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Nurses' knowledge about sepsis: development and psychometric testing of a new instrument

Wiedza pielęgniarek na temat sepsy: opracowanie i testowanie psychometryczne nowego narzędzia

Nicole Bartulewicz[A-I], Lena Serafin[B,E-I,K], Bożena Czarkowska-Pączek[A-B,E,G-I]

Clinical Nursing Department, Medical University od Warsaw, Polska

CORRESPONDING AUTHOR:
Lena Serafin
Clinical Nursing Department, Medical University of Warsaw, Polska
e-mail: lena.serafin@wum.edu.pl

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STRESZCZENIE

WIEDZA PIELĘGNIAREK NA TEMAT SEPSY: OPRACOWANIE I TESTOWANIE PSYCHOMETRYCZNE NOWEGO NARZĘDZIA

Cel pracy. Celem badania było opracowanie oraz psychometryczna ocena skali mierzącej poziom wiedzy pielęgniarek na temat sepsy.
Materiał i metody. W celu opracowania i walidacji skali zastosowano siedmioetapowe podejście obejmujące: generowanie pozycji, ocenę adekwatności treści, administrację kwestionariusza, analizę czynnikową, ocenę spójności wewnętrznej, ocenę trafności konstruktu oraz replikację. Walidacja została przeprowadzona na dogodnie dobranej próbie 265 uczestników w okresie trzech lat.
Wyniki. Eksploracyjna analiza czynnikowa wykazała, że najlepszym dopasowaniem do danych była struktura trójczynnikowa. Rzetelność poszczególnych czynników, oceniona za pomocą wzoru Kuder–Richardson 20, wyniosła 0,702 dla czynnika wiedzy oraz 0,631 dla czynnika dotyczącego postępowania. Dla czynnika postawy współczynnik alfa Cronbacha wyniósł 0,884.
Wnioski. Dysponowanie odpowiednim narzędziem do oceny poziomu wiedzy jest kluczowe dla określenia liczby przypadków sepsy oraz związanej z nią śmiertelności. Opracowanie narzędzia badającego poziom wiedzy pielęgniarek na temat sepsy pozwala na rzetelną ocenę ich kompetencji w tym zakresie. Prezentowana skala będzie przydatna zarówno dla pielęgniarek, jak i menedżerów ochrony zdrowia w ocenie poziomu wiedzy o sepsie, monitorowaniu jej zmian w trakcie rozwoju zawodowego oraz weryfikacji potrzeby i skuteczności szkoleń.

Słowa kluczowe: sepsa, epidemiologia, rozwój instrumentów, edukacja kliniczna, pielęgniarstwo chorób zakaźnych

ABSTRACT

NURSES' KNOWLEDGE ABOUT SEPSIS: DEVELOPMENT AND PSYCHOMETRIC TESTING OF A NEW INSTRUMENT

Aim. The aim of the study was to develop and psychometrically test nurses' knowledge about Sepsis Scale.
Material and methods. A 7-step approach, including item generation, content adequacy assessment, questionnaire administration, factor analysis, internal consistency assessment, construct validity, and replication was used to identify and validate the scale. Validation was carried out among a convenience sample of 265 participants over a period of three years.
Results. Exploratory factor analysis showed that a three-factor structure best fit the data. The reliability of the two factors based on the Kuder–Richardson Formula 20 was for the knowledge factor 0.702, for the proceedings factor was a score of 0.631. For the attitude factor Cronbach's Alpha was 0.884.
Conclusions. Having an appropriate tool to test knowledge levels is crucial for determining the number of cases and deaths due to sepsis; thus, creating a tool consisting of knowledge research is the best way to assess nurses' general knowledge about sepsis. The instrument will be useful for nurses and healthcare managers for assessing their knowledge of sepsis, monitoring changes in knowledge throughout professional development, and evaluating both the need for and effectiveness of training programs.

Key words: sepsis, epidemiology, instrument development, clinical education, infectious diseases nursing

INTRODUCTION

Sepsis is the leading cause of admission to and mortality in the intensive care unit (ICU) and readmission among people who have previously been treated in the ICU [1]. Out of 30 million cases per year, around six million of patients pass away. The exact number of mortality cases remains unknown because not enough information from countries with low gross domestic product (GDP), which represents 87% of people worldwide, is available. It is critical to receive appropriate treatment as soon as possible after diagnosis to facilitate a good prognosis. Therefore, understanding and awareness of sepsis is very important. Knowledge and skills in recognizing the symptoms of sepsis and managing it are crucial not only among ICU professionals but also among outpatient care professionals as many cases can be diagnosed outside the hospital setting [2]. Nevertheless, all healthcare professionals should be knowledgeable about sepsis and actions to take when early symptoms are diagnosed.

Over the years, the definition of sepsis has evolved due to rising mortality and challenges in early recognition. In 2016, a new definition was introduced, though treatment still emphasizes early detection and appropriate antibiotics [3]. In 2017, the WHO passed a resolution urging countries to improve sepsis prevention, diagnosis, and treatment [2]. The updated definition describes sepsis as life-threatening organ dysfunction caused by an abnormal response to infection. Organ dysfunction in the ICU is now assessed using the SOFA (Sequential Organ Failure Assessment) scale, which evaluates respiration, coagulation, and liver, cardiovascular, central nervous, and renal functions, to predict morbidity and mortality. A quick version, qSOFA, assesses three non-laboratory factors: systolic blood pressure, respiratory rate, and mental state. Its purpose is to alert clinicians to potential sepsis rather than diagnose it [4].

Nursing staff spend the most time at a patient's bedside, with key tasks including collecting blood samples, checking vital signs, and implementing asepsis. Their role goes beyond performing tasks; it includes interpreting results, identifying deviations, and understanding the consequences of inaction, all of which contribute to the early detection and prevention of sepsis [5]. A well-trained nursing team can significantly reduce sepsis recognition time, as nurses with strong knowledge of sepsis and good communication skills can prevent its progression [6]. However, studies have shown that nurses in various countries lack sufficient knowledge about sepsis [7-10]. The research conducted used a questionnaire based on older definitions of sepsis and relied mainly on the symptoms of systemic inflammatory response syndrome (SIRS) before the introduction of SOFA and qSOFA scales [10,11].

The increasing need for expanding knowledge about sepsis has emphasized the importance of first assessing knowledge gaps and then addressing them. To do this effectively, a reliable questionnaire needed to be created. This issue is relevant to many medical professions, as all can contribute to reducing illness rates. Nurses play a critical role by recognizing sepsis early and responding quickly, which can prevent further decline and reduce mortality. Nurses can gain knowledge through formal education, training, and self-directed learning. Lifelong learning is essential in nursing, making it crucial to regularly evaluate knowledge and reinforce education to maintain high-quality care.

As a result, efforts were made to develop and validate a new questionnaire based on the international definition of sepsis and aligned with WHO guidelines [3,12]. This questionnaire aims to assess knowledge of nursing staff about sepsis. The study's objective was to develop and psychometrically test a new instrument based on the new definition of sepsis for measuring knowledge of nursing staff concerning sepsis.

MATERIALS AND METHODS

Study design

This methodological study was conducted over a period of three years between January 2020 and December 2022. An online survey was used to collect data, and the link for the study survey was shared across different Polish nursing forums and professional nursing groups on social media. STROBE guidelines for cross-sectional studies informed reporting of this paper's research.

Study sample

Validation was carried out twice: first, on a convenience sample of 265 participants for the first step (Explanatory Factor Analysis) named study sample 1 and second, on another convenience sample of 201 nurses for the Confirmatory Factor Analysis named study sample 2. Inclusion criteria involved professionally active nursing status and working with patients on a unit ward or in a primary healthcare clinic for at least three months. Data has been collected in the same way as in both studies by sharing the link for the study survey on different Polish nursing professional network forums and professional nursing groups on social media.

Instrument

The development of the Nurses' Knowledge about Sepsis Scale (NuKSeS) followed the seven stages recommended by Hinkin et al. and included item generation, content adequacy assessment, questionnaire administration, factor analysis, internal consistency assessment, construct validity and replication [13]. The process has been thoroughly described in Supplementary File 1.

RESULTS

Participant Characteristics

Study sample 1

Of the 265 nurses, 251 (95%) were women. The overall median age was 34 years (the age of respondents ranged from 21 to 51 years). Also, 138 (52%) of subjects had work experience from three months to 10 years, and 18 (7%) participants had work experience of 31 to 40 years.

Study sample 2

Of the 201 nurses, 192 (95.5%) were women. The overall median age was 37.2 years (the age of respondents ranged from 22 to 47 years). The average length of professional experience of the respondents was 10.7 years (minimum 3 months, maximum 41 years).

Tab. 1 presents the specific participants' demographic data.

Tab. 1. Characteristic of the studied group

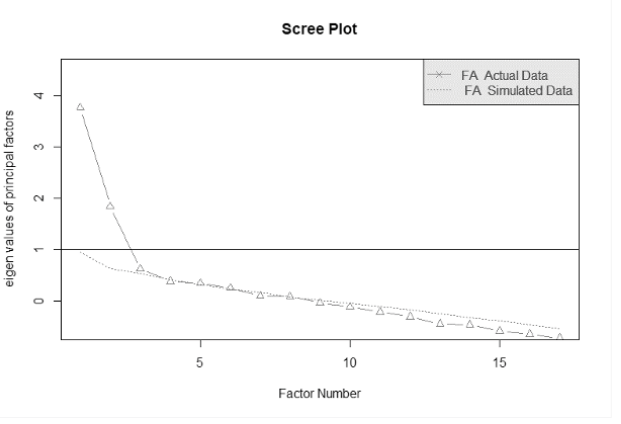
	EFA studied group		CFA studied group	
	n	%	n	%
Education				
Medical high school/post-secondary school	15	5.7	13	6.5
Bachelor of nursing	175	66	120	59.7
Master of nursing	70	26.4	63	31.3
Other	5	1.9	5	2.5
Supplementary qualifications				
Internal courses in the workplace	108	40.8	76	37.8
Specialization training	95	35.8	74	36.8
Qualification courses	132	49.8	80	39.8
Specialized courses	137	51.7	71	35.3
Other	19	7.2	4	2.0
None	38	14.3	42	20.9
Current workplace				
Department of Anaesthesiology and Intensive Care	46	17.4	29	14.4
Emergency Ward	15	5.7	7	3.6
Primary Healthcare	40	15.1	9	4.4
Pediatric Ward (other than ICU)	17	6.4	18	9.0
Epidemiological Nurse	1	0.4	0	0
Other	156	58.9	138	68.6
Number of patients per nurse in the workplace				
0-5	86	32.5	57	28.4
6-10	65	24.5	61	30.3
11-20	52	19.6	18	9.0
21 or more	62	23.4	65	32.3
Workplace				
Village	15	5.7	30	14.9
City up to 50 thousand residents	53	20.0	37	18.4
City from 50 to 150 thousand residents	42	15.8	39	19.4
City from 150 to 500 thousand residents	55	20.8	89	44.3
City over 500 thousand residents	100	37.7	6	3.0
Source of knowledge about sepsis				
Basic vocational education	175	66.0	151	75.1
Postgraduate/vocational education	64	24.2	51	25.4
Experience	137	51.7	99	49.2
Books	95	35.8	50	24.9
Internet, TV, newspapers	82	30.9	51	25.4
Other	32	12.1	30	14.9

n=265

Psychometric Testing

Exploratory factor analysis (EFA)

After initial verification of test items, an EFA was performed to establish the structure for the knowledge factor. Fig.1 shows a scree plot with the distribution of factors that were extracted from the analysis. Based on the plot and eigenvalue (both criteria indicated the same number of factors), it was decided to test the 2-factor solution. The eigen-value of the first factor was 3.76 (23.5% of total variance) and the second factor 1.61 (10.0% of total variance). KMO = 0.640; Bartlett: $\chi^2(136) = 024.56$; $p < 0.001$.



Ryc 1. Scree plot for exploratory factor analysis

Tab. 2 presents the values of the factor loadings for the distinguished factors. All values of the factor loadings had values above 0.3.

Internal Consistency Assessment

For the 11 items of 1-knowledge factor named "knowledge", KR-20 = 0.702 and for the six items of 2-knowledge factor named "proceedings", KR-20 = 0.631. Reliability of the total NuKSeS KR-20 was 0.735. Reliability of the attitude subscale measured by Cronbach's Alpha was 0.884.

Convergent validity and discriminant validity

The HTMT value between the factors was 0.333, which was below the threshold.

The Pearson correlation coefficient was used to test the relationship between the factors and the overall knowledge score. A strong positive association between the factors and the overall score ($r \geq 0.68$) was found. Both knowledge factors were positively but weakly correlated, r = 0.24 (Tab. 3). The correlation within a factor was stronger than between factors.

In the next step, the validity of the instrument was assessed based on an external criterion using the Pearson correlation. The relationship between the self-assessment of knowledge about sepsis and the factors distinguished during the analyses was checked. The analysis showed positive relationships between the variables for which higher results were obtained for knowledge factor and proceedings factor in addition to the general knowledge score with a higher self-assessment of knowledge. The results are summarized in Tab. 4.

■ Tab. 2. Factor loadings

KR-20		Factor 1	Factor 2
		0.702	0.631
q8	Sepsis is defined as an abnormal reaction of the immune system to infection, so it is important to use immunosuppressants as soon as possible to reduce the reaction.	0.66	
q11	The key to diagnosing sepsis is to collect blood for culture immediately after starting antibiotic therapy in order to minimize the effect of the antibiotic on the culture result.	0.60	
q18	Symptoms of organ failure may include anuria and decrease in blood creatinine levels.	0.57	
q19	While collecting material for culture, it is important to collect blood from only one place in order to minimize the number of invasive procedures.	0.57	
q21	Sepsis is a complication of a bacterial infection; therefore, there is no risk of its occurrence in the event of viral infection.	0.41	
q24	Proper hydration of the patient and control of fluid balance applied from the beginning of the treatment fully protects the patient against septic shock.	0.51	
q25	A 56-year-old patient reported to the Emergency Room. Two days ago, a tooth extraction was undertaken. She reports severe pain in the area of the surgery and sudden deterioration in well-being. Temp. body 38.0°C, number of breaths 30/minute, HR 94 beats/min, NBP 94/56mmHg. Is it possible to suspect developing sepsis?		0.30
q26	A routine activity in caring for patients with diagnosed sepsis is glycemic control regardless of previously diagnosed comorbidities.		0.55
q28	Maintaining asepsis while performing nursing procedures is not an activity that reduces the risk of sepsis in hospital conditions.	0.66	
q29	In additional tests, septic shock occurs with increased levels of lactate in the blood.		0.74
q31	Vasopressors are used in persistent hypotension after prior rehydration of the patient.		0.60
q32	At the time of receiving the results of the antibiogram, antibiotic therapy should not be changed to minimize the risk of antibiotic resistance.	0.63	
q34	It is possible to determine the risk of sepsis in outpatient conditions, without performing laboratory tests on the basis of number of breaths, systolic blood pressure, and the mental state of the patient.		0.43
q37	Hypotension and abnormal blood supply to organs contribute to multiorgan failure in sepsis, so if suspected, vasopressors should be administered first.	0.40	
q38	Blood lactate level should be determined in the first 3 hours after the occurrence of suspected sepsis.		0.87
q39	Wound and pressure ulcer care is not important in sepsis prevention.	0.38	
q40	Since sepsis may occur in the course of viral infection, initiation of an antibiotic in the initial stage of the disease is not recommended without confirmation of bacterial etiology.	0.49	
SS		3.34	2.50
Variance		0.20	0.15

[a] KR-20 – Kuder-Richardson Formula 20; [b] q – question; [c] SS – residual sum of squares

■ Tab. 3. Correlation matrix of factors and overall score

	General knowledge	Factor 1	Factor 2
General knowledge	-		
Factor 1	.87**	-	
Factor 2	.68**	.24**	-

■ Tab. 4. Correlation matrix between self-assessment and knowledge

	1	2	3	4
Self-assessment of sepsis knowledge	-			
Factor 1	0.15**	-		
Factor 2	0.13**	0.24**	-	
General knowledge	0.18**	0.87**	0.68**	-

■ Tab. 5. Correlation matrix between self-assessment and knowledge

	CR	AVE	Factor 1	Factor 2	Attitude	Knowledge
Factor 1	0.696	0.219	-			
Factor 2	0.683	0.285	0.34***	-		
Attitude	0.929	0.725	0.22**	0.30***	-	
Knowledge	0.953	0.245	0.90***	0.72***	0.30***	-

**p < 0.05; ***p < 0.001

Confirmatory factor analysis

As a first step, a 2-factor analysis was conducted to test the 2-factor structure of knowledge. The model was a moderate good fit to the data, $\chi^2(116) = 192.32$; $p < .001$; $\chi^2/df = 1.65$; CFI = 0.880; RMSEA = 0.057 [90%CI: 0.043; 0.071]; SRMR = 0.079. Only the CFI value was below the acceptable threshold. The lowest factor loading value was 0.12 (for question 11) while the highest was 0.65 (for question 29).

Confirmatory factor analysis was then conducted for the entire test model including 3 factors: attitude and 2 factors within knowledge. Detailed analysis of the results showed that the model was a good fit to the data, $\chi2(223) = 306.22$; $p < .001$; $\chi2/df = 1.37$; CFI = 0.934; RMSEA = 0.054 [90%CI: 0.040; 0.070]; SRMR = 0.092.

Analysis showed that the items p7, p11 and p24 were not significantly associated with factors ($p > 0.05$). Furthermore, items p24 and p11 were found to be negatively associated with the factor, contradicting the factor assumptions. Therefore, it was decided to test the model without including these items. After excluding these test items, the model was a good fit to the data – fit indices improved, $\chi2(164) = 164.77$; $p = .47$; $\chi2/df = 1.00$; CFI = 0.999; RMSEA = 0.006 [90%CI: 0.000; 0.041]; SRMR = 0.079. Factor loadings took on values ranging from 0.28 (for question 18) to 0.96 (for question 3).

In addition, a higher-order model (second-order factor) for knowledge was tested (two dimensions of knowledge were included in the higher-order factor). A detailed analysis of the results showed that the inclusion of the higher-order factor did not change the fit indices, $\chi2(164) = 164.77$; $p = .47$; $\chi2/df = 1.00$; CFI = 0.999; RMSEA = 0.006 [90%CI: 0.000; 0.041]; SRMR = 0.079. Therefore, both solutions are acceptable.

Tab. 5 presents the CR, AVE and intercorrelation values between factors. As a structure with a higher-order factor is also acceptable, an overall knowledge score is included in the table. The analysis showed a satisfactory level of reliability for Attitude, the overall Knowledge score and both components. The AVE values for these two factors were low, indicating low convergent validity, with CR values higher than 0.6 and therefore an acceptable structure, Attitude has a satisfactory level of convergent validity

(AVE > 0.5). Correlations between factors confirm differential relevance.

Difficulty of Test Items for the Knowledge Factor

In the next step, the difficulty of the test items was analyzed with respect to the knowledge factor. The difficulty of the test items was calculated according to the formula:

$$p_i = \frac{n_i}{N} \cdot 100\%$$

in which pi represents the difficulty of the i^{th} test position, ni is the number of people who correctly answered the given test item, and N indicates the number of all people who answered the given test item.

Supplementary file 2. provides detailed values for difficulty of the test items.

Supplementary File 2. Difficulty of test items for the knowledge factor

Key for the Instrument

Standards are created based on quartiles, i.e., 25% of the extreme results are low or high results, while the average is 50% of the middle results. Based on such an analysis of the results, table 6 presents a proposal for the interpretation of the tool's results.

DISCUSSION

Since the WHO published its resolution, no tool has been developed, to our knowledge, to evaluate nurses' knowledge of sepsis. Assessing knowledge on such a critical aspect of medical care is essential, especially in ICU and ED settings. Nurses play a vital role in recognizing early signs of sepsis, which contributes to early diagnosis, reducing complications, mortality, and healthcare costs [11]. Their frontline position makes them key players in sepsis identification and treatment [14].

Research has emphasized the need to evaluate nurses' knowledge of sepsis in recent years [8,9,11,15,16]. However, these studies used the pre-2018 definition of sepsis, with few tools developed by expert panels of nurses and physicians [8,15]. Like our tool, those instruments assessed knowledge of sepsis definitions, signs, and symptoms [8,9,11,15,16]. For example, Stamataki et al. used a tool to evaluate nurses' knowledge of sepsis prevalence and diagnosis in Greek hospitals [11], while Nucera et al. focused on procedures that increase sepsis risk [15]. In studies by Robson and Jefferey et al., the researchers prepared a few study cases for the study nurses. These descriptions of specific patient cases, in which sepsis could be diagnosed included a request to assess the patients' condition and define appropriate nursing activities. This approach allowed for a focus on practical skills regarding sepsis [16].

Our tool focuses on nurses' knowledge and was psychometrically tested, with validation from expert panels. It consists of a 17-item scale covering two factors: „knowledge" (11 items) and „proceedings" (6 items), along with a self-assessment of knowledge. This comprehensive assessment allows for targeted interventions to improve sepsis knowledge. To evaluate the factor structure of the 37-item tool, an Exploratory Factor Analysis (EFA) was conducted. This approach was also used to reduce the number of items, resulting in a shorter, 17-item version. However, as EFA is data-driven and not suitable for validating factor structure [17], a Confirmatory Factor Analysis (CFA) was then performed. The CFA confirmed the instrument's structure with a new sample, validating its construction.

Assessing psychometric properties focuses on homogeneity or one-dimensionality. The reliability of the main factors was measured using the KR-20 formula due to the dichotomous nature of the questions. After removing low-discriminant items, KR-20 was 0.702 for the „knowledge" factor and 0.631 for the „proceedings" factor, while the „attitude" factor had high internal consistency with Cronbach's Alpha at 0.884. Overall, the psychometric properties of the final NuKSeS tool were found to be satisfactory [18]. This tool can now be recommended for assessing nurses' sepsis knowledge and planning educational interventions based on WHO guidelines.

Although formative assessments typically avoid grading [19], we created a scoring key for the tool. This decision was driven by the observed gap between self-assessed knowledge and actual knowledge, enabling a clearer classification of low, medium, and high knowledge levels. This will help managers make more effective assessments and guide nurses in their learning. It also enhances comparability across future studies using this tool, increasing research reliability.

As mentioned, a crucial part of the tool's development is confirmatory analysis on a new sample. With WHO's global recommendations, the tool could be useful in other regions. Thus, psychometric testing of NuKSeS in different languages and cultures is recommended. The original Polish version was translated into English using a double back-translation for this manuscript, making it available for further testing with other nurse groups.

Limitations

This study has some limitations. lack of diversity in participants' education levels limits generalizability of the findings. The tool needs testing in more varied settings to ensure cross-cultural relevance. Additionally, data were collected online due to COVID-19 restrictions, which could be refined in future studies. Lastly, focus groups could further enhance the tool's development process.

CONCLUSIONS

The revision of the guidelines highlighted the need to assess nurses' knowledge about sepsis, as no research had been conducted using the new terminology since the updated definition. This led to the development of a validated tool focused on the new definition, which assesses knowledge, procedures, and attitudes. The tool is valuable for evaluating nurses' knowledge and guiding their learning needs. It can shape curricula and inform managerial actions while helping nurses identify strengths and areas for improvement. Its main strength lies in enabling targeted supplementary training if knowledge gaps are identified. A similar tool should be developed for other medical professionals involved in sepsis care.

ORCID

Nicole Bartulewicz https://orcid.org/0000-0001-7431-8028
Lena Serafin https://orcid.org/0000-0003-1364-5767
Bożena Czarkowska-Pączek https://orcid.org/0000-0002-1023-3057

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