Knowledge of patient observation among critical care nurses

ABSTRACT

Background

The clinical observations made by critical care nurses are vital for maintaining patient safety and making appropriate decisions in the care of patients who are critically ill. Evaluating the reliability of observations and applying analytical thinking are essential elements of patient observation. Previous studies of critical care nurses' knowledge have focused either on specific aspects of patient observation or on critical care nursing in general; therefore, the findings are not comprehensive.

Aim

The aim of this study was to evaluate critical care nurses' level of knowledge in patient observation and to explore the factors that are associated with it.

Study design

A cross-sectional knowledge test survey with critical care nurses in Finland was used.

Methods

Data were collected in seven adult intensive care units in all five university hospitals in Finland between September 2017 and January 2018 by using a knowledge test (20 items) developed for this study. All critical care nurses were eligible to participate. The data were analysed using descriptive and inferential statistics.

Results

Altogether, 372 nurses responded (response rate 49%). Their average scores in the knowledge test were 77% (mean 15.29/20, SD 2.41) for correct answers, 75% (mean 8.2/11, SD 1.54) in the sum-variable "Evaluating the reliability of observation" and 79% (mean 7.08, SD 1.45) for "Analytical thinking". A higher knowledge level was associated with education in special tasks in an intensive care unit.

Conclusion

The critical care nurses' knowledge level was considered to be suboptimal. There is a need for improving knowledge of patient observation among Finnish critical care nurses to ensure safe and good quality care.

Relevance to clinical practice

Finnish critical care nurses' knowledge of patient observation could be improved by providing specific continuing education for new nurses entering intensive care units and for experienced critical care nurses throughout their career.

Keywords: Critical care nursing, Intensive care unit, Patient observation, Continuing nursing education, Knowledge test

BACKGROUND

During the current COVID-19 pandemic, the global demand for critical care has become paramount [1]. The role of critical care nurses (CCNs) has become ever more important in providing care for increasing numbers of critically ill patients [1], [2], [3]. Observing a patient's clinical condition with vigilance in order to spot potentially rapid changes is one of a CCN's most essential tasks, because it is fundamental for ensuring safety [4], [5] and quality of care [6] for patients who are critically ill. When observing a patient's clinical condition, a CCN collects a substantial amount of information using both technical monitoring and physical assessment [5], [7]. The CCN then processes this information by evaluating the reliability of their observations and thinking analytically [8]. Through this process, CCNs can base clinical decisions on accurate and relevant information [9], [10], which can also be used in multidisciplinary decision-making [11], [12].

The information observed must be evaluated constantly for reliability. This involves identifying the factors that cause observational bias, such as technical errors, artefacts in monitoring and incorrect physical assessment [5], [13]. Unreliable observations can result in an inappropriate use of resources [14] and can lead to fatalities for patients [15]. An observational study [13] found that nearly 90% of ECG alarms were false positives – an example that illustrates the importance of evaluating reliability.

Analytical thinking enables CCNs to get a general overview of a patient's clinical condition [8], [16]. CCNs connect [7], [16] and compare [5], [17] information from different sources, and they exclude information that is insignificant [14], [18]. They make interpretations [18], [19] and diagnostic conclusions [8], [16], and they identify causal connections between clinical interventions and the progression of a patient's condition [9].

CCNs' knowledge of patient observation has been evaluated as part of general knowledge tests. One of these tests, the Basic Knowledge Assessment Tool (BKAT) [20], developed in the United States, and contains some items (e.g., monitor lining") that measure knowledge of patient observation. Another knowledge test, the Intensive Care Hundred Item Test (I-HIT) [21], developed in Australia, also contains some observation-related items (e.g., "hemodynamic monitoring"). These tests have shown variations in CCNs' knowledge levels. In the BKAT, the average CCN score was 82/100 in an international study conducted in seven

countries [20]), and 68/100 in a study specific to Finland [22]. Meanwhile, in the I-HIT, CCNs' average score in 20 European countries was 66/100 [21]. However, patient observation is not an independent domain in these tests.

CCNs' knowledge of more specific areas of patient observation has also been evaluated. These evaluations suggest that CCNs lack knowledge relating to correctly interpreting bowel sounds [23] identifying the signs of intra-abdominal hypertension [24] and preventing monitor alarm fatigue [25].

Previous studies of CCNs' knowledge of patient observation are relatively scarce, are not especially recent, and focused either on specific aspects of patient observation or on CCNs' knowledge in general. Thus, they do not provide a comprehensive or current view of CCNs' knowledge of patient observation, which is the focus of this study. Knowledge is the core of all competence [22], [26], and focusing on knowledge of patient observation has global, national and local importance for developing critical care nursing competence [27], [28]. Critical care can develop rapidly, requiring not only comprehensive orientation for CCNs but also constant evaluation and improvement in their knowledge and skills [3].

METHODS

Study aim

The aim of this study was to evaluate the level of CCNs' knowledge in patient observation and explore the associated factors. The research questions were:

1. What level of knowledge do CCNs have of patient observation?

2. What factors are associated with that level of knowledge?

The results of this study may be used to develop orientation and continuing education in intensive care units (ICUs) and in basic professional education in critical care nursing. The knowledge test developed for the study may provide a tool for the continuing assessment of competence in ICUs.

Study design, setting and participants

A multi-centre, cross-sectional knowledge test survey was conducted with CCNs in seven level III [29] mixed adult ICUs in all five university hospitals in Finland. Total sampling was used, so all CCNs working in the ICUs were invited to participate in the study.

The ICUs in Finland are managed by intensivists and ward managers, and the nurse-to-patient ratio is usually 1:1 [30] as recommended internationally [3]. Even though CCNs are the largest group of professionals in ICUs, there is no specialised postgraduate education in critical care [31] or anaesthesia nursing [32] in Finland. Therefore, extensive orientation programmes in ICUs have a very important role [22].

Instrument

Due to the lack of relevant instruments, a knowledge test was developed for this study. The test was based on a descriptive study [8] and previous literature [7], [10], [16], [18], [19], [23], [28], [33]. The test included two theoretical dimensions, which are also the sum-variables: "Evaluating the reliability of observation" (11 items) and "Analytical thinking" (9 items). These two dimensions were each divided into seven physiologic observation areas: (1) cardiovascular, (2) respiratory, (3) neurological, (4) renal, (5) gastrointestinal, (6) metabolic and (7) coagulation. Patient observation was limited to the physiological areas due to their fundamental role in the care of patients with potentially life-threatening conditions. Hence, these physiological areas of observation constitute an essential element of the knowledge base for CCNs.

The items included in the knowledge test (n=20, Table 1) consisted of true-or-false statements (n=14), multiple-choice questions (n=5), and an open-ended question (n=1). All the questions measured knowledge equally, with a maximum total score of 20: one point for each correct answer and zero points for each incorrect answer. The items were phrased to evaluate both the comprehension and the application of knowledge [34], [35], [36] and so that the CCNs were required to use critical thinking [37]. The stems of the items were formulated as either clinical statements or short descriptions of a patient case, as shown by the following examples:

> *Q8 (evaluating the reliability of observation). When measuring intra-abdominal pressure through a urinary catheter, the fluid column in the manometer tubing should be uniform in order to gain a reliable measurement. a. true, b. false*

Q19 (analytical thinking). You are taking care of a mechanically ventilated patient suffering from severe pneumonia. You observe the following results in the blood gas and acid-base balance: pH 7.24, PaCO2 5.78 kPa, PaO2 13.7 kPa, Lactate 8.6 mmol/l, Base excess -8.3. These results indicate: a. metabolic alkalosis, b. compensated respiratory alkalosis, c. metabolic acidosis, d. respiratory acidosis

The content validity of the knowledge test was evaluated by a panel of 11 experts in critical care nursing (practising CCNs, educators and researchers). The content validity index for the whole knowledge test (S-CVI) was 0.93, representing excellent content validity [38]. One item had a content validity index (I-CVI) lower than the recommended threshold of 0.78. However, because the item was theoretically relevant, it was included in the knowledge test. On the basis of the experts' evaluations, some minor modifications were made to the wording of the items. A physician who specialised in critical care provided assurance that the items were medically accurate.

To ensure the clarity and applicability of the knowledge test, a pre-test with convenience sampling was conducted with CCNs (n=46) in two ICUs (not included in the sample). On the basis of the findings, one item was revised for clarity.

Data collection

The pencil-and-paper knowledge test which also contained background questions was delivered by contact people to all CCNs (N=767) in the ICUs during the period September 2017–January 2018. The CCNs were instructed to answer the questions independently and place the questionnaires in a sealed envelope in a returns box located in the ICU.

Data analysis

IBM SPSS Statistics for Windows version 24 (IBM Corp., Armonk, NY) was used to analyse the data. Descriptive statistics were used to analyse the characteristics of the sample. Inferential statistics were chosen according to the conditions: the independent samples t-test and the Mann–Whitney U test were used to compare two groups, while one-way analysis of variance (ANOVA) and the Kruskal–Wallis test were used to compare multiple groups. The correlations between continuous variables were calculated using Pearson's

and Spearman's correlations. The variables that were significantly ($p < 0.05$) associated with CCNs' level of knowledge in the univariate analysis were included in a general linear model to identify the factors that were independently associated with level of knowledge. Only factors that were significantly associated with level of knowledge were retained in the model. The data from the participants who answered the background questions only (n=4) were excluded.

Ethics

The study protocol was approved by the Ethics Committee in the local university (37/2016). Permission to carry out the research was granted by the university hospitals. The CCNs were informed that the study was confidential and voluntary in the cover letter that accompanied the questionnaire. No identifying personal data were collected. Completing and returning the questionnaire was considered as giving informed consent. [39].

RESULTS

Participants

A total of 372 CCNs (49%) responded to the knowledge test. Most of the CCNs were female (n=316, 87%), and the mean age was 40 years (SD 10.32). They had an average of 15 years' experience in nursing (SD 9.76) and 12 years in critical care nursing (SD 9.25). Most had also experience of working in nursing fields outside critical care (n=296, 81%). Concerning their educational background, most CCNs had a bachelor-level nursing education (n=252, 69%), had completed a course in critical care nursing (n=254, 69%), and had been on a clinical placement in an ICU during the basic nursing education (n=261, 71%). Less than one-fifth (n=54, 15%) had completed formal continuing education in critical care. Of the respondents, 70% (n=252) had been educated in special tasks in the ICU (e.g., renal replacement therapies, medical emergency services). The characteristics of the CCNs are presented in Table 2.

To summarize, the CCNs were relatively experienced in terms of length of service and the different fields of nursing they had worked in. Most of them had participated in a range of professional development activities throughout their career.

Levels of knowledge among CCNs

The CCNs' mean score for correct answers in the knowledge test was 77% (mean 15.29/20, SD 2.41). For the sum-variable "Evaluating the reliability of observation", the mean score was 75% (mean 8.2/11, SD 1.54) and for "Analytical thinking" it was 79% (mean 7.08, SD 1.45). Only six respondents (1.6%) answered all the questions correctly (Table 1).

The proportion of correct answers was highest among the items in "Pulse oximetry monitoring: understanding the state of peripheral circulation in terms of reliable measurement" (99% correct) and in "Maintaining renal function: selecting an appropriate treatment option" (97% correct). At the other end of the scale, it was lowest in "Activated partial thromboplastin time (APTT) measurement: understanding the source of artefacts in measurement" (45% correct) and "EtCO2 monitoring: distinguishing PaCO2-EtCO2 gradient from measurement error" (47% correct). The proportion of correct answers for each item is presented in Table 1.

Factors associated with CCNs' knowledge levels

The adjusted analysis shows that the level of knowledge of patient observation was significantly higher among CCNs who were educated in special tasks in an ICU, had previous experience of working in a high-dependency unit, had been on a critical care placement during their nursing education or were highly confident in their critical care competence in general (Table 3).

For the sum-variable "Evaluating the reliability of observation", a significantly higher level of knowledge was demonstrated by the CCNs who had been educated in special tasks in an ICU, had special responsibilities in their work or had experience of working in emergency nursing. Meanwhile, in "Analytical thinking", a higher level of knowledge was demonstrated by the CCNs who had been educated in special tasks in an ICU, had been on a critical care placement during their nursing education or were highly confident in their general critical care competence in general (Table 3).

DISCUSSION

The aim of this study was to evaluate CCNs' level of knowledge in patient observation and explore the factors associated with that level of knowledge. The main result is an indication that CCNs have a suboptimal level of knowledge in patient observation. In this case, "suboptimal" refers to the relatively high proportion of incorrect answers and the very low proportion of CCNs who answered all the questions correctly. In a previous study [21], the authors speculated that even though in general answering 50% of the questions in a knowledge test correctly may be considered acceptable, the knowledge level among practising CCNs should be much higher if safe and competent care is to be ensured. This was the first time that this newly developed knowledge test was used, thus the accepted level of adequate knowledge was not pre-defined. However, patient observation is considered as a fundamental element in critical care nursing, thus optimally, CCNs would answer nearly all the questions correctly. Given the experience of the participants in the current study, it was reasonable to expect higher levels of knowledge. Hence, there are opportunities for improving CCNs' knowledge base in the area of patient observation.

Knowledge is at the core of competence [22], [26]. Therefore, the findings raise concerns about the reliability of CCNs' patient observation in practice, especially considering that the three items with the lowest scores (with less than 50% of the answers correct) were all related to evaluating reliability. Reliable observations are key to ensuring that safe and adequate care is provided for patients who are critically ill [5], [15].

Regarding the physiological areas, the lowest-scoring items occurred in the observation of coagulation and respiratory systems (Table 1). This low knowledge level, especially in observing respiratory systems, deserves attention. Respiratory failure is one of the most common reasons for admission to an ICU, and a considerable proportion of critically ill patients receive mechanical ventilation in ICUs [40]. This is especially the case during the current COVID-19 pandemic [2]. Therefore, many of the duties and responsibilities of CCNs are related to respiratory care [7], which requires adequate skills in observing patients' respiratory functions [41]. However, further conclusions should be drawn on the basis of evaluating CCNs' performance in authentic clinical situations, because a nurse's level of knowledge alone does not directly represent his or her performance or the quality of care provided [21]. The knowledge test could be

combined with observations in real clinical situations, and possible correlations between them could be examined.

A higher level of knowledge was associated with education in special tasks in the ICU. CCNs may be educated in various tasks that require special skills and knowledge, such as renal replacement therapies, extracorporeal life-support therapies, and working as a member of a medical emergency team. It is clear that these special tasks require advanced knowledge of patient observation to be covered in education. Moreover, it is possible that CCNs who willingly participate in continuing education and who already take responsibility for special tasks have a good level of knowledge and are motivated to develop this further.

The results indicate that there is a need to develop critical care nursing education in Finland. In contrast with many other countries, there is no specialised education in critical care nursing in Finland [31]. Studies among CCNs in Finland show that their knowledge levels are suboptimal not only in general areas [21], [22] but also in more specific ones, such as preventing ventilator-associated pneumonia [42]. Therefore, a combination of continuing professional development and systematic and specific on-the-job training in ICUs is crucial for developing CCNs' knowledge levels [43], [44]. The importance of continuing professional development is supported by the current findings: the amount of nursing experience was not independently associated with a higher level of knowledge in patient observation, which is contrary to the previous findings concerning CCNs' competence [45], [46]. Although experience alone may not increase knowledge levels among CCNs, their knowledge can be improved through ICU-specific continuing education throughout their career.

Continuing education in patient observation should focus on evaluating the reliability of observation and on the physiological areas in which the scores in the knowledge test were lowest. The importance of providing Finnish CCNs with education, especially in respiratory care, is supported by previous findings that revealed suboptimal knowledge in preventing ventilator-associated pneumonia [42]. Continuing education could be structured to provide both theoretical knowledge and simulation training, as this combination has proven to be beneficial for learning about patient observation in particular [47]. In addition to providing these opportunities, nurse managers and educators should focus on developing CCNs' learning skills and on creating a culture that supports continuous professional development and individual CCNs' motivation to

participate in lifelong learning [48]. Continuous professional development could include job-rotation and learning opportunities beyond unit boundaries, as diverse work experience in acute care was associated with higher levels of knowledge.

A higher level of knowledge was also associated with experience of clinical placements during nursing education. Clinical placements have been identified as developing critical care nursing knowledge in general [49], [50] and improving overall nursing competence [51] among graduating nursing students. However, the current finding was rather surprising, as the participants had graduated many years ago and had been working for a relatively long time. Therefore, further investigation is needed in order to draw any conclusions about the role of clinical placements in developing CCNs' knowledge of patient observation.

Strengths and limitations

The main strength of this study is its novelty in focusing on and providing information about CCNs' knowledge of patient observation, which is an essential and internationally identified component of competence in critical care nursing [27], [28]. This study provided a knowledge test as an objective tool for assessing CCNs' knowledge in patient observation. The second strength concerns the large national sample of the study, which included all university hospitals across the country. The sample contained CCNs with various amounts of experience and was large enough for statistical tests to identify factors associated with their levels of knowledge.

There are, however, also limitations. The first of these concerns the interpretation of CCNs' scores. Defining the thresholds for adequate or excellent scores on the knowledge test was difficult due to the lack of a suitable criterion instrument. Previous knowledge tests in critical care nursing – the BKAT [20] and I-HIT [21] – take a more general approach to CCNs' knowledge; therefore, they were not suitable criterion instruments. However, the content of the knowledge test represented essential areas of knowledge in patient observation with excellent content validity; therefore, experienced CCNs could be expected to gain high scores. Secondly, the response rate (49%) was moderate, even though the number of participants was fairly high. More than half of the CCNs did not respond, which limits the representativeness of the sample among CCNs in Finland. The third limitation has to do with the lack of control in answering. To promote

voluntariness, the CCNs were not controlled when answering the knowledge test, so the possibility of finding information from various sources and discussing it while answering the questions cannot be ruled out. However, in their clinical practice, CCNs have access to a wide range of materials and can have discussions with colleagues, so the knowledge test reflects the authentic situation in this sense. Moreover, the items in the knowledge test required the CCNs to apply their knowledge; thus, the answers were not easy to find directly from any resources. The fourth limitation is the possibility that CCNs could respond correctly by chance, simply by guessing without using actual knowledge about the topic. The risk of this bias is especially high in true-or-false statements, which were included in the test [37]. However, the proportion of correct answers in those statements was actually lower (mean 74%) than in the multiple-choice questions (mean 82%).

Implications and recommendations for practice

Knowledge of patient observation among CCNs could be promoted by providing continuing education systematically for new nurses entering ICUs and for more experienced CCNs throughout their career. Continuing education in Finland should focus especially on evaluating the reliability of observation and on respiratory care due to their essential nature in providing safe care. CCNs' knowledge of patient observation should be systematically assessed in ICUs, and this study provided a potential tool for that purpose. In addition to knowledge assessment, it is recommended to assess CCNs performance in patient observation in real or simulated clinical situations.

CONCLUSIONS

The level of knowledge demonstrated by Finnish CCNs in patient observation was suboptimal, given the essential role of patient observation in the safe care of a critically ill patient. The findings indicate the need for developing opportunities for continuous learning in ICUs. In future studies, CCNs' performance in patient observation should be evaluated in authentic clinical situations. The knowledge test should be further validated for use in more diverse contexts, including in level I and II ICUs and in ICUs outside Finland. Knowledge of patient observation is internationally identified as an essential element of critical care nursing, and international evidence was used in developing the knowledge test. Hence, it could be used in

international context after translation and cultural validation. Furthermore, the association between the knowledge test and other assessment methods should also be investigated.

WHAT IS KNOWN ABOUT THE SUBJECT

- Critical care nurses' role in observing a patient's clinical condition is crucial to ensure patient safety and quality of care.
- Critical care nurses constantly evaluate the reliability of observations and process observed information applying analytical thinking.
- Few studies have evaluated critical care nurses' knowledge of patient observation and they have focused either on critical care in general or on some specific observation area.

WHAT THIS PAPER CONTRIBUTES

- This study evaluated the level of Finnish critical care nurses' knowledge in patient observation in seven physiological areas, and furthermore explored the associated factors.
- Based on the findings, Finnish critical care nurses have a suboptimal level of knowledge in patient observation.
- Critical care nurses who had been educated for special tasks in intensive care units demonstrated higher knowledge level.
- Continuing education focusing on patient observation should be systematically provided for critical care nurses throughout their career.

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Table 1. Knowledge test items and results (n=368)

Physiological area	Item topic	Question type	Correct answers	Sum-variable	Knowledge test
Cardiovascular	1. Invasive pressure monitoring: understanding the idea of the use of the square wave test	T/F	48%	**Evaluating the reliability of observation** (max 11)	**Knowledge test overall** (max 20)
	2. Invasive pressure monitoring: understanding the importance of correct tubing	T/F	90%	Correct answers: 75%	Correct answers: 77%
	3. ECG artefacts: recognizing artefacts in ECG	T/F	71%	Mean 8.21	Mean 15.29
Respiratory	4. EtCO2 monitoring: distinguishing PaCO2-EtCO2 gradient from measurement error	T/F	47%	Median 8.00	Median 15.00
	5. Pulse oximetry monitoring: understanding the state of peripheral circulation in terms of reliable measurement	T/F	99%	SD 1.54	SD 2.41
Neurological	6. EEG monitoring: understanding the effects of nursing interventions on the quality of registration	T/F	91%	Min 5.00	Min 7.00
	7. Pupil assessment: understanding the effects of drugs (atropine and opioids) on reliable assessment	T/F	97%	Max 11.0	Max 20.0
Renal	8. Plasma creatinine measurement: understanding the impact of muscle mass on measurement	T/F	66%	IQR 7.00–9.00	IQR 14.0–17.0
Gastrointestinal	9. Intra-abdominal pressure monitoring: understanding the correct monitoring technique	T/F	94%		
Metabolic	10. Plasma potassium measurement: understanding correct sample handling to avoid incorrect results	T/F	72%		
Coagulation	11. Activated partial thromboplastin time (APTT) measurement: understanding the source of artefacts in measurement	T/F	45%		
Cardiovascular	12. Hypovolemia: detection on the basis of measured parameters and observed factors	MCQ	91%	**Analytical thinking** (max 9)	
	13. Atrial fibrillation: recognition in ECG	Open	88%	Correct answers: 79%	
Respiratory	14. Tidal volume: understanding observation in SIMV-ventilation	MCQ	54%	Mean 7.08	
Neurological	15. Cerebral perfusion pressure (CPP): identifying the adequate CPP	MCQ	87%	Median 7.00	
	16. Pain stimuli: interpreting the response	T/F	73%	SD 1.45	
Renal	17. Maintaining renal function: selecting an appropriate treatment option	MCQ	97%	Min 0	
				Max 9.00	
Gastrointestinal	18. Hepatic encephalopathy: identifying the factors worsening the condition	T/F	87%	IQR 6.00–8.00	
Metabolic	19. Metabolic acidosis: recognition in arterial blood gas analysis	MCQ	80%		
Coagulation	20. Postoperative bleeding: analysing the type/quality of bleeding	T/F	51%		

Items 1–11 = evaluating the reliability of observation, Items 12–20 = analytical thinking, SD = standard deviation, IQR = interquartile range, T/F = true/false statement, MCQ = multiple-choice question, Open = open-ended question

Table 2. Critical care nurses' characteristics (n=372)

Variable					
	Mean	Median	SD	Min	Max
Age, years (n=364)	39.8	39.0	10.3	23	63
Years of working experience in nursing (n=363)	15.0	14.0	9.8	0.6	39
Years of working experience in critical care nursing (n=368)	11.8	9.0	9.3	0.1	37
Confidence in own competence in critical care nursing (0-100, n=367)	74.8	77.0	16.5	3	100
Education (n=367)	n		%		
Bachelor level	252		69		
Diploma level	100		27		
Master level	15		4		
Gender (n=365)	n		%		
Female	316		87		
Male	49		13		
Working experience in other fields of nursing (n=366)	n		%		
Yes	296		81		
Surgical ward nursing	*129*		*35*		
Medical nursing	*109*		*30*		
Gerontological nursing	*103*		*28*		
High dependency unit nursing	*72*		*20*		
Emergency nursing	*64*		*18*		
Paramedic nursing	*42*		*12*		
Pediatric nursing	*41*		*11*		
Perioperative nursing	*33*		*9*		
Mental health nursing	*27*		*7*		
Outpatient nursing	*23*		*6*		
Other	*26*		7		
No	70		19		
Working experience in other ICUs (n=367)	n		%		
Yes	146		40		
No	221		60		
Critical care nursing courses in the nursing education (n=366)	n		%		
Yes	254		69		
No	112		31		
Clinical placement in ICU during nursing education (n=367)	n		%		
Yes	261		71		
No	106		29		
Continuing education in critical care nursing (n=365)	n		%		
Yes	54		15		
No	311		85		
Education in patient observation (n=363)	n		%		
Yes	222		61		
No	141		39		

Education in clinical assessment (n=361)	n	%
Yes	147	48
No	189	52
Education for special tasks in the ICU (n=362)	n	%
Yes	252	70
No	110	30
Special responsibilities in the ICU (n=365)	n	%
Yes	276	76
No	89	24
Independent information searching (n=366)	n	%
Yes	347	95
Databases	*285*	*78*
Hospital intranet	*225*	*62*
Professional journals	*222*	*61*
Textbooks	*219*	*60*
Internet	*205*	*56*
National scientific journals	*68*	*19*
International scientific journals	*38*	*10*
Other information source	*23*	*6*
No	19	5

Table 3. Independent factors associated with CCNs' level of knowledge (n=368)

Knowledge of patient observation, total, maximum score 20 (R^2=0.21, Adjusted R^2=0.18)					
Factor		n	Adjusted mean (95% CI)	Adjusted mean difference (95% CI) or adjusted β[a] [95% CI]	Adjusted p
Education in special tasks in an ICU					
	Yes	245	15.59 (14.85–16.24)	0.74 (0.20–1.27)	0.007
	No	107	14.81 (14.05–15.57)		
Experience of working in a high-dependency unit					
	Yes	69	15.52 (14.72–16.31)	0.67 (0.08–1.27)	0.026
	No	283	14.84 (14.17–15.52)		
Clinical placement in an ICU during nursing education					
	Yes	250	15.49 (14.81–16.17)	0.62 (0.11–1.12)	0.018
	No	102	14.87 (14.11–15.64)		
Confidence in own critical care nursing competence (0–100)		352		0.02[b] [0.00–0.03]	0.046

Knowledge evaluating the reliability of observation, maximum score 11 (R^2=0.14, Adjusted R^2=0.11)					
Factor		n	Adjusted mean (95% CI)	Adjusted mean difference (95% CI)	Adjusted p
Experience of working in emergency nursing					
	Yes	62	8.59 (8.08–9.11)	0.43 (0.03–0.84)	0.037
	No	287	8.16 (7.70–8.63)		
Special responsibilities in an ICU					
	Yes	264	8.58 (8.14–9.03)	0.41 (0.01–0.81)	0.045
	No	85	8.17 (7.64–8.71)		
Education in special tasks					
	Yes	242	8.56 (8.10–9.02)	0.36 (0.01–0.72)	0.045
	No	107	8.20 (7.69–8.70)		

Knowledge of analytical thinking, maximum score 9 (R^2=0.14, Adjusted R^2=0.13)

Factor		n	Adjusted mean (95% CI)	Adjusted mean difference (95% CI) or adjusted β [95% CI]	Adjusted p
Clinical placement in an ICU during nursing education					
	Yes	253	6.87 (6.56–7.18)	0.68 (0.36–0.99)	<0.001
	No	103	6.19 (5.82–6.57)		
Education in special tasks					
	Yes	248	6.75 (6.42–7.07)	0.43 (0.10–0.76)	0.011
	No	108	6.32 (5.95–6.68)		
Confidence in own critical care nursing competence (0–100)		356		0.13[b] [0.00–0.02]	0.012

General linear model, adjusted for other factors included in the model, [a] β=regression coefficient, [b] β for one score increase in confidence in own critical care nursing competence