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Evidence of learning on the insertion and care of peripheral venous catheters in nursing students: A mixed study

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ABSTRACT

Objectives: 1) To assess nursing students' evidence-based knowledge on the use of PVCs, and 2) to examine the perception of learning and teaching strategies aimed at this skill.
Background: Insertion and care of Peripheral Venous Catheters (PVCs) are essential skills in undergraduate nursing education. Appropriate knowledge of this skill is crucial to improve clinical practice and patient safety. Therefore, training becomes an enabler for safe practice.
Design: A multi-centre convergent parallel mixed-methods.
Setting and participants: A total of 675 second-, third- and fourth-year nursing students from 3 nursing schools took part in the study.
Methods: Quantitative data collection used a validated 15-question survey on knowledge of PVC management, and a descriptive and inferential analysis was carried out. Qualitative data were collected via a questionnaire consisting of 4 open-ended questions assessing knowledge, teaching methodologies and scenarios, and points for improvement.
Results: Most participants were female (74.04%), with a mean age of 22.45 (SD = 4.65), who had no experience in the health field (61.8%). They obtained a mean knowledge score of 7.27 (SD = 2.64) out of 15. The students who obtained higher scores had a mean professional experience of 7.96, SD = 2.66 (p 0.000) and were in their final year, with a mean of 8.59, SD = 2.56, (p 0.000). On the other hand, the students assessed their knowledge as basic but improving year by year. They also identified a need to apply more active and experiential methodologies that would allow for reflection.
Conclusion: Level of educational level and experience is associated with increased knowledge. In order to improve knowledge, changes must be made in the training process to incorporate methodologies such as simulation and online training. There is a need to develop programmes that favour the alignment of theory with clinical practice.

1. Background

Insertion and care of Peripheral Venous Catheters (PVCs) are basic skills taught in undergraduate nursing education. These widely used procedures in hospitalised patients provide quick and safe access to the bloodstream (Parreira et al., 2020; Souza et al., 2015). Nursing students must undergo training and supervised practice to develop the skill of delivering intravenous cannulation (Morgaonkar et al., 2017). It is important to note that the knowledge and skills to be developed should be based on: assessment, insertion, care, and management of vascular access devices (Carr et al., 2018). However, inadequate or unsound knowledge of PVCs can lead to a high likelihood of malpractice. Thus,

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the level of knowledge and skills acquired is directly associated with adherence to patient safety principles (Vaismoradi et al., 2020).

It has been shown that managed correctly, PVCs are safe devices with little risk to patients (Høvik et al., 2019). However, it is crucial to dispel the perception that PVCs are innocuous and associated with minimal risk of infection (Vendramim et al., 2020). The most common complications are phlebitis (44%), infiltration (16,3%) and, subsequently, a lower incidence of occlusion and catheter dislodgement (7.6% and 5.6%, respectively) (Simin et al., 2019). Although these complications may develop into more severe consequences such as bloodstream infections, they are less frequent (Mermel, 2017).

This all seems to confirm that the level of knowledge acquired by students is essential in two respects: to perform clinical practice placements that genuinely improve clinical experience and nursing competence (Cicolini et al., 2014; Woody and Davis, 2013; Simonetti et al., 2015); and to avoid complications and strengthen the quality of care and patient safety (Ahlin et al., 2017; Osti et al., 2019). Undoubtedly, to improve the management of PVCs and reduce failure rates, this knowledge needs to be grounded in evidence-based interventions (Alexandrou et al., 2018).

Previous studies (Dogu Kokcu and Cevik, 2020; Etafa et al., 2020; Simonetti et al., 2019) have identified nursing students' knowledge of this subject but have not explored the teaching-learning process entailed in its development. Identifying knowledge makes it possible to detect educational needs and establish priorities in educational programmes (Simonetti et al., 2019), but it is necessary to explore how and where. According to Zabalza (2011), it is not only important what information is provided but how it is supplied and how students process it. Therefore, it is indispensable to explore how students assess the learning process.

In line with the points detailed above, our study has a twofold objective: 1) to analyse nursing students' evidence-based knowledge of PVC management; and 2) to examine the perception of the learning and teaching strategies used in nursing education.

2. Methods

2.1. Study design

We proposed a multi-centre convergent parallel mixed-methods design study (Creswell, 2014).

2.2. Context and participants

A convenience sample of three university nursing schools took part in the study. These educational institutions, state, private and mixed (a private nursing school affiliated to a state university), represent all possible management models in Spain. The nursing Degree in Spain is a four-year full-time programme.

The population were nursing students in the second, third or fourth year of their course. First-year students were excluded due to their lack of knowledge of the subject matter and possible low level of competence, as well as students who did not consent to participate.

The total population who were invited to participate was 934 participants, from which 675 responses were received, which represents 72.26% of the total. Based on the literature (Cicolini et al., 2014; Labeau et al., 2008a, 2008b) the sample was sufficient and representative, being greater than 71%.

2.3. Instruments

Quantitative data on knowledge of PVC care were collected using an extended version of the questionnaire by Cicolini et al. (2014) on preventing peripheral venous catheter-related infections, based on a study by Labeau et al. (2008b) on central venous catheters. This version, which was translated, expanded and validated to the Spanish context by the research team within the same research project, became the instrument we termed Evidence-based knowledge on PVC management. The results of the validation process according to psychometric data of the questionnaire in Spanish showed a good concordance assessment according to the intraclass correlation coefficient values of 0.91. Likewise, the instrument showed adequate reliability, understood here as internal consistency, with a total Cronbach's alpha of 0.703. The instrument consisted of two parts: general data of the participants and 15 questions on their knowledge of PVCs. The question-answer model comprised one question and 4 answer options, with only one correct answer (score 1 point), 2 options for incorrect or distractor answers (score 0 points) and a final "I do not know" (score 0 points). The maximum obtainable score was 15 points, and the minimum score was zero. The random control formula was not applied, i.e. the possibility of answering a question incorrectly did not penalise the final score obtained.

Qualitative data were collected using a questionnaire consisting of 4 open-ended questions on: 1) perception of acquired knowledge, 2) teaching methodologies that had favoured knowledge development, 3) teaching scenarios that have allowed learning, and 4) aspects to improve the teaching-learning process.

2.4. Data collection

Quantitative and qualitative data were collected concurrently. The self-administered questionnaires were answered in an average time of 20–25 min between November 2019 and January 2020. Data facilitators collected each completed questionnaires in an envelope to guarantee confidentiality and anonymity.

2.5. Data analysis

Inferential analysis was performed for quantitative data, descriptive (frequencies, percentages, mean and standard deviation). We checked the conformity of the variables for normal distribution using the Kolmogorov-Smirnov test ($p\ 0.06 > 0.05$). Subsequently, parametric tests were performed using: student's *t*-test for the comparison of means of independent populations and ANOVA to simultaneously compare the means of more than two populations. The data were analysed using IBM SPSS Statistics 22, and the level of significance applied for all assessments was $p < 0.05$.

The qualitative data were analysed using the classical content analysis method (Leech and Onwuegbuzie, 2007), supported by Atlas-Ti version 8 software. This analysis allowed us to identify relevant concepts, patterns of ideas, and frequency of key ideas.

2.6. Rigour and quality criteria

The criteria of scientific rigour proposed by Onwuegbuzie and Burke (2006) of legitimation, design quality and interpretive rigour were ensured throughout the study. This multi-method strategy enabled complementarity and triangulation of the data. The researchers constantly reviewed the study to guarantee the consistency of the data and the inferences made.

2.7. Ethical approval

This study was approved by the CAERFIF research committee of the Faculty of Nursing and Physiotherapy, University of Lleida. Authorisation was obtained from the three participating nursing schools.

The students signed a written consent form to take part in the study. All data were treated confidentially and anonymously.

3. Results

3.1. Characteristics of the participants

The participants were 675 nursing students aged between 18 and 50 years, with an average age of 22.45 years (SD = 4.65), of whom 74.04% were female. The university access route was mostly secondary school level at 63.80%, and 61.8% had no work experience in the healthcare field. Table 1 shows the characteristics of the sample.

3.2. Level of evidenced-based knowledge

The participants obtained an overall mean score of 7.27 out of 15 points (SD = 2.64) in their level of knowledge. Their knowledge of PVCs showed no significant differences in score between genders ($t = 0.32$ and bilateral significance p 0.749 > 0.05). The female students scored a mean of 6.96 (SD = 2.50), and males a mean of 6.89 (SD = 2.37). No significant differences were found between the different access routes to the university either (Snedecor's ANOVA test F = 2624 p associated value p = 0.05 and multiple comparisons p > 0.05). The students with a secondary school access route obtained a mean score of 7.08 (SD = 2.7); the undergraduates scored a mean of 7.59 (SD = 2.39); and those students with other university Degrees obtained a mean score of 7.88 (SD = 1.99). The students who entered the university through the path of access for over 25 to 45 year olds, obtained the lowest score, with a mean of 6.7 (SD = 3.41).

In contrast and positively, professional healthcare experience influenced students' test scores ($t = 5.558$ and bilateral significance 0.00 < 0.05). Professional experience was related to students who are technicians or nursing assistants. The students with professional experience obtained a higher knowledge score, with a mean of 7.96 (SD = 2.66), than those with no experience, who obtained a mean of 6.63 (SD = 2.48).

The score by academic year rose steadily in all the participants, according to the contrast of the Snedecor F statistic, which scored 98.620 and its associated p value p = 0.000 < 0.50; favouring the higher year group. The second-year students obtained the lowest scores, with a mean of 5.58 (SD = 2.4), followed by the third-year students, with a mean of 7.76 (SD = 2.02). The fourth-year students received the highest scores, with a mean of 8.59 (SD = 2.56). Table 2 shows the complete instrument (questions and answers) and the results by responses and academic year.

The analysis by academic year showed that the percentage of correct answers per question was also broadly maintained gradually. The exception was question 6, which received an incorrect response across all three academic years, in contrast to the higher score of 2nd-year students. Following the previous data, the difficulty index was higher in the second year than in the last years (Table 3). This table shows significant differences (p < 0.05) in all the items included, implying that the students' academic year affected the response.

Fig. 1 shows all the students' overall results and each one of the questions according to whether they responded incorrectly, correctly or did not know.

Table 1
Characteristics of the sample: number (n) and frequencies (%).

Variables		n	%
Age[a]		22.45	4.65
Sex	Men	175	25.93
	Women	500	74.07
Path to university	Secondary school	430	63.80
	Training courses	189	27.90
	Other university degrees	36	5.34
	Over 25–45 years old	20	2.96
Nursing degree year	2nd	229	34
	3rd	243	36
	4th	203	30
Health worker	No	417	61.8
	Yes	258	38.2

[a] Mean and standard deviation (SD).

3.3. Assessment of learning and training strategies

A total of 2910 units of meaning were retrieved from the results of the qualitative data analysis on the students' perception of learning and the teaching strategies linked to the teaching of this subject. The units were then coded and classified according to similarity into 3 themes: the perception of acquired knowledge (589 units of meaning), training scenarios for assimilating and consolidating knowledge (885 units of meaning) and the detection of possible factors for improving the learning process (1376 units of meaning).

Table 4 shows the three themes, along with their corresponding main categories and example data.

4. Discussion

The dual purpose of this mixed-methods study was to assess nursing students' knowledge of PVC management to prevent infection and to explore elements of learning that can improve teaching.

4.1. Knowledge acquisition of PVCs

We found that the students' level of knowledge of PVCs was sufficient to low, which is consistent with the results of other studies (Dogu Kokcu and Cevik, 2020; Etafa et al., 2020; Simonetti et al., 2019). Similarly, those who had a higher knowledge were the senior students (Dogu Kokcu and Cevik, 2020; Simonetti et al., 2019) and the students with prior work experience (Etafa et al., 2020). This difference could be explained by their proximity to the clinical environment (Dogu Kokcu and Cevik, 2020). The incremental structure of the first-year curriculum includes basic subjects, which are more theoretical and include less clinical practice. This gradually progresses to nursing science subjects and more clinical practice. As in other studies, no gender differences were observed (Etafa et al., 2020; Simonetti et al., 2019, 2015).

The score analysis shows that the participants achieved a mean overall score of 7.27 out of 15 points (SD = 2.64). The average score did not reach the 7.5 pass grade. However, there was a definite trend towards a rise in the percentage of students passing (>7.5 points in the test): 21% in the second year, 55.6% in the third year and 63.5% in the fourth year. This confirms that the level of studies and the greater exposure to clinical practice contribute to higher knowledge uptake.

In what follows, the results per item and overall accuracy are discussed in a stepwise manner from highest to lowest. The questions obtaining the most correct scores were: site of PVC placement (83.4%), recognition of the upper extremities (EESS), the first action for phlebitis (76.1%), removing the catheter (Webster et al., 2019), and use of aseptic technique during connection/disconnection of infusion lines (75.1%). The last recommendation shows even higher results than those by Etafa et al. (2020). It is relevant to note that the same score was obtained for the question on the correct concentration of chlorhexidine before insertion of PVCs (70.7%) as in the study by Simonetti et al. (2019).

Compared with the study by Osti et al. (2019) conducted on nurses, the students did not recognise the type of gloves to use when inserting the different types of catheter (55.3%), choosing sterile ones for all peripheral and central catheters. Students often have difficulties assimilating the concepts of asepsis and sterility, and when in doubt, they choose the most protective one. In contrast, the nurses identified non-sterile catheters for peripheral lines. This is relevant because risk assessment and the adoption of preventive or aseptic measures is a nursing competence (Denton and Hallam, 2020). Therefore, acquired knowledge of protective and aseptic equipment should be assured during training.

Our results showed low scores regarding the infusion/administration set replacement after blood transfusion (53.5%), lipid emulsions

Table 2
Questionnaire results by academic year.

	Global		2nd		3rd		4th	
	n	%	n	%	n	%	n	%
1. Sterile gloves must be used when placing catheters::								
a. Peripherals	13	1.9	11	4.8	1	0.4	1	0.5
b. Centrals*	373	55.3	77	33.6	131	53.9	165	81.3
c. In all types of catheters	276	40.9	129	56.4	110	45.3	37	18.2
d. I do not know	13	1.9	12	5.2	1	0.4	0	0
2. It is recommended to perform an antiseptic hand wash before insertion of Peripheral Venous Catheters (PVCs)…								
a. No, it's sufficient to wash hands with a non-antimicrobial soap o with alcohol-based hand rubs *	159	23.6	27	11.8	61	25.1	71	35.0
b. No, you do this only for invasive procedure	25	3.7	9	3.9	6	2.5	10	4.9
c. Yes, always	471	69.8	177	77.3	173	71.2	121	59.6
d. I do not know	20	3.0	16	7.0	3	1.2	1	0.5
3. It is recommended to use an aseptic technique during connecting/disconnecting the infusive lines (i.e. no touch technique)…								
a. Yes, always *	507	75.1	142	62.0	204	84.0	161	79.3
b. No, it's sufficient to wash hands with an antimicrobial soap	115	17.0	42	18.4	34	14.0	39	19.2
c. No, because it increases the risk of infection	8	1.2	6	2.6	2	0.8	0	0
d. I do not know	45	3	39	17.0	3	1.2	3	1.5
4. It is recommended to use steel needles (butterfly type) for the administration of drugs…								
a. No, because they might cause tissue necrosis if extravasation occurs *	268	39.7	57	24.9	98	40.3	113	55.7
b. Yes, if I have to inject drugs for a short time	129	29.1	39	17.0	41	16.9	49	24.1
c. Yes, always	32	4.7	13	5.6	16	6.6	3	1.5
d. I do not know	246	36.4	120	52.5	88	36.2	38	18.7
5. It is recommended to change the dressing on the catheter insertion site…								
a. On a daily basis	44	6.5	19	8.3	16	6.6	9	4.4
b. Every 3 days	158	23.4	59	25.8	49	20.2	50	24.6
c. When indicated (soiled, loosened, …) and at least every five, six or seven days**	445	65.9	129	56.3	174	71.6	142	70.0
d. I do not know	28	4.1	22	9.6	4	1.6	2	o
6. It is recommended to cover up the catheter insertion site with…								
a. Polyurethane dressing (transparent, semipermeable)	523	77.5	145	63.3	205	84.4	173	85.2
b. Gauze dressing	33	4.9	17	7.4	13	5.3	3	1.5
c. Both are recommended because the type of dressing does not affect the risk for catheter related infections*	73	10.8	35	15.3	16	6.6	22	10.8
d. I do not know	46	6.7	32	14.0	9	3.7	5	2.5
7. It is recommended to disinfect the catheter insertion site with…								
a. 0.5% Chlorhexidine gluconate solution *	477	70.7	141	61.6	191	78.6	145	71.4
b. 0,2% tinture of iodine	70	10.4	19	8.3	20	8.2	31	15.3
c. 10% alcohol	63	9.3	22	9.6	23	9.5	18	8.9
d. I do not know	65	9.6	47	20.5	9	3.7	9	4.4
8. It is recommended to apply an antibiotic ointment at the insertion site of a PVC…								
a. Yes, because it decreases the risk for	49	7.3	21	9.2	20	8.3	8	3.9
b. No, because it causes antibiotic resistance *	229	33.9	55	24.0	79	32.5	65	32.0
c. No, because it does not decrease the risk for catheter related infections	221	32.7	68	29.7	88	36.2	65	32.0
d. I do not know	176	26.1	85	37.1	56	23.0	35	17.1
9. When lipid emulsions are administered through a PVC (peripheral parenteral nutrition), it is recommended to replace the administration set…								
a. Within 24 h *	279	41.3	64	27.9	123	50.6	92	45.3
b. Every 72 h	210	31.1	70	30.6	77	31.7	63	31.0
c. Every 96 h	8	1.2	4	1.8	1	0.4	3	1.5
d. I do not know	178	26.4	91	39.7	42	17.3	45	22.2
10. A Medium Venous Catheter (MVC) or Peripherally Inserted Central Catheter (PICC) should be substituted for the use of a PVC if intravenous (IV) therapies have a duration of more than:								
a. 3 days	64	9.5	27	11.8	31	12.8	6	3.0
b. 6 days*	160	23.7	54	23.6	34	14.0	72	35.5
c. 10 days	240	35.6	44	19.2	95	39.0	101	49.8
d. I do not know	211	31.3	104	45.4	83	34.2	24	11.7
11. It is recommended to use a system for manipulation and IV access through PVCs:								
a. With needle	172	25.5	76	33.2	50	20.6	46	22.7
b. Without needle*	260	38.5	52	22.7	121	49.8	87	42.9
c. Either way, both systems are valid.	42	6.2	13	5.7	17	7.0	12	5.9
d. I do not know	201	29.8	88	38.4	55	22.6	58	28.5
12. The site of choice for the placement of the PVC is...								
a. Upper or lower extremity	64	9.5	29	12.7	22	9.1	13	6.4
b. Upper extremity *	563	83.4	161	70.3	214	88.1	188	92.6
c. Lower extremity	14	2.1	9	3.9	4	1.6	1	0.5
d. I do not know	34	5.0	30	13.1	3	1.2	1	0.5
13. In the event of administering blood or blood products, the PVC set must be changed....								
a. Within 24 h of the start of the infusion*	361	53.5	80	24.9	144	59.3	137	67.5
b. Every 96 h	23	3.4	5	2.2	8	3.3	10	4.9
c. Upon removal of the PVC	90	13.3	32	14.0	42	17.3	16	7.9
d. I do not know	201	29.8	112	48.9	49	20.1	40	19.7
14. When signs of phlebitis (tenderness, warmth, erythema or palpable venous cord) or infection from the PVCs occur...								
a. The infusion must be halted and the equipment changed.	102	15.1	35	15.2	46	18.9	21	10.3
b. Antibiotics must be administered through the catheter itself.	15	2.2	13	5.7	1	0.4	1	0.5
c. The catheter must be removed*	514	76.1	141	61.6	193	79.4	180	88.7

(*continued on next page*)

Table 2 (*continued*)

	Global		2nd		3rd		4th	
	n	%	n	%	n	%	n	%
d. I do not know	44	6.5	40	17.5	3	1.3	1	0.5
15. It is recommended that the following PCV should be placed:								
a. Larger size	294	43.6	78	34.2	98	40.3	118	58.2
b. Smaller size*	243	36.0	63	27.6	104	42.8	75	36.9
c. Larger external diameter	15	2.2	7	3.3	7	2.9	1	0.5
d. I do not know	123	18.2	80	34.9	34	14.0	9	0.4

The asterisk* indicates the correct response.

Table 3
Percentage of correct responses and difficulty index per question and academic year.

No. question	Global	2nd	3rd	4th	F[a]	p
Qn_01	55.3% (0.45)	33.6% (0.66)	53.9% (0.46)	81.3% (0.19)	57.839	0.000
Qn_02	23.6% (0.76)	11.8% (0.88)	25.1% (0.75)	35.0% (0.65)	17.067	0.000
Qn_03	75.1% (0.25)	62.0% (0.38)	84.0% (0.16)	79.3% (0.21)	17.327	0.000
Qn_04	39.7% (0.60)	24.9% (0.75)	40.3% (0.60)	55.7% (0.44)	22.652	0.000
Qn_05	65.9% (0.34)	56.3% (0.44)	71.6% (0.28)	70.0% (0.30)	7.291	0.001
Qn_06	10.8% (0.89)	15.3% (0.85)	6.6% (0.93)	10.8% (0.89)	4.669	0.010
Qn_07	70.7% (0.29)	61.6% (0.38)	78.6% (0.21)	71.4% (0.29)	8.458	0.000
Qn_08	33.9% (0.66)	24.0% (0.76)	32.5% (0.67)	46.8% (0.53)	13.058	0.000
Qn_09	41.3% (0.59)	27.9% (0.72)	50.6% (0.49)	45.3% (0.55)	13.940	0.000
Qn_10	23.7% (0.76)	23.6% (0.76)	14.0% (0.86)	35.5% (0.65)	14.655	0.000
Qn_11	38.5% (0.61)	22.7% (0.77)	49.8% (0.50)	42.9% (0.57)	20.510	0.000
Qn_12	83.4% (0.17)	70.3% (0.30)	88.1% (0.12)	92.6% (0.7)	23.794	0.000
Qn_13	53.5% (0.47)	34.9% (0.65)	59.3% (0.41)	67.5 (0.33)	27.421	0.000
Qn_14	76.1% (0.24)	61.6% (0.38)	79.4% (0.21)	88.7% (0.11)	24.428	0.000
Qn_15	36% (0.64)	27.9% (0.72)	42.8% (0.57)	36.9% (0.63)	5.771	0.003

[a] Snedecor F statistic.

(41.3%), needle-system use (38.5%) and steel needle use (39.7%). The scores obtained were lower than those in other studies conducted in very different contexts, such as Italy (Simonetti et al., 2019) and Ethiopia (Etafa et al., 2020). Thus, given the students' uncertainty surrounding the basic guidelines for administration set replacement, training needs to be reinforced. The study by Cicolini et al. (2014), also conducted on novice nurses, reported that although the students recognised the need to replace administration sets after administration of lipid emulsions and blood, as well as the correct use of needle-free systems, they scored low results on the use of steel needles for administering drugs. Failure to be aware of this guideline increases the risk of extravasation.

Continuing on the theme of catheter selection and site, the students struggled to understand when to replace the catheter with a medium (MVC) or central catheter (CVC) (23.7%) and the correct size of the catheter to be placed (36%). These results could be explained by the fact that this is specialised information, typically covered in the higher years of nursing education. MVCs, especially CVCs, allow for prolonged therapy, infusion of vesicants and irritants, and reduce repeat phlebotomy (Mattox, 2017). Studies evaluating the association of a PVC over long periods are scarce; however, its use is not recommended when managing an infusion therapy pattern of more than 6 days (Wei et al., 2019). Several studies have linked the larger catheter size to more local complications such as phlebitis (Wei et al., 2019).

Deficient knowledge was observed on handwashing (23.6%) and the application of antibiotic ointment (33.9%). Students recognised the importance of handwashing but were confused about the correct type of hygiene. Few studies associate hand disinfection with PVC complications and do not offer specific guidelines on the type of soap or hydroalcoholic gel, dosage and duration (Lee et al., 2019). The misconception that antibiotics aid healing could explain the use of antibiotic ointment (Etafa et al., 2020).

The students correctly identified situations requiring dressing changes (65.9%), but they mistook the choice of dressing. This question received the lowest number of correct answers (10.8%). The students chose the transparent dressing as the best option, explained by its widespread use in clinical hospital practice. In contrast, evidence-based recommendations (Gorski et al., 2016; O'Grady, 2017) and other studies (Alexandrou et al., 2018) identify transparent and sterile gauze dressings as equally valid. However, it is essential to include in the protocols the type of dressing to secure the PVC to the patient's skin according to the viable options for each hospital (De Sousa Salgueiro-Oliveira et al., 2019).

The qualitative and quantitative results on the students' level of knowledge complement each other and are coherent. Students recognised that their knowledge is basic and insufficient in the qualitative phase, and they still have a great deal to learn.

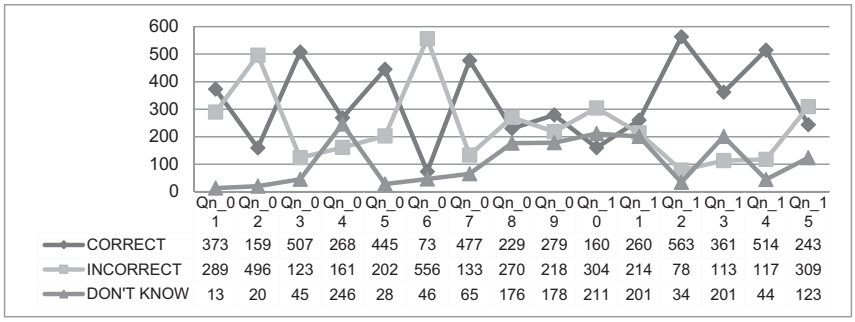

Fig. 1. Overall results by questions and answers: frequencies.

Table 4
Matrix of findings.

Themes	Categories	Example data (unit of meaning)
Perception of acquired knowledge	Knowledge is fundamental, hence, they still have much to learn	*"I admit that my knowledge is limited and that I had many doubts when answering the questionnaire." P55* *"My knowledge is good but insufficient to offer optimal care to patients"P241* *"I still have a lot to learn, but I see that year by year, I'm acquiring more knowledge and don't have as many doubts." P32*
	The higher their academic year, the higher their perception of having attained a higher level of knowledge	*"Little by Little I internalize the theoretical knowledge but I lack professional experience to reinforce it, but in each practice I find myself more sure"P192* *"My knowledge can be improved, but I see that the techniques are not always performed correctly in clinical practice…" P118*
Training scenarios for integrating and consolidating knowledge	The dichotomy between theory and practice is viewed as a barrier to learning	*"There should be a better link between the classroom and the hospital, if not for us, it is a mess… We do not know how to act"P443* *"It's important to be able to practice in the classrooms with the manikins and simulators; it helps you recognise the subject and gain a bit more confidence." P520* *"The skills classrooms make you feel sure about how to act in the clinic" P91* *"Theory helps us to do better in clinical practice placement, but in my opinion, the hospital is where you really learn." P19*
	Scenarios that practise and develop skills that help to prepare them better for clinical practice better (workshops, skills classrooms, case solving and problem-based learning seminars)	
	The importance of clinical practice placements as a genuinely relevant learning space	*"Doing practice is in my opinion very important, you learn by doing with the patient, and this really helps you to integrate"P599* *"Simulation is a near-real environment where you can allow yourself to make mistakes and learn as well."* P246" *…the images, the videos allow you to interact more realistically, then it's easier, you don't have to imagine because you experience it…"* P657
Factors for improving the learning process	Reinforcement of simulations, self-learning strategies and virtual resources	*"They should give classes that are more dynamic, with less theory and fewer explanations from teachers".* P343 *"The knowledge we learn should be based on the best evidence, which is sometimes not the case… there are different criteria among teachers." P125*
	More active, participatory, individualised and evidence-based methodologies	
	Strategies to promote inquiry and reflection	*"Methodologies should arouse our interest as students to query and reflect, and thus to investigate and study more." P324* *"We must be more critical of the information, not all the information available on the internet is valid"P63* *"Teaching the same protocols as those used in hospitals would be immensely helpful, so you don't get confused or don't recall how to act." P394* *"I like it when subjects propose joint sessions with clinical experts, they help us understand better"P637*
	Continuum between theory and practice, and unify criteria	

4.2. Learning process: contexts and teaching methodologies for improvement

Knowledge of nursing practice and patient safety, linked explicitly to PVCs, stems from formal education and nurse-patient interactions in the clinic (Muniz Braga et al., 2019). Therefore, nursing educators should emphasize evidence-based knowledge that can be correctly transferred to clinical practice (Simonetti et al., 2019). To do this, it is essential to improve information literacy and the ability to interpret research with interactive and clinically integrated teaching strategies (Fiset et al., 2017; Horntvedt et al., 2018). The integration of evidence-based practice in training allows us to graduate nurses who provide multidimensional, safe, profitable and high-quality care (Wakibi et al., 2021).

Student training on the use of PVCs is still based on technical skills, particularly needle insertion; this knowledge needs to be more comprehensive to include patient safety (Ravik et al., 2017). The students demand practical-theoretical knowledge that can be transformed into direct or experiential knowledge through workshops, skills classes, seminars or problem-based learning. Along these lines, the study by Brannan et al. (2016) details that students are more likely to have active, visual, sensing, and sequential learning styles, and that these styles have a greater impact on knowledge and ultimately improve clinical reasoning in practice.

Among the findings of our study, simulation emerges as a powerful learning tool. While low-fidelity simulation is limited, it helps skills performance and familiarity with the subject matter. However, it does not allow for safe practice because it does not simulate a real-world environment or a critical event (Ravik, 2015). Indeed the respondents who did most of their aseptic technique training in simulation or the clinical setting appeared more likely to feel confident in their ability to insert and maintain devices than those who received the majority of education in lecture (Carter et al., 2017). In the teaching process, students reported the enhancement of simulation and its combination with virtual resources as a point of improvement. Simulation coupled with technology enhances learning (De Souza-Junior et al., 2020). In consonance with other authors (Hinkin and Cutter, 2014), our results show a clear divergence between theory and practice. Furthermore, when students do not adequately integrate the knowledge acquired in the university, they may attach more importance to their knowledge of clinical practice, even if this is incorrect. Therefore, training should be extended to generic competencies such as critical thinking (Rahiman et al., 2018), enabling them to query their behaviour or actions without risk of conflict or embarrassment (Hinkin and Cutter, 2014). There are different ways to carry out nursing procedures correctly; students must be able to distinguish between these different interventions without jeopardising patient safety (Ewertsson et al., 2017). Other variables determining the level of knowledge on catheter care include self-efficacy, problem-solving, liking the profession and year of study (Dogu Kokcu and Cevik,

2020).

Students demand inquiry, questioning and reflection as elements that favour learning. Thus, there is a need to create a conscious and grounded practical knowledge through inquiry (Domingo and Gómez, 2014), given that students' knowledge and/or skills improve when reflecting on critical events or daily practice (Andersen, 2016). Clinical practice is where higher levels of reflection are achieved (Roca et al., 2020), that is, higher order cognitive skills. As students spend more time in the clinic they can become more aware of gaps in their knowledge and increase their confidence better with clinical practice in comparison to the classroom (Huang et al., 2020). Thus, students' perception of the learning context (clinical or academic) can change their learning approach, going from a more superficial to a deeper one (Takase and Yoshida, 2021).

It is crucial to harness the students' potential as future professionals, as noted in the study of Förberg et al. (2014), which reported that recently graduated nurses showed greater adherence to the principles of PVC care due to their having acquired more up-to-date knowledge and higher technological skills. Moreover, there is a need for constant knowledge reinforcement during the post-graduate period in the clinical context (Keleekai et al., 2016).

4.3. Limitations

This study allowed us to establish associations between variables but not causal relationships between possible predictors of knowledge among students. Similar studies should be conducted with nursing educators and clinical practice tutors to address this knowledge deficit comprehensively.

5. Conclusions

The students' level of knowledge of PVC insertion and care was generally low. Those who obtained the highest scores were senior-year students and those with previous clinical experience. Thus, the level of education and experience could explain these higher scores.

Basic knowledge of hand hygiene and aseptic techniques, selection of catheters and sites, site dressing regimens, skin preparation, replacement of administration sets and needleless intravascular catheter systems should be reinforced. This strengthening directly improves clinical practice and adherence to the principles of quality of care and patient safety.

Changes in nursing education must be structured on the following four levels: emphasis of scientific and experiential knowledge over theoretical and procedural knowledge; application of new teaching methodologies such as clinical simulation and online and technological or interactive resources; need to align theory with clinical practice by developing shared evidence-based programmes which emphasize continuous collaboration between students, professionals and educators to create a more positive attitude in all participants; and promotion of transversal competencies such as critical thinking, reflective thinking or problem-solving that promote student inquiry and the application of evidence-based nursing knowledge. Finally, for the development of evidence-based practice, it is essential that educators plan its development in a transversal and integrated way throughout the curriculum, using theoretical reference models and seriously planning the development context and the strategies to be used.

CRediT authorship contribution statement

Judith García-Expósito: Formal Analysis, Investigation, Resources, Writing – Review & Editing. **Mercedes Reguant:** Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review & Editing. **Olga Canet-Vélez:** Investigation, Resources, Data Curation. **Francisca Ruiz:** Investigation, Resources, Data Curation. **Teresa Botigué:** Investigation, Resources - Review & Editing. **Judith Roca:** Conceptualization, Methodology, Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review & Editing, Supervision.

Declaration of competing interest

All the authors have no conflict of interest.

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