rooted within the constructs of behavioral science. Coding was performed independently and in duplicate by at least two team members (inclusive of Research Associates with qualitative research expertise and experience using the TDF, and a Clinical Nurse Specialist with critical care nursing expertise [K.A.K., K.D.K., T.G.P.]) using NVivo software, Version 14 (41). The team met regularly to compare coding, discuss discrepancies, and iteratively develop a codebook to guide coding decisions.

TABLE 1.
Survey Demographics (*n* = 101)

Characteristic	*n* (%[a])
Gender	
Woman	87 (86.1)
Man	12 (11.9)
Non-binary gender	1 (1.0)
Prefer not to answer	1 (1.0)
Age	
Median, range	34, 22–64
20–25	8 (7.9)
26–30	17 (16.8)
31–35	33 (32.7)
36–40	16 (15.8)
41–45	14 (13.9)
46–50	7 (6.9)
51–55	2 (2.0)
≥ 56	4 (4.0)
Years of experience as a registered nurse	
Median, range	10, 0.1–43
< 2 yr	8 (7.9)
2–5	18 (17.8)
6–10	30 (29.7)
11–15	23 (22.8)
16–20	11 (10.9)
≥ 21	11 (10.9)
Years of experience in adult ICU	
Median, range	6, 0–38
< 2 yr	20 (19.8)
2–5	28 (27.7)
6–10	23 (22.8)
11–15	18 (17.8)
16–20	5 (5.0)
≥ 21	7 (6.9)
Outreach certification	
Yes	35 (34.7)
No	66 (65.3)

[a]Rounded to the 10th decimal.

RESULTS

A total of 101 completed survey responses were analyzed (a 19.7% response rate, based on final counts provided from local units reflecting a total of 513 eligible participants). Incomplete surveys were not analyzed, as per the implied consent script, this may have represented a withdrawal of consent. Participant demographics are presented in **Table 1**. Most RNs were women (86.1%, *n* = 87), between 31 and 35 years old

(32.7%, *n* = 33), and had been working as an RN for 6–10 years (29.7%, *n* = 30). Most RNs reported having 2–5 years of ICU nursing experience (27.7%, *n* = 28), with almost half (47.5%, *n* = 48) reporting 5 years of ICU experience or less. Most (65.3%, *n* = 66) were not certified in ICU outreach.

Sepsis Knowledge Assessment

Completed responses to the survey knowledge assessment component are presented within the **Supplemental Table 1** (http://links.lww.com/CCX/B450), mapped according to the accuracy (i.e., correctness) of the response. The responses (tied) with the highest accuracy (100% correct individual response, *n* = 101, within either single- or multiple-choice questions) included: correctly identified strategies to prevent infection (hand hygiene) and the identification of potential signs/symptoms of sepsis (confusion or disorientation, tachycardia, and temperature > 38°C). The most significant knowledge gaps included: the incorrect item of skin antisepsis with 2% Chlorhexidine before central line insertion from a multiselect pick list of strategies to prevent infection (incorrectly selected by 97% of respondents, *n* = 98), the identification of screening tools to identify sepsis/septic shock, as recommended by the Society of Critical Care Medicine (SCCM) (3) (with 11.9% of RNs correctly identifying the National Early Warning Score as a recommended tool (*n* = 12) and 77.2% incorrectly selecting the Sequential Organ Failure Score (SOFA) or quick SOFA (*n* = 78), and the missed identification of pregnancy (current/recent) as a risk factor for sepsis (31.7% correct, *n* = 32).

Factors Impacting Sepsis Recognition and Management Using the Theoretical Domains Framework

Likert-based responses, based on agreement with a statement and exploring factors impacting sepsis recognition and management as classified within TDF domains (22), are presented in **Figure 1**. RNs reported the highest agreement with the following statements (followed by TDF domain and percentage of agreement): "I believe that the early detection of sepsis saves lives" (Beliefs About Consequences, 97.0%, *n* = 98), "I believe that critically ill patients in the ICU are at high risk of sepsis" (Beliefs About Consequences, 96.0%, *n* = 97), "I believe that my care can improve outcomes for patients with sepsis or septic shock" (Optimism, 96.0%, *n* = 97), and "I believe obtainment of blood cultures and administration of antibiotics within 1 hour of sepsis identification should be a target…" (Goals, 96.0%, *n* = 97).

RNs recorded the lowest agreement with the statement: "When admitting a patient with sepsis/septic shock, it is easy to identify priority interventions on the basis of order urgency" (Memory, Attention, and Decision Processes (22), 52.5% agreement [*n* = 53] with 30.7% disagreement [*n* = 31]). Within statements exploring the TDF domain Emotions, some respondents indicated they were "concerned about missing sepsis (identification) in patients" (25.7% agreement [*n* = 26] with 48.5% disagreement [*n* = 49]), with fewer indicating they felt "anxious about caring for a hemodynamically unstable patient with septic shock" (14.9% agreement [*n* = 15] with 72.3% disagreement [*n* = 73]).

Open Text Comments: Barriers and Facilitators to Sepsis Recognition and Management, Classified According to the Theoretical Domains Framework

Numerous participants responded to the four open-ended questions exploring perceived barriers and facilitators to sepsis identification and management. Content analysis (inclusive of TDF domain classification [22], sub-themes, and participant quotes) is presented in **Supplemental Table 2** (http://links.lww.com/CCX/B450). Common TDF domains across all four questions included: Knowledge, Skills, Environmental Context and Resources, and Social Influences. Within these domains, reoccurring barrier-related subthemes included knowledge and competency deficits (associated with RN attrition and turnover), workload or staffing challenges, and equipment or resource availability. Facilitators were often presented as inverse to barriers and included support from colleagues (including senior nursing staff and multidisciplinary team members).

Sepsis Recognition. In addition to common TDF domains, approximately half of the respondents shared several barriers (57.4%, *n* = 58) and facilitators (62.4%, *n* = 63) that they perceived to impact sepsis recognition. Barriers (followed by TDF domains [22]) included sepsis recognition challenges such as "confounding pictures" (Skills), perceived confidence or competence

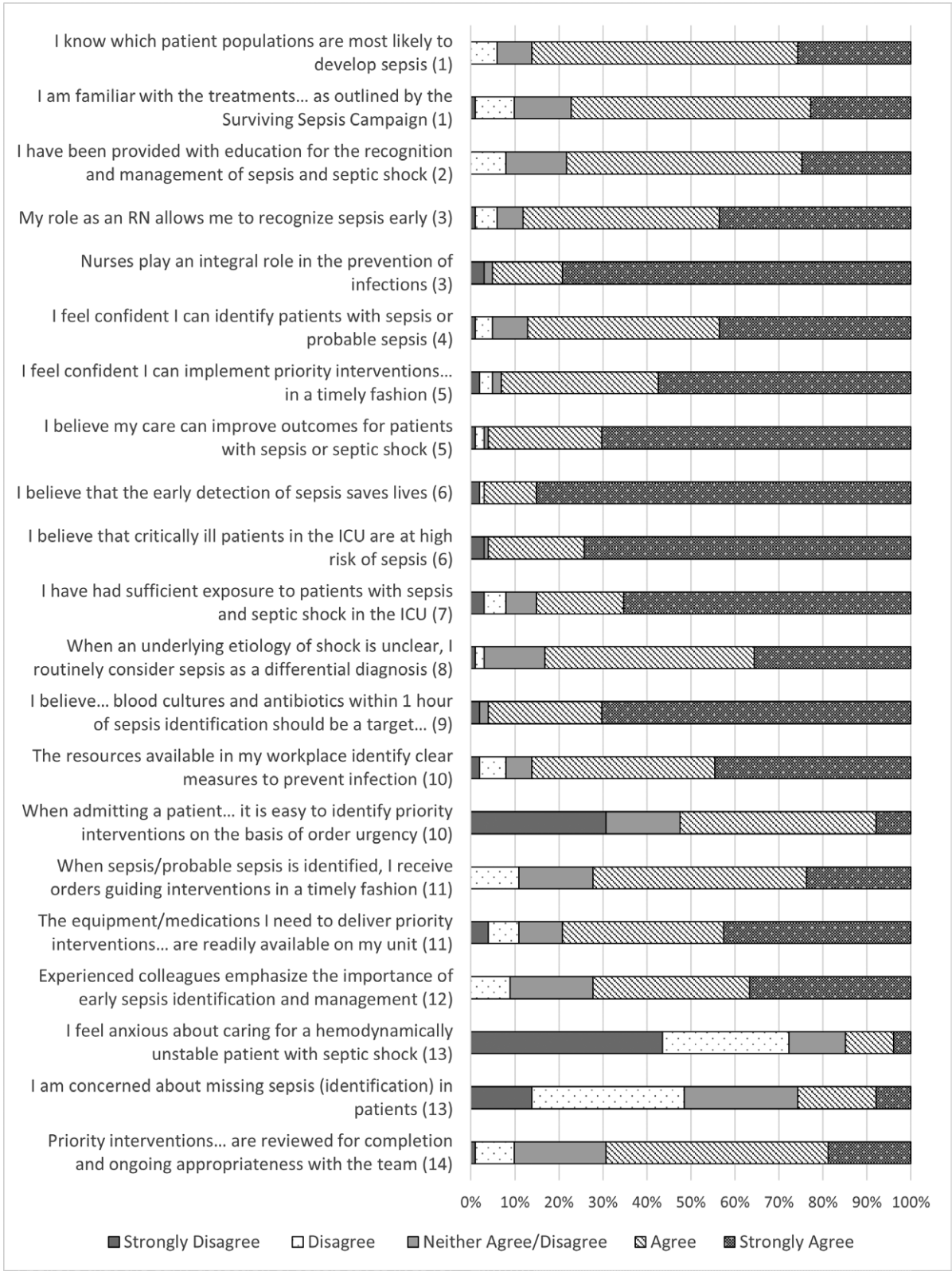

FIGURE 1. Factors impacting sepsis recognition and management, as classified within the Theoretical Domains Framework (22)[a,b]. [a]Questions abbreviated for presentation, refer to Additional File 1 (http://links.lww.com/CCX/B450) for questions in full. [b]Question classification per Theoretical Domains Framework Domain is labeled numerically, in brackets: (1) Knowledge, (2) Skills, (3) Social or Professional Role and Identity, (4) Beliefs About Capabilities, (5) Optimism, (6) Beliefs About Consequences, (7) Reinforcement, (8) Intentions, (9) Goals, (10) Memory, Attention and Decision Processes, (11) Environmental Context and Resources, (12) Social Influences, (13) Emotion, and (14) Behavioral Regulation. RN = registered nurse.

to identify signs and symptoms of sepsis or probable sepsis (Beliefs about Capabilities), a shift in care goals/priority setting since the COVID-19 pandemic (Goals), a lack of policy/resource or sepsis screening reminders (Memory, Attention, and Decision Processes), and laboratory drawn blood collection delays (Environmental Context and Resources). Many perceived facilitators were echoed as inverse to perceived barriers. Additional facilitators included multidisciplinary team rounds, patient problem lists, available policies or standards of practice, continual education (Reinforcement), and unit processes or equipment to facilitate continual patient monitoring (such as continual core temperature monitoring, Environmental Context and Resources).

Sepsis Management. In addition to the common TDF domains, many participants shared perceived barriers (72.3%, $n = 73$) or facilitators (59.4%, $n = 60$) to the implementation of priority sepsis treatment interventions. These included: challenges in navigating patient orders (TDF domain Memory, Attention, and Decision Processes [22]), delayed access to equipment or medications (including antibiotics), patient-specific factors (e.g., hemodynamic instability, limited IV access), workloads or availability of multidisciplinary team members, inter-departmental communication, and challenges posed by the electronic health record (e.g., pre-set medication administration times associated with order entry) (Environmental Context and Resources). Additional facilitators included policies or protocols and standards of practice (Knowledge, Skills, Reinforcement), readily available equipment and medications (including ward-stocked antibiotics, Environmental Context, and Resources), and availability and guidance from multidisciplinary team members (Reinforcement, Environmental Context and Resources, Social Support).

DISCUSSION

This cross-sectional study used a survey questionnaire to explore: 1) nursing knowledge, 2) individual and environmental or organizational factors using the TDF (22), and 3) perceived barriers and facilitators impacting ICU nurse recognition and management of sepsis. Study findings revealed targeted knowledge gaps regarding relevant risk factors, potential signs/symptoms, and priority interventions for patients with sepsis or septic shock. Many of the knowledge deficits identified within this study are echoed within the broader literature, such as the missed identification of temperature less than 36°C as a potential sign of sepsis (42) or identification of the appropriate disinfectant for skin antisepsis before central line insertion (43–45). In addition to these gaps, nurses within our study identified numerous other environmental/organizational factors and perceived barriers and facilitators to sepsis recognition and management. Barriers to sepsis recognition and management reported in this study and reoccurring within the literature include: atypical presentation or detection challenges in critically ill patient populations (17, 46), the need for ongoing education, training, or clinical exposure, a lack of policy or guidelines (or a lack of awareness of these resources), a lack of supervision or mentorship for novice nurses, workloads or nurse to patient staffing ratios, patient factors (such as a lack of IV access), and multidisciplinary teamwork or communication (17). Based on our findings, we recommend interventions in three modifiable areas: 1) deliberate and enhanced ICU RN sepsis training and support, 2) reinforcement measures targeting sepsis identification and priority management, and 3) equipment or resource optimization.

Within this study, changes to the ICU nursing workforce occurring since the COVID-19 pandemic have highlighted opportunities for deliberate and enhanced training and support. Other studies have similarly highlighted challenges pertaining to skill and competency acquisition among nursing students during the pandemic because of reductions in clinical exposures (47). To support novice ICU nurses' skill and competency development, we first recommend enhanced senior nurse on-unit availability to offer direct, ongoing mentorship to novice critical care nurses (e.g., to aid in early detection and priority setting). To address concerns regarding workload (senior nursing staff not available to support) or where clinical gaps exist (e.g., due to high volume of novice learners), a formalized, on-unit, and supernumerary resource nursing support role should be considered to provide mentorship, foster competency acquisition, and support clinical safety (48–50). Prior research also informs that ICU nursing competency development requires clinical exposure, situational management, and collaboration (51), therefore the development of robust competency descriptions and the tracking of experiential learning is essential (52). Although historically, our units

have used skill tracking and competency development checklists to track learning at the local level, it is possible that in light of nurse turnover and to support the transition of newer nurses into the ICU, an expanded set of competency measures (developed locally) are required.

Second, to overcome perceived barriers (e.g. knowledge deficit, sepsis detection challenges), we propose teams must use reinforcement strategies, both leveraging facilitators from a team-based perspective and further exploring advanced technological solutions. Actionable facilitators identified in this study involving the interdisciplinary team included reinforcement of priorities, such as the use of patient problem lists or reinforcement (e.g. identifying signs of early sepsis), team-based training via interdisciplinary simulation, or teaching on daily interdisciplinary rounds. Given nurses identified challenges prioritizing orders within the electronic system (cognitive overload, lack of clarity), we further suggest that the interdisciplinary team collectively identify (and verbalize) priority sepsis interventions at the time interventions are identified and with re-evaluation. The creation of interdisciplinary tools (e.g. checklists, pocket cards) outlining priority management strategies may serve as bedside tools and enhance knowledge translation (28): inclusion of similar bedside tools with future *SCCM* Surviving Sepsis Guideline (3) iterations may further enhance rapid knowledge translation. Further, awareness and utilization of screening tools integrated within early warning systems (EWS) may be limited among our respondent population, given these systems are disabled within the ICU to reduce alarm fatigue. To combat this concern, Rich et al (53) recently evaluated a modified sepsis alert among patients within MICUs. Using revised systemic inflammatory response syndrome criteria, generated alerts had a 72% positive predictive value (53). Other integrated technologies reflected in the literature and demonstrating increased sepsis bundle compliance include the addition of integrated chart reminders, embedded within the electronic medical record once sepsis was acknowledged electronically as the likely diagnosis (54). Adopting a similar approach could address many of the barriers identified within this study, such as knowledge deficit, or cognitive overload and challenge prioritizing patient orders. Further, studies have demonstrated the ability of machine learning algorithms (MLAs) to predict sepsis, severe sepsis, and septic shock earlier than conventional scoring tools or EWS (55, 56). In one randomized control trial, the prospective use of an MLA-generated alert with clinician notification led to reductions in the in-hospital mortality rate and length of stay, and faster time to antibiotic administration (vs. the use of conventional scoring tools/EWS alone) (57). Ongoing research regarding the use of these integrative strategies as clinical decision supports and their patient-associated outcomes should be prioritized for critically ill patients.

Our third recommendation based on study findings includes an optimization of the resources or equipment required for sepsis detection and implementation of priority measures. Within our ICUs, continual core temperature measurement is a patient monitoring standard, given the accuracy limitations of peripheral thermometers (58). This monitoring standard was a perceived facilitator among respondents. Conversely, gaps in equipment availability were also perceived to impact priority sepsis management, such as delayed access to antibiotics. In addition to requisite follow-up at the local level (including root cause analysis of this concern), this identified barrier further identifies the need for the engagement of interdisciplinary stakeholders, including pharmacy, to co-develop solutions, and supports the need for expanded evaluation of system-integrated alerts targeting adherence to priority management strategies.

This study has some limitations. By nature of the study design, the findings may be subject to respondent bias (59), although surveillance of demographic criteria during survey conduction confirmed participant respondents had a wide variety of demographic responses (e.g., years of ICU nursing experience), mitigating risk. Further limitations include the inability to establish causality (e.g., the reasons for perceived antibiotic delay at the local level are unknown and require further evaluation) or associations among variables (e.g., relationships between reported optimism, knowledge assessment findings, or perceived barriers and facilitators) (59). While the deductive approach to analyzing open-text comments was systematic and theory-informed, it may have limited our ability to capture the more dynamic, interrelated, or emergent patterns that may have been uncovered with inductive methods. Although the findings of this study are directly applicable to and should be considered

within the context of the local study population, it is possible these findings are more broadly generalizable, given they echo numerous findings within the existing literature, and given global concerns regarding the retention of the critical care nursing workforce post-pandemic (60, 61). This study adds to the current body of evidence in using the TDF (22) to explore individual, environmental, and organizational factors impacting sepsis recognition and management among ICU RNs. Further study strengths include the comprehensive nature of the survey and mixed methods design, and the robust, iterative process undertaken to analyze the open-text comments exploring barriers and facilitators to sepsis recognition and management. Finally, given the delivery of critical care services may vary based on the setting, the inclusion of the survey (Additional File 1, http://links.lww.com/CCX/B450) offers a framework for future evaluation of nursing knowledge, barriers, and facilitators to sepsis recognition and priority management within the context of local settings.

Collectively, the findings within this study highlight numerous optimization opportunities to address current knowledge translation gaps. These opportunities can be identified at the individual nursing, environmental, and organizational levels, intersecting across numerous TDF domains (22). Optimization opportunities for nurses include the provision of enhanced and intentional support aimed at fostering sepsis-related competency development. Reinforcement opportunities require a multi-modal approach and the support of the interdisciplinary team. Future research is required to further explore the use of integrative technologies to aid early sepsis recognition and priority management (e.g., utilization of advanced and integrated clinical decision support tools) and to further evaluate optimization efforts from the perspectives of the interdisciplinary team. At the local level, ongoing evaluation is needed to measure the effectiveness of optimization efforts.

CONCLUSIONS

Sepsis remains a health priority and nurses working within the ICU play a pivotal role in the timely recognition of sepsis, as well as the implementation of priority sepsis interventions. Despite a wealth of prior literature indicating that delays in sepsis recognition and management impact patient outcomes, ICU nurses within our study and the broader literature continue to experience sepsis-related knowledge gaps and face numerous barriers to sepsis recognition and management within the clinical setting. Using the Theoretical Domains Framework, this study identified numerous facilitators as well as optimization opportunities for sepsis recognition and management. Future endeavors should address these complex challenges at the individual, environmental, and organizational levels, and be re-evaluated to determine the short- and long-term effectiveness of implementation efforts.

1 *Department of Critical Care Medicine, Alberta Health Services, AB, Canada.*

2 *Faculty of Nursing, University of Calgary, Calgary, AB, Canada.*

3 *Department of Critical Care Medicine, University of Calgary, Calgary, AB, Canada.*

4 *O'Brien Institute for Public Health, University of Calgary, Calgary, AB, Canada.*

5 *Libin Cardiovascular Institute, University of Calgary, Calgary, AB, Canada.*

6 *Department of Community Health Sciences, University of Calgary, Calgary, AB, Canada.*

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (http://journals.lww.com/ccejournal).

Ms. Kissel, Dr. Krewulak, Dr. Parhar, Dr. Niven, Ms. Doiron, and Dr. Fiest were involved in study conception. Ms. Kissel, Dr. Krewulak, Ms. Poulin, and Dr. Fiest were involved in data analysis. All authors reviewed and revised the article. All authors approved the final article.

This study was undertaken in part (by Ms. Kissel) as a trainee practicum objective for the Sepsis Canada and Life-Threatening Illness National Group (LifTING) Research Training Program and has been partially funded by the Canadian Association of Critical Care Nurses (CACCN) Research Grant. Sepsis Canada, LifTING, and the CACCN were not involved with the study conduction. The remaining authors have disclosed that they do not have any potential conflicts of interest.

For information regarding this article, E-mail: kmfiest@ucalgary.ca

REFERENCES

1. Singer M, Deutschman CS, Seymour CW, et al: The third international consensus definitions for sepsis and septic shock (Sepsis-3). *JAMA* 2016; 315:801–810
2. Sepsis Canada: Home—Sepsis Canada. Available at: https://www.sepsiscanada.ca/. Accessed June 26, 2023
3. Evans L, Rhodes A, Alhazzani W, et al: Surviving sepsis campaign: International guidelines for management of sepsis and septic shock 2021. *Crit Care Med* 2021; 49:e1063–e1143

4. Kleinpell R, Blot S, Boulanger C, et al: International critical care nursing considerations and quality indicators for the 2017 surviving sepsis campaign guidelines. *Intensive Care Med* 2019; 45:1663–1666
5. Markwart R, Saito H, Harder T, et al: Epidemiology and burden of sepsis acquired in hospitals and intensive care units: A systematic review and meta-analysis. *Intensive Care Med* 2020; 46:1536–1551
6. Sakr Y, Jaschinski U, Wittebole X, et al; ICON Investigators: Sepsis in intensive care unit patients: Worldwide data from the intensive care over nations audit. *Open Forum Infect Dis* 2018; 5:ofy313
7. Guirgis FW, Jones L, Esma R, et al: Managing sepsis: Electronic recognition, rapid response teams, and standardized care save lives. *J Crit Care* 2017; 40:296–302
8. Newman-Toker DE, Wang Z, Zhu Y, et al: Rate of diagnostic errors and serious misdiagnosis-related harms for major vascular events, infections, and cancers: Toward a national incidence estimate using the "Big Three". *Diagnosis* 2021; 8:67–84
9. Neilson HK, Fortier JH, Finestone PJ, et al: Diagnostic delays in sepsis: Lessons learned from a retrospective study of Canadian medico-legal claims. *Crit Care Explor* 2023; 5:e0841
10. Liu CX, Wang XL, Zhang K, et al: Study on clinical nursing pathway to promote the effective implementation of sepsis bundle in septic shock. *Eur J Med Res* 2021; 26:69
11. Tromp M, Hulscher M, Bleeker-Rovers CP, et al: The role of nurses in the recognition and treatment of patients with sepsis in the emergency department: A prospective before-and-after intervention study. *Int J Nurs Stud* 2010; 47:1464–1473
12. Milano PK, Desai SA, Eiting EA, et al: Sepsis bundle adherence is associated with improved survival in severe sepsis or septic shock. *West J Emerg Med* 2018; 19:774–781
13. Ferrer R, Artigas A, Levy MM, et al; Edusepsis Study Group: Improvement in process of care and outcome after a multicenter severe sepsis educational program in Spain. *JAMA* 2008; 299:2294–2303
14. Cronshaw HL, Daniels R, Bleetman A, et al: Impact of the surviving sepsis campaign on the recognition and management of severe sepsis in the emergency department: Are we failing? *Emerg Med J* 2011; 28:670–675
15. LeMaster CH, Hoffart N, Chafe T, et al: Implementing the central venous catheter infection prevention bundle in the emergency department: Experiences among early adopters. *Ann Emerg Med* 2014; 63:340–350
16. Lennox L, Eftychiou L, Matthew D, et al: What risks to sustainability are identified throughout care bundle implementation and how can they be addressed? A mixed methods case study. *BMJ Open* 2021; 11:e048815
17. Rababa M, Bani Hamad D, Hayajneh AA: Sepsis assessment and management in critically ill adults: A systematic review. *PLoS One* 2022; 17:e0270711
18. Curtis K, Fry M, Shaban RZ, et al: Translating research findings to clinical nursing practice. *J Clin Nurs* 2017; 26:862–872
19. Vanderspank-Wright B, Lalonde M, Squires J, et al; Canadian Association of Critical Care Nurses and the National Emergency Nurses Association: Identifying, describing, and assessing interventions that support new graduate nurse transition into critical care nursing practice: A systematic review protocol. *Syst Rev* 2020; 9:241
20. Beck NM, Murray P, Quintanilla B: Reimagining critical care education during COVID-19 with high-level technology. *J Nurses Prof Dev* 2023; 39:92–96
21. Kissel KA, Filipek C, Folz E, et al: The impact of a three-tiered model of nursing redeployment during the COVID-19 pandemic: A cross-sectional study. *Intensive Crit Care Nurs* 2023; 77:103431
22. Atkins L, Francis J, Islam R, et al: A guide to using the Theoretical domains framework of behaviour change to investigate implementation problems. *Implement Sci* 2017; 12:77
23. Von Elm E, Altman DG, Egger M, et al; STROBE Initiative: Strengthening the reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies. *Ann Intern Med* 2007; 147:573–577
24. Ghaferi AA, Schwartz TA, Pawlik TM: STROBE reporting guidelines for observational studies. *JAMA Surg* 2021; 156:577–578
25. Sharma A, Minh Duc NT, Luu Lam Thang T, et al: A consensus-based checklist for reporting of survey studies (CROSS). *J Gen Intern Med* 2021; 36:3179–3187
26. Steinmo SH, Michie S, Fuller C, et al: Bridging the gap between pragmatic intervention design and theory: Using behavioural science tools to modify an existing quality improvement programme to implement "Sepsis Six". *Implement Sci* 2016; 11:14
27. Parhar KKS, Zjadewicz K, Knight GE, et al: Development and content validation of a multidisciplinary standardized management pathway for hypoxemic respiratory failure and acute respiratory distress syndrome. *Crit Care Explor* 2021; 3:e0428
28. Parhar KKS, Knight GE, Soo A, et al: Designing a behaviour change wheel guided implementation strategy for a hypoxaemic respiratory failure and ARDS care pathway that targets barriers. *BMJ Open Qual* 2023; 12:e002461
29. Centres for Disease Control and Prevention: What is sepsis? Available at: https://www.cdc.gov/sepsis/what-is-sepsis.html#anchor_1547213983. Accessed July 12, 2023
30. Isac C, Samson HR, John A: Prevention of VAP: Endless evolving evidences—systematic literature review. *Nurs Forum* 2021; 56:905–915
31. Ling ML, Apisarnthanarak A, Jaggi N, et al: APSIC guide for prevention of central line associated bloodstream infections (CLABSI). *Antimicrob Resist Infect Control* 2016; 5:16
32. Buetti N, Marschall J, Drees M, et al: Strategies to prevent central line-associated bloodstream infections in acute-care hospitals: 2022 update. *Infect Control Hosp Epidemiol* 2022; 43:553–569
33. Safer Healthcare Now: Prevent central line infections: Getting started kit. 2012. Available at: https://www.patientsafetyinstitute.ca/en/toolsResources/Documents/Interventions/Central/Line/Associated/Bloodstream/Infection/CLIGettingStartedKit.pdf. Accessed May 17, 2023
34. Safer Healthcare Now: Prevent ventilator associated pneumonia: Getting started kit. 2012. Available at: https://era.library.ualberta.ca/items/448441a4-ef59-4817-88f7-b1b20c0e0d5c/view/c6726737-c02f-4c61-9112-b1aa-5003ec8d/VAPGettingStartedKit.pdf. Accessed May 17, 2023

35. Timsit JF, Baleine J, Bernard L, et al: Expert consensus-based clinical practice guidelines management of intravascular catheters in the intensive care unit. *Ann Intensive Care* 2020; 10:118
36. World Health Organization: Sepsis. 2023. Available at: https://www.who.int/news-room/fact-sheets/detail/sepsis. Accessed July 20, 2023
37. Burns KEA, Duffett M, Kho ME, et al; ACCADEMY Group: A guide for the design and conduct of self-administered surveys of clinicians. *CMAJ* 2008; 179:245–252
38. Qualtrics: Qualtrics, Provo, UT. 2022. Available at: https://www.qualtrics.com/. Accessed July 20, 2023
39. Jolley SE, Regan-Baggs J, Dickson RP, et al: Medical intensive care unit clinician attitudes and perceived barriers towards early mobilization of critically ill patients: A cross-sectional survey study. *BMC Anesthesiol* 2014; 14:84
40. StataCorp: Stata statistical software release 18. College Station, TX, StatCorp LLC, 2023. Available at: https://www.stata.com/
41. QSR International: NVivo qualitative data analysis software. 2023. Available at: https://support.qsrinternational.com/nvivo/s/
42. Öztürk Birge A, Karabag Aydin A, Köroğlu Çamdeviren E: Intensive care nurses' awareness of identification of early sepsis findings. *J Clin Nurs* 2022; 31:2886–2899
43. Chi X, Guo J, Niu X, et al: Prevention of central line-associated bloodstream infections: A survey of ICU nurses' knowledge and practice in China. *Antimicrob Resist Infect Control* 2020; 9:186
44. Dyk D, Matusiak A, Cudak E, et al: Assessment of knowledge on the prevention of central-line-associated bloodstream infections among intensive care nurses in Poland—a prospective multicentre study. *Int J Environ Res Public Health* 2021; 18:12672
45. Badparva B, Ghanbari A, Karkhah S, et al: Prevention of central line-associated bloodstream infections: ICU nurses' knowledge and barriers. *Nurs Crit Care* 2023; 28:419–426
46. Vincent JL: The clinical challenge of sepsis identification and monitoring. *PLoS Med* 2016; 13:e1002022
47. Powers K, Pate K, Montegrico J, et al: Faculty perceptions of the impact of the COVID-19 pandemic on new graduate nurses' transition to practice: A qualitative study. *J Prof Nurs* 2022; 43:33–41
48. Nadeau M, Madden MW, Glassman EL: How clinical resource nurses can support new nurses and address safety concerns. *Nursing* 2024; 54:47–53
49. MacKay LJ, Bellamy-Stack C: The use of a clinical resource nurse for newly graduated nurses in a pediatric oncology setting. *J Pediatr Oncol Nurs* 2010; 27:338–343
50. Maloney M, Nelson A: The use of the clinical resource nurse to solve the eternal dilemma of financial responsibility versus staffing requirements. *J Obstet Gynecol Neonatal Nurs* 2013; 42:S72
51. DeGrande H, Liu F, Greene P, et al: Developing professional competence among critical care nurses: An integrative review of literature. *Intensive Crit Care Nurs* 2018; 49:65–71
52. Øvrebø LJ, Dyrstad DN, Hansen BS: Assessment methods and tools to evaluate postgraduate critical care nursing students' competence in clinical placement. An integrative review. *Nurse Educ Pract* 2022; 58:103258
53. Rich RL, Montero JM, Dillon KE, et al: Evaluation of an intensive care unit sepsis alert in critically ill medical patients. *Am J Crit Care* 2024; 33:212–216
54. Leisman DE, Deng H, Lee AH, et al: Effect of automated real-time feedback on early-sepsis care: A pragmatic clinical trial. *Crit Care Med* 2024; 52:210–222
55. Mao Q, Jay M, Hoffman JL, et al: Multicentre validation of a sepsis prediction algorithm using only vital sign data in the emergency department, general ward and ICU. *BMJ Open* 2018; 8:e017833
56. Desautels T, Calvert J, Hoffman J, et al: Prediction of sepsis in the intensive care unit with minimal electronic health record data: A machine learning approach. *JMIR Med Inform* 2016; 4:e28
57. Shimabukuro DW, Barton CW, Feldman MD, et al: Effect of a machine learning-based severe sepsis prediction algorithm on patient survival and hospital length of stay: A randomised clinical trial. *BMJ Open Respir Res* 2017; 4:e000234
58. Niven DJ, Gaudet JE, Laupland KB, et al: Accuracy of peripheral thermometers for estimating temperature: A systematic review and meta-analysis. *Ann Intern Med* 2015; 163:768–777
59. Wang X, Cheng Z: Cross-sectional studies: Strengths, weaknesses, and recommendations. *Chest* 2020; 158:S65–S71
60. Vogt KS, Simms-Ellis R, Grange A, et al: Critical care nursing workforce in crisis: A discussion paper examining contributing factors, the impact of the COVID-19 pandemic and potential solutions. *J Clin Nurs* 2023; 32:7125–7134
61. Xu G, Zeng X, Wu X: Global prevalence of turnover intention among intensive care nurses: A meta-analysis. *Nurs Crit Care* 2023; 28:159–166