Nurse Education Today 142 (2024) 106340

Contents lists available at ScienceDirect

Nurse Education Today

journal homepage: www.elsevier.com/locate/nedt

Research article

Psychometric validation of an instrument to assess undergraduate nursing student's knowledge of the aetiology, prevention and treatment of venous leg ulcers

Iván Durán-Sáenz [a,e,*], José Verdú-Soriano [b], Héctor González-de la Torre [c,d], Pablo López-Casanova [b], Miriam Berenguer-Pérez [b]

[a] Bioaraba, Basque Nurse Education Research Group, Vitoria-Gasteiz, Spain
[b] Community Nursing, Preventive Medicine, Public Health and History of Science Department, Faculty of Health Sciences, University of Alicante, Carretera San Vicente Del Raspeig s/n, 03690, San Vicente Del Raspeig, Alicante, Spain
[c] Research Support Unit, Insular Maternal and Child University Hospital Complex, Canary Health Service,35016, Las Palmas de Gran Canaria, Spain
[d] Nursing Department, Faculty of Healthcare Science, Universidad de Las Palmas de Gran Canaria (ULPGC), 35016, Las Palmas de Gran Canaria, Spain
[e] Osakidetza Basque Health Service, Araba University Hospital, Vitoria-Gasteiz School of Nursing, Vitoria-Gasteiz, Spain

ARTICLE INFO

Keywords:
Varicose ulcer
Students, nursing
Knowledge
Surveys and questionnaires
Reproducibility of results
Rasch analysis

ABSTRACT

Background: In the management of individuals with venous leg ulcers, education serves as a pivotal tool for acquiring knowledge, fostering appropriate attitudes, and promoting best practices. Consequently, assessing knowledge, skills, attitudes, confidence, and commitment becomes essential, necessitating the development of suitable evaluation instruments. Pre- and post-test assessments align with Level 2 of Kirkpatrick's model. Moreover, nurse educators should integrate assessment into the teaching-learning sequences.
Aim: To psychometrically validate an instrument designed to assess undergraduate nursing students' knowledge of the aetiology, prevention, and treatment of venous leg ulcers.
Design: A multi-phase study was designed to develop the tool and subsequently validate its psychometric properties.
Setting(s): The study was conducted at three sites within the University of the Basque Country and one site within the University of Alicante.
Participants: A total of 516 students from all four years of the nursing degree program participated.
Methods: The construct definition and instrument development were previously published. This article presents the psychometric evaluation, which involved classical item analysis, analysis of psychometric properties according to the Rasch model, differential item functioning analysis, construct validity analysis through hypothesis testing in known groups, and reliability analysis via internal consistency.
Results: The results validated the Knowledge on Venous Leg Ulcer Questionnaire, reducing it from 72 initial items to 36 definitive items. It was found to be a valid and reliable instrument, capable of detecting statistically significant differences between known groups. Knowledge scores on a 0–100 scale were found to be 33.1 (SD = 19.5) for the first-second year groups, and 48.3 (SD = 17.5) for the third-fourth year groups, demonstrating a progressive and logical increase in knowledge each year.
Conclusions: The Knowledge on Venous Leg Ulcer Questionnaire appears to be a valid and reliable instrument for measuring nursing students' knowledge of venous leg ulcers. However, further research in different contexts is required to confirm these results.

1. Introduction

Recent studies confirm that venous leg ulcers (VLU) have a combined prevalence of 0.32 % and a combined incidence of 0.17 % (Probst et al., 2023). According to Guest et al. (2020), the number of individuals suffering from this condition in the United Kingdom (UK) increased by

* Corresponding author at: José Atxotegi s/n, 01009 Vitoria-Gasteiz, Basque Country, Spain.
E-mail address: ivan_duran001@ehu.eus (I. Durán-Sáenz).

https://doi.org/10.1016/j.nedt.2024.106340
Received 21 March 2024; Received in revised form 6 July 2024; Accepted 1 August 2024
Available online 8 August 2024

101 % between 2012/2013 and 2017/2018, rising from 27,800 to 56,000 patients. This condition significantly impacts the quality of life for both sufferers and those around them, particularly in terms of emotional well-being and body image. Improved wound healing is associated with enhanced scores on the EuroQol 5-Dimensional 5-Level (Chan et al., 2023; Folguera-Álvarez et al., 2022; González de la Torre et al., 2017; Miertová et al., 2016). Additionally, Phillips et al. (2020) identified nurse visits as the primary cost factor in VLU care. However, the implementation of nurse-led models can facilitate early diagnosis and treatment, thereby reducing healing times and costs (Bourke and Scott, 2021).

Despite therapeutics and other technical aspects, education is a fundamental tool for mitigating the impact of VLU in patient care. The Registered Nurses Association of Ontario's (Registred Nurses Assosiation of Ontario, 2004) best practice guideline on the assessment and management of VLUs recommends that all healthcare professionals receive training to competently perform VLU assessment and management.

In European universities, the teaching-learning processes underwent significant methodological reform with the introduction of the university system into the European Higher Education Area (EHEA) (Bologna Declaration, 1999). A key measure adopted was the shift towards competency-based learning and lifelong learning methodologies. These are defined as a set of knowledge, skills, abilities, and behaviours necessary for effective job performance (BOE-A-2003-10715 Ley 16/2003, n.d.). Additionally, the World Health Organization, in its publication "Nurse Educator Core Competencies," outlines competencies for nursing educators. These include implementing innovative strategies that facilitate active learning, theoretical and clinical reasoning, and integrating evidence-based teaching and learning processes in safe environments (WHO, 2016).

Therefore, incorporating new technologies and methodologies into everyday teaching should be associated with design-based research (DBR), which involves the design, implementation, and evaluation of Teaching-Learning Sequences (Guisasola et al., 2020). Every research process requires an analysis phase, and DBR methodology emphasizes the need for multiple and convergent assessment tools that explicitly evaluate various aspects of teaching-learning sequences (Nieveen, 2010). This underscores the need to validate a knowledge assessment tool, in the absence of an adequate one, and incorporate it with other tools to evaluate skills and attitudes comprehensively within the area of VLU teaching and care.

Furthermore, according to Kirkpatrick's model (Kirkpatrick and Kaiser, 2016), which provides a framework for evaluating training and capacity-building programs, level 2 involves assessing acquired knowledge. This necessitates the design of appropriate tools, such as pre- and post-tests, for this level.

This need is further reinforced when considering the three phases of assessment programs and activities (planning, assessment, and demonstration of value). The first phase, planning, includes designing knowledge assessment tools. Investigating how nursing students learn can reveal whether the acquired knowledge is declarative, information stored in memory (Ausubel, 2002) or argumentative, involving reasoned and evidence-based assertions (Cohen et al., 2017; Toulmin, 2007; Toulmin et al., 1984).

In the realm of nursing, the pace of advances in evidence-based practices often outstrips the progression of university training programs. To address this disparity and ensure that training remains relevant, it is imperative to employ measurement tools that align with the latest evidence and are tailored to assess nursing competencies effectively. By doing so, we can close the training cycle and enhance the preparedness of nursing professionals.

Looking for the evidence of validated tools to measure VLU knowledge, Durán-Sáenz et al. (2022) concluded in their review that no ideal tool exists for quantifying declarative knowledge for VLU. Two studies utilized validated questionnaires to assess theoretical declarative knowledge. Van Hecke et al. (2011) developed and psychometrically validated an instrument that yielded acceptable test results for registered nurses but only regarding lifestyles associated to VLU. Subsequently, Ylönen et al. (2017, 2019) employed an instrument they termed the Perceived Knowledge, Attitudes, and Theoretical Knowledge (PKAK), which was based on translations of the tools used by Graham et al. (2001) and Van Hecke et al. (2011), also targeting postgraduate nurses. However, none of these instruments were considered suitable for measuring VLU knowledge among undergraduate nursing students.

2. Aim

The aim of the study was to psychometrically validate an instrument designed to assess the knowledge of undergraduate nursing students regarding VLU aetiology, prevention, and treatment.

3. Methods

3.1. Design

The study follows a structured multi-phase approach to instrument development and psychometric validation as outlined by Mishel (1989) and subsequently replicated by Beeckman et al. (2010) and Van Hecke et al. (2011). The stages are detailed below:

1. defining the construct of the instrument.
2. instrument development.
3. psychometric evaluation.

Fig. 1 Provides an overview of the development and validation process.

The method for each of the above-mentioned phases is presented below.

3.1.1. Phase 1: defining the construct of the instrument

This phase was published in a previous article (Durán-Sáenz et al., 2023). Nevertheless, in the results section, a summary is presented to provide the reader with a clearer understanding of the entire process. This summary aims to encapsulate the key findings and essential steps undertaken during the previous research, ensuring that the reader can grasp the core aspects of the study without delving into the detailed methodology. By highlighting the main outcomes and significant observations, the summary serves as a concise reference point for comprehending the overall implications and conclusions drawn from the research.

3.1.2. Phase 2: instrument development

The second phase consisted of evaluating the Levels of Agreement (LA) for the first version of the questionnaire. This part was also published in a previous article (Durán-Sáenz et al., 2023). As in phase 1 a summary is also provided in the results section.

3.1.3. Phase 3: psychometric evaluation

A convenience sample of 1972 nursing students was selected from the four-year groups of the nursing programs at two participating universities. While a consensus on the sample size is not necessary for psychometric validation of an instrument, classical methodological recommendations for questionnaire validation suggest selecting between 5 and 10 participants per item. In this case, with 72 items in the instrument, the recommended sample size ranges from 360 to 720 participants (Roco Videla et al., 2021).

The study was conducted across three campuses of the University of the Basque Country (Álava, Bizkaia, and Gipuzkoa) and one campus of the University of Alicante between November and December 2022. Participants were invited via a Google Forms® link, following recommendations from the CHERRIES® initiative, which provides guidelines for comprehensive descriptions of web-based surveys (Eysenbach,

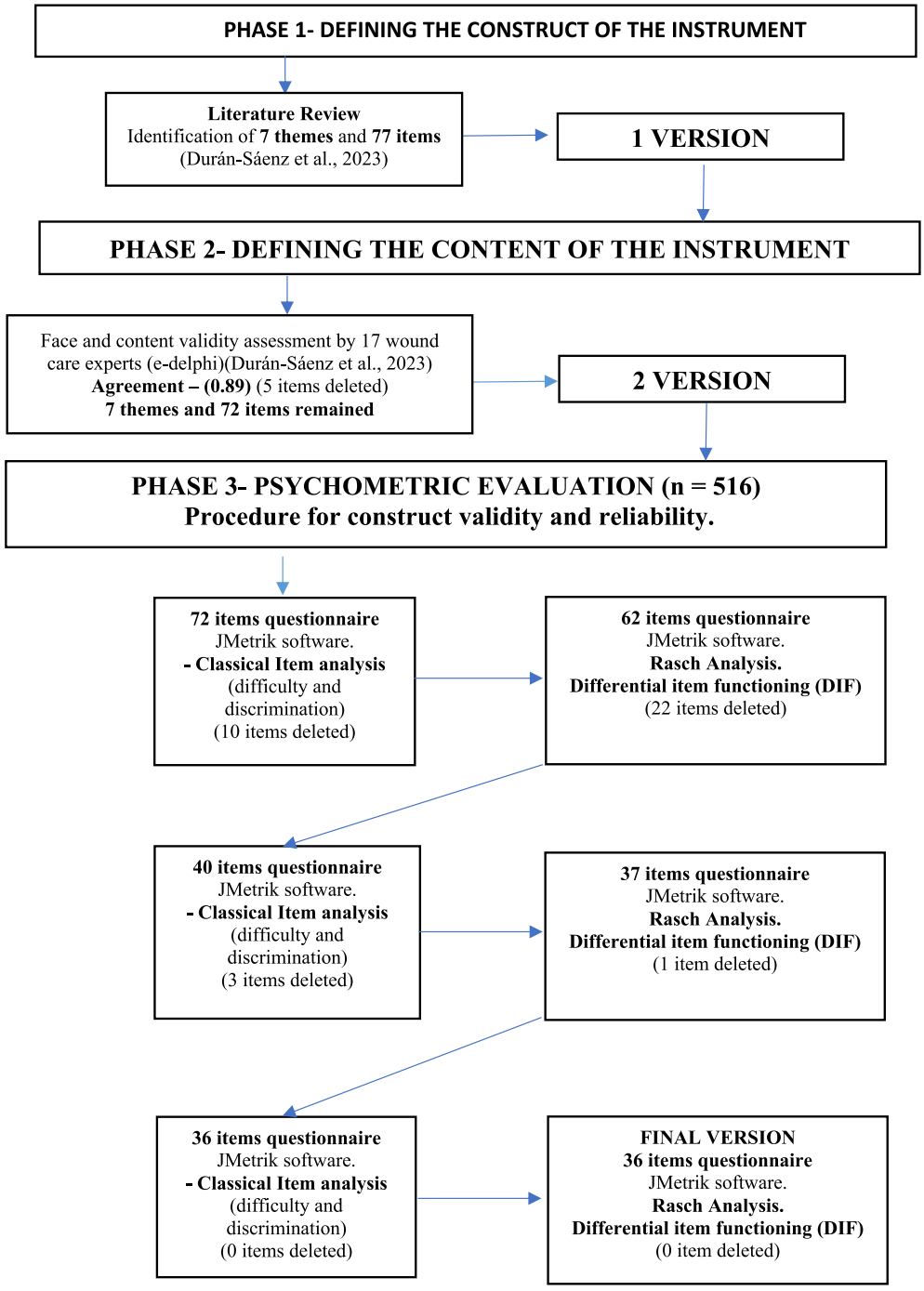

Fig. 1. Summary of the process and methods used.

2004). Participants received detailed information about the study, including its purpose and procedures, and confidentiality was ensured through coding and anonymity protocols. Completing and submitting the survey was taken as consent to participate. The estimated time to complete the survey was 30 min. Feedback, including the final score, was provided at the end of the test. A version of the instrument used is available as supplementary material (Supplementary Material 1).

3.1.3.1. Descriptive analysis of the sample. The analysis aimed to characterize the studied sample. Categorical and ordinal variables were reported as frequencies and percentages, while continuous variables were described using mean, median, and standard deviation. These analyses were performed using Jamovi software (The jamovi project, 2023).

3.1.3.2. Procedure for construct validity and reliability. The collected data were tabulated, coded, and organized in a purpose-built database prior to analysis. The validation process of the questionnaire utilized classical item analysis and methods based on Item Response Theory, specifically Rasch analysis (Rasch, 1960).

3.1.3.2.1. Classical item analysis. In the item analysis, responses were converted into dichotomous outcomes, namely correct or incorrect. Correct answers were coded as 1, while incorrect or blank answers were coded as 0, yielding the total score for the questionnaire. These scores were normalized to a 0–1 scale by dividing the number of correct answers by the total number of possible answers, then multiplying by 100 to obtain a percentage score, as follows:

Total score = (number of correct answers/total number of questions) x 100.

From these scores, indices of difficulty, discrimination, and unfamiliarity were estimated. For the **unfamiliarity index**, the items were left in their original format to calculate the percentage of "don't know/no answer" responses for each item.

The **difficulty index** indicates the percentage of participants who correctly answer each question (Mehrens and Lehmann, 1984). When an item is answered very frequently or infrequently (above 90 % or below 10 %), it provides little discriminatory power between individuals and yields minimal information (Argimon Pallás and Jiménez Villa, 2019). The difficulty index is interpreted as follows: very easy (>90 % correct), easy (75–90 %), somewhat easy (50–75 %), somewhat difficult (26–50 %), difficult (10–25 %), and very difficult (<10 %).

Item discrimination measures the extent to which an item differentiates between participants who achieve varying scores on the test. It is evaluated by the polyserial correlation between the latent item score and the total test score. High discrimination indicates that the item effectively differentiates between participants with similar, but not identical, scores. Conversely, low discrimination suggests that the item only distinguishes between participants with significantly different scores. Ideally, discrimination values should range between 0.3 and 0.7 (Meyer, 2014).

3.1.3.2.2. Analysis of psychometric properties according to the Rasch model. Rasch analysis (Rasch, 1960) stands out as a powerful and refined statistical tool within the field of nursing research for the evaluation and enhancement of measurement instruments, particularly concerning surveys and competency assessments. Unlike other statistical models that may rely on less stringent assumptions about the data, the Rasch model excels in converting qualitative responses (e.g., correct/incorrect, agree/disagree) into quantitative measures along a continuum of ability or attitude. Lower values on this continuum represent frequently occurring or easily observable characteristics, while higher values indicate characteristics that are rarely observed or more difficult to achieve (Meyer, 2014).

Fundamentally, the Rasch model is a mathematical construct with a logistic probability function, assuming that the probability of a correct response to an item (or the selection of a particular response on a scale) depends solely on the difference between the individual's level of ability and the item's difficulty (Rasch, 1960). This unique feature allows the Rasch model to provide measurements independent of both persons and items, a property known as **measurement invariance** (Lord, 1980). In other words, the model can measure both people and items on a single dimension and estimate the relationship between respondent ability and item difficulty (Belvedere and De Morton, 2010). This ensures that the measurements do not depend on the specific set of items presented or the respondent population in the sample (Alfaro and Rojas, 2013; Belvedere and De Morton, 2010; Boone, 2016; Prieto and Delgado, 2003).

Another crucial component is the **hierarchy or calibration of items** (Prieto et al., 2003), a process that estimates the difficulty of each item within a dataset. Items and individuals are ordered along the same continuum, where more likely items are positioned at the lower end. The hierarchy of items along the continuum determines their placement concerning the distribution of individuals. Calibration is essential to ensure that items are adequately comparable and to facilitate the construction of fair and equitable tests.

Additionally, the Rasch model relies on two key assumptions (Linacre, 2023; Kline, 2005): the **unidimensionality** of the instrument and the **local independence of items**. Unidimensionality implies that the instrument measures a single dimension of ability or attitude. Local independence means that individuals' responses to each item are independent of each other once their ability in the evaluated dimension has been accounted for. In other words, local independence means that the probability of an individual correctly responding to a particular item is not influenced by their responses to other items, once their level of ability in the evaluated dimension is considered.

Rasch analysis does not require data to fit a specific distribution, making it particularly versatile and robust for different types of assessments (Matas-Terrón, 2010). This characteristic underscores the importance of the Rasch model in creating reliable and valid measurement instruments, facilitating its application across a wide range of contexts.

Regarding the analysis, the Joint Maximum Likelihood Method of Estimation (JMLE) was used to estimate the parameters (Meyer, 2014). Model fit was assessed using outfit: unweighted mean square of normalized residuals (UMS) and infit: weighted mean square of normalized residuals (WMS). Fit index values between 0.8 and 1.2 indicate a good fit, while values between 0.5 and 1.5 indicate an acceptable fit (Yen, 1984).

An item map and a scatter plot between direct scores and the estimated value of the latent variable (theta) were also created. The local independence assumption between the items was tested using the Yen Q3 test (Argimon Pallás and Jiménez Villa, 2019), which evaluates the matrix of correlations of the residues. Although reference values between 0.2 and 0.3 are generally used in the literature to estimate local independence, there is no uniform criterion as this value depends on the sample size, the number of items, and the number of response categories (Christensen et al., 2017).

Differential item functioning analysis (DIF) can identify items which have different responses in different groups. This is a statistical characteristic of an item which shows the extent to which the item might be measuring different abilities for members of separate subgroups. For this technique, two groups (called the focus group and the reference group) are compared without any special criteria, where clear group identification is paramount. The DIF analysis was performed by comparing the focus group (1st and 2nd year students) with the reference group (3rd and 4th year students). The effect size was calculated using the common Odds Ratio (OR) and its 95 % confidence interval. An item was considered not to have differential functioning when the common OR had values between 0.65 and 1.53. Items with an effect size <0.53 or > 1.89 were considered to have a large DIF, and those between 0.53 and 0.65 or 1.53 and 1.89 were considered to have a low DIF (Meyer, 2014; Zwick and Ercikan, 1989). In this sense, results are normally presented with the letters A, B and C and with + or - signs. The letter A indicates no DIF, the letter B a moderate DIF and C a high DIF. On the other hand, the + or - signs are applied to the letters B or C depending on whether the result favours the focus group or the reference group (Meyer, 2014).

Rasch and DIF analysis were performed using JMETRIK software (jMetrik, 2018).

3.1.3.2.3. Analysis of construct validity by means of hypothesis-testing in known groups. To further analyse the construct validity established through Rasch analysis, a known-groups analysis was performed. This involved comparing two groups with theoretically different levels of experience (Polit and Hungler, 2000). The groups compared were nursing students from all four-year cohorts, analysed both individually and in two broader categories: 1st and 2nd-year students versus 3rd and 4th-year students.

This analysis was carried out with Jamovi (The jamovi project, *2023*).

3.1.3.2.4. Rasch and internal consistency reliability analysis. The internal consistency reliability analysis was conducted using the Kuder-Richardson 21 (KR21) index (Bachman, 1995; Kuder and Richardson, 1937; Meyer, 2014), which is suitable for binary data and assumes all items are equally difficult. For comparative purposes and due to its widespread use, the alpha coefficient was also calculated, along with its 95 % confidence interval.

Additionally, the Rasch analysis provides its own model reliability estimates. Scale quality statistics, including reliability and separation, can be computed for both items and persons. Person reliability is like the

reliability coefficient in classical test theory, with values over 0.8 being desirable. Person separation is akin to reliability, representing the extent to which a measurement can consistently reproduce and rank scores. Separation values over 2 are desirable (Meyer, 2014).

This analysis was performed using JMetrik software (jMetrik, *2018*).

3.1.3.2.5. Ethical considerations. This study adhered to The Code of Ethics of the World Medical Association for experiments involving humans (Declaration of Helsinki) and research on health databases (Declaration of Taipei). The procedure was approved by the Ethics Committee for Research Involving Human Subjects of the University of the Basque Country (CEISH-UPV/EHU) under the reference M10_2021_312.

In October 2021, during the development of an educational intervention with nursing students, the researchers informed participants that the data collected between November and December 2022 would be anonymous and used exclusively for research purposes. Participants were provided with an informed consent form before completing the questionnaire. The collected data were securely stored in a digital file, accessible only to the research team. The entire research protocol was registered with the Open Science Framework OSF (2024) under the identifier DOI 10.17605/OSF.IO/3C86R in January 2023.

4. Results

4.1. Descriptive analysis of the sample

A total of 516 students took part from all four year-groups in the nursing degree courses. The general description of their characteristics is presented in Table 1.

4.2. Phase 1. Defining the construct of the instrument

To define the construct of the instrument, a comprehensive manual search of publications related to VLU was conducted, along with a thorough search of major databases. The gathered information was reviewed, analysed, and summarized into a single document, organized into seven themes. This process resulted in the creation of the first version of the questionnaire. For more information, read Durán-Sáenz et al. (2023).

4.3. Phase 2. Instrument development

The initial version of the questionnaire comprised seventy-seven statements (with possible true, false, don't know answers) across seven domains. These statements underwent a double round of an e-Delphi method to evaluate their relevance and clarity (Durán-Sáenz et al., 2023). A Likert-type scale was utilized for expert assessment. Additionally, each statement was paired with an open-ended question to solicit expert feedback on its appropriateness, accuracy, and relevance.

The research team analysed the experts' feedback, making modifications to various items based on their responses. The revised questionnaire was then re-sent to the same experts for further evaluation of the proposed changes, again using the Likert scale from the initial round. Levels of Agreement (LA), assumed to be equivalent to the Content Validity Index (CVI) in this study, were calculated. The CVI was determined by dividing the number of experts who responded "Completely agree" and "Agree" by the total number of experts who assessed the items. The CVI score ranges from −1 to 1, with a score closer to 1 indicating better content validity; a CVI $\geq$ 0.49 is considered adequate for 15 experts (Lawshe, 1975). Items with a CVI below 0.7 were reconsidered and reassessed for appropriateness. Communication and data collection were facilitated via email and Google Forms®.

Following the first round of consultation, 48 items were retained based on expert feedback, 25 items were revised, and 4 items were removed. In the second round, 61 items were retained, 11 items were adjusted, and 1 item was deleted. Ultimately, a 72-item instrument was developed. To ensure a balance of true and false answers, some items were intentionally written to elicit a "False" response. This process resulted in a second version of the questionnaire with a total CVI of 0.89.

Table 1
Characteristics of the sample.

Student nurses (n = 516)	% (n)
Gender (% female)	83.1 % (429)
Study centre	
University of Alicante	18 % (93)
University of the Basque Country Gipuzkoa campus	14.9 % (77)
University of the Basque Country Bizkaia campus	27.7 % (143)
University of the Basque Country Álava campus	39.3 % (203)
Course year-group	
1st year	23.4 % (121)
2nd year	14.5 % (75)
3rd year	47.7 % (246)
4th year	14.3 % (74)
Age (n = 511, Missing data 5)	Mean 22; Median 20, SD 5.78, min 17, max 51

4.4. Phase 3: psychometric evaluation

4.4.1. Psychometric evaluation of the 72-item questionnaire

The psychometric evaluation commenced with the 72-item version of the questionnaire. The initial step involved analysing item difficulty, discrimination, and unfamiliarity indices.

The unfamiliarity index results are presented in Table 2, which also summarizes the findings for each stage of the evaluation. Based on the difficulty and discrimination indices, 10 items were eliminated, reducing the questionnaire to 62 items. Specifically, items with a difficulty index score below 0.10 (items 21 and 46) and those with a score above 0.90 (items 10 and 24) were removed. Additionally, items with a discrimination index score below 0.30 (items 6, 16, 17, 21, 27, 46, 48, and 51) were eliminated. There were no items with a discrimination index score over 0.70, further justifying the removal of items 21 and 46.

Subsequently, the Rasch model was employed to analyse the psychometric properties of the remaining 62 items. The results indicated outfit (UMS) and infit (WMS) values within acceptable ranges, between 0.85 and 1.22, and 0.75 and 1.46, respectively. No items were eliminated following this analysis. A Differential Item Functioning (DIF) analysis was then performed, leading to the deletion of 22 additional items (items 1, 4, 8, 13, 18, 19, 22, 25, 26, 33, 35, 37, 38, 39, 50, 52, 54, 55, 56, 63, 65, and 68) as detailed in Table 2 and Supplementary Material 2.

4.4.2. Evaluation of the 40-item version

The psychometric evaluation proceeded with a 40-item version of the questionnaire. Difficulty and discrimination analyses led to the elimination of three more items, resulting in a 37-item questionnaire. All remaining items had difficulty index scores within acceptable ranges. However, items 2 (discrimination score 0.29), 62 (discrimination score 0.71), and 70 (discrimination score 0.72) were removed. The Rasch analysis was repeated for these items, with outfit (UMS) and infit (WMS) values remaining within acceptable ranges, between 0.86 and 1.12, and 0.76 and 1.15, respectively. No items were eliminated after this analysis. A subsequent DIF analysis recommended the deletion of one additional item (item 53), as detailed in Table 2.

4.4.3. Final analysis of the 36-item version

The final 36-item version underwent further analysis, with all results falling within normal values (Table 2 and Supplementary Material 3). This version demonstrated excellent fit and psychometric properties. The complete instrument is available in Supplementary Materials 4 and

Table 2
Results of the psychometric assessment using the classical method and Rasch.

KVLUQ	72 Items			62 Items			40 Items		37 Items			36 Items				
item	Difficulty	Discrimin.	Ignorance %	Outfit	Infit	DIF	Difficulty	Discrimin.	Outfit	Infit	DIF	Difficulty	Discrimin.	Outfit	Infit	DIF
1	0.68	0.52	23.3	1.06	1.05	B-	Dropped									
2	0.60	0.30	23.6	1.36	1.22	A	0.60	0.29	Dropped							
3	0.51	0.45	31.6	1.04	1.08	A	0.51	0.45	1.05	1.09	A	0.51	0.44	1.05	1.09	A
4	0.71	0.55	21.1	1.01	1.03	B-	Dropped									
5	0.67	0.51	22.9	1.07	1.05	A	0.67	0.53	1.07	1.04	A	0.67	0.52	1.08	1.04	A
6	0.37	0.29	16.3	Dropped												
7	0.70	0.58	25.6	1.02	1.00	A	0.70	0.57	1.02	1.01	A	0.70	0.57	1.02	1.01	A
8	0.15	0.45	67.1	0.98	0.95	B+	Dropped									
9	0.55	0.49	39.5	1.06	1.06	A	0.55	0.46	1.13	1.09	A	0.55	0.45	1.14	1.1	A
10	0.94	0.61	4.7	Dropped												
11	0.74	0.52	18.8	1.09	1.07	A	0.74	0.50	1.12	1.08	A	0.74	0.49	1.13	1.09	A
12	0.64	0.60	33.3	0.9	0.96	A	0.64	0.60	0.93	0.96	A	0.64	0.60	0.93	0.96	A
13	0.88	0.47	7.6	1.46	1.14	B-										
14	0.29	0.44	42.4	1.06	1.00	A	0.29	0.44	1.09	1.01	A	0.29	0.45	1.09	1.01	A
15	0.21	0.40	42.8	1.1	1.00	A	0.21	0.39	1.14	1.00	A	0.21	0.40	1.14	1.00	A
16	0.48	0.17	22.3	Dropped												
17	0.12	0.20	31.6	Dropped												
18	0.51	0.54	26.9	0.98	0.99	B-	Dropped									
19	0.39	0.51	52.9	0.95	0.99	B-	Dropped									
20	0.64	0.44	25.2	1.16	1.13	A	0.64	0.44	1.18	1.12	A	0.64	0.44	1.19	1.13	A
21	0.09	0.28	49.6	Dropped												
22	0.43	0.46	53.7	1.13	1.05	B-	Dropped									
23	0.26	0.49	59.5	0.89	0.98	A	0.26	0.45	0.97	1.01	A	0.26	0.45	1.00	1.02	A
24	0.91	0.55	5.6	Dropped												
25	0.84	0.57	12.8	1.03	1.06	B-	Dropped									
26	0.41	0.48	38.2	1.04	1.01	B-	Dropped									
27	0.15	0.29	41.7	Dropped												
28	0.66	0.51	21.5	1.08	1.05	A	0.66	0.50	1.07	1.05	A	0.66	0.50	1.09	1.05	A
29	0.84	0.62	13.8	0.89	1.00	A	0.84	0.65	0.83	0.98	A	0.84	0.64	0.83	0.99	A
30	0.17	0.42	59.1	1.00	1.00	A	0.17	0.41	0.97	0.99	A	0.17	0.43	0.96	0.99	A
31	0.34	0.51	57.9	0.93	0.98	A	0.34	0.47	0.97	1.01	A	0.34	0.47	0.98	1.02	A
32	0.18	0.45	29.8	0.9	0.97	A	0.18	0.40	0.95	0.98	A	0.18	0.42	0.94	0.98	A
33	0.57	0.53	35.3	1.08	1.01	B-	Dropped									
34	0.26	0.52	63.6	0.94	0.96	A	0.26	0.47	1.08	0.97	A	0.26	0.49	1.08	0.98	A
35	0.18	0.44	56.4	0.93	0.97	B+	Dropped									
36	0.24	0.51	69.4	0.82	0.97	A	0.24	0.48	0.88	0.99	A	0.24	0.48	0.9	0.99	A
37	0.16	0.35	39.5	1.01	1.05	B+	Dropped									
38	0.35	0.36	53.1	1.09	1.12	B+	Dropped									
39	0.31	0.43	55.6	0.98	1.03	B+	Dropped									
40	0.60	0.64	34.1	0.84	0.91	A	0.60	0.64	0.87	0.92	A	0.60	0.63	0.88	0.92	A
41	0.17	0.38	38.4	0.96	1.02	A	0.17	0.36	1.13	1.04	A	0.17	0.36	1.12	1.04	A
42	0.56	0.57	32.8	0.91	0.95	A	0.56	0.58	0.94	0.97	A	0.56	0.57	0.94	0.97	A
43	0.37	0.43	50.8	0.98	1.05	A	0.37	0.41	1.06	1.09	A	0.37	0.39	1.08	1.1	A
44	0.67	0.65	27.7	0.84	0.91	A	0.67	0.66	0.83	0.92	A	0.67	0.64	0.84	0.92	A
45	0.61	0.55	25.2	0.93	0.99	A	0.61	0.56	0.94	0.99	A	0.61	0.55	0.95	0.99	A
46	0.09	0.26	31.0	Dropped												
47	0.27	0.43	27.9	0.99	1.02	A	0.27	0.43	1.00	1.01	A	0.27	0.44	1.00	1.02	A
48	0.20	0.27	28.3	Dropped												
49	0.48	0.65	45.3	0.81	0.87	A	0.48	0.65	0.82	0.88	A	0.48	0.65	0.83	0.88	A
50	0.36	0.49	54.3	0.94	1.01	B-	Dropped									
51	0.12	0.27	27.3	Dropped												
52	0.27	0.45	41.3	0.96	1.00	B+	Dropped									
53	0.48	0.45	43.6	1.13	1.06	A	0.48	0.42	1.15	1.11	B+	Dropped				
54	0.32	0.48	58.7	0.94	1.00	B+	Dropped									
55	0.21	0.32	36.6	1.33	1.05	B+	Dropped									
56	0.45	0.53	42.2	1.11	0.97	B+	Dropped									
57	0.12	0.42	39.3	0.92	0.96	A	0.12	0.38	0.92	0.95	A	0.12	0.41	0.92	0.95	A
58	0.32	0.64	56.2	0.75	0.86	A	0.32	0.64	0.76	0.86	A	0.32	0.64	0.76	0.86	A
59	0.38	0.63	55.2	0.79	0.88	A	0.38	0.61	0.81	0.9	A	0.38	0.61	0.82	0.91	A
60	0.11	0.36	29.1	1.07	0.97	A	0.11	0.34	1.15	0.97	A	0.11	0.34	1.17	0.97	A
61	0.48	0.60	37.8	0.87	0.92	A	0.48	0.60	0.9	0.95	A	0.48	0.57	0.91	0.95	A
62	0.60	0.70	32.2	0.77	0.85	A	0.60	0.71	Dropped							
63	0.51	0.50	39.3	1.04	1.02	B+	Dropped									
64	0.18	0.40	72.3	0.97	1.00	A	0.18	0.36	1.04	1.04	A	0.18	0.36	1.05	1.04	A
65	0.14	0.41	35.7	0.92	0.96	B+	Dropped									
66	0.22	0.52	48.1	0.79	0.93	A	0.22	0.53	0.78	0.92	A	0.22	0.54	0.78	0.92	A
67	0.37	0.62	53.5	0.8	0.89	A	0.37	0.62	0.8	0.89	A	0.37	0.62	0.81	0.89	A
68	0.55	0.57	31.0	0.95	0.97	B-	Dropped									
69	0.63	0.58	22.9	0.92	0.97	A	0.63	0.58	0.94	0.99	A	0.63	0.57	0.94	0.99	A
70	0.72	0.68	22.1	0.79	0.91	A	0.72	0.72	Dropped							
71	0.63	0.61	24.4	0.9	0.95	A	0.63	0.61	0.95	0.95	A	0.63	0.59	0.96	0.96	A
72	0.28	0.51	35.5	0.8	0.95	A	0.28	0.52	0.91	0.95	A	0.28	0.52	0.9	0.95	A

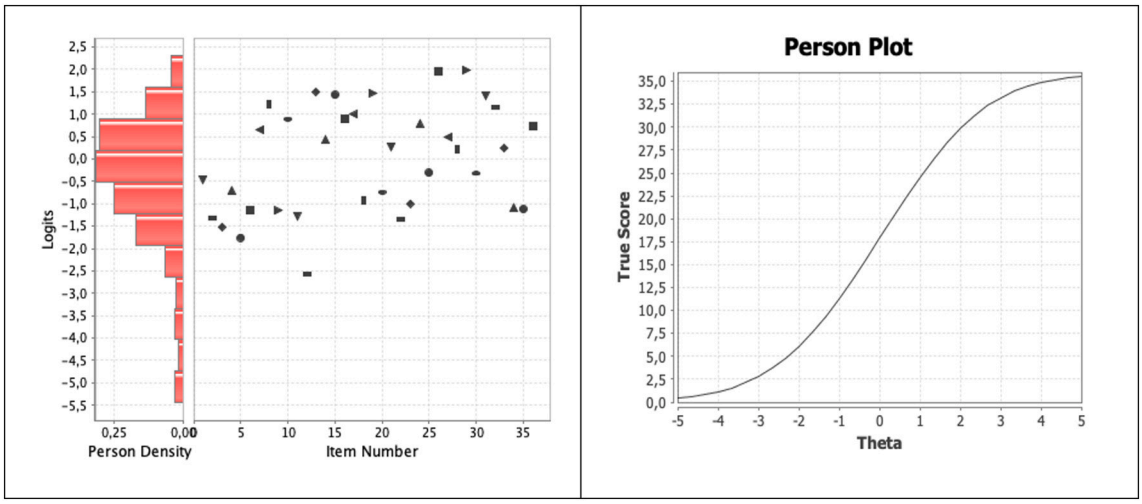

Fig. 2. Wright map or item-person plot and item characteristic curve (ICC).

5. Fig. 2 (Wright map or item-person plot) illustrates the distribution of respondents and items on the same scale (theta). The person density indicates the distribution of scores obtained by participants (expressed in logit units), with values above 0 indicating high knowledge and values below 0 indicating low knowledge. The horizontal axis shows the item numbers (1 to 36), while the vertical axis represents item difficulty, with higher values indicating more difficult items. Fig. 2 also displays the Item Characteristic Curve (ICC), which follows an S-shaped or sigmoid trajectory, suggesting that the questionnaire aligns with the measurement model. Local item independence was confirmed using Yen's Q3 statistic (Supplementary Material 6).

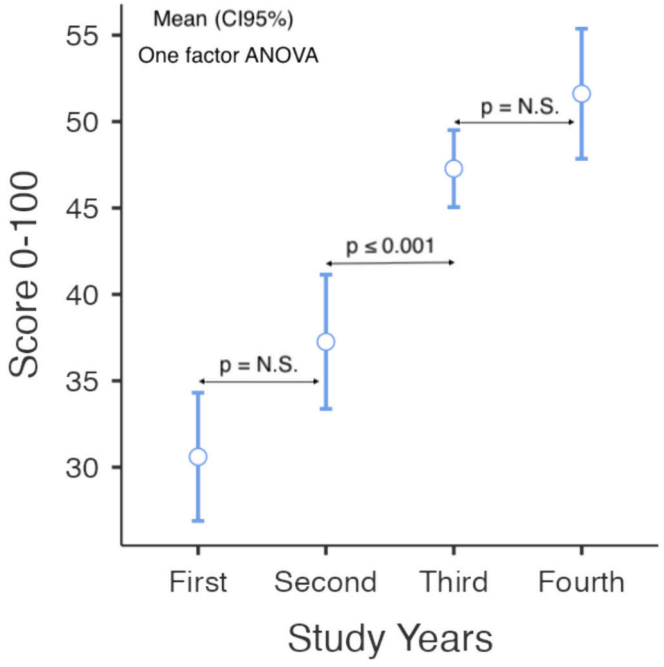

Fig. 3. Knowledge differences between students regarding study year (One Factor ANOVA).
Note: Y axis represents the score's scale. The dots on the graph are the mean score for students at each study year. The lines up and down from the dots are the 95 % confidence intervals of the score. Horizontal lines with arrows explain the statistical significance between study years.

4.4.4. *Construct validity through hypothesis testing in known groups*

Construct validity was further evaluated through hypothesis testing in known groups. The Kolmogorov-Smirnov test confirmed that the knowledge variable data followed a normal distribution (*p*-value: NS). An analysis of variance (ANOVA) test revealed statistically significant differences among the four nursing year groups (p-value $\leq$0.01). Knowledge scores were as follows: first-year (mean = 30.6, SD = 20.6), second-year (mean = 37.3, SD = 16.9), third-year (mean = 47.3, SD = 17.57), and fourth-year students (mean = 51.6, SD = 16.2). Post-hoc tests using the Games-Howell test (as equal variances are not assumed) indicated significant differences between first-year versus third and fourth-year students (p-value <0.01) and second-year versus third and fourth-year students (p-value <0.01), with no significant differences between third and fourth-year or first and second-year students (Fig. 3).

Further analysis regrouped first and second-year students against third and fourth-year students. The t-student test showed statistical significance (p-value $\leq$0.01), with knowledge scores of 33.1 (SD = 19.5) for the first-second group and 48.3 (SD = 17.5) for the third-fourth group.

4.4.5. *Reliability analysis*

Reliability analysis using internal consistency and Rasch for the 36-item version indicated a KR21 coefficient of 0.84 and an alpha coefficient of 0.88 (95 % CI: 0.86–0.89), demonstrating good reliability. The Rasch analysis yielded a separation index of 10.40 for items and 2.56 for persons, with reliability scores of 0.99 for items and 0.86 for persons.

5. Discussion

This study was conducted as part of a comprehensive effort to develop and validate a questionnaire designed to evaluate the knowledge of nursing students regarding the care of individuals with VLU. This assessment is critical for evaluating the competency scope following the implementation of specific teaching-learning sequences (Guisasola et al., 2020). The analysis of psychometric properties, employing classical item analysis, the Rasch model, and Differential Item Functioning, facilitated the adjustment of items considered for inclusion in the final version of the questionnaire.

The findings indicated that the Knowledge on Venous Leg Ulcer Questionnaire (KVLUQ) is a reliable instrument with robust psychometric properties according to the Rasch model when administered to nursing students. The Wright map analysis revealed a deviation towards the first quartile, with 46 (8.9 %) extreme elements scoring below −2.5 in theta value. This deviation could influence the questionnaire's

validation, as these individuals may possess different characteristics compared to the rest of the sample. However, it was decided to retain these extreme values in the analysis. An alternative approach could have been to exclude these extreme values and reassess the properties, but since all participants were students, they were retained.

Regarding the items, the difficulty range was well-adjusted and distributed, with no correlation between the questions, allowing for differentiation between students with varying levels of knowledge. High reliability results were also obtained from the internal consistency and Rasch model analyses.

Despite the Rasch model being an established method since 1960 (Rasch, 1960), it is infrequently used in nursing research. The scoping review by Stolt et al. (2022) advocates for its application in the nursing discipline. Furthermore, the literature review reveals a scarcity of publications using the Rasch model in nursing, particularly concerning VLU knowledge (Stolt et al., 2022). One notable study on the psychometric evaluation of an instrument related to VLU knowledge was conducted in Belgium (Van Hecke et al., 2011). This study found the difficulty index for knowledge questions ranged from 0.12 to 0.78. Items with a discrimination index below 0.2 were eliminated, while those with values between 0.21 and 0.55 were retained. In our study, reference values for the discrimination index ranged from 0.3 to 0.7.

The instrument developed in our study demonstrated its capability to differentiate between known groups. Results indicated a clear distinction between first- and second-year students, who had minimal training, and third- and fourth-year students, who had received training on the evaluated topic. A linear progression in knowledge acquisition was observed across year groups, consistent with findings in studies on other types of skin lesions (Pérez-López et al., 2021; Simonetti et al., 2015; Usher et al., 2018). The overall knowledge level for grouped courses was, on average, below 50 % of the questions, although third- and fourth-year students scored significantly higher. This low level of knowledge might be attributed to the limited coverage of these topics in nursing curricula (Romero-Collado et al., 2015; Tobajas-Señor et al., 2017).

5.1. Limitations

A test-retest reliability analysis of the questionnaire was not conducted, though it is planned for the final version in a future student sample. This future study will analyse temporal reliability-stability (in a test with two close-time measurements without intervention) and sensitivity to change (in a pre-post-test study following an educational intervention).

Given that the sample was convenience-based and participation was voluntary, there is a potential for selection bias, as students with higher knowledge or motivation may be more inclined to participate. Additionally, there was a disproportionate participation by year group, with a greater representation of third-year students, potentially influencing group comparisons. Although the participation of students from different universities facilitated a broad questionnaire analysis, it complicated comparisons due to potential differences in education despite a shared curriculum.

6. Conclusions

In conclusion, through a rigorous process, we developed the 36-item KVLUQ, a valid and reliable instrument for measuring nursing students' knowledge of venous leg ulcers. Nonetheless, further research involving different contexts (more universities or students with enhanced education on the topic) is necessary to confirm our findings.

Funding sources

No funding has been obtained from the public, private, or non-profit sectors.

CRediT authorship contribution statement

Iván Durán-Sáenz: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **José Verdú-Soriano:** Writing – review & editing, Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Héctor González-de la Torre:** Writing – review & editing, Validation, Methodology, Formal analysis. **Pablo López-Casanova:** Writing – review & editing, Methodology, Conceptualization. **Miriam Berenguer-Pérez:** Writing – review & editing, Validation, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The results of the data analysis of the different phases of the validation and development of the questionnaire can be found at: https://data.mendeley.com/datasets/cdxmjzwp24/1
DOI:10.17632/cdxmjzwp24.1

Acknowledgments

We acknowledge the contributing faculty of the BaNER Research Group and thank the nursing students from the University of the Basque Country and the University of Alicante for their voluntary collaboration in developing this research.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.nedt.2024.106340.

References

Alfaro, K.J., Rojas, E.M., 2013. Aplicación del modelo de Rasch, en el análisis psicométrico de una prueba de diagnóstico en matemática. Revista Digital: Matemática, Educación e Internet 13 (1). https://doi.org/10.18845/RDMEI.V13I1.1628.

Argimon Pallás, J., Jiménez Villa, J., 2019. Métodos de investigación clínica y epidemiológica (5ª). Elsevier.

Ausubel, D.P., 2002. Adquisición y retención del conocimiento: una perspectiva cognitiva. Paidós.

Bachman, L.F., 1995. Fundamental Considerations in Language Testing (Third). Oxford University Press.

Beeckman, D., Vanderwee, K., Demarré, L., Paquay, L., Van Hecke, A., Defloor, T., 2010. Pressure ulcer prevention: development and psychometric validation of a knowledge assessment instrument. Int. J. Nurs. Stud. 47 (4), 399–410. https://doi.org/10.1016/j.ijnurstu.2009.08.010.

Belvedere, S.L., De Morton, N.A., 2010. Application of Rasch analysis in health care is increasing and is applied for variable reasons in mobility instruments. J. Clin. Epidemiol. 63 (12), 1287–1297. https://doi.org/10.1016/j.jclinepi.2010.02.012.

BOE-A-2003-10715 Ley 16/2003. de 28 de mayo, de cohesión y calidad del Sistema Nacional de Salud. (s/f). Boe.es. Recuperado el 6 de julio de 2024, de. https://www.boe.es/buscar/act.php?id=BOE-A-2003-10715.

Bologna Declaration, 1999. The European Higher Education Area. Joint Declaration of the European Ministers of Education.

Boone, W.J., 2016. Rasch analysis for instrument development: why,when,and how? CBE Life Sciences Education 15 (4). https://doi.org/10.1187/cbe.16-04-0148.

Bourke, A., Scott, N., 2021. A new district nursing model improves venous leg ulcer healing rates. Wound Practice and Research 29 (4), 206–210. https://doi.org/10.33235/wpr.29.4.206-210.

Chan, K.S., Lo, Z.J., Wang, Z., Bishnoi, P., Ng, Y.Z., Chew, S., Chong, T.T., Carmody, D., Ang, S.Y., Yong, E., Chan, Y.M., Ho, J., Graves, N., Harding, K., 2023. A prospective study on the wound healing and quality of life outcomes of patients with venous leg ulcers in Singapore—interim analysis at 6 month follow up. Int. Wound J. 20 (7), 2608–2617. https://doi.org/10.1111/iwj.14132.

Christensen, K.B., Makransky, G., Horton, M., 2017. Critical values for Yen's Q3: identification of local dependence in the Rasch model using residual correlations.

Appl. Psychol. Meas. 41 (3), 178–194. https://doi.org/10.1177/0146621616677520.
Cohen, L., Manion, L., Morrison, K., 2017. Research methods in education. In: Research Methods in Education, 7th ed. Routledge. https://doi.org/10.4324/9780203720967.
Durán-Sáenz, I., Verdú-Soriano, J., López-Casanova, P., Berenguer-Pérez, M., 2022. Knowledge and teaching-learning methods regarding venous leg ulcers in nursing professionals and students: a scoping review. Nurse Educ. Pract. 63 (March) https://doi.org/10.1016/j.nepr.2022.103414.
Durán-Sáenz, I., Verdú-Soriano, J., Cariñanos-Ayala, S., López-Casanova, P., Berenguer-Pérez, M., 2023. Content, implementation strategies and knowledge assessment tool on venous leg ulcers: an e-Delphi study. Nurse Educ. Pract. 68 (January), 103602 https://doi.org/10.1016/j.nepr.2023.103602.
Eysenbach, G., 2004. Improving the quality of web surveys: the checklist for reporting results of internet E-surveys (CHERRIES). J. Med. Internet Res. 6 (3) https://doi.org/10.2196/jmir.6.3.e34. JMIR Publications Inc.
Folguera-Álvarez, C., Garrido-Elustondo, S., Rico-Blázquez, M., Verdú-Soriano, J., 2022. Factors associated with the quality of life of patients with venous leg ulcers in primary care: cross-sectional study. Int J Low Extrem Wounds 21 (4), 521–528. https://doi.org/10.1177/1534734620967562.
González de la Torre, H., Quintana-Lorenzo, M.L., Perdomo-Pérez, E., Verdú, J., 2017. Correlation between health-related quality of life and venous leg ulcer's severity and characteristics: a cross-sectional study. Int. Wound J. 14 (2), 360–368. https://doi.org/10.1111/IWJ.12610.
Graham, I.D., Harrison, M.B., Moffat, C., Franks, P., 2001. Leg ulcer care: nursing attitudes and knowledge. Can. Nurse 97 (3), 19–24.
Guest, J.F., Fuller, G.W., Vowden, P., 2020. Cohort study evaluating the burden of wounds to the UK's National Health Service in 2017/2018: update from 2012/2013. BMJ Open 10 (12), 1–15. https://doi.org/10.1136/bmjopen-2020-045253.
Guisasola, J., Ametller, J., Zuza, K., 2020. Investigación basada en el diseño de Secuencias de Enseñanza-Aprendizaje: una línea de investigación emergente en Enseñanza de las Ciencias. Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias 18 (1), 1801. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2021.v18.i1.1801.
jMetrik (Version 4.1.1). (2018).
Kirkpatrick, J.D., Kaiser, K.W., 2016. Kirkpatrick's Four Levels of Training Evaluation (In ATD Press).
Kline, T.J., 2005. In: Kline, T.J., Kline, T.J. (Eds.), Modern Test Theory: Assumptions, Equations, Limitations, and Item Analyses. SAGE Publications Ltd.
Kuder, G.F., Richardson, M.W., 1937. The theory of the estimation of test reliability. Psychometrika 2 (3), 151–160. https://doi.org/10.1007/BF02288391/METRICS.
Lawshe, C.H., 1975. A quantitative approach to content validity. Pers. Psychol. 28 (4), 563–575. https://doi.org/10.1111/J.1744-6570.1975.TB01393.X.
Linacre, J.M., 2023. Winsteps® Rasch Measurement Computer Program User's Guide. Version 5.6.0. Winsteps, Portland, Oregon.
Lord, F.M., 1980. Applications of Item Response Theory to Practical Testing Problems. Lawrence Erlbaum, Hilsdale, NJ.
Matas-Terrón, A., 2010. Introducción al análisis de la Teoría de Respuesta al Ítem. https://riuma.uma.es/xmlui/handle/10630/4711.
Mehrens, W.A., Lehmann, I.J., 1984. Measurement and Evaluation in Education and Psychology, 1st ed. Holt, Rinehart, and Winston.
Meyer, J.P., 2014. In: Routledge (Ed.), Applied Measurement with jMetrik. Routledge.
Miertová, M., Dlugošová, K., Ovšonková, A., Čáp, J., 2016. Chosen aspects of quality of life in patients with venous leg ulcers. Central European Journal of Nursing and Midwifery 7 (4), 527–533. https://doi.org/10.15452/CEJNM.2016.07.0025.
Mishel, M., 1989. Methodological studies: instrument development. In: Brink, P., Wood, M. (Eds.), Advanced Design in Nursing Research. Sage.
Nieveen, N., 2010. Formative Evaluation in Educational Design Research, pp. 153–169. ISBN: 978 90 329 2329 7.
Open Science Framework OSF, 2024. https://osf.io/.
Pérez-López, C., López-Franco, M.D., Comino-Sanz, I.M., Pancorbo-Hidalgo, P.L., 2021. Validación del cuestionario de Conocimientos sobre prevención de lesiones por presión en estudiantes de Enfermería: análisis Rasch. Enferm. Clin. 31 (1), 12–20. https://doi.org/10.1016/J.ENFCLI.2020.07.001.
Phillips, C.J., Humphreys, I., Thayer, D., Elmessary, M., Collins, H., Roberts, C., Naik, G., Harding, K., 2020. Cost of managing patients with venous leg ulcers. Int. Wound J. 17 (4), 1074–1082. https://doi.org/10.1111/iwj.13366.
Polit, D., Hungler, B., 2000. Evaluación de la calidad de los datos. In: Investigación Científica en Ciencias de la Salud, 6th ed. McGraw-Hill Interamericana.
Prieto, G., Delgado, A.R., 2003. Análisis de un test mediante el modelo de Rasch. Psicothema 15 (1), 94–100.
Prieto, L., Alonso, J., Lamarca, R., 2003. Classical test theory versus Rasch analysis for quality of life questionnaire reduction. Health Qual. Life Outcomes 1 (1), 27. https://doi.org/10.1186/1477-7525-1-27.
Probst, S., Saini, C., Gschwind, G., Stefanelli, A., Bobbink, P., Pugliese, M. T., Cekic, S., Pastor, D., & Gethin, G. (2023). Prevalence and incidence of venous leg ulcers—a systematic review and meta-analysis. In *Int. Wound J.* (Vol. 20, issue 9, pp. 3906–3921). John Wiley and Sons Inc. doi:https://doi.org/10.1111/iwj.14272.
Rasch, G., 1960. In: Wright, B.D. (Ed.), Probabilistic Models for some Intelligence and Attainment Tests. Copenhagen, Danish Institute for Educational Research. University of Chicago Press.
Registred Nurses Assosiation of Ontario, 2004. Assessment and Management of Venous Leg Ulcers. GBP Ontario RNAO.
Roco Videla, Á., Hernández Orellana, M., Silva González, O., 2021. ¿Cuál es el tamaño muestral adecuado para validar un cuestionario? Nutr. Hosp. 38 (4), 877–878. https://doi.org/10.20960/nh.03633.
Romero-Collado, A., Raurell-Torreda, M., Zabaleta-del-Olmo, E., Homs-Romero, E., Bertran-Noguer, C., 2015. Course content related to chronic wounds in nursing degree programs in Spain. J. Nurs. Scholarsh. 47 (1), 51–61. https://doi.org/10.1111/jnu.12106.
Simonetti, V., Comparcini, D., Flacco, M.E., Di Giovanni, P., Cicolini, G., 2015. Nursing students' knowledge and attitude on pressure ulcer prevention evidence-based guidelines: a multicenter cross-sectional study. Nurse Educ. Today 35 (4), 573–579. https://doi.org/10.1016/J.NEDT.2014.12.020.
Stolt, M., Kottorp, A., Suhonen, R., 2022. The use and quality of reporting of Rasch analysis in nursing research: a methodological scoping review. Int. J. Nurs. Stud. 132, 104244 https://doi.org/10.1016/J.IJNURSTU.2022.104244.
The jamovi project, 2023. Version 2.4. Jamovi.
Tobajas-Señor, E.M., Lozano Del Hoyo, M.L., Armalé Casado, M.J., Juan, Brocate San, M., Moreno Fraile, R., & Martes López, C., 2017. Formación actual sobre heridas crónicas en el Grado de Enfermeriá de las universidades espanõlas. Gerokomos 28 (1), 38–41.
Toulmin, S., 2007. Los usos de la argumentación. In: Ethics, 1st ed. Ediciones peninsula. Issue 1.
Toulmin, S., Rieke, R., Janik, A., 1984. An introduction to reasoning. In: Book, , 2nd edvol. 86, Issue 4. Macmillan.
Usher, K., Woods, C., Brown, J., Power, T., Lea, J., Hutchinson, M., Mather, C., Miller, A., Saunders, A., Mills, J., Zhao, L., Yates, K., Bodak, M., Southern, J., Jackson, D., 2018. Australian nursing students' knowledge and attitudes towards pressure injury prevention: a cross-sectional study. Int. J. Nurs. Stud. 81, 14–20. https://doi.org/10.1016/J.IJNURSTU.2018.01.015.
Van Hecke, A., Goeman, C., Beeckman, D., Heinen, M., Defloor, T., 2011. Development and psychometric evaluation of an instrument to assess venous leg ulcer lifestyle knowledge among nurses. J. Adv. Nurs. 67 (12), 2574–2585. https://doi.org/10.1111/j.1365-2648.2011.05683.x.
WHO, 2016. World Health Organization. Nurse Educator Core Competencies, 30.
Yen, W.M., 1984. Effects of local item dependence on the fit and equating performance of the three-parameter logistic model. Appl. Psychol. Meas. 8 (2), 125–145. https://doi.org/10.1177/014662168400800201.
Ylönen, M., Viljamaa, J., Isoaho, H., Junttila, K., Leino-Kilpi, H., Suhonen, R., 2017. Internet-based learning programme to increase nurses' knowledge level about venous leg ulcer care in home health care. J. Clin. Nurs. 26 (21−22), 3646–3657. https://doi.org/10.1111/jocn.13736.
Ylönen, M., Viljamaa, J., Isoaho, H., Junttila, K., Leino-Kilpi, H., Suhonen, R., 2019. Congruence between perceived and theoretical knowledge before and after an internet-based continuing education program about venous leg ulcer nursing care. Nurse Educ. Today 83, 104195. https://doi.org/10.1016/j.nedt.2019.08.013.
Zwick, R., Ercikan, K., 1989. Analysis of differential item functioning in the NAEP history assessment. J. Educ. Meas. 26 (1), 55–66. https://doi.org/10.1111/J.1745-3984.1989.TB00318.X.