Teaching bedside ultrasound in undergraduate nursing: An integrative review

RESUMO | Objetivo: Analisar a produção de pesquisas que adotaram como objeto de investigação programas educacionais para o desenvolvimento de competência em ultrassonografia à beira leito em nível de graduação, assim como os conteúdos programáticos e avaliações. Método: Revisão integrativa a partir de 13 artigos na íntegra, levantados por combinações booleanas, sem delimitação de períodos, disponíveis nas bases de dados PubMed Central, Scopus, CINAHL e Web of Science, nas línguas: portuguesa, inglesa e espanhola. Desses, apenas um atendeu aos critérios de seleção e à pergunta da pesquisa. Resultados: O artigo decorre de pesquisa quase experimental, com análise positiva para a aquisição de o conhecimento de estudantes de enfermagem sobre acesso vascular guiado por ultrassom. Conclusão: Os currículos de enfermagem precisam incorporar a formação da competência para que o aluno da graduação em enfermagem possa agregar a ultrassonografia como um recurso de sua prática clínica.
Descritores: Ultrassonografia; Programas de Graduação em Enfermagem; Cuidados de Enfermagem.

ABSTRACT | Objective: To analyze the production of research that adopted as an object of investigation educational programs for the development of competence in bedside ultrasound at undergraduate level, as well as the syllabus and evaluations. Method: Integrative review based on 13 articles in full, raised by Boolean combinations, without delimitation of periods, available in the PubMed Central, Scopus, CINAHL and Web of Science databases, in the following languages: Portuguese, English and Spanish. Of these, only one met the selection criteria and the research question. Results: The article stems from quasi-experimental research, with a positive analysis for the acquisition of knowledge by nursing students about ultrasound-guided vascular access. Conclusion: Nursing curricula need to incorporate competence training so that undergraduate nursing students can add ultrasound as a resource to their clinical practice.
Keywords: Ultrasonography; Nursing Graduate Programs; Nursing care.

RESUMEN | Objetivo: Analizar la producción de investigaciones que adoptaron como objeto de investigación los programas educativos para el desarrollo de la competencia en ecografía de cabecera a nivel de pregrado, así como el plan de estudios y las evaluaciones. Método: Revisión integrativa basada en 13 artículos en su totalidad, levantados por combinaciones booleanas, sin delimitación de períodos, disponibles en las bases de datos PubMed Central, Scopus, CINAHL y Web of Science, en los siguientes idiomas: portugués, inglés y español. De estos, solo uno cumplió con los criterios de selección y la pregunta de investigación. Resultados: El artículo surge de una investigación cuasi-experimental, con un análisis positivo para la adquisición de conocimientos por parte de los estudiantes de enfermería sobre el acceso vascular guiado por ultrasonido. Conclusión: Los planes de estudios de enfermería deben incorporar la formación de competencias para que los estudiantes de pregrado en enfermería puedan agregar el ultrasonido como recurso a su práctica clínica.
Palabras claves: Ultrasonografía; Programas de Posgrado en Enfermería; Cuidado de enfermera.

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INTRODUÇÃO

In the context of health technologies, ultrasound has broken the medical domain and radiology as a specialty, to serve as a daily tool for other health professionals in the clinical evaluation of the patient, during the physical examination or to provide greater security for decision-making in procedures in hospital settings[1], as well as in Primary Care (PC)[2].

It should be noted that the professional who performs bedside ultrasound will act as a sonographer, unlike traditional diagnostic radiological modalities.

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He selects the ultrasound system and transducer settings, acquires the images and interprets them, based on knowledge of ultrasound physics and imaging[3].

In Brazil, COFEN Resolution No. 679/2021 approves the standardization of performing ultrasound at the bedside and in the pre-hospital environment as a private activity of the Nurse, within the scope of the nursing team, through specific training for carrying out nursing care of greater technical complexity, aiming to increase safety for professionals and users, however, the issuance of reports and their use for nosological diagnosis purposes is prohibited[4].

The literature has been increasingly pointing to the use of ultrasound at the bedside by nurses, offering them greater security in the physical assessment and supporting them in procedures with greater security in decision-making for patient safety, such as: access peripheral venous[5], to control the positioning of gastric[6] and enteral[7] tubes, management of chronic constipation[8], as well as to control the residual volume of urine, protocol criterion managed by the nurse to maintain or remove indwelling urinary catheter[9] and for obstetric evaluation[10].

Although focused ultrasound (at the bedside), performed by nurses, is highly accurate, consistent and safe when prepared, as well as training for professional development to use the technology, more research is needed to assess the accuracy diagnostic ultrasound performed by them in a wide range of conditions[11].

Considering a new competence to be formed in undergraduate students and in view of the need, this study aimed to analyze the production of research that adopted as an object of investigation educational programs for the development of competence for the use of ultrasound at the bedside at a level graduation, as well as the syllabus and assessments.

In the light of this study, it is intended to support the teaching-learning process of ultrasound to be developed in undergraduate nursing curricula.

METHOD

This is an integrative literature review[12], with the guiding question: What are and how are the teaching plans composed, at the undergraduate level, for the development of competence in nursing students regarding bedside ultrasound?

The integrative review is one of the research methods used in Evidence--Based Practice (EBP), as a resource for incorporating evidence into clinical practice, which makes it possible to gather and synthesize research results on a particular topic or issue, in a systematic and orderly manner[13]. The method comprised the six recommended stages: (1st) identification of the theme and selection of the hypothesis or research question; (2nd) establishment of criteria for inclusion and exclusion of studies/sampling or literature search; (3rd) definition of information to be extracted from selected studies/categorization of studies; (4th) evaluation of the studies included in the integrative review; (5th) interpretation of results; (6th) presentation of knowledge review/synthesis[12].

The selection of the sample was based on access to the databases: Latin American and Caribbean Literature in Health Sciences (LILACS), MEDLINE Complete - EBSCO, SCOPUS, Current Nursing and Allied Health Literature (CINAHL) and Web of Science (WoS), without specifying a specific search field (article title; abstract; keywords), but opting for "all fields". Controlled descriptors combined with Boolean operators, arranged in Medical Subject Headings (MeSH), were used as a search strategy. In the LILACS database, Health Sciences Descriptors (DeSC) were used, as shown in Chart 1.

The following inclusion criteria were adopted: complete articles with abstracts and related to the research object, in Portuguese, English and Spanish, published in national and international journals, indexed in the referred databases, without delimitation of periods in the databases.

All records arising from the databases [13] were organized by Mendeley's reference manager, in folders named after the Databases, from which the articles were derived. Procedure that made it possible to eliminate duplicates (- 3), as well as, after reading the title and abstract, those that did not meet the inclusion criteria (- 1). In this way, the eligible ones were obtained (analysis corpus), which consis-

PICTURE 01:Search strategies for Boolean combinations in CINAHL databases; SCOPUS; Web of Science, MEDLINE complete (EBSCO); LILACS, without determining periods in the databases, 2022.

Data base	Boolean combinations	Articles colected
CINAHL	educational programs AND ultrasonography AND (nurse students or nursing students or students' nurses) 1 double	2
SCOPUS	(TITLE-ABS-KEY (educational AND programs) AND TITLE--ABS-KEY (ultrasonography) AND TITLE-ABS- KEY (nurse AND students) OR TITLE-ABS-KEY (nursing AND undergraduate))	3
WEB OF SCIENCE	Teaching (All fields) and ultrasonography (All fields) and nurse students (All fields)	3
MEDLINE complete (EBSCO)	educational programs AND ultrasonography AND (nurse students or nursing students or students' nurses)	5
LILACS/	Ultrasound AND Teaching AND Graduation AND Nursing	0

Source: authors' data, 2022.

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ted of nine articles, which were read in full, allowing the exclusion of three (-8) that did not answer the review question. So, the final sample was limited to one article (Picture 1).

For the analysis of the article, instruments that made up tables 2 and 3 were used, with the data extracted: authors, year of publication, journal, resulting database, country where the study took place and in which scenario, language of the article, type of research and research participants, instruments used and level of evidence, perspective, educational program design (time, participants, purpose, strategies, content), research results and conclusions. The evaluations were carried out by consensus, after double checking and independent analysis, conducted by two components of the research team, formed by the specialist and the advisor, with which there was no disagreement.

It is noteworthy that during the analysis of the articles, they were classified according to the levels of evidence proposed by Melnyk and Fineout-Overholt[15], with the quality analyzed according to the tools available in EQUATOR[16].

The seven levels to qualify scientific evidence, according to Melnyk and Fineout Overholt[15] are:

Level I: Evidence from systematic review or meta-analysis of all randomized controlled clinical trials or from clinical guidelines based on systematic reviews of randomized controlled clinical trials;

Level II: Evidence derived from a well-designed randomized controlled clinical trial;

Level III: Evidence obtained from well-designed clinical trials without randomization;

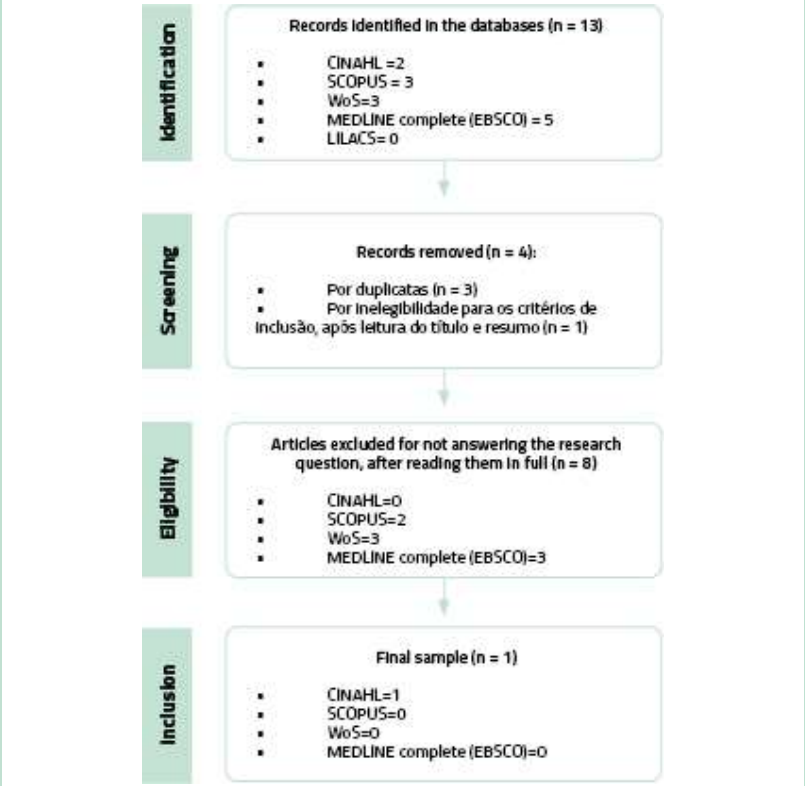
Level IV: Evidence from well-designed cohort and case-control studies;

Level V: Evidence from a systematic review of qualitative and descriptive studies;

Level VI: Evidence derived from a single descriptive or qualitative study;

Level VII: Evidence from the opinion of authorities and/or the report of expert committees.

Picture 1. Sample constitution flowchart, adapted from PRISMA(14).



Source: author's data, 2022.

As it is a review research, carried out exclusively with scientific articles, which respect national and international ethical principles, this study was exempt from registrations and evaluations by the CEP/CONEP system, as provided in Resolution No. 510, of 07/04/2016 , Art. 1st, Sole Paragraph, Item VI[17].

RESULTS

Search strategies for Boolean combinations in CINAHL databases; SCOPUS; Web of Science, MEDLINE complete (EBSCO); LILACS, without determining periods, allows the survey and analysis of only one study, resulting from a quasi-experimental research, conducted in the United States, to analyze the knowledge of nursing students about ultrasound-guided vascular access, after the implementation of an educational course and simulation[18] (Charts 2 and 3).

DISCUSSION

With the review, there was a scarcity of studies that evaluate the development of educational programs/plans regarding the development of competence in undergraduate nursing students, for the use of ultrasound at the bedside. The only article found was specifically aimed at ultrasound-guided venous access[18].

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PICTURE 2:Characterization of an article with an investigation object: educational programs for the development of competence for the use of ultrasound at the bedside at the undergraduate level, as well as the syllabus and evaluations, according to author(s), year of publication, country and setting where the study took place, as well as type of design, level of evidence and objective(s), published in a journal indexed in the databases: CINAHL, SCOPUS and MEDLINE complete (EBSCO), without determining periods in the databases, 2022.

Authors/Year/Journal/ Database	Country where the study took place/Scenario/ Article language	Type of research/research participants/instruments/level of evidence	Goals
Article 1. Kaganovskaya, Wuerz (2021) (18) Development of an educational program using ultrasonography in vascular access for nurse practitioner students/ 2021/British Journal of Nursing/ CINAHL	United States/Catholic Private University School of Nursing in New York State/ English	Quasi-experimental study/29 graduate nurses in the nursing course/10-item Likert-type questionnaire before and after the course/IV	To analyze the knowledge of nursing students about ultrasound-guided vascular access, after the implementation of an educational and simulation course

Source: author's data, 2022

Picture 3:Characterization of an educational program for the development of competence for the use of ultrasound at the bedside at the undergraduate level, as well as syllabus and evaluation, published in a journal indexed in the databases: CINAHL, SCOPUS and MEDLINE complete (EBSCO), without determining periods in the databases, 2022.

Authors:	Course Name/Time/Participants/ Objective(s)/Strategies	Content	Results	Conclusions
(Article 1) Kaganovskay, Wuerz (2021)(18)	Name of the course:Ultrasound--guided venous access course; Time: 60 minutes Participants: undergraduate nursing students Objectives:By the end of the course, participants will understand the anatomy of major vessels such as the brachial, basilic and cephalic veins, as well as the differentiation between arteries and veins and the selection of veins by ultrasound. Participants will also understand techniques for vessel selection, as well as identifying potential complications with vascular access devices. Strategies:The ultrasound simulation was performed with two portable ultrasound devices in two stations.	I.Introduction / Objectives reviewed (5min) II.Ultrasound review (20 min) a)History of ultrasound b)Device functionality c)Handling and mechanics of access devices III. Vessel selection using ultrasound (20 min) a)Vein selection on ultrasound b)Artery compressibility on ultrasound c)Identify nerve structures near veins. IV Potential Complications with Vascular Access Devices (10 min) a)Incorrect placement of vascular access devices b)Anatomical variations for complications	The mean knowledge progressed from the pre-test (62%) to the post-test (78%) after the educational intervention simulating ultrasound-guided venous access. There was statistical significance for understanding the techniques ($p<0.05$). Although students cannot practice ultrasound-guided Peripherally Inserted Central Venous Catheter (PICC) placement, after simulation, most students (86%) revealed a high level of confidence for the applicability of this skill in practice.	Overall, ultrasound is a cost-effective tool that can improve patient outcomes when used for PICC placement. Nursing and health professionals should adopt ultrasound in their practice as an auxiliary tool for PIC insertion. Proficiency and skills with the use of ultrasound improve with formal training and skills practice. The results of this study demonstrated that undergraduate nursing students' knowledge improved after implementing an introductory course and simulation training. As a result, nursing programs and healthcare organizations should consider formal curriculum/training, skills and simulation practice to improve knowledge and skills related to the use of ultrasound in their practice. Valid, standardized educational curriculum and simulation training should be developed and further studies conducted to analyze the impact of formal education and simulation training on the use of ultrasound during placement of the PICC.

Source: author's data, 2022

The evaluated program lasts 60 minutes, considered to be quick to operate, using ultrasound simulation as a strategy, with two portable devices in two stations. The results are surprising, because in addition to the progression of knowledge, although the students did not insert a Peripheral Central Venous Catheter (PICC) guided by ultrasound, after the simulation, most of them (86%) revealed an important level of confidence for the applicability this skill in practice[18].

It is a program with targeted content and divided into four topics: (I) Revised Introduction/Objectives [5 min]; (II) Ultrasound review [20 min] – a) ultrasound history, b) device functionality, c) Handling and mechanics of access devices;

(III) Selection of blood vessels using ultrasound [20 min] - a) Selection of the vein on ultrasound, b) Compressibility of the artery on ultrasound, c) Identifying nerve structures close to the veins; (IV) Potential complications with vascular ac-

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cess devices [10 min]

- a) Incorrect positioning of vascular access devices, b) Anatomical variations for possible complications[18].

Bearing in mind that a good quality ultrasound device is relatively expensive and having several for a group of nursing students can make teaching difficult. There is already a team working on the development of a virtual reality (VR) application, to offer students the opportunity to master skills in the use of ultrasound technologies. Due to the job market starting to demand the necessary skill of nurses for ultrasound, the application developer group uses the CenarioVR™ authoring tool and by capturing video images of a nurse operating the ultrasound equipment, students will be able to use a VR for an immersive experience. Proponents of the technology are betting that this is a less expensive teaching strategy, as it allows students to acquire skills in a virtual environment, as well as posing less risk to both equipment and patients[19].

In Medicine, studies evaluating educational programs for teaching ultrasound are more frequent[20-21-22]. Even so, like most undergraduate medical courses in the United States, it faces challenges in training physicians with sufficient preparation for using technology. Recently, the American College Taskforce on Radiology Ultrasound Education, together with the American College of Radiology, through a recent evaluation of teaching plans involving the teaching of ultrasound to medical students, verified that the teaching of ultrasound occurs almost exclusively during the of clinical training, however with the need for improvements in offering, in the face of intradepartmental (teachers and resources) and institutional (curricular) barriers[23].

While in undergraduate nursing courses, student education is still incipient for the formation of competence regarding the use of ultrasound in support of clinical decision-making and patient safety, and, given this knowledge gap and the professional's need, there is a range of studies, the results of which derive from the research object "educational programs for the use of ultrasound by nurses". Such advances that may guide the training of undergraduate students.

The literature has been increasingly pointing to the use of ultrasound at the bedside by nurses, offering them greater security in the physical assessment and supporting them in procedures with greater security in decision-making for patient safety, such as: access peripheral venous(5), to control the positioning of gastric(6) and enteral[7] tubes, management of chronic constipation(8), as well as to control the residual volume of urine[24], protocol criterion managed by the nurse to maintain or remove indwelling urinary catheter[9] and for obstetric evaluation[10].

Another indication of the use of ultrasound by nurses is related to checking the positioning of nasogastric (NGT) and nasoenteral (NET) tubes, common nursing procedures performed by professionals not only in hospitals, but also in Primary Care. Researches have pointed to safe positioning control by portable ultrasonography of these tubes, avoiding X-ray controls[6].

Furthermore, for NET insertion, the technique of using saline solution as an acoustic window to guide the tube by ultrasound was developed. So that the end of the feeding tube is fixed to the surface of the stomach with a greater curvature, which can be bent due to the non-compressing function of gastric peristalsis, and thus was prevented from entering the antrum and pylorus locations. After this procedure, the metal wire was removed and the tube was pushed through a "drift" approach to allow it to enter the bowel[7].

To support nurses in meeting elimination needs, the literature recommends the use of ultrasound to manage colorectal feces retention[25-26] and to control residual bladder volume[9].

With the population aging in Japan and the increase of elderly people in Long Stay Institutions (ILPI), it was verified that 74.4% of them have been suffering from fecal retention. Faced with the need for affected elimination, the researchers developed an algorithm to support visiting nurses in making clinical decisions, according to ultrasound observations of this retention[25-27]. In view of this algorithm and the research having signaled that the nurse has safety and efficacy for the care with the elimination of feces, based on colorectal ultrasound observations the authors proposed an educational program on the applicability of ultrasound, as a professional tool, to evaluate and determine different types of constipation at the person's point of care[28].

This course takes place over seven days, using four strategies: e-learning, seminar, self-learning and objective structured clinical exams (OSCEs) and their evaluative results meet the objectives, so that the professional nurse has the competence to observe the retention colorectal stool with ultrasound device[28].

Thus, the educational program for the management of constipation with stool retention should include: (a) procedure for observation of colorectal retention to assess constipation, using portable ultrasound; (b) an algorithm for selecting and providing defecation care based on ultrasound findings[25].

To develop this program, a multidisciplinary research team was formed, consisting of physicians, surgeons, nurses and an ultrasonographer. They specialize in defecation care, ultrasound imaging, and medical education, including objective structured clinical examinations (OSCEs). Based on team consensus, the final program comprised four components: e-learning, hands-on seminar, self-learning and OSCEs as in the previous study[27].

Currently, for nurses to effectively manage protocols to reduce the duration of indwelling urinary catheter (SVD) and urinary tract infection (UTI) in hospitalized adult and elderly patients, it will

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require the use of bedside ultrasound to frequently estimate the residual volume of urine[9].

Finally, the use of ultrasound by nurses to monitor pregnancy is discussed, such as the experience in Indonesia in primary care. The four-week course is divided into six sessions held over three to four days, depending on the participant's availability. Sessions include lectures and hands-on training for healthcare professionals: doctors, nurses, or midwives(29).

Each training session started with a 1-hour lecture followed by hands-on training in the US (3 hours). Therefore, professionals received a total of 6 hours of lecture and 18 hours of hands-on training in the US. During hands-on training, there were four stations with two medical student instructors per machine. Each station was limited to 10 practitioners.v The instructor to student ratio was approximately 1:4 or 1:5[29].

The six sessions developed the following themes (Picture 2):

According to the authors, this portable ultrasound training has the potential to improve patient care and outcomes, especially for those providing primary care in Indonesia, of which nurses and midwives may make up the majority in rural areas. Midwives, nurses, and physicians showed similar knowledge acquisition and demonstrated practical skill acquisitions. Studies should assess the retention period of knowledge and skills among groups of professionals, their ability to interpret problems and the impact on patient outcomes[29].

In summary, it was verified that, despite the scarcity of studies that evaluate educational programs for training nursing students in the use of ultrasound, there is a range of research that has been evaluating the success of courses aimed at the professional nurse, including pointing out the impact on population health that can already be perceived, as well as that which has yet to be evaluated.

A limitation of this research was considered to be the fact that it is an integrative review that, despite using a careful survey of the literature, may have failed to consider some research that were outside the inclusion criteria for Portuguese, English and Spanish, as well as a statement in other forms of publication.

This study pointed to the need to implement the theoretical-practical basis of the use of portable ultrasound in nursing curricula, as a resource for nurses to offer safer assistance, by attributing more security to decision-making in procedures that are exclusive to the professional.

CONCLUSION

With the review, there was a scarcity of studies that evaluate the development of educational programs/plans regarding the development of competence in undergraduate nursing students, for the use of ultrasound at the bedside.

The studies that evaluate this development focus on the nurse as a target audience, since the market is demanding this training from professionals, in view of resolvability and safety in care, not only in the hospital environment, but also in the basic care that the use of technology confers.

Nursing care technologies must be associated with the teaching of nursing sciences, inserted along with the curricular components, as well as in the teaching plans of each discipline. Nursing curricula need to incorporate competence training so that undergraduate nursing students can add ultrasound as a resource to their clinical practice.

Picture 2:Topics covered in the ultrasound course(29),, 2022.

Teaching Sessions	1	2	3	4	5	6
Topics (One hour of speech, followed by three hours of practical training for each topic)	Image Optimization (Knobology)	Lung Ultrasound	Cardiac Ultrasound	Abdominal Ultrasound	Pelvic/Obstetric Ultrasound	Quick Scans
Clinical details	ultrasound physics, Machine, Knobology Manipulation, Scanning techniques	pleural effusions, pneumothorax, Pneumonia	mitral valve regurgitation Pericardial Effusion, cardiomyopathy	abdominal aortic aneurysm, Dehydration, ascites, Hemoperitoneum, Bowel obstruction, gallstones	location of the placenta, Estimation of gestational age, sex determination, ovarian cyst evaluation	Employee to evaluate trauma and tuberculosis HIV-associated tuberculosis

Source: author's data, 2022.

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