Rev Rene. 2024;25:e93870.
DOI: 10.15253/2175-6783.20242593870
www.periodicos.ufc.br/rene

Review Article

# Methodological pathways for the development, evaluation, or validation of serious games on neonatology: an integrative review*

## Percursos metodológicos para o desenvolvimento, avaliação ou validação de serious games sobre neonatologia: revisão integrativa

**How to cite this article:**
Moreira AR, Nascimento ERP, Malfussi LBH, Costa R, Nascimento KC, Acosta AS, et al. Methodological pathways for the development, evaluation, or validation of serious games on neonatology: an integrative review. Rev Rene. 2024;25:e93870. DOI: https://doi.org/10.15253/2175-6783.20242593870

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*Extracted from the thesis entitled "GAMENEO: construção e validação do protótipo para avaliação hemodinâmica do neonato no transporte", Universidade Federal de Santa Catarina, 2023.

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**Conflict of interest:** the authors have declared that there is no conflict of interest.



**ABSTRACT**

**Objective:** to analyze the methodological pathways used in the development, evaluation, and/or validation of serious games on neonatology. **Methods:** integrative review conducted using the databases MEDLINE, EMBASE, CINAHL, SCOPUS, Web of Science, LILACS, BDENF, and SCIELO. Studies published between 2010 and 2024 that employed methodological pathways in serious games were selected. **Results:** ten studies were identified. The development of serious games considered the target audience, literature review, and professional routines. Evaluation was conducted using pre/post-tests, questionnaires, and feedback from experts and users. Some studies validated serious games using validated instruments and evaluative questionnaires, with Likert-type scales. Content validity index was used. **Conclusion:** methodological and quantitative studies predominated, developed based on participant needs, scientific evidence, and professional experiences. Most serious games underwent an evaluation phase; however, validation was described in only five studies. Simulation was a foundation for teaching neonatal resuscitation. **Contributions to practice**: the results may contribute to the development of guidelines that assist researchers in creating digital technologies based on scientific evidence, enhancing care for newborns, and providing valuable insights for clinical practice and professional training. They also highlight gaps and opportunities for future research on the integration of digital games in health education.
**Descriptors:** Neonatal Nursing; Educational Technology; Video Games; Health Education; Validation Study.

**RESUMO**

**Objetivo:** analisar os percursos metodológicos utilizados no desenvolvimento, na avaliação e/ou validação dos *serious games* sobre neonatologia. **Métodos:** revisão integrativa realizada nas bases de dados MEDLINE, EMBASE, CINAHL, SCOPUS, *Web of Science*, LILACS, BDENF, SCIELO. Selecionaram-se estudos publicados de 2010 a 2024, com percursos metodológicos utilizados nos *serious games*. **Resultados**: identificaram-se 10 estudos. O desenvolvimento dos *serious games* considerou público-alvo, revisão da literatura e rotina profissional. A avaliação ocorreu com pré/pós-testes, questionários, *feedback* de especialistas e usuários. Estudos validaram os *games* utilizando instrumento validado e questionário avaliativo, escala tipo Likert. Utilizou-se índice de validade de conteúdo. **Conclusão:** predominaram estudos metodológicos, quantitativos, desenvolvidos com base nas necessidades identificadas pelos participantes, evidências científicas e situações vivenciadas pelos profissionais. Maior parte dos *games* foram submetidos à etapa de avaliação. Entretanto, a validação foi descrita em cinco estudos. A simulação foi base para ensino da reanimação neonatal. **Contribuições para a prática**: contribui para o desenvolvimento de diretrizes que auxiliem pesquisadores na criação de tecnologias digitais fundamentadas em evidências científicas, qualificando o cuidado prestado aos recém-nascidos, e oferecer *insights* valiosos para a prática clínica e formação profissional, evidenciando lacunas, e oportunidades para futuras investigações sobre a integração de jogos digitais na educação em saúde.
**Descritores:** Enfermagem Neonatal; Tecnologia Educacional; Jogos de Vídeo; Educação em Saúde; Estudos de Validação.

Received: Aug. 1st 2024; Accepted: Oct. 8th 2024.

## Introduction

The neonatal period is characterized by high morbidity and mortality rates, with causes related to prematurity, low birth weight, hemodynamic alterations, and congenital malformations, requiring the multidisciplinary team to be well-prepared and qualified to assist newborns[1-2]. In this context, digital resources serve an educational purpose and assist in team training[3].

Among educational technologies, serious games stand out due to their creative potential, ability to link theory and practice, and stimulation of participants' clinical reasoning[4]. These are games whose primary goal is to teach, using multimedia resources. They represent an effective and accessible alternative for acquiring knowledge and developing skills[5-6].

The development process of serious games is described in stages or phases, but there is no scientific consensus on the methodology or number of stages/phases required. Thus, each framework has its own guiding principles for development, and the choice depends on the proposed learning objectives[6-7].

It is important to note that the development of serious games in neonatology follows similar methodological principles as other fields but with specific adaptations due to the unique characteristics of the target audience and care settings. In general, development involves phases such as analysis, design, development, and validation. However, in neonatology, methodologies need to be tailored to address the delicate needs of neonates, who have unique physiological and clinical characteristics, as well as specific care settings like the Neonatal Intensive Care Unit (NICU)[8-9].

Given this, investigating the methodological processes employed in the development, evaluation, and/or validation of serious games in neonatology may assist researchers in constructing essential digital technologies to improve neonatal care. This allows professionals to develop practical skills in complex scenarios while offering valuable insights for clinical practice and professional training. It also highlights gaps and opportunities for future research on the integration of games in health education.

Thus, the objective of this study was to analyze the methodological pathways used in the development, evaluation, and/or validation of serious games on neonatology.

## Methods

This is an integrative review conducted in five stages[10]: 1) Identification of the research question; 2) Search and selection of literature; 3) Evaluation of studies; 4) Analysis, synthesis, and comparison of data; Presentation of results.

To formulate the research question, the PICo search strategy was used to retrieve health information: P: population (serious games focused on neonatology), I: phenomenon of interest (development, evaluation, and validation of serious games), Co: context (neonatology). Thus, the research question was: What are the methodological processes used in the development, evaluation, and/or validation of serious games in the context of neonatology?

The search for scientific evidence was conducted in July 2024 across the following databases: Medical Literature Analysis and Retrieval System Online (MEDLINE) via PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), SCOPUS, Web of Science (WoS), *Literatura Latino-Americana e do Caribe em Ciências da Saúde* (LILACS), EMBASE, Scientific Electronic Library Online (SCIELO), and *Base de Dados de Enfermagem* (BDENF).

Study selection followed a search protocol designed for this study and validated by a librarian from the Universidade Federal de Santa Catarina. Search strategies were applied according to the selected database. For the EMBASE database, additional terms from the Emtree vocabulary were also used, as it is the standard for that database. Equivalent terms from Medical Subject Headings (MeSH) and *Descritores em Ciências da Saúde* (DeCS) were used: Enfermagem Neonatal (enfermería neonatal, neonatal nursing); Jogo

Sério (juego sério, serious game); Jogo Neonatal (juego neonatal, neonatal game); Jogo Quiz (juego quis, game quiz). The terms were combined in various ways in Portuguese, English, and Spanish. For advanced search, the Boolean operators "AND" and "OR" were used. The result of the search strategy is shown in Figure 1.

| Database | Search strategy |
|---|---|
| MEDLINE | ("Neonatology"[Mesh] OR "Neonatology" OR "Neonatal" OR "Neonatal Nursing"[Mesh] OR "Neonatal Nursing" OR "Nurses, Neonatal"[Mesh] OR "Nurses, Neonatal" OR "Neonatal Nurses" OR "Infant, Newborn"[Mesh] OR "Infant, Newborn" OR "Newborn Infant" OR "Newborns" OR "Newborn" OR "Neonate" OR "Neonates") AND ("Video Games"[Mesh] OR "Video Games" OR "videogame" OR "videogames" OR "Game" OR "Games" OR "Games, Recreational"[Mesh] OR "Games, Recreational" OR "Recreational Games" OR "Gamification") AND ("Nursing"[Mesh] OR "Nursing" OR "Nursings" OR "Nurses"[Mesh] OR "Nurses" OR "Nurse") |
| EMBASE | ("Neonatology" OR "Neonatal Care" OR "Neonatal Nursing" OR "Neonatal Nurse" OR "Neonatal Intensive Care" OR "Nurses, Neonatal" OR "Neonatal Nurses" OR "Newborn Infant" OR "Infant, Newborn" OR "Newborns" OR "Newborn" OR "Neonate" OR "Neonates") AND ("Video Game" OR "Computer Game" OR "Serious Game" OR "Video Games" OR "videogame" OR "videogames" OR "Game" OR "Games" OR "Educational Game" OR "Simulation Game" OR "Game Quiz" OR "Games, Recreational" OR "Recreational Games" OR "Gamification") AND ("Nursing" OR "Nursings" OR "Nurses" OR "Nurse") |
| CINAHL | ("Neonatology" OR "Neonatal" OR "Neonatal Nursing" OR "Nurses, Neonatal" OR "Neonatal Nurses" OR "Infant, Newborn" OR "Newborn Infant" OR "Newborns" OR "Newborn" OR "Neonate" OR "Neonates") AND ("Video Games" OR "videogame" OR "videogames" OR "Game" OR "Games" OR "Games, Recreational" OR "Recreational Games" OR "Gamification") AND ("Nursing" OR "Nursings" OR "Nurses" OR "Nurse") |
| SCOPUS | ("Neonatology" OR "Neonatal" OR "Neonatal Nursing" OR "Nurses, Neonatal" OR "Neonatal Nurses" OR "Infant, Newborn" OR "Newborn Infant" OR "Newborns" OR "Newborn" OR "Neonate" OR "Neonates") AND ("Video Games" OR "videogame" OR "videogames" OR "Game" OR "Games" OR "Games, Recreational" OR "Recreational Games" OR "Gamification") AND ("Nursing" OR "Nursings" OR "Nurses" OR "Nurse") |
| Web of Science | ("Neonatology" OR "Neonatal" OR "Neonatal Nursing" OR "Nurses, Neonatal" OR "Neonatal Nurses" OR "Infant, Newborn" OR "Newborn Infant" OR "Newborns" OR "Newborn" OR "Neonate" OR "Neonates") AND ("Video Games" OR "videogame" OR "videogames" OR "Game" OR "Games" OR "Games, Recreational" OR "Recreational Games" OR "Gamification") AND ("Nursing" OR "Nursings" OR "Nurses" OR "Nurse") |
| LILACS and BDENF | ("Neonatologia" OR "Enfermagem Neonatal" OR "Enfermeiras Neonatologistas" OR "Recém-nascido" OR "Recém-Nascidos" OR "Recém-Nascida" OR "Recém Nascidas" OR "Neonato" OR "Neonatos" OR "Enfermería Neonatal" OR "Enfermeras Neonatales" OR "Recién Nacido" OR "Recién Nacidos" OR "Neonatology" OR "Neonatal" OR "Neonatal Nursing" OR "Nurses, Neonatal" OR "Neonatal Nurses" OR "Infant, Newborn" OR "Newborn Infant" OR "Newborns" OR "Newborn" OR "Neonate" OR "Neonates") AND ("Jogos de Vídeo" OR "Videojogos" OR "Videojogo" OR "Jogos" OR "Jogo" OR "Jogos Recreativos" OR "Gamificação" OR "Juegos de Video" OR "Juegos" OR "Juego" OR "Juegos Recreacionales" OR "gamificación" OR "Video Games" OR "videogame" OR "videogames" OR "Game" OR "Games" OR "Games, Recreational" OR "Recreational Games" OR "Gamification") AND ("Enfermagem" OR enfermeir* OR "enfermeria" OR enfermer* OR "Nursing" OR "Nursings" OR "Nurses" OR "Nurse") |
| SCIELO | ("Neonatologia" OR "Enfermagem Neonatal" OR "Enfermeiras Neonatologistas" OR "Recém-nascido" OR "Recém-Nascidos" OR "Recém-Nascida" OR "Recém Nascidas" OR "Neonato" OR "Neonatos" OR "Enfermería Neonatal" OR "Enfermeras Neonatales" OR "Recién Nacido" OR "Recién Nacidos" OR "Neonatology" OR "Neonatal" OR "Neonatal Nursing" OR "Nurses, Neonatal" OR "Neonatal Nurses" OR "Infant, Newborn" OR "Newborn Infant" OR "Newborns" OR "Newborn" OR "Neonate" OR "Neonates") AND ("Jogos de Vídeo" OR "Videojogos" OR "Videojogo" OR "Jogos" OR "Jogo" OR "Jogos Recreativos" OR "Gamificação" OR "Juegos de Video" OR "Juegos" OR "Juego" OR"Juegos Recreacionales" OR "gamificación" OR "Video Games" OR "videogame" OR "videogames" OR "Game" OR "Games" OR "Games, Recreational" OR "Recreational Games" OR "Gamification") AND ("Enfermagem" OR enfermeir* OR "enfermeria" OR enfermer* OR "Nursing" OR "Nursings" OR "Nurses" OR "Nurse") |

**Figure 1** – Data search strategies applied in the selection of studies. Florianópolis, SC, Brazil, 2024

Original research studies, whether quantitative or qualitative, published in full in indexed journals in Portuguese, English, or Spanish, between 2010 and 2024, were included. This time frame was chosen due to the significant advancement of digital technologies in the last decade, including the increasing use of educational games and simulators in healthcare[8]. Since 2010, the popularization of mobile devices and digital platforms has driven the development of interactive games aimed at professional training and health education in the context of neonatology, making this period relevant for analyzing published studies[11].

The studies had to present the methodological stages of development, evaluation, or validation of a serious game focused on neonatology. Studies without a direct connection to neonatology were excluded.

The studies were selected with the help of the Mendeley reference manager, allowing for the removal of duplicate studies. Two independent reviewers assessed the studies for eligibility criteria, applying the double-blind technique. There were no disagreements between the reviewers. The organization of the selected studies, as well as the writing of this study, was guided by the recommendations of the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) statement[12], as this tool serves as a guide for organizing and selecting review studies, whether systematic or not.

The analysis and organization of the selected studies were conducted using an instrument developed by the lead researcher, containing the following data: study title, year of publication, country where the research was conducted, methodology, study objectives, main results, levels of evidence, stage of development, evaluation and/or validation, technology developed, and neonatal care setting. The studies were coded using the letter "S" for study, followed by an Arabic numeral (S1, S2, S3...).

The level of evidence for each study was determined using a hierarchical classification composed of seven levels: Level I: Evidence from a systematic review or meta-analysis of all relevant randomized controlled trials (RCTs); Level II: Evidence obtained from well-designed RCTs; Level III Evidence from well-designed controlled trials without randomization; Level IV Evidence from well-designed case-control and cohort studies; Level V: Evidence from systematic reviews of descriptive and qualitative studies; Level VI: Evidence from single descriptive or qualitative studies; and Level VII: Evidence from expert opinions and/or reports from expert committees[13].

Finally, the results were presented along with the respective processes of development, evaluation, and/or validation, as well as the neonatal care setting addressed in the serious games. As this was an integrative literature review conducted using publicly accessible databases, it was not necessary to submit the study for approval by a Research Ethics Committee.

## Results

Initially, 252 articles were selected, with the majority identified in the MEDLINE database (n=56; 22.2%). After applying inclusion and exclusion criteria and thoroughly reviewing the studies, the final sample consisted of 10 articles, as described in the flowchart in Figure 2. Among these, publications S1 and S3 originate from the same study, as do articles S2 and S6. The year 2020 showed the highest prevalence of publications (n=4; 40%). There was a predominance of publications in international journals (n=8; 80%).

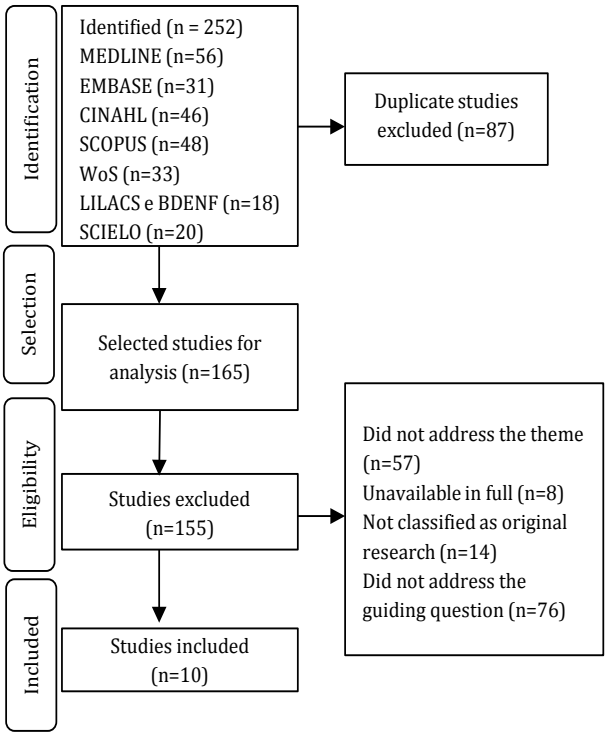


**Figure 2** – Flowchart of the process of study identification, selection, eligibility, and inclusion. Adapted from PRISMA. Florianópolis, SC, Brazil, 2024

Regarding the country of origin, Brazil stood out with three (30%) studies (S1, S3, S4), followed by Canada with two (20%) published studies (S2, S6) on the topic. As for the type of research, four articles were methodological studies. There was a predominance of studies with level VI evidence (n=7; 70%), as described in Figure 3.

| Study | Authors, Year and Country | Methodology | Main results | LE |
|---|---|---|---|---|
| S1 | Aredes et al[5]<br>2018<br>Brazil | Methodological study<br>Quantitative | The serious game was built in 3D. Validated by experts across all heuristics, of the 36 items analyzed, 18 (50%) were considered free of issues. None of the items had more than 25% of problems classified at levels 3 and 4, according to Nielsen's classification. | VI |
| S2 | Cutumisu et al[14]<br>2019<br>Canada | Methodological study<br>Quantitative | A 10% increase in knowledge retention was observed between the pre- and post-test (49-59%). Temperature management showed the highest knowledge gain between the pre- and post-test (14-46%), respectively. | VI |
| S3 | D'Agostini et al[6]<br>2020<br>Brazil | Methodological, Qualitative Study | The game was satisfactorily evaluated in terms of content, appearance, and usage dynamics, motivating participants to learn. | VI |
| S4 | Pereira et al[15]<br>2020<br>Brazil | Methodological, Quantitative and Qualitative Study | Thirteen experts participated in the study and positively validated the virtual environment, with a validity index of 0.97. Twenty-six students found the content suitable for nursing students. | VI |
| S5 | Michelet et al[16]<br>2020<br>France | Randomized Controlled Trial<br>Quantitative | Participants in the debriefing group achieved higher scores than the control group during session 1. Their scores remained higher, with no statistical difference, during session 2. The debriefing group had higher self-efficacy ratings in session 2. | II |
| S6 | Ghoman et al[17]<br>2020<br>Canada | Methodological, Quantitative Study | The serious game can be used as a summative assessment tool, offering a relevant and low-cost alternative to meet the ongoing need for continuous education in neonatal resuscitation for healthcare professionals. | VI |
| S7 | Chau et al[18]<br>2021<br>China | Methodological Study, Mixed Methods | There were statistically significant improvements in the students' knowledge levels. The students were highly satisfied with the program, appreciating the video vignettes and the interactive small-group discussions with academics and physicians. | VI |
| S8 | Sarvan; Efe[19]<br>2022<br>Turkey | Randomized Controlled Trial<br>Quantitative | Post-test measures indicated a statistically significant positive difference in ventilation and chest compression in the intervention group. A considerable increase was found in the knowledge and skill levels of both groups after the game. The mean scores on the Student Satisfaction and Self-Confidence in Learning Scale and its subdimensions were high for both groups. | II |
| S9 | Wanyama et al[20]<br>2022<br>Kenya | Methodological study | To date, the app has been downloaded over 6,000 times. Results regarding the app's effectiveness and qualitative outcomes on users' perceived experiences are currently being processed. | VI |
| S10 | Billner-Garcia et al[4]<br>2024<br>United States | Quantitative Study<br>quasi-experimental | The average time to initiate positive pressure ventilation before the game was significantly longer than the average time to initiate positive pressure ventilation after the game. | III |

S: Study; LE: Level of evidence

**Figure 3** – Summary of the selected studies. Florianópolis, SC, Brazil, 2024

Regarding the methodological pathways described in the studies, the development process of serious games in neonatology was based on different approaches. The identification of needs presented by the target audience was highlighted, consisting of parents of premature newborns (S3), professionals working in neonatology (S1, S2, S4, S6, S9, and S10), and students (S4, S5, S7, S8, S9); the search for scientific evidence (S1, S7, S9, and S10) on the proposed topic to support the content of the serious game (S2, S3, S4, S6); and the experiences of professionals (S8, S10). One study did not describe how the content of the serious game was developed (S5). In four studies, a prototype was built and evaluated before the development of the serious game (S1, S3, S8, S10).

Regarding the evaluation process, seven studies (n=7; 70%) involved the participation of the target audience (S2, S3, S4, S5, S6, S7, and S9), in five studies (n=5; 50%) the evaluation was conducted by healthcare professionals (S2, S4, S6, S9, S10), and in five studies (n=5; 50%) by undergraduate students (S4, S5, S7, S8, S9). The pre- and post-test strategy was employed to evaluate the developed serious game in half of the studies (n=5; 50%) (S2, S4, S6, S7, and S8).

As for the validation of serious games, this stage was described in four studies (n=4; 40%) (S1, S4, S8, and S9). Two studies (S1 and S8) validated the serious games with experts in neonatology. S1 used an evaluative instrument, translated and validated into Portuguese, the Heuristic Evaluation for Digital Education Games (HEDEG). This instrument has 36 items distributed across five heuristics: interface, educational elements, content, gameplay, and multimedia. The validation criterion adopted was achieving 75% absence of errors or errors classified as type 2, and a minimum approval of 75% for each group in the corresponding validated heuristic. S8 employed a questionnaire for validation with experts after all stages of the game were completed (the intervention carried out by students and the results obtained).

In another study (S4), experts used a structured questionnaire with a Likert scale scoring from 1 to 4. The content validity index was used, and the authors defined a value of 0.90 to consider the questions validated. In S9, validation was carried out by scientific societies, as described in Figure 4.

| Study | Development | Evaluation | Validation |
|---|---|---|---|
| S1 | A discussion group was conducted with nurses working in a neonatal unit, based on the experience of the researchers and the nurses who participated in the scope definition stage, along with an integrative literature review on clinical evaluation and skin care for premature neonates. | This stage was not carried out by the authors. | Four experts used the Heuristic Evaluation for Digital Educational Games. The validation criterion was at least 75% absence of errors or type 2 errors, and a minimum of 75% to consider the heuristic validated. |
| S2 | A simulated board game was used, consisting of three evidence-based neonatal resuscitation scenarios. | Thirty professionals participated in the study. A written pre-test was administered, followed by playing the board game (intervention), and then a post-test was conducted. The pre- and post-test responses were compared to assess knowledge retention. | This stage was not described by the authors. |
| S3 | A participatory design was used for the game's scope. Interviews were conducted with parents of hospitalized premature newborns. Qualitative data were analyzed using Bardin's framework, leading to the proposal of a script with questions, answers, and a navigation prototype for the serious game. | An evaluation was carried out by the participants (parents of the newborns), who played the prototype and provided suggestions and critiques regarding gameplay, comprehension, realism, and educational capacity. | This stage was not described by the authors. |
| S4 | The virtual environment was developed based on a previous study, outlining five topics related to medication administration. | Evaluation was conducted by two groups: expert judges in pediatrics and neonatology, and undergraduate nursing students. | The validation of the virtual learning environment was performed by expert judges, using the content validity index and percentage agreement. |

(the Figure 4 continue in the next page...)

| | | | |
|---|---|---|---|
| S5 | The screen-based simulation was developed by a private company (Medusims®). The virtual environment was a 3D delivery room with a newborn placed on a neonatal resuscitation table. | Evaluation was conducted with obstetrics students randomized into two groups (debriefing group, subjected to computer-based debriefing, and control group, which received none). After the simulation, a knowledge questionnaire was administered. | This stage was not described by the authors. |
| S6 | The board game simulator scenarios were formulated based on evidence from real resuscitations in the delivery rooms of the study hospital. | Evaluation was conducted by neonatal healthcare professionals, implementing a neonatal resuscitation scenario using a pre-test, resuscitation scenario, and post-test questionnaire. | This stage was not described by the authors. |
| S7 | The development was based on learning principles grounded in scientific evidence. Each scenario consisted of videos, critical thinking exercises, discussion guides, and interactive games. | Evaluation was conducted with students who watched the videos, based on simulated scenarios, in which they completed critical thinking exercises, discussion guides, interactive games, and reading materials pre- and post-intervention within one month. | This stage was not described by the authors. |
| S8 | Obtaining expert opinions and their evaluation of the software, development of the game version, and application of the game (pilot test). | Ninety nursing students were randomized into control and intervention groups. An online pre-test and post-test questionnaire was administered. | For validation, an opinion questionnaire was applied to the experts after all stages of the game were completed (intervention performed by the students and results obtained). |
| S9 | A systematic review was conducted to define the instructional design (educational theoretical basis) of the app, and questionnaires and expert feedback were employed. | The evaluation was carried out by various users (the app development project team, pediatricians, neonatologists, pediatric nurses, and neonatology nurses), as well as academics, professors, and university tutors through questionnaires and feedback. | The validation was performed by two scientific societies: the Kenya Paediatric Association (for medical professionals) and the Nursing Council of Kenya (for nurses). |
| S10 | Three simulation game scenarios were developed by neonatology experts using motivational design and the scientific reference for neonatal resuscitation from the American Academy of Pediatrics, the American Heart Association, and the design framework. | The evaluation was conducted with 19 participating nurses. The Attention, Relevance, Confidence, and Satisfaction model was used in pre- and post-tests to measure the perceived level of motivation and engagement in the games. An online form was provided for descriptive evaluation. | This stage was not described by the authors. |

**Figure 4** – Description of the selected articles regarding the methodological stages of development, evaluation, and/or validation of serious games in the field of Neonatology. Florianópolis, SC, Brazil, 2024

The development of serious games in various neonatal care settings was highlighted, with a focus on neonatal resuscitation (S2, S5, S6, S8, S9, S10). In the serious games developed, the main tool used by researchers for the teaching-learning process was virtual simulation (S1, S2, S3, S5, S6, S8, S9, S10) (Figure 5).

| Study | Developed technology | Neonatal care setting |
|---|---|---|
| S1 | Serious games e-Baby: skin integrity. Virtual simulation using 3D technology, audio, and text. | Skin integrity: clinical evaluation and care for diaper dermatitis, candidiasis infection, antiseptic application before venous puncture, hygiene and management of adhesives, puncture, and temperature sensor positioning. |
| S2 | Tabletop simulation board game on neonatal resuscitation in the delivery room. | Neonatal resuscitation. |
| S3 | Serious games, virtual simulation using 3D technology, audio, and text. | Care for premature newborns: addressing basic human needs related to oxygenation, feeding, and thermoregulation. |
| S4 | Virtual learning environment in pediatrics and neonatology, available on an online platform with free access. | Medication administration. |
| S5 | 3D virtual simulation environment of a delivery room. | Neonatal resuscitation. |
| S6 | Resuscitation TrAINing for Healthcare Professionals® board game for tabletop and virtual simulation. | Neonatal resuscitation. |
| S7 | Online and free-access learning program, consisting of videos, scenarios, and interactive games. | Prevention and management of extravasation injuries. |
| S8 | Virtual learning environment in neonatology available on the Microsoft Teams® online platform. | Neonatal resuscitation. |
| S9 | Virtual learning environment in neonatology available through a smartphone app. | Neonatal resuscitation. |
| S10 | Serious games, virtual simulation. | Neonatal resuscitation. |

**Figure 5** – Description of the developed technologies and the neonatal care settings addressed in the serious games. Florianópolis, SC, Brazil, 2024

## Discussion

Digital technologies encompass methods, processes, and tools that, when applied systematically, have the capacity to build knowledge[21]. To achieve this, it is essential that they are developed with methodological rigor, ensuring that the content is relevant, adds value to the technology, is acceptable to the target audience, and is validated by experts in the field[7,22-23].

In this context, the development of serious games is widely discussed in the literature and has been considered a promising alternative for training healthcare professionals, including in neonatology[11,24]. Although development methods from other fields can serve as a foundation for the neonatal context, it is important to highlight that neonatology has unique characteristics, such as the high complexity of care, technological density, and the fragility of neonates. These factors require simulations that reflect the critical situations encountered in these care environments.

Thus, serious games developed in this field demand approaches tailored to its specificities, such as the integration of clinical protocols and the need for rigorous validation by experts to ensure safety and efficacy[25-26]. It is crucial to maintain ethical and practical standards in newborn care, respecting the vulnerability of patients and the sensitivity of procedures[27] These factors make investigating the methodological pathways for developing and validating games in neonatology particularly relevant, as incorrect information can directly impact newborn care.

In this context, methodological research stands out as a means to develop, evaluate, and/or validate technologies, as seen in the studies analyzed in this review. This type of methodology, due to its critical-reflective nature, encourages participant involvement in the teaching-learning process[28], promoting reflection, planning, and practice modification[22,29].

Regarding the development phase of serious games, it is important to highlight that the prototyping or game evaluation stage identified in the selected studies is an essential strategy. It helps ensure product quality[5], allows cost control, evaluates formulated content, and identifies and corrects flaws before the final version. In the context of serious games for neonatology, for example, prototyping can simulate complex clinical scenarios[17], facilitating content refinement and educational interactions based on feedback from experts and users, thus ensuring that the game meets its objectives and is ready for validation[5].

Regarding the neonatal care scenarios addressed in the content of serious games, various themes were identified, with neonatal resuscitation being prominent through virtual simulation environments. It is known that around 90% of newborns are born without respiratory hemodynamic instability; however, 10% will require respiratory support at birth. Of these, approximately one in ten live births over 34 weeks will require complex resuscitation maneuvers[30].

Neonatal resuscitation is a clinical emergency, potentially stressful, requiring quick and accurate decisions from professionals to ensure hemodynamic stability in a short response time[31]. Well-prepared and trained teams impact prognosis and reduce neonatal morbidity and mortality rates[32].

The use of virtual simulation as an active methodology to train and guide students and professionals was also highlighted in the analyzed studies. The relevance of developing high-fidelity learning scenarios applied to neonatology is justified by providing professionals with experiences involving high-risk situations in a controlled environment, with a high degree of technical and emotional detail, unlike others[33]. The emotional burden and clinical risk are limiting factors, requiring that simulated practice be more robust and focused, with multiple attempts at trial and error[30,32] Educational serious games that do not include these specificities may fail to promote the development of technical skills and critical decision-making necessary for this field[24].

Neonatology requires professionals to continually engage in continuing education, especially considering the advancement of medical technolo-

gies. Therefore, it is crucial to ensure that healthcare professionals stay updated with the latest advances in neonatal care, such as respiratory therapies and specialized nutritional support for premature infants. Technologies like high-frequency mechanical ventilation and surfactant therapy have transformed the treatment of respiratory complications, highlighting the importance of ongoing education in this area[32,34].

Thus, this study demonstrated that investigating the methodological pathways for developing and validating serious games, specifically in neonatology, allows for the creation of more effective training tools that can improve both the quality of professional training and newborn care[5,14-15,17].

Finally, it was observed that most studies did not describe the validation phase of serious games. Despite this, it is known that this phase, although essential for credibility, minimizing inconsistencies, and enhancing the teaching and learning provided by serious games, is a time-consuming and costly process due to the various adjustments required based on feedback from referees or users. Validation is usually performed by expert referees in the addressed topic. However, even among experts, there may be disagreements regarding the relevance and accuracy of the content, which can lead to multiple adjustment cycles[34].

It is also noteworthy that for serious games developed in neonatology, feedback from judges during the validation phase allows for interactive adjustments, resulting in more effective games aligned with neonatal practice needs. Judges assess pedagogical quality and content suitability, increasing the game's credibility[33].

## Study limitations

The limitations of this study are related to the lack of methodological robustness in the selected articles, particularly due to the absence of validation with expert referees. This may compromise the safety and efficacy of serious games applied to neonatology, as validation contributes to the game's accuracy and applicability in clinical contexts, reducing the risk of conceptual or practical flaws.

## Contributions to practice

The results of this study can contribute to the development of guidelines that assist researchers in creating digital technologies grounded in scientific evidence, improving the quality of care provided to newborns. Additionally, these findings can be used as strategies for continuing health education, applicable both in educational institutions and in care settings. This article offers insights for clinical practice and professional training while highlighting gaps and opportunities for future research on the integration of digital games in health education, reinforcing the need for further studies in this emerging field.

## Conclusion

Methodological studies with a quantitative approach predominated. The serious games were developed based on identified participant needs, published scientific evidence, and situations experienced by professionals. The evaluation of the games was conducted by the target audience in most studies; however, validation by experts was described in only a few studies, which may indicate methodological weaknesses in the developed technologies given the health risks associated with applying unvalidated technology. The use of simulation as an educational strategy was highlighted. Thus, this study demonstrated that investigating the methodological pathways for developing and validating serious games, specifically in neonatology, enables the creation of more effective training tools that impact both professional training quality and newborn care.

## Authors' contributions

Conception and design or data analysis and in-

terpretation: Moreira AR, Nascimento ERP. Writing of the manuscript or relevant critical review of the intellectual content: Malfussi LBH, Costa R, Nascimento KC, Acosta AS, Lohn A. Final approval of the version to be published and agreement to be accountable for all aspects of the text in ensuring the accuracy and integrity of any part of the manuscript: Moreira AR, Nascimento ERP, Malfussi LBH, Costa R, Nascimento KC, Acosta AS, Lohn A.

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