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Screening Tools Used by Nurses to Identify Sepsis in Adult Patients

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Screening Tools Used by Nurses to Identify Sepsis in Adult Patients

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The purpose of this thesis was to describe screening tools used by nurses in the identification of sepsis in adult patients. The research question was: what are the screening tools that nurses use to identify sepsis in adult patients? The objective of this thesis is to raise awareness of sepsis screening tools and support nurses in their role of early identification of sepsis. Sepsis is a worldwide public health issue that needs the same attention as other deadly diseases like cancer, diabetes and cardiovascular diseases. Clinical studies on sepsis indicate that early recognition is crucial for survival from sepsis infection and that nurses play a vital role in its identification process.

The literature review methodology was used to investigate this topic. The material was searched through academic online databases (Laura Finna, CINAHL (EBSCOhost), ProQuest, PubMed, ScienceDirect and Google scholar) using search words related to the purpose and research question. Inclusion and exclusion criteria were established to evaluate the relevance of the articles retrieved. Critical appraisal tool (CASP) was used to assess the quality of the potential review articles. Twelve (12) scientific peer-reviewed articles with high critical appraisal scores were selected as the material for the analysis which was carried out through the inductive content analysis process. This process entails four phases: decontextualisation, recontextualisation, categorisation, and compilation using both the manifest (explicit) and latent(implicit) interpretations of the data.

The findings revealed five groups of screening tools used by nurses to identify sepsis in adult patients: tools based on patient data, clinical criteria of sepsis (SIRS) in conjunction with other clinical variables, tools based on the international consensus definition of sepsis, tools based on scoring systems, and other sepsis screening tools. The conclusion was that sepsis screening tools should be flexible to detect sepsis in all patients and that nurses should consider the patients' characteristics when assessing sepsis. Based on the findings of this thesis, it was recommended that further research on this topic is needed. Also, additional training should be provided to nursing students and nurses on how to effectively assess patients with suspected sepsis within different care environments.

Keywords: Sepsis, Sepsis Screening tools, Adult Patients, Sepsis Identification by Nurses

Abbreviations

CASP	Critical Appraisal Skills Programme
CDC	Centre for Disease Control
CRP	C-reactive protein
EWRS	Early Warning and Response System
EMs	Emergency Departments
EMD	Emergency Medical Dispatch
EMS	Emergency Medical Service
ETCO ₂	End-Tidal Carbon Dioxide
GCS	Glasgow Coma Scale
GSA	Global Sepsis Alliance
HR	Heart Rate
ICU	Intensive Care Unit
MAP	Mean Arterial Pressure
PaCO ₂	Carbon Dioxide In Arterial Blood
PaO ₂ /FiO ₂ Ratio	Arterial Oxygen to Fractional Inspired Oxygen Concentration
PCT	Procalcitonin
POC	Point of Care
PPV	Positive Predictive Value
PRESEP	Prehospital Early Sepsis Detection score
PRESS	Pre-hospital Severe Sepsis Score
qSOFA	quick SOFA
RR	Respiratory Rate
sBP	Systolic Blood Pressure
SIRS	Systematic Inflammatory Response Syndrome
SOFA	Sequential [Sepsis-Related] Organ Failure Assessment
SpO ₂	Oxygen Saturation
SSC guidelines	Surviving Sepsis Campaign guidelines
StO ₂	Skeletal Muscle Tissue Oxygenation
WBC	White Blood Cell
WHO	World Health Organisation

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1 Introduction

The World Health Organisation (WHO), Centre for Disease Control (CDC) and the Global Sepsis Alliance (GSA) considers sepsis as a global public health infection which needs prevention. Sepsis has a worldwide incidence estimate of thirty-one (31) million cases every year and six (6) million of which result in death (Global Sepsis Alliance 2017). It is one of the leading causes of hospitalisation, morbidity, and mortality in recent times despite development in modern medicine and treatment of the infection. One of the challenges in the identification of sepsis results from its complex pathophysiology. The signs and symptoms that a patient with sepsis may present are usually very similar to those of other infections or diseases; this may cause a delay in its diagnosis. Clinical studies on sepsis have unanimously concurred sepsis infection requires the same urgency as other life-threatening conditions like diabetes, heart attack and trauma. Mortality from sepsis increases every eight (8) hours that the treatment is delayed (Käypä hoito 2014; CDC 2017; Birriel 2013; Gatewood, Wemple, Greco, Kritek & Durvasula 2015).

The Surviving Sepsis Campaign (SSC) guidelines indicate that sepsis identification requires the collaboration of a multidisciplinary team (nurses, doctors, laboratory technicians and infection specialist), and the use of sepsis screening tools. This guideline also states that the nurses play a significant role in early sepsis identification. The nurse is usually the first member of this multidisciplinary team who assesses the patient when they develop the signs and symptoms of sepsis or notice the deterioration in the patient's health (Birriel 2013; Bhattacharjee, Edelson & Churpek 2017, 898; Casey 2016). Unfortunately, some studies have also indicated that nurses lack sufficient knowledge and skills in detecting sepsis resulting from an inadequate education, and limited evidence-based literature relating to sepsis screening tools (O'Shaughnessy, Grzelak, Dontsova, & Braun-Alfano 2017, 251; Westphal & Lino 2015 97; Gauer 2013, 44).

Therefore, this thesis would help to fill the gap in the lack of evidence-based knowledge on sepsis screening by nurses, it would add to the literature materials that nursing students and nurses can use to familiarise/educate themselves on sepsis screening tools. The reason for choosing to investigate this topic comes from the writer's interest in how nurses can identify sepsis in adult patients.

This thesis is a literature review, and the purpose is to describe screening tools used by nurses to identify sepsis in adult patients. The key concepts forming the background literature for this thesis include sepsis, sepsis screening tools, adult patients and sepsis identification by nurses.

2 Sepsis

The aspects of sepsis such as sepsis etiology (causation), pathophysiology, the controversies and development of the sepsis definition will facilitate the understanding of sepsis identification.

2.1 Etiology and pathophysiology

The most common organisms associated with sepsis are the gram-positive infections (Staphylococcus aureus, coagulase-negative staphylococcus, streptococcus pyogenic enterococci) as well as the gram-negative infections (such as Proteus, Serratia, and Pseudomonas aeruginosa), fungi infections, and anaerobic organisms (Mearelli, Orso, Fiotti, Altamura, Breglia, De Nardo, Paoli, Zanetti, Casarsa, Biolo 2015; Mossier 2013, 162-167; Suarez De La Rica 2016). A research conducted on 14,000 intensive care unit (ICU) patients across 75 countries revealed that majority of sepsis infections comes from gram-negative bacteria, followed by gram-positive bacteria and fungi (Angus & Van de Poll 2013).

The pathophysiology describes the development process of a disease. Sepsis results from the presence of a pathogen in the circulatory system caused by an infection. In the normal immune response, anti-inflammatory mechanism produces antigens (induces the formation of antibodies) which fight against an incoming infection, localises it and limits the spread of the infection and repair the damaged cell tissues. This response involves activation of pro-inflammatory and anti-inflammatory mediators by the phagocytes and endothelial cells. The presence of these mediators in the circulatory system helps to create a balance between these two groups of mediators. Hence, protecting the host against the invading pathogens and facilitate tissue healing in the host immune system. However, sepsis develops when there's an exaggerated immune response to an invading pathogen which spreads and goes beyond the infected site causing an imbalance in the mediators. The microbes begin to reproduce rapidly, and the body is unable to remove them at an adequate rate. The pathogens overwhelm the immune system, initiating the systematic inflammatory response syndrome (SIRS) (Jones 2017; Gauer 2013; Casey 2016).

2.2 Development of sepsis definitions

Throughout the 18th and 19th centuries, many researchers worked to pave the way for recognition and definition of sepsis. In 1989, an ICU specialist Roger C. Bone (1941-1997) presented a sepsis definition that is still valid today. He defined sepsis as: "an invasion of microorganisms and their toxins into the bloodstream, along with the organism's reaction to this invasion." This definition of sepsis upholds the understanding that sepsis is not only the presence

of an infection but also the host organism (human) response to the infection (German Sepsis Society n.d.).

The definition of sepsis has evolved over the years. In 1991, an international consensus panel stated sepsis is a progressive infection which has three stages: sepsis, severe sepsis, and septic shock). The term sepsis refers to the body's inflammatory response to an infection also known as the systemic inflammatory response syndrome (SIRS). The consensus panel defined "severe sepsis" as instances in which acute organ dysfunction complicates the inflammatory response to an infection. Septic shock was defined as sepsis infection which is complicated by either hypotension which is refractory to fluid resuscitation (Beesley & Lanspa 2016; Mossie 2013; Bhattacharjee et al. 2017; Gauer 2013; Angus and Van de Poll 2013; Vanzant & Schmelzer 2011, 49; Singer, Deutschman, Seymour, Shankar-Hari, Annane, Bauer, Bellomo, Bernard, Chiche, Coopersmith, Hotchkiss, Levy, Marshall, Martin, Opal, Rubenfeld, van der Poll, Vincent & Angus 2016).

However, after two decades of using this first definition of sepsis, it was evident that this definition evoked many controversies and is tinted with limitations especially in the efficient identification of patients with sepsis or those at risk of developing sepsis. The first criterion used to determine sepsis (systemic inflammatory response syndrome -SIRS) is considered to be sensitive in detecting an infection but not specific enough to distinguish sepsis infection from other infections and does not reflect the pathophysiology (Bhattacharjee et al. 2017; Beesley & Lanspa 2016; Gaieski & Goyal 2014).

The second international consensus panel in 2001 updated the 1991 definition of sepsis and added the specific criteria for sepsis, severe sepsis, and septic shock. First, the committee stated that for a patient to have 'sepsis' the patient must have at least two or more criteria of the systemic inflammatory response syndrome (SIRS). These are: an alternating temperature greater than 38°C or less than or equal to 36°C, tachycardia with heart rate (HR) of 90 per minute, respiratory rate (RR) greater than 20 per minute or partial pressure of carbon dioxide in arterial blood (PaCO₂) less than 32mmHg, and white blood cell (WBC) count greater than 1200/mm or less than 4000/or greater than 10 percent immature bands. Second, "severe sepsis" is indicated by the presence of sepsis infection (two or more SIRS) and one or more organ dysfunction. Thirdly, "septic shock" was defined as: suspected sepsis accompanied by refractory hypotension and dependence on vasopressor despite adequate fluid resuscitation. Refractory hypotension criteria are systolic blood pressure (sBP) less than 90mmHg or the mean arterial pressure (MAP) less than 70mmHg) (Käypä hoito 2014; Beesley & Lanspa 2016; Singer et al. 2014a).

The second consensus panel warned that the signs of systemic inflammatory response to an infection such as tachycardia or elevated white blood cell count are common in many infectious

and non-infectious conditions and therefore is not ideal for distinguishing sepsis from other illnesses especially in adult patients. Therefore, the consensus panel recommended additional SIRS criteria such as mental status, hyperglycaemia, acute oliguria (low output of urine) and decreased capillary refill. The rationale for this recommendation was to ensure the identification of sepsis even in patients without the visible 'sepsis look' as presented in the first definition (Angus & Van de Poll 2013; Gaieski & Goyal 2014). Despite these benefits, the second approach of defining sepsis increased subjectivity in the identification of patients. Also, it was not sensitive enough to detect sepsis, especially in patients in critical care settings who already have these abnormal variables resulting from different health conditions. Thus, there was an urgent need for another definition of sepsis to solve the shortcomings of the second definition (Birriel 2013; Singer et al. 2016; Gaieski & Goyal 2014).

In 2015, the third international consensus presented a new definition of sepsis. This third definition divided sepsis into two categories: "sepsis" and "sepsis shock" as compared to the former definition which included severe sepsis. It defined sepsis as a "life-threatening organ dysfunction caused by a dysregulated host response to infection" (Birriel 2013; Singer et al. 2016). According to this third consensus panel, sepsis is defined as the presence of an infection accompanied with organ dysfunction which is indicated by two or more points of the Sequential [Sepsis-related] Organ Failure Assessment (SOFA) score. The SOFA score assesses six organ systems in the body, which are the respiratory (pressure of arterial oxygen to fractional inspired oxygen concentration [PaO₂/FiO₂ ratio]), coagulation (platelets), liver (serum bilirubin), cardiovascular (hypotension), central nervous system (Glasgow Coma Scale) and renal (serum creatinine and urine output). The higher the SOFA score, the higher the severity of sepsis and risk of mortality (Singer et al. 2016). Vincent, Moreno, Takala, Willatts, de Mendonça, H. Bruining, C. Bruining, Suter & Thijs (1996) provides figure 1 showing SOFA score and cut-off points for each variable.

SOFA score	0	1	2	3	4
Respiration PaO ₂ /FIO ₂ (mm Hg) SaO ₂ /FIO ₂	>400	<400 221–301	<300 142–220	<200 67–141	<100 <67
Coagulation Platelets 10 ³ /mm ³	>150	<150	<100	<50	<20
Liver Bilirubin (mg/dL)	<1.2	1.2–1.9	2.0–5.9	6.0–11.9	>12.0
Cardiovascular^b Hypotension	No hypotension	MAP <70	Dopamine ≤5 or dobutamine (any)	Dopamine >5 or norepinephrine ≤0.1	Dopamine >15 or norepinephrine >0.1
CNS Glasgow Coma Score	15	13–14	10–12	6–9	<6
Renal Creatinine (mg/dL) or urine output (mL/d)	<1.2	1.2–1.9	2.0–3.4	3.5–4.9 or <500	>5.0 or <200

Figure 1: SOFA score and its variables (Vincent et al. 1996)

On the other hand, the third consensus defined septic shock as a "subset of sepsis in which particularly profound circulatory, cellular, and metabolic abnormalities substantially increase mortality" (Birriel 2013). It also stated the three clinical criteria for septic shock are sepsis infection coupled with the presence of hypotension requiring vasopressors/mechanical ventilation to maintain mean arterial pressure (MAP) higher than 65mmHg. Also, serum lactate greater than or equal to 2mmol/L (these criteria must be present after adequate fluid resuscitation) (Slesinger & Dubensky 2016; Birriel 2013; Bhattacharjee et al. 2017).

The third consensus panel started the term "severe sepsis" was absolute and hence excluded from the sepsis definition and classification. The reason given was that severe sepsis (sepsis and at least one organ dysfunction) was limited to the information obtained during the first 24 hours of the diagnosis (Beesley & Lanspa 2016). The third consensus definitions aim to offer more specificity in understanding the disease which could improve sepsis diagnosis. These new definitions of sepsis and septic shock reflect considerable advances made in the understanding of sepsis pathophysiology, epidemiology and treatment of sepsis (Birriel 2013; Bhattacharjee et al. 2017). Westphal and Lino stated that the terms "sepsis, severe sepsis and septic shock represent the chronological evolution of the same syndrome [...]"(2015).

	OLD	NEW
Sepsis	<p>Suspected Infection + ≥ 2 SIRS criteria:</p> <p>Temp >38°C or < 36°C, HR > 90per min, RR > 20per min. or PaCO₂ < 32 mm Hg, WBC count > 12,000/mm³, < 4,000/mm³, or > 10% bands</p>	<p>Suspected Infection + ≥ 2 SOFA score:</p> <p>PaO₂/FiO₂ ratio, platelets, serum bilirubin, hypotension, GCS, serum creatinine and urine output OR ≥ 2 qSOFA score:</p> <p>RR= 22/min, altered mentation, or sBP≤100 mmHg</p>
Severe sepsis	<p>Sepsis + ≥ 1 organ dysfunction</p>	Category removed
Septic shock	<p>Sepsis + Persistent Hypotension (sBP <90 mmHg or MAP <70 requiring vasopressor after adequate fluid resuscitation)</p>	<p>Sepsis + Persistent Hypotension requiring vasopressors to maintain MAP > 65mmHg + Lactate level ≥ 2 mmol/L (both after adequate fluid resuscitation)</p>

Table 1: The summary of the old and new classifications of sepsis

It is important to state that a new sepsis scoring tool (qSOFA) was created by the third international consensus to enhance the diagnosis of sepsis in adult patients in out-of-hospital, emergency department, where the collection or measurement of SOFA variables is not feasible. Singer et al. states:

"[...] adult patients with suspected infection can be rapidly identified as being more likely to have poor outcomes typical of sepsis if they have at least 2 of the following clinical criteria that together constitute a new bedside clinical score termed quickSOFA (qSOFA): respiratory rate of 22/min or greater, altered mentation, or systolic blood pressure of 100 mm Hg or less" (2016, 801).

Each variable of qSOFA has one point and the score range (0-3). The higher the score, the higher the risk of mortality from sepsis (Franchini & Duca 2016).

3 Sepsis screening tools and adult patients

Sepsis screening tools refer to a set of clinical criteria that have been developed by clinicians to assist in the identification of sepsis. The SSC guidelines and the Institute for Healthcare Improvement have laid down the essential characteristics of any sepsis screening tools. It stipulates that every sepsis screening tool should identify three crucial components. The history of a new infection, signs and symptoms of an infection (hyperthermia or hypothermia, tachycardia, tachypnoea, acute mental status change, leucocytosis, and hyperglycaemia), and the indication of organ failure (hypotension, increasing oxygen requirements, elevated lactate, creatinine, or bilirubin level, thrombocytopenia, and coagulopathy) (Birriel 2013; NICE 2017). Many institutions have created and implemented their sepsis screening tools for adult patients based on the SSC guidelines (SSC n.d.)

According to WHO (2013) guidelines relating to age groups and populations, an adult is "a person older than 19 years of age unless national law defines a person as being an adult at an earlier age". From a medical perspective, an adult is a person who has attained characteristics of full growth and maturity (Medical dictionary n.d.). Sepsis definitions and cut-offs values for sepsis criteria (physiological and organ dysfunction) are different in children (Sepanski, Godambe, Mangum, Bovat, Zaritsky & Shah 2014; NICE 2017). Thus, the scope of this thesis is limited to only sepsis screening tools used by nurses to identify sepsis in adult patients.

4 Sepsis identification by (registered) nurses

A register nurse is a person who has received nursing education and met requirements of a licensing authority to practice nursing. In Finland, the registered nurse education is provided in universities of applied sciences and the length is 3.5years (Suomen sairaanhoitajaliitto 2017). Valvira is the licencing body for all healthcare professionals. The nursing care processes of identifying sepsis depend on the care environment or pre-established care/ treatment protocols of healthcare institutions. Nurses care for patients with sepsis at the triage or emergency departments (EM), community care units, ICU or in-hospital care settings. Irrespective of the healthcare settings, sepsis identification requires escalating levels of expertise on the clinical criteria for sepsis categories, and assessment skills. The nurse's role in sepsis identification includes evaluation/assessment, monitoring, communication and documentation (Birriel 2013).

4.1 Assessment and monitoring

The nurse assesses the patient for sepsis by looking at the signs and symptoms of sepsis that the patient might present, review the medical history to determine the presence of a new infection, evaluate risk for sepsis, and lastly screen for the presence of sepsis infection or organ dysfunction (Birriel 2013; NICE 2017).

The examination of the patient for signs and symptoms is a very critical step in the nursing assessment process as accurate assessment enables early recognition of sepsis. The Global Sepsis Alliance (2017), presents signs of sepsis in the 'S.E.P.S.I.'S acronym. 'S' is for shivering, fever, or very cold; 'E' for extreme pain or general discomfort; 'P' pale or discoloured skin; 'S' sleepy, difficulties to stay awake or confused; 'I' I feel like I might die and 'S' shortness of breath. Assessment of patient's symptoms includes measuring vital signs such as temperature, blood pressure, respiratory rate, arterial blood pressure, white blood cell count, level of consciousness and blood sugar levels. The signs and symptoms manifested by a patient sepsis usually depend on the initial site of infection, the type of pathogen causing the infection and the type, as well as the extent of organ dysfunction. It also depends on the underlying health status of the patient, and the interval before initiation of treatment (Jones 2017,279; Vanzant & Schmelzer 2011, 48; Gauer 2013, 45; Mearelli et al. 2015, 2; Mossie 2013, 161; Casey 2016; Käypä hoito 2014).

Second, the nurse also assesses the health history to determine the presence of new infection and to evaluate the patient's predisposition for developing a sepsis infection. In adults, pneumonia, kidney or urinary tract infection, meningitis, post-surgical infections, gastrointestinal tract infections and skin infections or wounds are the most common of such infections preceding sepsis. The sepsis causative organisms are transmittable to a person when they become infected. The patient's pre-disposition for infection relates to the patient's genetic composition and health status (chronic illnesses or impaired immune system). It also refers to pre-existing organ dysfunction the patient might have and therapeutic interventions that the patient is receiving or might have undergone (for example surgery or catheterisation or intravenous treatment) (Jones 2015; Sepsis Alliance 2017; Pomeroy 2009).

Third, the nurse accesses the patient's risk for sepsis. Sepsis is a non-discriminatory infection, to which people from all over the world, regardless of their race, age, and sex are susceptible. However, sepsis is known to be more common in infants and elderly persons than in other age groups, more common in people with chronic illnesses or an impaired immune system than in healthy people, more common in man compared to women, and more common in blacks than in whites. The risk factors for acquiring sepsis and the rate of progression of sepsis depends on the patient's predisposition for infection or chronic diseases (Angus & Van de Poll 2013; Gauer 2013; Marelli et al. 2014)

Lastly, nursing assessments require the nurse to collect blood samples from the patient for blood testing, blood culture test and blood clotting test (usually requested by the physician). Blood testing includes serum lactate levels (elevated levels indicates that the organs are not receiving enough oxygen), complete white blood cell count, and C-reactive protein and procalcitonin test (a blood protein that rises if there is a bacterial infection). Blood culture test determines the source of an infection (bacteria or fungi). Blood clotting test determines if there is an organ failure due to the limited flow of blood and oxygen to any organs due to blood clots (Sepsis Alliance 2017; Vanzant & Schmelzer 2011 50-51; Casey 2016). Sepsis is a dynamic infection with clinical and laboratory manifestations changing over time, and all criteria may not be present at the same time which causes a challenge in diagnosing sepsis. Thus, when screening a patient for sepsis, all relevant diagnostic tests must be used and done regularly (Pomeroy 2009).

On the other hand, the nurse's role in monitoring patient's health consists of checking of the patient's vital signs and laboratory data frequently. Monitoring is usually done either manually or through electronic surveillance systems which provide a constant and timely detection of any changes in the patient's health situation. It is essential for the nurse to the ability to recognise abnormal vital signs and laboratory test results (Birriel 2013; Kleinpell 2017).

4.2 Communication and documentation of patient information

The nurses play a vital role in the diagnosis of patients with sepsis by communicating patient's conditions to the doctors and healthcare team, and by documenting patient information accurately in the health records. Nurses are expected to notify the doctors when they identify a patient with suspected sepsis. Also, the nurse's effective communication skills enable proper collection and reporting of all relevant patient information.

Accurate documentation of the patient's condition/information is essential for early recognition of sepsis as it helps the caregiving team to track and evaluate the patient's condition. An omission or error in documentation can lead to misinformation, which may cause a delay in treatment initiation, initiation of wrong treatment or risk of missing sepsis indicators. This may lead to sepsis progression and death of the patient. The nurses' communication and documentation enable the smooth transition of patients between healthcare units especially when the treatment requires a transfer from one health care unit to another (Angus & Wax 2001; Gauer 2013 44-45; Kleinpell 2017; O'Shaughnessy et al. 2017 25).

5 Purpose, objective and research question of the thesis

The purpose of this thesis is to describe screening tools used by nurses in the identification of sepsis in adult patients. The objective of this thesis is to raise awareness of sepsis screening tools and support nurses in their role of early identification of sepsis.

The research question:

1. What are the screening tools nurses use to identify sepsis in adult patients?

6 Methodology

The methodology seeks to explain the actions taken when investigating a research problem. This thesis methodology shall examine how the data was retrieved and how it was analysed to answer the research question (what are the screening tools nurses use to identify sepsis in adult patients?). This thesis was carried out following the literature review methodology. Booth, Papaioannou and Sutton (2012, 1-2) quoting from Fink (2005) defined a literature review as a: "a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners". A literature review methodology allows for the extensive study and critically summarisation of significant studies published on a topic (Aslam & Emmanuel 2010).

The reason for choosing to carry out this thesis as a literature review is because, healthcare professionals consider it as a valuable information source for evidence-based practices as they provide a more comprehensive summary on a given research topic (Randolph 2009 4; Aveyard 2010, 6).

This literature review process was conducted in four successive steps (formulation of the research question, the search of data, evaluation of data, and analysis of data). The first step was deciding on the topic, the aim of the study (discussed above) and the formulation of the research question. The formulation of this thesis research question was done using the clinical question of the PICO (P-patient, I-intervention, C-comparison, and O-outcomes). The 'patient' is the adult patient, 'intervention' is screening for sepsis, and the intended 'outcome' is the sepsis screening tools used by nurses. There was no comparison in this thesis (Aslam & Emmanuel 2010). The second step consisted of searching for data from academic database using different search terms. The third was to evaluate the relevance and the quality of the potential review articles. Evaluation of the relevance of the materials was done by setting inclusion and exclusion criteria, while the assessment of quality was through critical appraisal (Critical Appraisal Skills Programme (CASP) tool. The fourth step and last step, consisted of analysing the content of the selected data material, interpreting, summarizing and critically presenting them as the findings. Reliability and validity of the literature process were examined, and ethical considerations, trustworthiness, conclusions and recommendations stated (Booth et al. 2012)

6.1 The Data retrieval

The data retrieval process started by choosing suitable database engines to search for review articles. A search for the appropriate academic database led to the selection of the following electronic database: Laurea Finna, CINAHL (EBSCO), ProQuest, PubMed, ScienceDirect and Google scholar. Laurea Finna provided access to e-journals in English as well as the possibility to use both basic and advanced search options (using more than one search terms and search

limitation like the year, title, author, and abstract). CINAHL has over 600 full-text articles on nursing 3000 journals. Through CINAHL, it was easy to insert inclusion criteria (year of publication, peer review articles, and full-content) which significantly made the search more specific. ScienceDirect was selected because it is a multidisciplinary database with thousands of full-text scientific articles. PubMed was easy to use and provided access to other online journals and websites such as MEDLINE and Pub-Med Central, Ovid, Wiley online library, Medline, BMJ and Saga. These journals had many full- text content articles that were relevant to this thesis. ProQuest database had many relevant peer-reviewed articles with full-text content and advanced search options. The Google scholar database provided access to wide range of scholarly literature free of charge and without any subscription requirements (Ave-yard 2010, 74-76; Laurea LibGuides 2017; Bell 2005, 92; Aslam & Emmanuel 2010).

Aveyard (2010, 78-79) proposed the use of a collection of specific keywords to narrow down the search results in a literature review. To this effect, search terms were formulated based on the keywords (sepsis, screening tools, nurse and adult patients), on the purpose and research question of this thesis. The writer decided to add Boolean operators ('AND', 'OR' and 'NOT') between search terms in alternating combinations to broaden and or narrow down the search results. In cases where the database did not provide the possibility to add these Boolean operators (for example in google scholar), the writer added the words AND, OR and NOT manually between the search terms. To avoid over restriction of search terms and the possibility of excluding valid search results, short sentences were also used as search words (Bell 2005, 84-85; Davis 2016 65; Bjork & Räisänen 1997 238; Rory 2013 3; Booth et al. 2012 76; Aveyard 2010 83).

It is important to mention that some of the database engines like the Science Direct and CINAHL EBSCOhost, provided advanced search options wherein, it was possible for the inclusion criteria of 'peer-reviewed', 'full-text' and 'publication date 2007-2017' to be directly inserted alongside the search terms. However, not all database search engines had this type of advanced search options, hence, in such instances, only the search terms or phrases were used to get the search results. All the search terms formulated were inserted into the database as presented in Table 2.

Search Terms	Databases					
	Laurea Finna	CINAHL EBSCOhost	ProQuest	Science Direct Elsevier	PubMed	Google Scholar
Screening tools AND Sepsis AND Adults	2 445	5	4 891	6 812	51	17 900
Sepsis AND Screening Tool AND Adult patients	2 426	3	4 726	6 046	5 164	18 100
Adults AND Sepsis AND screening tools	2 445	5	4 891	203	46	18 100
Sepsis AND Screening Tools AND Adult patient	2 255	5	4 726	195	36	18 100
Nurse AND Sepsis screening	2 423	6	2 733	251	34	17 700
Nurses AND Sepsis Screening AND Adult Patients	1 447	0	2 030	147	12	17 800
Screening sepsis by Nurses AND Adults	1 410	1	2 029	151	6	17 500
Types of Sepsis screening tools	2 888	199	5 764	296	2	17 300
Types Screening AND Sepsis AND Adults	4 997	1	7 331	399	68	18 700
Nurse AND Sepsis Screening AND Adults	3 830	1	2 070	151	19	17 200
Identify OR Screen AND Sepsis AND Patients	4 364	2 9912	1 197 890	3 346	857	212 000
Identifying OR Screening AND Sepsis AND Adults	2 770	8 121	568 164	1 398	3 636	39 800
Sepsis AND Screening AND Adults NOT Neonatal	2 360	5 586	6 532	368	3 346	17 400
Sepsis AND screening AND Adults NOT Children	5 114	12	3 749	205	16 552	19 900
Diagnose Sepsis AND nurse AND Adults	544	0	1 098	176	28	18 100
Detect Sepsis AND Nurse AND Adults	1 079	0	2 077	186	2	17 500
Nurse AND Diagnose AND Sepsis AND Adult Patient	546	0	1 091	174	111	18 200
Nurse AND Diagnostic Tools AND Sepsis AND Adult Patient	677	0	1 707	80	8	17 800
Total number of relevant articles (N=195)	N=44	N=18	N=34	N=23	N=37	N=39

Table 2: Search terms and database search results

6.2 Inclusion and exclusion criteria

The inclusion criteria refer to attributes of an article, essential for their selection while the exclusion criteria relate to characteristics, which require their removal from the data collection. These requirements help the writer of this literature review to identify and collect only articles that address the research question (Aveyard 2010, 71). This initial search produced a massive number of articles. The inclusion criteria (peer-reviewed, sepsis screening tools) and exclusion criteria (published before 2007, studies on infants and less than 18years old as study participants) were used to narrow results of the search. This search led to the selection of total of one hundred and ninety-five (n=195) articles from all database. Table 1 (last columns) shows the number of articles selected from each electronic database using these initial criteria. Forty articles (n=40) articles were removed based on duplicity reasons (appeared in more than one database). One hundred and fifty-five articles (n=155) were collected at this point.

To further narrow down the number of articles to only relevant articles, further inclusion and exclusion criteria were included. An additional one hundred and thirty-six articles (n=136) were excluded based on more inclusion and exclusion criteria. Nineteen (n=19) peer-reviewed articles were selected as potential data material for the analysis of this literature based on their relevance to this thesis aim. The purpose of adding more inclusion and exclusion criteria was to retrieve only articles that answered the research question and to minimise the possibility of selection bias of the data by the writer of this thesis (Rory 2013, 4). Table 3 shows all inclusion and exclusion criteria used in this data retrieval process.

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> ▪ Peer-reviewed articles ▪ Study population: adult patients ▪ Sepsis screening tools ▪ Publication date 2007-2017 ▪ Full-text content 	<ul style="list-style-type: none"> ▪ Books, Journals, Master dissertations, reports ▪ Infants and less than 18years old as study participants ▪ Published before 2007 ▪ Articles without full-text content ▪ Articles with scanty reference list ▪ Articles involving screening tools not used by nurses ▪ Studies with very small sample size (less than a hundred people) ▪ Articles which did not add any additional information

Table 3: Inclusion and exclusion criteria

After the search was completed and documented, the next step was to evaluate of the quality of articles obtained during the data search. Figure 2 illustrates the steps taken in this data retrieval process.

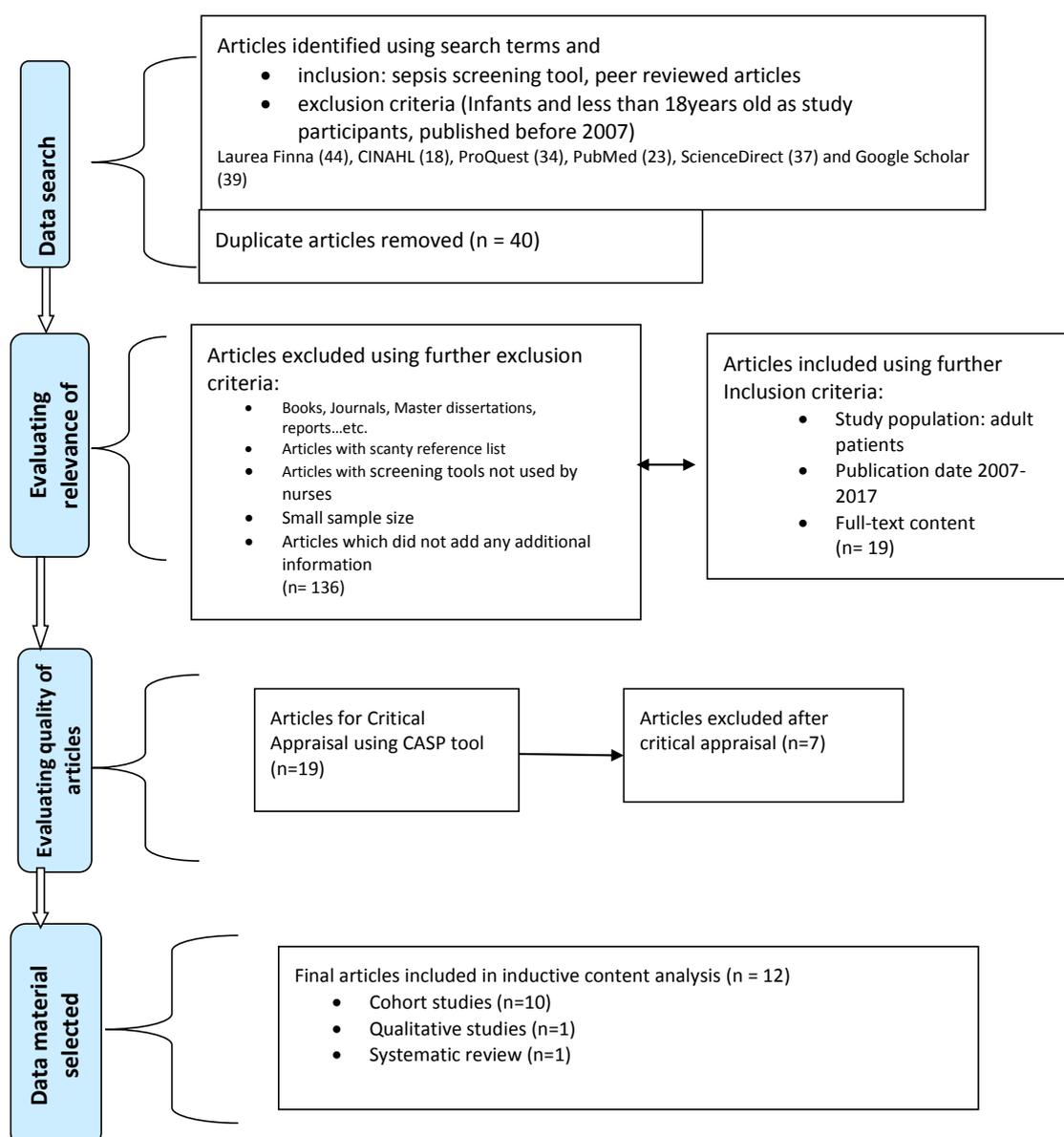


Figure 2: Steps in data retrieval process

6.3 Critical appraisal

The data appraisal of potential review articles for this thesis was through critical appraisal which is a well-defined process in which, the strengths and limitations of research articles are vigorously examined to determine whether their contents can be used in a literature review (Aveyard 2010, 93). Young and Solomon, defined critical appraisal as: "an application of rules of evidence to a study to assess the validity of the data, completeness of reporting, methods and procedures, conclusions, compliance with ethical standards [...]" (2009). In principle, articles selected as possible review articles for data analysis in a literature review should be peer-reviewed articles. However, these articles need to be rigorously tested for their validity and reliability because 'peer-reviewed' does not equal validity (Solomon 2007). The purpose of the

critical appraisal is to ascertain three things. First, to assess if the articles to be used for the literature review have appropriate research designs and methodologies. Secondly, to determine if the evidence presented in the results are free of bias from the author(s). Thirdly, to determine if the results can be used as evidence-based knowledge (Young & Solomon 2009, 82; Russell, Chung, Balk et al. 2009). Through a critical appraisal process, the evidence presented in the peer-reviewed articles are tested against defined fundamental reliability concepts hence preventing the use of low-quality researchers in the literature review. It also helps to assess the trustworthiness of study materials and distinguishes its clinical evidence from opinion, assumptions, and beliefs of the researchers (Young & Solomon 2009; Aveyard 2010, 119-122).

Scientific articles are critically appraised by using a quality appraisal or assessment tool. Im and Chang (2012, 634) define a critical appraisal tool as tools used to verify the quality of each retrieved data material for a literature review. These tools may be in the form of checklists, criteria or statements. Critical appraisal tools are dependent on the study design of the articles. There are different appraisal criteria to verify the quality of systematic review studies, quantitative and qualitative studies (Im & Chang 2012, 634; Russell, Chung, Balk et al. (2009). Given the different research designs of the potential data material, the Critical Appraisal Skills Programme (CASP) tool was the most appropriate and suitable tool for this critical appraisal as it was easy to use and has the checklists for all study designs of the potential review articles. However, the CASP tool does not state the acceptable critical appraisal score that an article should have for it to be selected as a review article, nor does it specify the cut-off points for classifying the scores into high, medium and low-quality materials. Therefore, the articles selected were based on the hierarchy of the CASP tool scores for the various study designs (CASP 2017; Russell et al. 2009).

Based on these recommendations, seven (n=7) of the articles were rejected because they had significantly lower validity scores as compared to the others. A total number of twelve (n=12) articles were accepted as data material for the analysis (ten cohort studies, one qualitative research, one systematic review). The CASP checklists for cohort studies have twelve questions, qualitative studies have ten questions, and systematic review studies have ten questions with a total score of 28, 20 and 20 respectively (CASP 2017). Appendix 1 shows the CASP checklist for all research designs and the appraisal scores of each selected article.

6.4 Data analysis

As stated earlier, the twelve articles selected for this data analysis had different research designs (cohort studies, a systematic review and a qualitative study). Bengtsson (2016, 12) stipulated that content analysis can be used to analyse data from all types of research designs as

it has both quantitative and qualitative methodology which can be applied inductively or deductively. Hence, the inductive content analysis was the appropriate method to use to analyse the data for this thesis. Bengtsson (2016, 9) quoting from Krippendorff (2004, 18), defined content analysis: "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use". An inductive content analysis method was ideal for this literature review as it did not require any previous theoretical assumptions (Bengtsson 2016, 10-12). Appendix 2 provides a brief description of all twelve articles (n=12) retrieved as data material for this literature review (author (s), year, title, design, sample size, country, and results/conclusion).

The process of inductive content analysis was in four phases (decontextualisation, recontextualisation, categorisation, and the compilation). During the first phase of decontextualisation, all data material was independently read several times to enable a detailed comprehension of their contents, followed by highlighting all relevant sentences/phrases from the articles. These sentences were given meanings which were labelled as 'codes'. Several codes emerged from the raw data, and a list of codes from each article was written on a separate sheet of paper. In the second phase of recontextualisation, the original content of all data material was reread and compared with the list of the codes to ensure the inclusion of all the information from the raw data which answered the research question (Bengtsson 2016, 13).

The third stage, categorisation, started by grouping the 'codes' to form sub-categories. The grouping of the sub-categories was based on their similarities, information emerging from the data and on the key concepts of this thesis (Part 2,3 and 4). No 'code' was left out of the categorisation process nor grouped into more than one sub-category. The 'codes' which did not fit into any sub-category were grouped as one sub-category. The sub-categories were externally heterogeneous and internally homogenous. These sub-categories were later grouped into main categories which answered the research question. At this point, five groups of screening tools used by nurses to identify sepsis emerged. These form the main categories, which completes the categorisation step (Bengtsson 2016 13). Figure 3 illustrates how the inductive content analysis was carried out to create the first main category. The formation of other main categories (2,3,4,5) is shown in Appendix 3.

The last stage of content analysis is a compilation of information. It is related to the interpretation (manifest /or latent content analysis) and summarization of the data materials. Ward (2012), referring to Neuendorf (2002) and Krippendorff (2004) states that study results obtained through the latent analysis or manifest content can produce study results that are both reliable and valid. Therefore, the inductive content analysis of data material in this literature review was carried out through the manifest (explicit) and latent(implicit) meanings. The presentation of the content of all data relating to the aim and research question was done objectively and

bearing in mind the inherent or implied meanings of the relevant information in the articles (Bengtsson 2016, 13).

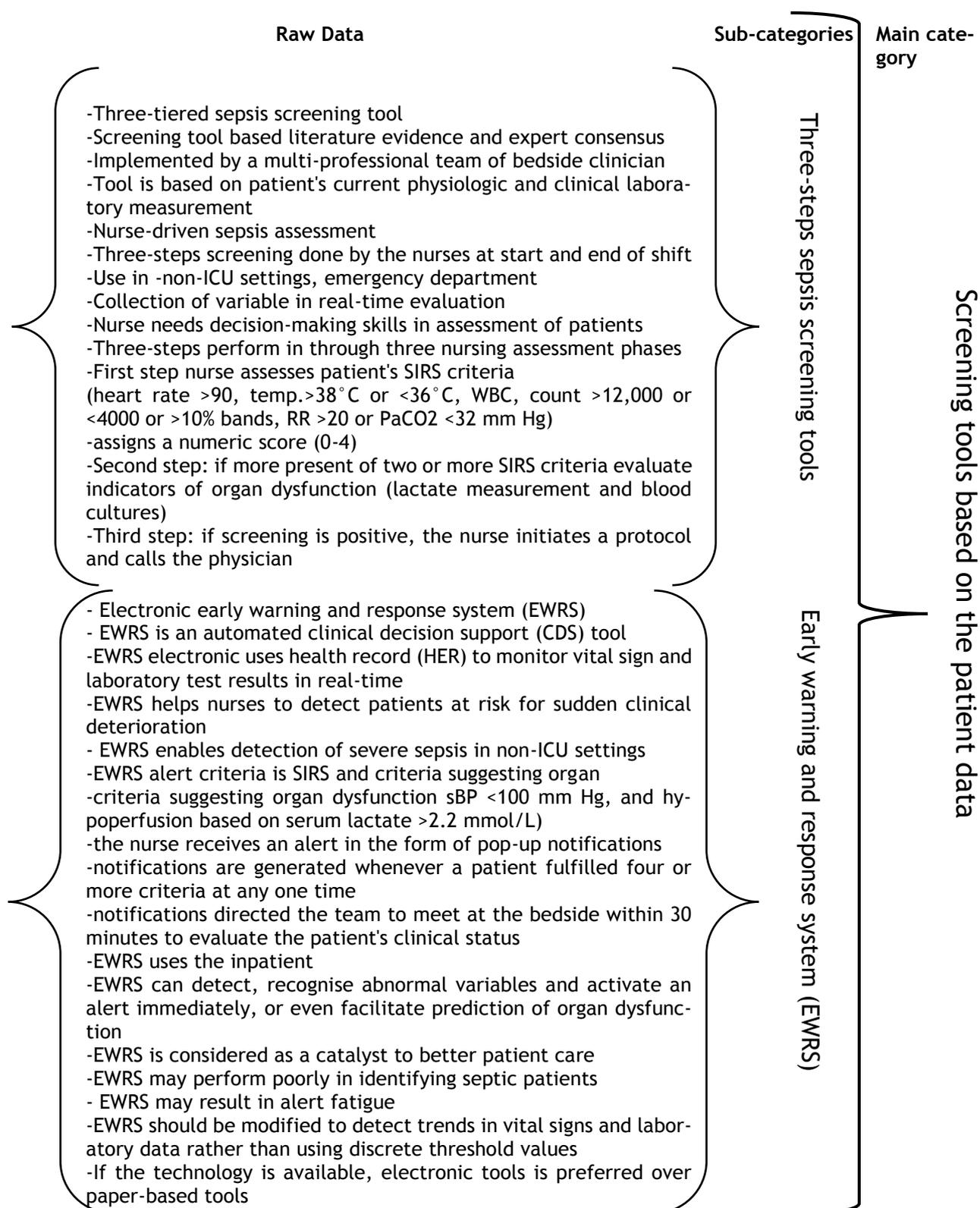


Figure 3: Shows data analysis to form main category 1 and sub-categories

7 Findings

The purpose of this thesis is to describe screening tools used by nurses in the identification of sepsis in adult patients. The research question posed is: "What are the screening tools nurses use to identify sepsis in adult patients?". Data analysis was conducted using inductive content analysis, wherein, twelve peer-reviewed articles were interpreted and summarised. The findings reveal five main groups of sepsis screening tools used by nurses to detect sepsis in adult patients. These are: screening tools based on patient data (three-steps and EWRS), screening tools based on the combination of clinical criteria of sepsis and other clinical variables (StO₂, ETCO₂ and bedside POC lactate levels), screening tools based on the international consensus definition of sepsis (SIRS, SOFA and qSOFA), screening tools based on scoring systems (PRESEP and PRESS tools), and other sepsis screening tools (Robson screening tool, BAS 90-30-90 and clinical judgement). Figure 4 shows the summary of the findings.

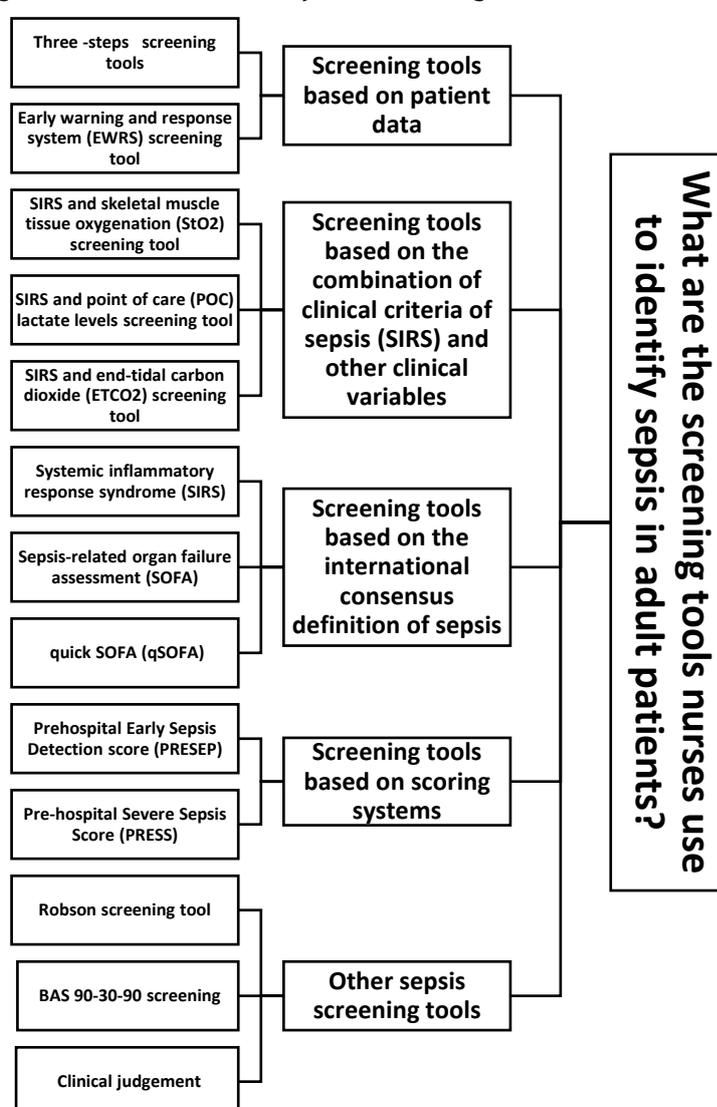


Figure 4: Summary of the findings showing (left to right) the sub-categories, main categories and the research question

7.1 Screening tools based on patient data

Sepsis screening tools based on the patient's data includes three-step or tiered sepsis screening tool and the early warning and response system (EWRS).

7.1.1 Three-steps screening tool

The three-steps sepsis screening tool is a paper-based screening tool to be completed by the bedside register nurse for the early detection of sepsis in adult patients. It is a nurse-driven sepsis assessment tool used in both surgical and medical intensive care adult patients and has been widely advocated by researchers. It is also known as the three-tiered screening tool. This tool was adapted from Surviving Sepsis Campaign guidelines and is used by a multidisciplinary team to screen the patient's current physiological and clinical laboratory measurements routinely done by bedside nurses (Moore, Jone, Kreiner, McKinely, Sucher, Todd, Turner, Valdivia & Moore F. 2009). As the name implies, it is a three-step real-time evaluation and escalating decision-making skills of a nurse. The efficient use of this tool requires the nurse to have clinical decision-making skills and knowledge in identifying patients with sepsis (Gyang, Shieh, Forsey, & Maggio 2015; Moore et al. 2009; Alberto, Marshall., Walker & Aitken 2017).

During the first phase, the nurse screens the patient for the presence of SIRS (temperature (T), heart rate (HR), respiratory rate (RR), and white blood cell count (WBC). There were no cut-off numbers stated, and variables such as like the partial pressure of carbon dioxide (PaCO₂) were excluded (Moore et al. 2009). However, in recent studies such as in Gyang et al. (2015), cut-off scores for parameters of SIRS have been added, and PaCO₂ included. The new criteria of SIRS are temperature 36°C or greater than 38°C, WBC count greater than 12,000ul or less than 4000ul or greater than 10% immature bands, HR greater 90mm/Hg, and RR greater than 20 breaths per minute or PaCO₂ less than 32 mmHg. When the patient has two or more SIRS criteria, and the nurse proceeds to the second step of screening. The nurse measures these variables either at the end or the beginning of their shifts (Gyang et al. 2015; Donnelly, Safford, Shapiro, Baddley & Wang 2017; Gyang et al. 2015; Moore et al. 2009; Alberto et al. 2017).

In the second phase of three-steps screening tool, the nurse seeks to identify the type and source of the suspected infection. The nurse determines if the physiologic derangements seen in the SIRS parameters are an indication of an infection. If the nurse ascertains that no infection is present, further sepsis screening ends. On the other hand, if an infection is detected, the patient meets the criteria for further sepsis screening. The third phase is screening to assess the severity of organ dysfunction. The second and third steps of this tool seek to increase the specificity of the screening tools as it determines the possible sources of infection and the severity of organ dysfunction, respectively (Gyang et al. 2015; Alberto et al. 2017; Moore et al.

2009; Donnelly et al. 2017). If the patient is screening positive for sepsis (≥ 2 SIRS) and positive for the suspicion of a new infection and has end-organ dysfunction, treatment actions are initiated immediately following the hospital's sepsis guidelines. Studies affirmed that this tool is an accurate nurse-driven and SIRS-based sepsis screening tool for early identification of sepsis in medical and surgical patients in a non-intensive care setting (Gyang et al. 2015; Moore et al. 2009; Alberto et al. 2017).

However, the three-step paper-based tool has some limitations. First, it relies heavily on the nurse's assessment skills as they make critical decisions based on their knowledge of the disease and the patient's clinical status. Thus, the result of this test depends on the effectiveness of the nurse's assessment skills in recognising symptoms of sepsis and or organ dysfunction (Gyang et al. 2015). It is stated by Seymour, Liu, Iwashyna, Brunkhorst, Rea, Scherag, Rubenfeld, Kahn, Shankar-Hari, Singer and Deutschman (2016) that SIRS criteria are a traditional tool which has poor predictive validity among patients who are infected. Second, SIRS criteria can be non-specific in the post-operative patients who have hemodynamic changes and elevated systematic inflammatory response due to other health conditions. As a solution to this limitation, studies suggested that the patient's symptoms should be allocated scores only when they emerge within the previous eight (8) hours of the nurse's assessment. Also, a score for comorbidity should be added to improve the predictive value of the screening tool in surgical patients. This is because if a patient is currently undergoing immunosuppressive therapy, it is appropriate to add points to their cumulative score for this reasonable risk factor (Gyang et al. 2015; Moore et al. 2009).

7.1.2 Early warning and response system (EWRS)

The Early Warning and Response System (EWRS) is a sepsis screening tool created to meet the shortcomings of using the old paper-based tool and improve the detection of sepsis (Guidi, Clark, Upton, Umscheid, Lane-Fall, Mikkelsen, Schweickert, Vanzandbergen, Betesh, Tait, Hanish, Smith, Feeley & Fuchs 2015). EWRS uses inpatient electronic health records to monitor current vital signs and laboratory data of patients at risk of experiencing deteriorating health and/or developing sepsis. The EWRS alert parameter consists of SIRS criteria (temperature, heart rate, respiratory rate or arterial carbon dioxide tension (PaCO₂), white blood cell count). EWRS alert criteria also rely on additional variables to detect organ dysfunction (systolic blood pressure, and hypoperfusion based on a serum lactate and mean arterial pressure (MAP) (Alberto et al. 2017; Guidi et al. 2015).

An alert is generated as a pop-up notification whenever a patient has four or more of the above mentioned evaluating criteria at one time. The nurses are the primary response personnel to

sepsis alerts. The nurses apply complex clinical decisions about the patient condition and respond to the sepsis alerts according to specific protocols. The nurse verifies the patient's health record to determine vital signs that triggered the EWRS alert and ensures that all vital signs and laboratory test results are updated in the system. EWRS sepsis screening tool accelerates care process, improved documentation, and ICU transfer which may have reduced sepsis mortality. Studies show that timely response to sepsis alerts by the nurses decreases the risk of mortality. However, the nurse should consider the patient's clinical status whenever an alert is triggered. For example, the patient may have unstable and abnormal SIRS criteria during an immediate postoperative period (Alberto et al. 2017; Guidi et al. 2015).

A significant limitation of this tool is related to alert fatigue, a phenomenon wherein excessive, repetitive, or irrelevant notifications causes nurses and other health caregiving team members to become soothed to warnings which may compromise patient safety. A solution to alert fatigue is that the alert could be signal-to-noise ratio with more focus on sepsis, which could reduce alert fatigue by identifying more general clinical deterioration (Guidi et al. 2015). EWRS tool needs improvement in identifying variability in patient's vital signs, and laboratory test which relates only to distinct sepsis threshold values to decrease the number of false-positive alerts for patients with known baseline laboratory or vital sign abnormalities (Guidi et al. 2015).

7.2 Screening tools based on the SIRS criteria and other clinical variables

The three tools under this category are; sepsis screening tool which combines SIRS criteria with other clinical variables of the patient such as skeletal muscles tissue oxygenation (StO₂), point of care (POC) lactate levels and end-tidal carbon dioxide (ETCO₂).

7.2.1 SIRS and skeletal muscles tissue oxygenation (StO₂) screening tool

Skeletal muscles tissue oxygenation (StO₂) is another screening tool used by nurses at triage to detect sepsis by incorporating the SIRS criteria (heart rate, respiratory rate, and temperature). StO₂ is measured by nurses in triage settings using a Spot Check device. The reason for using this combination tool (SIRS and StO₂) is that unlike in ICU and in-hospital care settings, white blood cell count test is not available at triage. Thus, StO₂ value (instead of WBC count) is combined with SIRS criteria to form a useful sepsis screening tool at triage.

The nurse measures the StO₂ level of the patient by placing the instrument on the thenar eminence of patient's hands while the patient is seating in a relaxed position with the hands placed on their laps. The combination of the score of this StO₂ device with vital signs obtained by triage nurses indicate the presence or absence of sepsis infection. Two or more points of SIRS criteria is a positive screen for sepsis. Interpretation of the StO₂ values is as follows: one

point is given to each variable if it is within the range of a "positive" value. StO₂ measurements are either abnormal or normal (<75% or ≥90% respectively). High StO₂ percentages denote the possibility of non-sepsis. Hence, this means that irregular heart rate, temperature, and low triage StO₂ (<75%) are independent predictors of sepsis at triage. The StO₂ score exhibits a slight correlation with lactate levels (Goerlich, Wade, McCarthy, Holcomb & Moore 2014).

In Goerlich et al. (2014), SIRS criteria and StO₂ sepsis screening tool measurements are non-invasive and have a good diagnostic potential for the early identification of sepsis by triage nurses. However, this tool should be used with precaution as static StO₂ measurements may not adequately assess microcirculatory disturbances in septic patients. Some patients may experience active arteriovenous shunting and decreased peripheral microcirculation, whereas, others may have these symptoms shortly after the shock and are adequately compensating with minimal peripheral circulatory compromise. Other patients may even present in a post-hypoxic, reactive hyperaemic state, a possible manifestation of abnormally high StO₂. The recommendation for the SIRS and StO₂ sepsis screening tool is that it could be incorporated with simple screening questions that nurses can use to determine the potential source of an infection (Goerlich et al. 2014).

7.2.2 SIRS and point of care (POC) lactate levels screening tool

The clinical sepsis criteria (SIRS) use in combination with bedside point-of-care (POC) lactate levels can be used by nurses to detect suspected sepsis, severe sepsis and septic shock (main outcome). The results of this combination (SIRS and POC lactate) can help the nurse to determine if the patient needs vasopressors in the ED, admission or transfer to the ICU, or if the patient is at risk of in-hospital mortality (secondary outcome). The variables for SIRS are a temperature greater than 38°C or less than 36°C, heart rate greater than 90 beats/min, respiratory rate greater than 20 breaths/min, or altered mental status). The parameter of POC lactate testing is greater or equal to 2.0 mmol/L. Lactate levels correlates with sepsis severity, that is, the higher the lactate level, the more severe the sepsis infection. High bedside lactate levels correlate with poor outcomes, ICU admissions, and increased mortality (Singer, Taylor, Domingo, Ghazipura, Khorasonchi, Thode, Henry & Shapiro 2014).

One of the benefits of using SIRS criteria in combination with bedside POC lactates is that not all patients with sepsis will appear to be severely ill. Thus, it is difficult to detect visible signs of sepsis through patient assessment. Measuring lactate is an increasingly well-utilized procedure which enables screening patients with severe occult sepsis, also known as a cryptic shock. This is a situation when the patient's blood pressure and mental status are normal, but the patient is still at substantial risk of mortality from a sepsis infection (Singer et al. 2014).

The nurse is required to apply precaution when using SIRS criteria and POC lactate to screen for sepsis in patients who have underlying conditions. These may include: "diabetes mellitus, chronic obstructive pulmonary disease (COPD), congestive heart failure, coronary artery disease, HIV, end-stage renal disease, active malignancy, organ transplant, indwelling vascular line, and residents of a nursing home" (Singer et al. 2014). The rationale for this is that some patients may have high serum lactate levels because of underlying comorbidities. For example, patients with diabetes or COPD had significantly higher levels of lactate compared to those without these underlying diseases (Singer et al. 2014).

The nurse should also be aware that, even though, elevated lactate levels, especially when higher than 4 mmol/L, is highly specific for all stages of the sepsis categories. However, normal lactate level should not be used to exclude a possible diagnosis of sepsis. This is because patients may have septic shock and can be unresponsive to fluid resuscitation despite normal initial lactate levels. It is possible that patient's lactate levels might have been measured at the very beginning of the disease process, and therefore tissue hypoperfusion may not have been present long enough for lactate levels to rise significantly (Singer et al. 2014).

7.2.3 SIRS and end-tidal carbon dioxide (ETCO₂) screening tool

Hunter, Silvestri, Ralls, Stone, Walker and Papa (2016) research examine a prehospital sepsis screening protocol which utilises a systemic inflammatory response syndrome (SIRS) criteria and end-tidal carbon dioxide (ETCO₂) to detect sepsis in adult patients in emergency medical settings. This study emphasises that SIRS criteria, when combined with ETCO₂ levels in the prehospital setting, could help to predict sepsis and severe sepsis and potentially decrease time to therapeutic intervention. ETCO₂ has a higher discriminatory power to predict sepsis, severe sepsis, and mortality than other vital signs collected in prehospital settings.

Nurses working in prehospital care setting can obtain ETCO₂ levels (through the LIFEPAK device) simultaneously with traditional vital signs- SIRS criteria (respiratory rate, systolic blood pressure diastolic blood pressure (DBP), pulse (P) and oxygen saturation (SpO₂)). When using this sepsis screening tool (SIRS and ETCO₂ level), the nurse initiates an alert sepsis when an adult patient has three important determinants: a suspected infection coupled with two or more SIRS criteria and ETCO₂ lower than 25mmHg (Hunter et al. 2016).

In prehospital settings, ETCO₂ replaces serum level as a marker of hypoperfusion in recognition of severe sepsis. This is because the collection of serum lactate levels in the prehospital environment can be difficult and expensive to obtain. Thus, the nurses in prehospital setting may carry out sepsis screening by using the LIFEPAK device to measure ETCOs (instead of lactate serum) to test for hypoperfusion. Unlike serum lactate levels, ETCO₂ levels can be measured immediately and non-invasively, making it a simple and clinically useful outcome predictor of

sepsis in the prehospital environment. Using ETCO₂ as an objective marker for hypoperfusion may help discriminate between potentially septic and severely septic patients (Hunter et al. 2016). Abnormal prehospital ETCO₂ is correlated with metabolic acidosis and elevated serum lactate levels. Low ETCO₂ levels relate to lactic acidosis which is a well-accepted marker for hypoperfusion. Hypoperfusion is the leading cause of end-organ dysfunction and cardiovascular collapse (severe sepsis and septic shock). Hence, ETCO₂ is an indicator of organ dysfunction and risk of mortality in patients with suspected sepsis in emergency departments (Hunter et al. 2016).

Despite the advantages of this tool, the nurse should consider the appropriate time to measure ETCO₂ levels. ETCO₂ measurement is in real-time. Thus, ETCO₂ levels may change relatively quickly as compared to serum lactate levels. Also, factors such as the respiratory rate of the patient and certain medications can alter ETCO₂ levels; this makes it challenging for the nurses to interpret ETCO₂ levels in critically ill patients. More studies is needed to establish the validity of ETCO₂ in predicting sepsis (Hunter et al. 2016).

7.3 Screening tools based on Third International Consensus definitions of sepsis

The screening tools based on the third international consensus definitions of sepsis include systemic inflammatory response syndrome (SIRS) criteria, sepsis-related organ failure assessment (SOFA) score, and quick SOFA (qSOFA) score (Seymour et al. 2016; Donnelly et al. 2017). The SIRS criteria focus on identifying the presence of an infection. The patient is considered to have an infection if at least two SIRS criteria variables are positive (Donnelly et al. 2017). A positive screen in SIRS criteria requires admission into ICU.

The SOFA score detects screens for organ failure. The patient variables assessed by the nurse using SOFA score to detect sepsis include: altered mentation, mean arterial pressure, vasopressor administered, serum creatinine (mg/dL), bilirubin (mg/dL), platelet count (10 cells per L), and pressure of arterial oxygen to fractional inspired oxygen concentration (PaO₂/FiO₂ ratio). If the patient has at least two or more SOFA score points, sepsis can be diagnosed and is considered high and an indication of infection-related organ dysfunction (Donnelly et al. 2017). Screening for sepsis using the SIRS criteria, SOFA score, is done 48 hours before, and 24 hours after the onset of infection or on each calendar day (Seymour et al. 2016).

The qSOFA score screens for sepsis outcomes. It uses three (3) clinical variables without laboratory tests. It is an efficient screening tool for used outside of ICU because complicated laboratory tests are less available in non-ICU settings. The three variables that the nurse measures are systolic hypotension (≤ 100 mm Hg) tachypnoea (≥ 22 /min), and altered mental status (Glasgow coma score < 14). The qSOFA score ranges from 0-3 points (one point for each variable). The time window for the nurses to measure qSOFA variables is three (3) or twelve (12) hours

(before/after) the onset of infection. In these studies, the predictive validity of qSOFA score was not significantly different when the nurses used the GCS score <15 compared with the model which used GCS score ≤ 13 . Patients with high qSOFA have the highest prognosis of in-hospital mortality, 28-day mortality rate and 1-year death after discharge compared with patients with infection who met only SIRS criteria or who had elevated SOFA scores (Seymour et al. 2016; Donnelly et al. 2017). However, nurses should apply precaution when using this tool and should take into consideration whether the patient has pre-existing organ dysfunction, concurrent organ support, treatment received before admission, and the presence of dementia. Patients with dementia (abnormal GCS score at baseline) will always have one qSOFA point due to an altered mental status variable but may not be as likely to have sepsis as a patient with normal baseline. Ongoing organ support (for example, mechanical ventilation or vasopressors) and effects of some medications may alter qSOFA score variables and hence produce false identification of sepsis (Seymour et al. 2016).

Examining the effectiveness of SIRS, SOFA and the qSOFA score in the light of each other, the studies revealed that SOFA and qSOFA score is more sensitive to identify patients at increased risk of poor sepsis outcomes. They have a higher Positive Predictive Value (PPV) than SIRS criteria.

7.4 Screening tools based on scoring systems

These screening tools were developed from EMS personal data on the patient and depend on different scoring methods to detect septic patients and severe sepsis in adult patients in pre-hospital settings.

7.4.1 Prehospital Early Sepsis Detection score (PRESEP)

The PRESEP is an early warning scoring system used by nurses to identify septic patients in a pre-hospital setting. PRESEP score is defined as the sum of simplified weights which includes patient variables (based on the consensus diagnostic SIRS criteria) such as temperature, heart rate (HR), respiratory rate (RR), peripheral capillary saturation (SaO₂), Glasgow Coma Scale (GCS) score, blood glucose, and systolic blood pressure (sBP). These patients' variables are routinely assessed by the nurses in pre-hospital settings (Bayer, Schwarzkopf, Stumme, Stacke, Hartog, Hohenstein, Kabisch, Reichel, Reinhart & Winning 2015).

The PRESEP score cut-off values are as follows: temperature > 38°C (4 points) or temperature < 36°C (1 point). HR > 90 beats/min (2 points), RR > 22 breaths/min (1 point), SaO₂ < 92% (2 points), sBP < 90 mm Hg (2 points). No points are attributed to GCS and blood glucose levels

but their cut-off values were < 15 and > 6.6 mmol/L respectively. PRESEP score is calculated as the sum of simplified weights of the patient variables which ranges between 1 and 4 as shown above. The nurse identifies the patient as septic if the patient has four or more points in PRESEP score (Bayer et al. 2015).

Despite its practicability, the nurse should consider the underlying health conditions of the patients when using PRESEP score as a screening tool for sepsis. This is because, PRESEP score may indicate a positive sepsis diagnosis in patients with non-infectious diseases. For example, a patient with heat stroke has elevated temperature, tachycardia and low systolic blood pressure. Such patient may be considered as having a high PRESEP score, thus, producing a false positive diagnosis of sepsis. Based on these variables, the patient PRESEP score equal to eight (8) at baseline. Hence, the nurse considers a PRESEP score as a valid positive diagnosis of sepsis only when the evidence of the disease is present or likely to be present before antimicrobial therapy had started (Bayer et al. 2015).

7.4.2 Pre-hospital Severe Sepsis Score (PRESS)

The PRESS sepsis screening tool is a novel 'predictive' tool developed in American Emergency Medical Service (EMS) to help nurses to detect severe sepsis. Unlike other screening tools, the identification of sepsis using the PRESS score does not require the nurse to screen the patient. Rather, the nurse identifies the 'at risk factors' from pre-collected EMS clinical information of the patient. PRESS score has six risk factors which are significant predictors of severe sepsis: older age, transport from the nursing home, Emergency Medical Dispatch (EMD) chief complaint category of "Sick Person", hot tactile temperature, low systolic blood pressure, and low oxygen saturation (Polito, Isakov, Yancey, Wilson, Anderson, Bloom & Sevransky 2015).

In Polito et al. (2015), the nurse calculates the risk factor points using clinical judgement as follows: EMD chief complaint of a 'sick person' (3points), EMS transport of patient from nursing home to the emergency department (4points), age of the patient is calculated as 18-39 (0 points) ,40-59 (4points), 60years or more (2points). Hot tactile temperature (3points). Systolic blood pressure (mmHg) 100-109 (0 point), 90-99 (1 point), 80-89 (2 points),70-79 (3 points), 60-69 (4 points) and less than 60 (5 points). Oxygen saturation (%) greater than or equal to 90 (0 points), 80-89 (1 point), 70-79 (3 points), 60-69 (4 points) and less than 60 (5 points). The total points for PRESS score are (0-24). Two or more (≥ 2) PRESS scores increases the patient's risk for severe sepsis.

7.5 Other sepsis screening tools

Robson screening tool is a Swedish pre-hospital or emergency medical services sepsis screening tool to identify septic patients. This sepsis screening tool is an adaptation of the Surviving Sepsis Campaign diagnostic criteria. Identification of sepsis using this tool is carried in two steps. First, the nurse assesses the patient for the following SIRS criteria: temp. $<36^{\circ}\text{C}$ or $>38^{\circ}\text{C}$; HR >90 beats/min; RR >20 breath/min; acutely altered mental status; and plasma glucose >6.6 mmol/l unless diabetic. Second, the nurse examines the history of the patient, if it suggests the presence of a new infection. The nurse considers that the patient has sepsis if two or more of the SIRS criteria as mentioned earlier are present or new to the patient, and if the patient has a history of a new infection (Wallgren, Castren, Svensson & Kurland 2014). This tool has been criticized for not adequately specifying the definition of 'history suggestive of new infection' and not stating the 'acutely altered mental status' cut-off value. However, studies indicate that a modified version of Robson tool has been created which includes a definition of the history of suggestive of a new infection and cut-off value for altered mental status. In Bayer et al. (2015), modified Robson screening tool cut-off value for altered mental status is GCS < 15 . Polito et al. (2015), stated that the new Robson tool uses modified SIRS criteria, the presence of a suspected infection and evaluates if the patient has end-organ dysfunction (systolic blood pressure, oxygen saturation, anuria, lactic acidosis,) and prolonged bleeding from injury or gums. Robson screening tool demonstrates high sensitivity, but its specificity and positive predictive value (PPV) are lower compared to other tools. The most important benefit of the Robson tool is its positive effects on the pre-hospital identification of sepsis and timely administration of treatment. Robson screening tool has a high sensitivity but also requires incorporation of data that may not be routinely available in emergency settings (Wallgren et al. 2014; Polito et al. 2015; Bayer et al. 2015).

Another Swedish sepsis screening tool is BAS 90-30-90. This tool is founded on the Swedish EMS guidelines for sepsis screening, and it uses three clinical indicators. BAS 90-30-90 is an acronym for vital signs (systolic blood pressure < 90 mm Hg; respiratory rate > 30 breaths/min and oxygen saturation $< 90\%$) (Bayer et al. 2015; Polito et al. 2015; Wallgren et al. 2014). One or more positive values of these parameters indicate sepsis. The purpose of this screening tool is to detect severe sepsis as well as identify patients who are septic but have no organ failure (Wallgren et al. 2014).

In Wallgren et al. (2014), 'clinical judgement' is a sepsis screening tool used in EMS department to identify septic patients. The clinical judgement of sepsis includes all the documentation related to "suspected sepsis/septicaemia/urosepsis/blood poisoning" in their primary assessment of the patient. The sensitivity of this tool in detecting sepsis in this study is one of the lowest. However, Gyang et al. state that: "clinical judgment could be further bolstered by

adding promising laboratory tests such as C-reactive protein or procalcitonin as objective adjuncts to an initial assessment for sepsis which could potentially increase screening test PPV" (2015).

8 Discussion

As earlier mentioned, the purpose of this thesis is to describe screening tools used by nurses to identify sepsis in adult patients. The research question (what are the screening tools nurses use to identify sepsis in adult patients?) was thoroughly investigated to achieve the aim of the thesis. The discussion of this work would consist of arguments based on the findings and the literature review process.

8.1 Discussion of the findings

Previous studies have confirmed the use of paper-based and electronic sepsis screening tools by nurses to assess sepsis in adult patients. In the first case (paper-based), the nurse gathers the data required to indicate sepsis; while in the second case (electronic), the nurse receives the alert of sepsis. It is important to note that there has been a shift in the three-steps screening tool from paper version to an electronic version. This change is because the paper-based screening tool has been considered as labour intensive for the nurses as each criterion of sepsis must be searched for in the patient record and scores added by hand which may create an opportunity for inaccuracy. Also, many healthcare institutions currently use electronic medical records (EMR) for their patients which facilitates the use of electronic screening tools to be used in sepsis identification (Birriel 2013).

The findings reveal that the three-step (paper-based) sepsis screening tools are a valid nurse-driven screening tool which can be useful in community health centres and in low resource countries where the availability of technology to support electronic sepsis tools like EWRS is widely lacking. These findings have been correlated in other studies. In most developed countries, patients in ICU are under 24hour continuous screening through electronic surveillance systems. Also, EWRS screening tools have been incorporated in the care of critically ill patients. For example, in the United Kingdom, a modified version of the EWRS known as National Early Warning Scores (NEWS) sepsis screening tools have been developed and implemented as a standardised assessment tool for patients with acute illnesses. In addition, a card and a smartphone app have been designed and linked directly to the NEWS tool, making it a popular sepsis screening tool in primary and community healthcare settings (Kleinpell 2017; Jones 2015; Sepsis Alliance 2017; Gatewood et al. 2015).

The findings also reveal that the SIRS criteria combined with other patient's clinical variables such as STO_2 , $ETCO_2$ and POC lactate levels provide sepsis screening tools with high predictive values. The findings show that using only the SIRS criteria in the diagnosis of sepsis is not sufficient. This is because the SIRS criteria have overlapping clinical and laboratory variables and are not specific enough to distinguish sepsis from other types of infections. This may lead to diagnostic mistakes which may delay diagnosis of sepsis which is life-threatening. Patient variables such as STO_2 , $ETCO_2$ and POC lactate levels measures can enhance the nurse's ability to identify sepsis. These tools are non-invasive and can detect not only the inflammatory response but also the source of an infection; detect a patient with cryptic sepsis, and can accurately differentiate the severity and risk or mortality of the sepsis infection respectively. POC lactate is an effective biomarker for sepsis detection. In earlier studies, biomarkers such as C-reactive protein (CRP) and Procalcitonin (PCT) were considered as excellent biomarkers, and they have higher predictive values than serum lactate. However, these thesis findings did not reveal information on currently used sepsis biomarkers for detection of sepsis in adult patients.

The third category of the findings are the screening tools based on the new consensus definition of sepsis. The qSOFA score is better predictive validity than SIRS and SOFA score. Nurses in out-of-hospital settings can easily measure its variable (respiratory rate, altered mentation, or systolic blood pressure). The background literature concurs with findings that diagnostic criteria for sepsis, severe sepsis and septic shock are SIRS, SOFA and qSOFA (see paragraph 2.1.2). It also confirms that qSOFA score is not a direct diagnostic tool for sepsis but a tool to determine the prognosis of sepsis. Hence, qSOFA should not replace SIRS as the definition of sepsis, but it should substitute SIRS as a sepsis screening tool (Franchini & Duca 2016).

Sepsis screening based on scoring systems include the PRESEP and PRESS scores, the former uses patient risk features for sepsis and latter uses six predictors of sepsis to determine sepsis in adult patients. The background literature supports the findings. Nurses in their role of assessment of patient must evaluate the patient for the risk factors of sepsis. Thus, PRESEP is supported by previous studies. However, the PRESS score was developed from a specific standpoint, and its application is not meant for all patients in the EMS setting. This tool needs further validation for use in other patient groups.

The last group of sepsis screening includes Robson screening tool, BAS 90-30-90 and clinical judgement. The implementation of these tools leads to the effective identification of sepsis. However, research studies indicate that Robson screening tool was more sensitive than the BAS 90-30-90 or clinical judgement. Even though, findings of this thesis show that clinical judgment is a less superior screening tool compared to others. The opinion of the writer is that clinical judgement is a tool which directs all other sepsis screening tools. This is because the nurse

needs clinical decision making when assessing the patients' signs and symptoms as well as to understand and interpret the results of the variables measured using any screening tool.

In summary, it is evident that even though these sepsis screening tools have been created and validated in different care settings, they are more similar than different from each other. From the SSC guidelines relating to the three components of an effective sepsis screening (source of infection, the presence of SIRS, and organ dysfunction), it is safe to say that some screening tools demonstrate better efficiency in detecting one or two or all three components than others (Birriel 2013). This concurs with previous studies which suggested that when screening for sepsis, all relevant diagnostic test must be used (Pomeroy 2009).

8.2 Ethical considerations

The Laureas' thesis guidelines 2015 on thesis writing was read by the writer to acquire knowledge on ethical principles in thesis writing. A binding thesis contract was signed where the author accepted to follow the rules of academic writing. There was no fabrication of material evidence for this work. All the references are stated (within the text and in the reference list). Hence, eliminating the possibility of plagiarism (Day & Gastel 2011, 26). All the articles used as data material were articles from academic journals which had as a prerequisite the ethical treatment of all participants in the studies. Also, most of the studies used for this literature review had no conflicts of interest and those researchers which had, disclosed such conflicts (Day & Gastel 2011, 27). The writer of this thesis remains unbiased throughout the process of data retrieval, data evaluation, critical appraisal and data interpretation.

The following considerations were made for setting inclusion and exclusion criteria which were pre-determined to help limit the risk of bias in the data collection process. Firstly, materials such as books and master dissertation were excluded because they do not undergo the same scrutiny as a peer review article which offers the best quality and reliable material source from which conclusions can be made (Aveyard 2010, 73). Secondly, articles with participants under ages of 18 years were excluded because the scope of this work is limited to sepsis screening tools for an adult patient, this ensured that only useful materials used and scope of the work maintained (Booth et al. 2012, 55). Thirdly, setting a time limit for ten (10) years was made on the basis that sepsis screening for in adult patients has evolved over the years due to advancement in technology and the growing knowledge on sepsis infection. The ten years period (2007- 2017) as a time-limit for a study was conducted is an adequate time frame to evaluate different sepsis screening tools which have been used by nurses over this period (Bell 2005, 85). It was stated in Rory (2013, 5) that, articles which provide rich material sources but are only available in another language unfamiliar to the author(s) could be translated and use as a data material. Therefore, the English language was not considered as either an inclusion or exclusion

criterion for reasons that it might limit the search results. This led to the selection an international data material, thus, a possible real reflection of sepsis screening tools used by nurses all over the world.

8.3 Trustworthiness of the thesis

The trustworthiness of a qualitative content analysis is assessed through the principles of dependability, credibility, transferability, and conformability (Bengtsson 2016, 13).

Dependability assesses the extent to which data changed over time and subsequent alterations made during the data analysis. It is related to reliability which seeks to measure the extent to which a research study when done for the second time or by another author(s), and using the same research methodology and given that every other thing stays constant, would produce the same (or related) results /findings. Reliability assesses the consistency or repeatability of a research study. As earlier mentioned, literature review methodology was strictly followed and extensively described in all clarity so that another researcher investigating this topic and using these techniques would be able to achieve similar findings (Bell 2005, 117; Booth et al. 2012, 112; Bengtsson 2016,13).

Credibility is related to the validity of a study which seeks to assess if the research achieved what it was supposed to accomplish and whether the evidence is valid enough to be applied in practical situations. The research question of this thesis was answered by the findings, thus achieved the purpose of the thesis. Data material was selected based on their relevance to the topic and their quality (inclusive and exclusive criteria, critical appraisal) and not on the writers' subjective reasoning. This ensures that the findings of this work are not tinted with bias during the data collection phase. In addition, the validity of a literature review is based on the quality of the articles reviewed, and its findings are only as good as the primary studies upon which it is based. If the data materials are flawed, the findings and conclusions will not be valid. All research included in this data analysis process were selected using inclusion and exclusion criteria, and they had considerably high critical appraisal scores. (Bell 2005, 117; Bengtsson 2016, 13). The writer believes that these aspects ensure the credibility of this work.

Transferability relates to generalization and it seeks to assess the degree to which the findings of a research may be applicable to other settings or groups of participants. The writer believes that the findings of this thesis would add to the limited amount of literature available on nurse-driven sepsis screening tools. This research can also be conducted as a qualitative survey study (Bengtsson 2016, 13). Confirmability, on the other hand, is related to authenticity, it assesses the objectivity or neutrality of the findings. As earlier stated, all findings were presented objectively, personal bias, as well as previous knowledge on sepsis screening tools, did not influence how the data was analysed and how findings were presented. This work is not a repetition

or duplication of another thesis; its findings are unique to a certain extent (Bengtsson 2016, 13). However, this work has some limitations.

8.4 Strengths and limitations of the study

Aveyard (2010, 132) stated that it is important to examine the strength and weaknesses of a literature review. This literature review has the following strengths (international perspective, new insights, findings are applicable, and supported by previous studies). Firstly, the articles used were based on studies conducted in countries such as USA, Sweden, Germany, and Italy. This has accredited an international perspective to the findings. Also, some of the research studies were conducted in multiple centres with an enormous sample size and included patient's encounters from different units of acute care (see Appendix 2 describing the reviewed articles). These aspects also ascertain the validity and transferability of this thesis findings. Secondly, this thesis seeks to investigate sepsis screening tools from a unique and new angle. The writer is optimistic the findings of this work would provide new insights and add to the few existing evidence-based literatures available on sepsis screening tools which nurses can use to identify sepsis in adult patients. Thirdly, thorough background knowledge of important concepts related to this study is provided. Most of the reference materials used throughout this work were from journal articles, books, and other recognized web pages. This is a conscious decision by the writer to avoid using information from blogs, links and articles written anonymously or lacking academic credibility to maintain the validity throughout this work. Lastly, the findings of this thesis are feasible and meaningful in the care of adult patients with sepsis. The possible impact of the application of these findings into real-life situations can lead to early diagnosis and timely administration of treatment therapies. However, the application of these findings in practical situations would depend on the healthcare institutions, and the knowledge as well as the willingness of the nurses and health care professionals to use these screening tools.

One of the limitations of this work is that only one writer reviewed the data collected. Two or more writers may have added more conformity to the data selection process (Smyth et al. 2016). However, this literature review process was diligently and carefully executed in such a way that the selection of the data by one writer would not have been very different to produce contradictory findings if there were two or more writers. Also, the analysis was done through inductive manifest and latent content analysis, which may be a risk for objectivity in the compilation phase. Strict measures were taken to ensure that the writer maintained objectivity throughout the process. For example, the writer used codes to extract raw data material and cross-checked several times to ensure that the 'codes' reflected the content of the data materials. Personal assumptions and opinions about the findings of this work were mentioned in discussion and not in the findings section (Smyth et al. 2016; Bell 2005, 117). Another limitation of this work relates to the limited scientific materials on sepsis screening tools that can be use

by nurses to determine sepsis in adult patients in Finland. No article based on Finnish studies made it through the selection process.

9 Conclusions and further recommendations

The findings reveal five groups of sepsis screening tools with varying effectiveness in detecting sepsis. It indicated the variables to be measured when using such screening tools, and stated the benefits, limitations, and considerations for the application of the screening tools. Thus, it is not an overstatement to acknowledge that these aspects of the findings answered the research question and hence, achieved the purpose of this thesis which is to describe screening tools used by nurses in the identification of sepsis in adult patients. The objective of this thesis is to raise awareness of sepsis screening tools for adult patients and to support nurses in their role of identification of sepsis. Based on personal experience relating to how much valuable evidence-based knowledge has been acquired during the investigation of this topic, the writer believes the findings of this thesis will help to raise awareness on the importance of sepsis identification through screening tools. Nursing students, nurses or other health care professionals reading this work may educate themselves on how to detect sepsis in adult patients which may be a minor yet a proactive step in the fight against sepsis.

In conclusion, it is imperative to state that, the findings indicate that sepsis screening is not "a one-fits-all" type of screening as the sepsis criteria-systematic inflammatory response is manifested differently in patients. Factors such as the patient's underlying medical conditions, age and medication affect what signs and symptoms a patient might present causing a challenge in sepsis identification (Jones 2017). Hence, the nurses need to be flexible in the use of sepsis screening tools. It is vital to take into consideration the patient's individual characteristics to minimise false negative and false positive screening results. The nurses, as well as the other healthcare professionals, should consider the best sepsis screening tools for each patient depending on their work environment.

The writer recommends that training on sepsis should be incorporated immensely into nursing school curriculums as its the case with other diseases such as cancer, cardiovascular disease and HIV/AIDS. This will enhance student nurses' clinical assessment skills for sepsis identification, and support them in their prospective roles as nurses. Healthcare institutions should periodically provide training to nurses and healthcare professionals on current evidence-based knowledge on practices to promote the early diagnosis of sepsis. Furthermore, additional clinical studies should be conducted to validate existing sepsis screening tools as well as the development of new tools for widespread use by nurses in the identification of sepsis in adult patients.

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Appendix 2: Description of articles selected for data analysis

Author(s)/ Year	Title	Aim	Research Method/data size/country	Results/Screening tool	Academic Database	Critical appraisal tool/validity score
1 Wallgren, Castren, Svensson & Kurland (2014)	Identification of adult septic patients in the prehospital setting: a comparison of two screening tools and clinical judgment	Compares the effectiveness of two pre-hospital sepsis screening tools with clinical judgment by emergency medical services (EMS) in sepsis identification.	A retrospective cross-sectional study of 353 adult patients. Sweden	Robson screening tool had a sensitivity superior to both BAS 90-30-90 and clinical judgment.	CINAHL EBSCOhost	CASP =25/28
2 Gyang, Shieh, Forsey, & Maggio (2015)	A Nurse-Driven Screening Tool for the Early Identification of Sepsis in an Intermediate Care Unit Setting	Examine the performance of a nurse-driven sepsis screening tools both medical and surgical non-ICU settings.	Observational pilot studies. A total of 2143 screens on 254 adult patients in academic centre over a 1month period. USA	Three-tiered paper-based screening tool had high sensitivity and specificity for identification of sepsis	PubMed	CASP =27/28
3 Bayer, Schwarzkopf, Stumme, Stacke, Hartog, Hohenstein, Kabisch, Reichel, Reinhardt & Winning (2015)	An Early Warning Scoring System to Identify Septic Patients in the Prehospital Setting: The PRESEP Score	Develop and evaluate an early sepsis detection score for the prehospital setting.	A retrospective analysis of 375 patients at EMS in Jena University Hospital. Germany	PRESEP score surpassed MEWS and BAS 90-60-90 for sensitivity. Robson screening tool had a higher sensitivity.	PubMed	CASP =26/28
4 Seymour, Liu, Iwashyna, Brunkhorst, Rea, Scherag, Rubenfeld,	Assessment of clinical criteria for sepsis: for the Third International	Evaluate the validity of clinical criteria to identify patients with	Retrospective studies conducted 2010-2012 and included 1.3million patients.	Initial clinical criteria for sepsis identification (SIRS, SOFA, and LODS) and new novel criteria (qSOFA).	PubMed	CASP =26/28

Appendix 2

Author(s)/ Year	Title	Aim	Research Method/data size/country	Results/Screening tool	Academic Database	Critical appraisal tool/validity score
Kahn, Shankar-Hari, Singer & Deutschman (2016)	Consensus Definitions for Sepsis and Septic Shock (Sepsis-3).	suspected infection who risk developing sepsis.	USA and Germany			
5 Donnelly, Safford, Shapiro, Baddley & Wang (2017)	Application of the Third International Consensus Definitions for Sepsis (Sepsis-3) Classification: a retrospective population-based cohort study.	Investigate incidence and long-term outcomes of patients diagnosed with the ICD of sepsis classifications	A retrospective analysis using data from 30 239 participants from the USA who were aged at least 45 years	SIRS, SOFA, and qSOFA criteria identified different incidences and mortality. Findings support the identification of sepsis patients using criteria.	ScienceDirect (ELSEVIER)	CASP =27/28
6 Hunter, Silvestri, Ralls, Stone, Walker, & Papa (2016)	A prehospital screening tool utilizing end-tidal carbon dioxide predicts sepsis and severe sepsis.	Determine the utility of a prehospital sepsis screening protocol utilizing systemic inflammatory response syndrome (SIRS) criteria and end-tidal carbon dioxide (ETCO ₂).	A prospective cohort study among patients transported by a single EMS in several regional hospitals during a one-year period USA	SIRS criteria, ETO ₂ , Lactate level	ProQuest	CASP =27/28

Author(s)/ Year	Title	Aim	Research Method/data size/country	Results/Screening tool	Academic Database	Critical appraisal tool/validity score
7 Singer, Taylor, Domingo, Ghazipura, Khorasonchi, Thode, Henry & Shapiro (2014)	Diagnostic Characteristics of a Clinical Screening Tool in Combination with Measuring Bedside Lactate Level in Emergency Department Patients with Suspected Sepsis	Determine the diagnostic characteristics of a clinical screening tool in combination with measuring early POC lactate levels in emergency department (ED) patients with suspected sepsis.	An observational study set in a suburban academic ED with an annual census of 90,000. USA	Elevated bedside lactate levels were associated with sepsis severity, ICU admission and need for vasopressors	Google scholar through online Wiley online library	CASP =21/28
8 Polito, Isakov, Yancey, Wilson, Anderson, Bloom & Sevransky (2015)	Prehospital recognition of severe sepsis: development and validation of a novel EMS screening tool	Derive and validate a predictive model and novel emergency medical services (EMS) screening tool for severe sepsis (SS).	A retrospective cohort study of all adult patients transported by Grady EMS to Grady Memorial Hospital was conducted between 2011-2012. USA	Six EMS characteristics to be predictors of sepsis. Robson tool	ProQuest	CASP =27/28
9 Goerlich, Wade, McCarthy, Holcomb & Moore (2014)	Validation of sepsis screening tool using StO ₂ in emergency department patients	Develop a screening tool for the early identification of sepsis in emergency department patients using readily available information at triage	Observational study for over a 10 week, all patients were seen at triage were the screen. USA	StO ₂ play a complementary role in screening sepsis at triage	LaureaF-inna	CASP =26/28

Author(s)/ Year	Title	Aim	Research Method/data size/country	Results/Screening tool	Academic Database	Critical ap- praisal tool/validity score
10 Guidi, Clark, Upton, Umscheid, Lane-Fall, Mikkelsen, Schweickert, Vanzandber- gen, Betesh, Tait, Hanish, Smith, Feeley & Fuchs (2015)	Clinician Perception of the Effec- tiveness of an Auto- mated Early Warning and Response System for Sepsis in an Academic Medical Cen- tre	Survey clini- cians, and nurse after EWRS notifi- cation about perceptions of the sys- tem	Prospective ob- servational sur- vey (Qualitative study) of 6weeks USA	EWRS alert for identi- fying sepsis	PubMed	CASP =20/20
11 Alberto, Marshall, Walker & Ait- ken 62017)	Screening for sepsis in general hos- pitalized pa- tients: a sys- tematic re- view	Examine the application of sepsis screening tools for early recog- nition of sepsis in general hos- pitalized pa- tients in threefolds	Systematic re- view., 6 arti- cles.	Electronic tools. Pa- per-based, nurse-led screening tools	ScienceDi- rect (ELSE- VIER)	CASP =18/20
12 Moore, Jone, Kreiner, McKinely, Sucher, Todd, Turner, Valdi- via & Moore F. (2009)	Validation of a Screening Tool for the Early Identi- fication of Sepsis	Develop screening tool to in- crease early identifica- tion of sepsis in surgical ICU	Retrospective observational study, period over 5months 4,991 screens performed on 920 patients. USA	The three-step sepsis A screening tool is a valid tool for the early identification of sep- sis.	CINAHL EBSCOhost	CASP= 28/28

Appendix 3: Data analysis to form main category 2,3,4,5 and respective sub-categories

