Review Paper

Investigating the Effectiveness of Serious Games in Educating Neonatal Resuscitation: A Systematic Review

Parisa Farshid[1] ◍, Kayvan Mirnia[2] ◍, Peyman Rezaei-Hachesu[1] ◍, Elham Maserat[3] ◍, Taha Samad-Soltani[1*] ◍

1. Department of Health Information Technology, Faculty of Management and Medical Informatics, Tabriz University of Medical Sciences, Tabriz, Iran.
2. Department of Pediatrics, Children's Medical Center, Tehran University of Medical Sciences, Tehran, Iran.
3. Department of Medical Informatics, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran.

Use your device to scan and read the article online

A B S T R A C T

Background: Neonatal resuscitation is a critical skill that requires regular training and practice; however, traditional training methods are often limited by accessibility, cost and engagement. Serious games (SGs) have emerged as a promising educational tool to address these challenges. This systematic review assesses the effectiveness of SGs in neonatal resuscitation education.

Objectives: This systematic review assesses the effectiveness of SGs in neonatal resuscitation education.

Methods: This systematic review followed the preferred reporting items for systematic reviews and meta-analysis guidelines and utilized a comprehensive search strategy across multiple databases (PubMed, Scopus, Web of Science, Embase, Cochrane and ProQuest) using keywords and MeSH terms related to neonatal resuscitation and SGs. Studies published in English up to July 25, 2024, focusing on SGs for neonatal resuscitation training were included. Two independent reviewers screened titles, abstracts, and full texts, resolving disagreements through discussion.

Results: SGs were as effective as video lectures in improving neonatal resuscitation performance. Also, remote digital SGs provided interactive and enjoyable learning experiences for anesthesiologists and pediatric trainees. Paramedics and registered nurses significantly improved neonatal resuscitation performance and knowledge using SGs. Nursing students exhibited increased knowledge, problem-solving abilities and self-confidence with virtual reality-based SGs.

Conclusions: SGs demonstrate promise as a complementary tool for neonatal resuscitation education. They can enhance knowledge acquisition, and skills development, and potentially improve motivation and engagement. However, further research is needed to optimize game design, investigate long-term learning outcomes, and assess skills transfer to clinical practice. Integrating SGs with traditional simulation-based training methods could offer a comprehensive and effective approach to training healthcare professionals in this critical skill set.

---

* **Corresponding Author:**
Taha Samad-Soltani, Associate Professor.
Address: Department of Health Information Technology, Faculty of Management and Medical Informatics, Tabriz University of Medical Sciences, Tabriz, Iran.
Tel: +98 (41) 31776002
E-mail: samadsoltani@tbzmed.ac.ir

Introduction

Neonatal asphyxia is responsible for 20.9% of neonatal deaths. Although 90% of newborns make the transition from intrauterine to extrauterine life without assistance, about 10% need help to start breathing at birth, and roughly 1% require extensive resuscitation [1-4]. The success of neonatal resuscitation relies heavily on healthcare providers' knowledge and skills. Therefore, the education and training of healthcare professionals in neonatal resuscitation are crucial to ensure the best outcomes for newborns needing immediate medical care [5]. While traditional simulation-based education programs like the neonatal resuscitation program (NRP) are effective in improving learning outcomes, gaps in non-technical skills, such as communication, teamwork, situational awareness, decision-making and leadership persist [6]. The current simulation-based education model demands substantial resources, including specialized equipment, mannequins and instructors, making it time-intensive, expensive and not widely available in many healthcare settings [7, 8]. As a result, innovative educational methods like virtual simulation and serious games (SGs) are being explored as potential supplements to traditional neonatal resuscitation training [9, 10].

SGs have expanded their utility beyond entertainment, finding applications in various fields such as art, military, healthcare, and medical education [11-13]. The numerous benefits of SGs in educational settings, such as enhancing learner engagement and motivation, improving information retention, and fostering critical thinking skills, have significantly contributed to their widespread adoption [14-16]. In neonatal resuscitation training, SGs offer advantages like controlled, risk-free learning environments, opportunities for repetitive practice, customized training, objective assessment and feedback, easy accessibility, and a less stressful learning experience [17]. Various studies have investigated the impact of SGs on the education and training of healthcare providers in neonatal resuscitation [10, 18-21]. For example, Sarvan and Efe demonstrated that SGs effectively enhanced nursing students' skills in performing ventilation and chest compressions [10]. Conversely, Yeo et al. found that a web-based game did not significantly improve the knowledge scores and technical skills of healthcare professionals in neonatal resuscitation [19].

Acknowledging the mixed results of SGs on educational outcomes, this systematic review evaluates their role in enhancing healthcare professionals' understanding and application of neonatal healthcare providers. This review underscores the effectiveness of SGs' adoption in neonatal resuscitation training outcomes such as knowledge and skill enhancement.

Methods

Databases and search strategy

This systematic review was conducted based on the preferred reporting items for systematic reviews and meta-analyses guidelines. We searched PubMed (Medline and PMC), Scopus, Web of Science, Cochrane Database of Systematic Reviews, ProQuest (dissertation and thesis global databases), and gray literature (Google Scholar and manual search) up to July 25, 2024. Search terms were determined after consultation with relevant experts in information technology, medical informatics, and neonatal care. Table 1 presents the search strategy used in the PubMed database. The risk of bias was systematically examined through the Joanna Briggs Institute's specialized evaluation tools designed for quasi-experimental and randomized controlled study designs.

Eligibility criteria

The population, interventions, comparisons, and outcomes framework for the research question was formulated as follows: Population=healthcare professionals; intervention=immersive or non-immersive serious game/digital game/video game; comparison=any comparison mentioned in the studies; outcome=learning outcomes.

Studies that investigated the effect of SGs on medical students' knowledge of the neonatal resuscitation process were included in this systematic review. Other types of information technology (e.g. computer simulation and non-game-based virtual reality, non-digital games), non-English papers, protocols, conference/congress abstracts, review papers, letters to editors, and a lack of access to the full text of articles were excluded.

Study selection and data extraction

The EndNote software, version 8 was used to manage the results of the search strategy. After eliminating the duplicated papers, two independent authors (PF and TSS) checked the eligibility of the results in three stages: Title, abstract and full text. Disagreements were resolved through discussion between the authors and if an agreement was not reached, the third author assisted in resolving it. We extracted data from the included papers using a Table in Microsoft Excel, including information, such as author(s)/year, aim, samples,
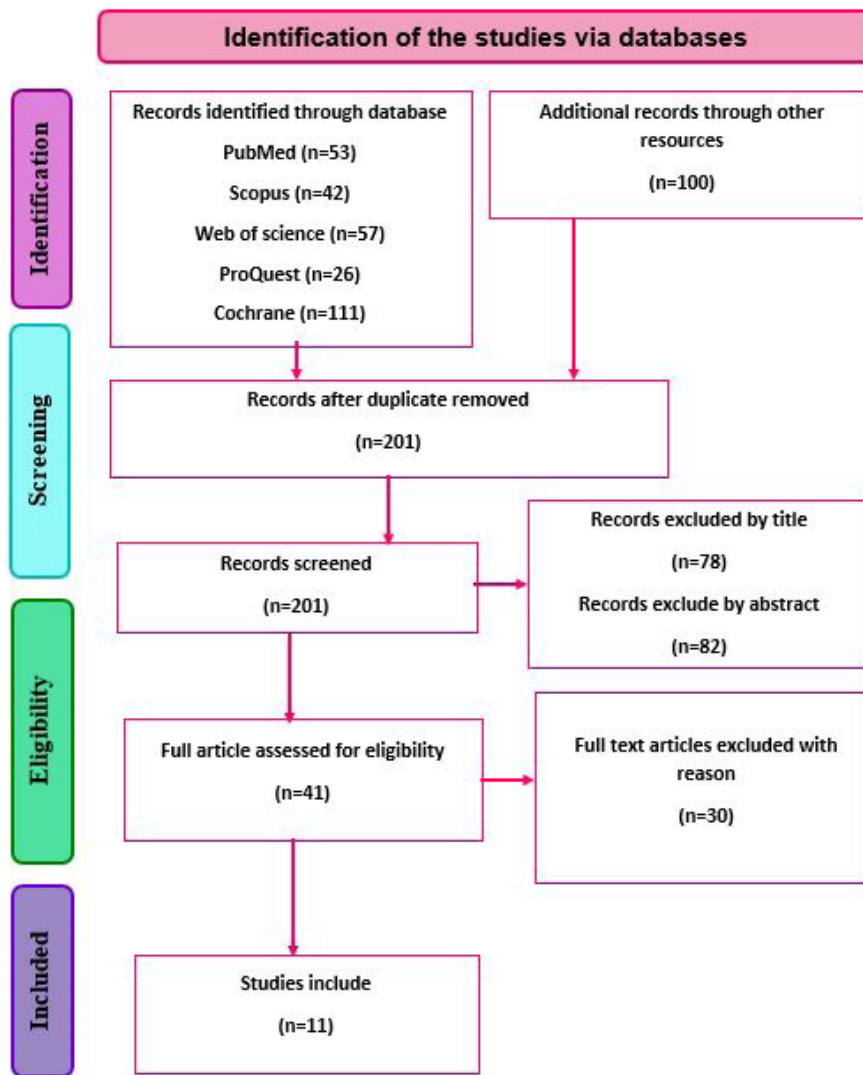
Figure 1. Preferred reporting items for systematic reviews and meta-analyses flow diagram for the process of identification, selection, and inclusion of studies

study design, intervention type, assessment variables, assessment tools, technical characteristics of selected studies and main findings.

Quality assessment

The Joanna Briggs Institute checklist was used for quality assessment of included papers by two independent researchers [22, 23]. This checklist was applied to both randomized controlled trials (RCTs) and quasi-experimental studies. The RCT checklist contained 13 questions, while the quasi-experimental studies checklist had 9 questions. These questions were answered with the following options: "Yes," "No," "Unclear," or "NA."

Results

Study selection

The selection pathway for the studies was illustrated using a flowchart, which adheres to the guidelines recommended by the preferred reporting items for systematic reviews and meta-analyses (Figure 1). A total of 289 records were located in various gray literature and database sources. Meanwhile, 201 records remained after duplicates were eliminated. Out of the 41 papers that were evaluated for eligibility, 11 records were found to be eligible for inclusion.

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.

345

Table 1. The search strategy for the pubmed database

ID	Query	Results
1	("Video games"[mesh]) OR ((serious game*[title/abstract]) OR (gamification[title/abstract]) OR (video game*[title/abstract]) OR (computer-based game[title/abstract]) OR (digital game[title/abstract]) OR (electronic game[title/abstract]) OR (simulation game[title/abstract]) OR (educational game[title/abstract]) OR (game-based training[title/abstract]) OR (game-based teaching[title/abstract]) OR (game-based learning[title/abstract]) OR (online game[title/abstract]) OR (web based game[title/abstract]))	13594
2	(Neonatal[title/abstract]) OR (newborn[title/abstract]) OR (infant[title/abstract]) OR ("infant, newborn"[mesh])	848953
3	(Education[title/abstract]) OR (train*[title/abstract]) OR (learn*[title/abstract]) OR (medical education[title/abstract]) OR ("education, medical"[mesh]) OR ("education"[mesh]) OR (learning [mesh terms])	2459775
4	1 AND 2 AND 3	53

Journal of Pediatrics Review

Data extraction

The samples of this research consisted of 11 studies. The fundamental characteristics of the selected studies included the elements of authors (year), country, aim/title, study type, samples, study design, Mean±SD age of samples, assessment variables, assessment tools, intervention duration, main findings (Table 1) and the technical aspects included the elements of authors (year), product name, design software, hardware, game type, scenario/content of the game (Table 2).

Characteristics of the selected studies

A total of 11 studies were identified in relation to the effectiveness of SGs in improving the knowledge of the neonatal resuscitation process in healthcare providers. According to Table 1, all studies were conducted between 2020-2024. But most of them were related to 2022 (5 studies), which indicates the growing trend of serious game design in teaching the process of neonatal resuscitation in 2022.

In this systematic review, we identified five RCTs and an equal representation of both experimental and quasi-experimental studies, with three articles from each category. Among the included studies, three originated from Canada and two from Italy. The remaining selected articles were conducted in America, South Korea, Turkey, China, Kenya, and Singapore, with each country contributing one article. One study was related to Lagos, Nigeria, Busia, and Western Kenya. The objective of the included studies was to investigate the impact of the game on the resuscitation knowledge of healthcare providers. Healthcare professionals (n=282[38%]) were an important part of the people evaluated in the studies (7 and 11). The samples related to pediatric/neonatal residents (n=100[13%]) (studies 6 and 2) were ranked second. In the research focused on nursing personnel (n=192[29%]), studies involving undergraduate nursing students (study 8) accounted for ninety (14%), while nursing students (study 5) were the subject of 83(13%) and registered nurses (n=4 19[3%]). In other included studies (studies 9.1 and 10), undergraduate medical students (n=81 [11%]), healthcare providers (HCPs) (n=51 [7%]), and had the lowest number of samples, respectively.

In the context of evaluating the impact of SGs on neonatal resuscitation training, the most frequently assessed variables seem to be knowledge and skills. These are central to the training's effectiveness and are consistently mentioned across various assessment variables. They are not only fundamental in gauging the immediate learning outcomes (as seen in studies 3, 7 and 8) but also in determining the long-term retention and application of the training (studies 8 and 11). Additionally, the emphasis on knowledge gain, retention, and transfer, as well as the influence of a growth mindset on performance (study 10), underscores the importance of these core variables. Thus, knowledge and skills serve as the cornerstone for assessing the efficacy of SGs in enhancing neonatal resuscitation training outcomes.

In four of the included studies (as seen in studies 5, 6, 7, and 8), the neonatal resuscitation knowledge test was used to evaluate the groups that represent its significance in assessing the theoretical knowledge of neonatal resuscitation.

Technical characteristics of selected studies

The use of unity game design software has only been mentioned in two games, the virtual reality neonatal resuscitation gamification program (study 5) and DIANA (study 6), while other included studies do not mention any game design software. Unity is a powerful tool that lets creative minds build exciting worlds and interactive experiences, from video games to virtual reality adventures [32].

Table 2. Summary characteristics of selected studies

No.	1	2	3
Author(s), Year	Bilodeau et al. 2024 [24]	Bardelli et al. 2024 [25]	Cutumisu et al. 2024 [26]
Country	Canada	Italy	Canada
Aim/Title	Whether participants enjoyed the retain digital game simulator and whether it was at least as good as a video lecture at refreshing and maintaining participants' neonatal resuscitation knowledge	The study aimed to develop and evaluate an original remote digital serious game for neonatal resuscitation training.	
Study Type	Randomized controlled simulation trial	Experimental	Experimental
Samples	42 labor and delivery room HCPs	52 anesthesiologist trainees and pediatric trainees	42 paramedics from the Edmonton Zone Emergency ambulance service
Study Design	Digital game group (n=91); Lecture video group (n=88)	Pre-test-post-test	Pre-test-post-test: Traditional method (n=21) and digital game (n=21)
Mean Age of Samples, Standard Deviation	Lecture video=9.86(1.71; 2); Digital game=9.62(1.56; 2)	Not mentioned	
Assessment variables	Neonatal resuscitation performance, attitudes toward resuscitation training for healthcare professionals (RETAIN)	Knowledge, skills, and satisfaction with the game	Neonatal resuscitation performance (knowledge)
Assessment Tools	Pre-test and post-test using a manikin, survey of attitudes toward RETAIN	Tools: Pre- and post-training knowledge tests, performance-based assessment, and user satisfaction questionnaire	Manikin, tests (pre-test, post-test and post-test after two months) and attitude questionnaire
Intervention Duration	20-30 min	Four game sessions, each enduring 20 minutes	20 min
Main Findings	Both training methods (digital game simulator and video lecture) effectively improved healthcare providers' neonatal resuscitation performance immediately after training. Performance declined in both groups after two months, showing that both methods were initially effective but not sustained over time. The study highlights that digital game simulators can be attractive and effective alternatives to traditional training methods.	The digital-game-based learning remote training approach is a valuable tool that can provide users with an interactive, effective, and enjoyable learning experience.	This experimental study involving paramedics found that participants improved their neonatal resuscitation performance from the pre-test to the post-test, regardless of whether they used a video lecture or a digital game for instruction. The findings suggest that digital games like RETAIN can be effective and enjoyable alternatives to traditional training methods for enhancing neonatal resuscitation skills.

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.

347

No.	4	5	6
Author(s), Year	Billner-Garcia & Spilker 2022 [27]	Yang & Oh 2022 [28]	Bardelli et al. 2022 [29]
Country	USA	South Korea	Italy
Aim/Title	Assessing the effectiveness of a self-directed, online game-based refresher training program for registered nurses in improving their neonatal resuscitation knowledge and skills; the study will also examine how this motivationally designed, game-based approach influences nurses' engagement and motivation to learn.	Analyzing the impact of a neonatal resuscitation gamification program that utilizes immersive virtual reality and is based on Keller's attention (A), relevance (R), confidence (C) and satisfaction (S). model; it will assess how this program influences neonatal resuscitation nursing knowledge, problem-solving, and clinical reasoning abilities, self-confidence in practical performance, degree of anxiety, and learning motivation.	Training pediatric and neonatology residents in neonatal resuscitation. The game covers all aspects of the resuscitation algorithm, from procedural knowledge to ventilation and chest compression rates.
Study Type	Experimental	Quasi-experimental	Randomized controlled trial
Samples	19 registered nurses	83 nursing students	48 pediatric/neonatology residents
Study Design	pre-test-post-test interventional design (n=19)	The virtual reality group (n=29); simulation group (n=28) and control group (n=26)	Intervention group (n=21); control group (n=27)
Mean Age of Samples, Standard Deviation	Not mentioned	Not mentioned	Not mentioned
Assessment variables	Knowledge, skills, motivation, and engagement	Neonatal resuscitation knowledge, problem-solving ability, self-confidence, anxiety and learning motivation	Procedure knowledge, knowledge retention, equipment checklist, ventilation/chest compression rate, and satisfaction with a new methodology
Assessment Tools	Scoring rubric, instructional materials motivation survey	Neonatal resuscitation knowledge test, problem-solving ability questionnaire, clinical reasoning ability questionnaire, Self-confidence scale, anxiety (state-trait anxiety inventory [STAI]), and learning motivation scale	Knowledge tests, the performance of different session game scores, and satisfaction questionnaire
Intervention Duration	12 weeks	One week (50 min)	Game group participants played four 20 min sessions over four different days
Main Findings	Results: Indicated that a self-directed, online game-based refresher; training was motivating,; engaging and improved nurses'; resuscitation knowledge and skill performance.	The virtual reality group showed significant increases in neonatal resuscitation knowledge, problem-solving ability, self-confidence, and learning motivation compared to the simulation group.	The digital game-based learning methodology was as effective as classic specialist training for neonatal resuscitation in terms of both algorithm memorization and knowledge retention. User appreciation for the methodology and ease of administration, including remote,;, support for the use of Digital game-based learning methodologies for pediatric/neonatology residents' education.

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.

No.	7	8	9	10
Author(s), Year	Ezenwa et al. 2022 [30]	Sarvan et al. 2022 [10]	Hu et al. 2021 [18]	Lu et al. 2021 [31]
Country	Lagos, Nigeria, and Busia, Western Kenya	Turkey	China	Canada
Aim/Title	Investigating the possibility and effectiveness of using mobile virtual reality for preparing healthcare professionals for neonatal resuscitation training before the course.	Examining the effects of incorporating serious game simulation (SGs) into neonatal resuscitation training on the knowledge, skills, satisfaction with training, and self-confidence of nursing students in learning neonatal resuscitation.	"NEOGAMES" is a training program designed for undergraduate medical students to learn neonatal resuscitation in a cost-effective and accessible manner. The program aims to determine if serious game-based training improves long-term knowledge retention in medical students.	The study aims to answer two questions: 1) do RETAIN simulators improve healthcare providers' knowledge and skills in neonatal resuscitation? 2) does having a growth mindset affect healthcare providers' long-term performance in neonatal resuscitation?
Study Type	Randomized controlled trial	Randomized controlled trial	Quasi-experimental	Quasi-experimental
Samples	179 health care professionals in obstetrics and newborn care units at 20 secondary and tertiary health care facilities	90 undergraduate nursing students	81 undergraduate medical students	50 healthcare providers
Study Design	Virtual reality group (n = 91); control group (n=88)	Intervention group (n=45) and control group (n=45)	Game group (n=41); control group (n=40)	Pre-test-post-test-delayed post-test-transfer test
Mean Age of Samples, Standard Deviation	Virtual reality group: Mean±SD=37± 9; control group: Mean±SD=37± 9	Intervention group: 20.71±0.84; control group: 20.51±0.97	Game group: 22.1±0.5; control group: 22.3±0.6	Not mentioned
Assessment variables	Knowledge and skills related to HBB	Knowledge, skills, satisfaction, and self-confidence	Short-term and long-term knowledge retention of neonatal resuscitation	Neonatal resuscitation knowledge gain, retention, and transfer, growth mindset moderates healthcare providers' longitudinal performance in neonatal resuscitation
Assessment Tools	The HBB, second edition, knowledge check; the multiple-choice questionnaire, the bag, and the mask ventilation skills check and the objective structured clinical; examination	Neonatal resuscitation knowledge test, neonatal Resuscitation skills checklist, simulation design scale, self-confidence scale	Multiple-choice questions	RETAIN digital simulator, Likert scale, growth mindset; Questionnaire, checklist, and binary scores
Intervention Duration	A minimum of 20 min	Five times on; different days	Not mentioned	20 to 30 min
Main Findings	The use of digital interventions, such as mobile virtual reality simulations, may be a viable approach to pre-course preparation; in neonatal resuscitation training for health care professionals in low- and middle-income countries.	The serious game simulation group had significantly higher post-test scores of knowledge, skills, satisfaction, and self-confidence than the control group.	The use of the specifically developed educational neonatal; resuscitation game NEOGAMES could facilitate learning and; promote short-term and long-term knowledge retention in; medical students.	Digital simulators for neonatal resuscitation training can effectively facilitate healthcare providers' knowledge gain, maintenance, and transfer. Besides, a growth mindset shows a positive moderating effect on the longitudinal performance improvement in simulation-based training.

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.

349

No.	Author(s), Year	Country	Aim/Title	Study Type	Samples	Study Design	Mean Age of Samples, Standard Deviation	Assessment variables	Assessment Tools	Intervention Duration	Main Findings
11	Yeo et al. 2020 [19]	Singapore	The study examines whether a game is effective in helping individuals retain knowledge and skills related to resuscitation.	Randomized controlled trial	103 healthcare professionals	Non-intervention group: Control+non players (n=87); intervention group: Players (n=16)	Not mentioned	Knowledge and skills (retention of resuscitation knowledge and skills)	A multiple-choice question test, a manikin-based skills test (a standardized scenario and a checklist	Not-mentioned	The web-based game did not have a significant effect on the retention of knowledge and skills in neonatal resuscitation compared to the control group

Journal of Pediatrics Review

HBB: Helping babies breathe.

Figure 2. Classification of main findings based on game type and users

Journal of Pediatrics Review

Table 3. Technical characteristics of selected studies

No.	Author(s), Year	Product Name	Design Software	Hardware	Game Type	Scenario/Content of The Game
1	Bilodeau et al. 2024 [24]	RETAIN	Not mentioned	PC with keyboard and mouse	Digital game simulator (non-immersive)	The learner must perform the following neonatal resuscitation steps: suction, adjustment of baby's head position, use of a bag and mask to assist breathing, compression of the baby's chest, or endotracheal intubation and administration of epinephrine.
2	Bardelli et al. 2024 [25]	DGBL	Unity	PC with keyboard and mouse	Remote digital serious game	Not mentioned
3	Cutumisu et al. 2024 [26]	RETAIN	Not mentioned	PC with keyboard and mouse	Digital game simulator (non-immersive)	By playing through the game scenarios, the player assesses and provides the; appropriate care for a simulated neonate (i.e. newborn baby) experiencing breathing difficulties at birth. In the clinical case scenarios, the player experiences different delivery room; scenarios and performs various steps of the neonatal resuscitation process (e.g. suction and adjustment of the head position, assisted breathing using the bag and mask, chest; compressions or endotracheal intubation and administration of epinephrine).
4	Billner-Garcia & Spilker 2022 [27]	Neonatal resuscitation game	Not mentioned	Desktop computer, laptop, tablet, or smartphone	Serious game (non-immersive)	Three educational games were created to enhance the resuscitation skills of neonatal nurses. Each game simulated a different birth scenario: A term newborn, a premature newborn, and a newborn with meconium-stained fluids. Utilizing motivational design principles such as storytelling and quests, the games engaged learners and built their confidence. They incorporated animated videos, knowledge checks, and a final timed scenario for practicing positive pressure ventilation. The games were designed to be completed in 7 minutes or less to fit within shift downtimes.
5	Yang & Oh 2022 [28]	An immersive virtual reality neonatal, resuscitation gamification program	Unity	HMD; Oculus RiftS®	Immersive virtual reality	The game is based on the neonatal resuscitation game algorithm and includes 14 virtual reality scenarios.
6	Bardelli et al. 2022 [29]	DIANA	Unity	PC with keyboard and mouse	digital serious game (non-immersive)	The game features four levels, each depicting a different scenario of neonatal resuscitation: normal, mild, moderate, and severe asphyxia. Players must follow the correct algorithmic actions, guided by feedback from the game interface. The game tracks the rate of ventilation and chest compressions and assigns a score based on the player's accuracy and speed.
7	Ezenwa et al. 2022 [30]	eHBB	Not mentioned	Smartphone and virtual reality headset	Mobile virtual reality simulation (immersive)	The game simulates neonatal resuscitation scenarios based on the HBB algorithm and provides feedback and debriefing to the players.
8	Sarvan et al. 2022 [10]	NR-SGS application	Not mentioned	Laptop and mouse	game-based simulated (non-immersive)	The game consists of four levels that cover the main steps of neonatal resuscitation: Initial steps, ventilation, chest compressions, and medications.

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.

351

No.	Author(s), Year	Product Name	Design Software	Hardware	Game Type	Scenario/Content of The Game
9	Hu et al. 2021 [18]	NEOGAMES	Not mentioned	Personal computers	serious computer game (non-immersive)	The game simulates a neonatal resuscitation scenario in which the player has to perform the correct steps according to the NRP algorithm. The game also includes 7 question cards with real-time feedback after each decision.
10	Lu et al. 2021 [31]	RETAIN	Not mentioned	iPad Pro and Apple Pencil	Digital game simulator (non-immersive)	Neonatal resuscitation scenarios are based on the NRP guidelines, such as assessing the newborn's condition, providing positive pressure ventilation, performing chest compressions, administering medications, etc.
11	Yeo et al. 2020 [19]	Web-based neonatal resuscitation game	Not mentioned	Not mentioned	Web-based game (non-immersive)	The game is a single-player, unguided web-based game that simulates neonatal resuscitation scenarios based on the NRP guidelines. It has four levels of difficulty, feedback, and scoring.

Journal of Pediatrics Review

Abbreviations: RETAIN: Resuscitation training for healthcare professionals; DGBL: Digital game-based learning; HMD: Head-mounted display; DIANA: Digital application in newborn assessment; eHBB: Electronic helping babies breathe; SGS: Serious game simulation.

In most of the included studies (as seen in studies 4, 6, 7, 8 and 9) the hardware considered for serious gaming was mostly desktop computers, laptops, and smartphones. Among the included studies (studies 5 and 7) were two immersive games. Regarding the scenario or content, most of the games were designed based on the NRP algorithm. The immersive VR neonatal resuscitation gamification program (study 5), specifically designed to train nursing students in neonatal resuscitation, offered the most scenarios (14 scenarios). Only in study No.3, the games used motivational design principles, such as storytelling and quests, to engage learners and build confidence (Table 3).

Study outcome

Examining the main findings of the included studies showed that SGs, including virtual reality simulations, have significantly enhanced neonatal resuscitation knowledge, problem-solving abilities, self-confidence, and learning motivation among healthcare professionals (study 5). SGs that were not of the virtual reality type were found to be just as effective as traditional training in memorizing algorithms and retaining knowledge for infant resuscitation, with added benefits like user appreciation, and ease of use among pediatric/neonatology residents (study 6). SGs consistently led to higher post-test scores in knowledge, skills, satisfaction, and self-confidence among undergraduate nursing students,

demonstrating improved learning outcomes (study 8). Specifically designed games, such as NEOGAMES, have been shown to support the long-term retention of critical information and skills of undergraduate medical students related to neonatal resuscitation (study 9). Digital simulators effectively facilitate healthcare professionals in gaining, maintaining, and transferring knowledge, with a growth mindset positively influencing performance enhancement (study 10). Table 2 shows more details. In addition, the main findings from the selected articles are visually summarized in Figure 2.

Quality assessment and critical appraisal

In a review of eleven studies five RCTs and an equal representation of both experimental and quasi-experimental studies, with three articles from each category (Table 4). Researchers carefully examined potential biases in scientific studies by using the Joanna Briggs Institute's thoughtful evaluation tools, focusing closely on quasi-experimental and randomized controlled research approaches. The RCTs had 13 checklist items, while the quasi-experimental studies had nine. The studies adhered to internal validity criteria, such as blinding and follow-up. However, issues arose with two RCTs by Bardelli et al. and Ezenwa et al. [25, 30] which provided unclear answers to initial questions, suggesting a need for clearer reporting on study populations and interventions. Additionally, three studies by Ezenwa et

Figure 3. Breakdown of the product names, functionalities, and potential strengths and weaknesses   *Journal of Pediatrics Review*

al. [30] Sarvan et al. [10] and Yeo et al. [19] lacked data on certain RCT design elements, necessitating an explanation for these omissions. Moreover, Yeo et al.'s study [19] showed a discrepancy in the baseline comparability between control and intervention groups, indicating a possible bias. Overall, while most studies demonstrated good internal validity, some lacked clarity and completeness in their reporting, warranting further examination.

Discussion

This systematic review explored the effectiveness of SGs in educating healthcare professionals on neonatal resuscitation. The studies included in this review employed various game formats (digital and virtual reality) and targeted different learner groups, including nurses, medical students, healthcare professionals, and residents. Studies showed that SGs, including virtual reality simulations, have significantly enhanced neonatal resuscitation knowledge, problem-solving abilities, self-confidence, and learning motivation among healthcare professionals. Overall, the findings suggest that SGs hold promise as a valuable addition to traditional neonatal resuscitation training.

Several studies reported significant improvements in knowledge scores following serious game interventions compared to control groups [10, 18, 21, 27, 28, 31]. Notably, Lu et al. [31] (2021) demonstrated knowledge retention benefits, indicating that SGs can enhance both immediate learning and long-term retention. Studies observed positive impacts on practical skills related to neonatal resuscitation [10, 27, 30]. SGs provide an interactive and engaging platform for practicing essential skills, contributing to better performance in clinical scenarios. Some recent systematic reviews outlined that SGs can revolutionize medical education by enhancing engagement, interactivity, and effectiveness, while also

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.

353

Table 4. Quality assessment of included studies using joanna briggs institute checklist

Author(s), Year	Study Type	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Bilodeau et al. 2024 [24]	Randomized controlled trial	Y	Y	Y	NA	NA	Y	Y	Y	Y	Y	Y	Y	Y
Bardelli et al. 2024 [25]	Experimental	Y	Y	Y	N	Y	Y	Y	Y	Y				
Cutumisu et al. 2024 [26]	Experimental	Y	Y	Y	N	Y	Y	Y	Y	Y				
Billner-Garcia & Spilker 2022 [27]	Experimental	Y	Y	Y	N	Y	Y	Y	Y	Y				
Yang & Oh 2022 [28]	Quasi-experimental	Y	Y	Y	Y	Y	Y	Y	Y	Y				
Bardelli et al. 2022 [29]	Randomized controlled trial	U	U	Y	NA	NA	Y	Y	Y	Y	Y	Y	Y	Y
Ezenwa et al. 2022 [30]	Randomized controlled trial	U	U	NA	NA	NA	Y	N	Y	Y	Y	Y	Y	Y
Sarvan et al. 2022 [10]	Randomized controlled trial	Y	Y	Y	NA	N	Y	Y	Y	Y	Y	Y	Y	Y
Hu et al. 2021 [18]	Quasi- experimental	Y	Y	Y	Y	Y	Y	Y	Y	Y				
Lu et al. 2021 [31]	Quasi-experimental	Y	Y	Y	N	Y	Y	Y	Y	Y				
Yeo et al. 2020 [19]	Randomized controlled trial	N	N	Y	NA	NA	Y	Y	Y	Y	Y	N	Y	Y

Abbreviations: N: No; Y: yes; NA: Not available.

Journal of Pediatrics Review

catalyzing innovative technology development and research [33]. SGs leverage technologies such as web and mobile applications, game engines, augmented reality, virtual reality, mixed reality, and artificial intelligence. However, challenges include the need for adequate technological infrastructure, complex effectiveness assessments, and integration into existing curricula. These approaches combine learning activities (such as feedback, testing and spaced repetition) with active and immersive participation and autonomy, resulting in positive experiences for students [34].

Billner-Garcia et al. [27] 2022 found that the game-based training was motivating and engaging for participants. Enhanced motivation may lead to better learning outcomes and sustained interest in neonatal resuscitation training. Their study has some strength points including engaging modules that cater to busy schedules and Storytelling and quests enhance motivation. On the other hand, limited information on design software and hardware restricts replicability. Also, their game focuses on knowledge checks and may not provide extensive practice opportunities for complex skills. Highly immersive virtual reality offers a realistic training environment and including 14 diverse scenarios for comprehensive learning were the advantage of Yang et al. [28] 2022 study. Also, their game requires specialized virtual reality equipment that potentially limits accessibility. These studies emphasize the value of game-based approaches

in neonatal resuscitation training, supporting the idea that motivation and engagement play crucial roles in improving learning outcomes. However, it's essential to consider the limitations, such as replicability challenges and the focus on knowledge checks rather than extensive practice opportunities for complex skills.

SGs offer advantages in terms of accessibility and scalability compared to traditional simulation-based training [29, 30]. SGs are highly suitable for transferring knowledge or stimulating behavioral changes. They provide an interactive environment that allows learners to practice and compete while retaining information. This accessibility ensures that learners engage with the content more frequently and for longer periods [35]. Unlike pure simulation-based training, which often requires physical resources and specialized equipment, SGs can be easily scaled up. They can be accessed remotely, allowing learners to train at their own pace and adapt to individual needs. This scalability is particularly valuable in addressing the global shortage of health workers and improving efficiency through effective training interventions [36].

Yeo et al. [19] 2020 did not find a significant effect of a web-based game on knowledge and skills retention compared to controls. Highlighting the need for further research, it underscores the importance of optimizing serious game design for long-term learning outcomes. In a study by Johanson et al. [37] 2023, researchers explored

354

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.

the impact of modifying serious game design elements on learning outcomes. They found that tailoring game mechanics, feedback mechanisms, and difficulty levels significantly improved knowledge retention and skill acquisition over time. Another review of SGs in medical education was conducted. Their findings highlighted the importance of personalized content, adaptive challenges, and engaging narratives. When serious game design aligned with these principles, learners demonstrated better retention and application of knowledge [38].

The studies included in this review employed a variety of designs, with RCTs providing the strongest evidence [10, 29, 30]. Future research would benefit from a larger number of high-quality RCTs to strengthen the evidence base. Also, Different HCP groups were targeted across studies. Further research is needed to explore the effectiveness of SGs for specific professions and skill levels. Tailoring serious game interventions to the unique needs of different learner groups could enhance their impact. A systematic review by Ijaz et al. [39] 2019 evaluated the performance of SGs as a training tool for healthcare professionals. The review included RCTs and found that SGs can be an effective alternate or complementary component of the healthcare training curriculum. However, existing assessment methodologies may not accurately depict the effectiveness of games, emphasizing the need for more robust RCTs and research designs.

The studies reviewed used various game formats. Further investigation is needed to identify the most effective design elements for neonatal resuscitation training. Elements, such as interactivity, feedback mechanisms, and realism play a crucial role in shaping the learning experience. While some studies assessed knowledge retention, limited research explored the transfer of learned skills to real-world clinical scenarios [18]. Future studies should investigate how well skills acquired through SGs translate into actual practice. A meta-review by Damaševičius et al. [40] 2023 analyzed 53 survey papers on SGs and gamification. It revealed that SGs and gamification techniques are increasingly used for a wide range of health conditions. The focus is shifting toward mobile and digital platforms, virtual reality, and personalized interventions. Schrader [41] 2023 highlighted that SGs allow educators to virtually model real-world tasks, enabling learners to interact and learn by doing. These games encourage risk-taking and different learning approaches with lower consequences of failure. Tailoring serious game interventions to specific learner groups enhances their impact on cognitive, affective, motivational-behavioral, and social levels.

The studies included in the review explored a variety of serious game designs for neonatal resuscitation education. In Figure 3, we provide a breakdown of the product names, functionalities, and potential strengths and weaknesses.

Overall, the studies showcase a range of serious game designs with the potential to enhance neonatal resuscitation training. A systematic review conducted in 2022 provided design and implementation recommendations for developing and implementing SGs in nurse education to enhance students' knowledge and performance, based on the evidence reviewed. They claimed that the use of SGs improved nursing students' and nurses' knowledge and performance [20]. Another study revealed that serious gaming significantly enhances educational outcomes in nursing compared to conventional methods such as lectures, reading materials, and clinical simulations. This approach not only supports but also strengthens the teaching and learning framework within the field of nursing by providing robust scientific backing for the integration of SGs [21]. So, future research could explore the effectiveness of combining different design elements (e.g. storytelling, feedback mechanisms, immersive environments) to optimize learning outcomes. Additionally, investigating the cost-effectiveness and scalability of these games, particularly in low-resource settings, would be valuable.

Conclusion

The future vision for SGs in neonatal resuscitation education includes the integration of more advanced technologies like virtual reality and augmented reality, which can provide immersive and interactive learning experiences. The authors believe that these games can revolutionize medical education by making it more engaging and effective, thus potentially improving patient outcomes. Using SGs in neonatal resuscitation training provides a flexible, scalable and cost-effective solution for continuous education. These methods can effectively bridge the gap between theoretical knowledge and practical skills, ensuring that healthcare professionals are better prepared for real-life scenarios. In Iran, the adoption of SGs for medical education is still in its nascent stages. However, given the increasing emphasis on modernizing medical training, these innovative methods could gain traction and become an integral part of the curriculum shortly. The health system can benefit greatly from these educational methods by reducing training costs, improving the efficiency of training programs, and enhancing the overall quality of care provided by well-trained professionals. Integrating SGs

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.

355

with traditional training methods could offer a comprehensive and effective approach to training healthcare providers. SGs demonstrate significant promise as complementary tools for neonatal resuscitation education, showing the potential to enhance knowledge acquisition, skill development, motivation, and engagement among healthcare professionals. However, this review acknowledges several limitations, including variability in study designs, outcome measures, publication bias, and limited data on the long-term retention of skills and knowledge. Future research should focus on optimizing game design, investigating long-term learning outcomes and assessing the transfer of skills to clinical practice.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of the Tabriz University of Medical Sciences, Tabriz, Iran (Code: IR.TBZMED.REC.1399.692). The participants were made aware of the research goals and the various stages of the study. They were assured that their information would remain confidential. Additionally, they had the right to withdraw from the study at any time, and if they wished, they could receive the results of the research.

Authors contributions

Conceptualization, methodology: Parisa Farshid, and Kayvan Mirnia; Data Collecttion: Parisa Farshid; Investigation: Parisa Farshid, and Kayvan Mirnia, and Elham Maserat; Analysis: Parisa Farshid, and Kayvan Mirnia, and Elham Maserat and Peyman Rezaei-Hachesu; Supervision: Taha Samad-Soltani, and Parisa Farshid; Writing the original draft: Parisa Farshid, Kayvan Mirnia and Taha Samad-Soltani; Review and editing: Taha Samad-Soltani, Parisa Farshid; Final approval: All authors.

Conflicts of interest

The authors declared no conflict of interest.

References

1. American Heart Association; American Academy of Pediatrics. 2005 American Heart Association (AHA) guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiovascular care (ECC) of pediatric and neonatal patients: Neonatal resuscitation guidelines. Pediatrics. 2006; 117(5):e1029-38. [DOI:10.1542/peds.2006-0349] [PMID]

2. Chadha IA. Neonatal resuscitation: Current issues. Indian J Anaesth. 2010; 54(5):428-38. [DOI:10.4103/0019-5049.71042] [PMID]

3. Kariuki E, Sutton C, Leone TA. Neonatal resuscitation: Current evidence and guidelines. BJA Educ. 2021; 21(12):479-85. [DOI:10.1016/j.bjae.2021.07.008] [PMID]

4. World Health Organisation (WHO). New WHO guidelines for neonatal resuscitation. Geneva: WHO; 2010. [Link]

5. Utomo MT, Sampurna MTA, Widyatama RA, Visuddho V, Angelo Albright I, Etika R, et al. Neonatal resuscitation: A cross-sectional study measuring the readiness of healthcare personnel. F1000Res. 2023; 11:520. [DOI:10.12688/f1000research.109110.2] [PMID]

6. Niermeyer S. From the Neonatal Resuscitation Program to Helping Babies Breathe: Global impact of educational programs in neonatal resuscitation. Semin Fetal Neonatal Med. 2015; 20(5):300-8. [DOI:10.1016/j.siny.2015.06.005] [PMID]

7. Mileder LP, Urlesberger B, Schwindt J, Simma B, Schmölzer GM. Compliance with guidelines recommending the use of simulation for neonatal and infant resuscitation training in Austria. Klin Padiatr. 2014; 226(1):24-8. [DOI:10.1055/s-0033-1361106] [PMID]

8. Mileder L, Urlesberger B, Szyld E, Roehr CC, Schmölzer G. Simulation-based neonatal and infant resuscitation teaching: A systematic review of randomized controlled trials. Klin Padiatr. 2014; 226(5):259-67. [DOI:10.1055/s-0034-1372621] [PMID]

9. Umoren RA, Schmölzer GM. Virtual simulations for neonatal education. Semin Perinatol. 2023; 47(7):151826. [DOI:10.1016/j.semperi.2023.151826] [PMID]

10. Sarvan S, Efe E. The effect of neonatal resuscitation training based on a serious game simulation method on nursing students' knowledge, skills, satisfaction and self-confidence levels: A randomized controlled trial. Nurse Educ Today. 2022; 111:105298. [DOI:10.1016/j.nedt.2022.105298] [PMID]

11. Asadzadeh A, Shahrokhi H, Shalchi B, Khamnian Z, Rezaei-Hachesu P. Serious educational games for children: A comprehensive framework. Heliyon. 2024; 10(6):e28108. [DOI:10.1016/j.heliyon.2024.e28108] [PMID]

12. Ivanjko T, Lucić D, Trzun Z. Gamification in support of decision making in military higher education. Pper presented 2024 47th MIPRO ICT and Electronics Convention (MIPRO). 20-24 May 2024; Opatija, Croatia. [DOI:10.1109/MIPRO60963.2024.10569635]

13. Zhao L, Hussam E, Seong JT, Elshenawy A, Kamal M, Alshawarbeh E. Revolutionizing art education: Integrating AI and multimedia for enhanced appreciation teaching. Alex Eng J. 2024; 93:33-43. [DOI:10.1016/j.aej.2024.03.011]

14. Akl EA, Kairouz VF, Sackett KM, Erdley WS, Mustafa RA, Fiander M, et al. Educational games for health professionals. Cochrane Database Syst Rev. 2013; (1):CD006411. [PMID]

15. Tsoy D, Sneath P, Rempel J, Huang S, Bodnariuc N, Mercuri M, et al. Creating GridlockED: A serious game for teaching about multipatient environments. Acad Med. 2019; 94(1):66-70. [DOI:10.1097/ACM.0000000000002340] [PMID]

16. de Lesquen H, Paris R, Fournier M, Cotte J, Vacher A, Schlienger D, et al. Toward a serious game to help future military doctors face mass casualty incidents. J Spec Oper Med. 2023; 23(2):88-93. [DOI:10.55460/IJCP-BLY6] [PMID]

17. Sitzmann T. A meta-analytic examination of the instructional effectiveness of computer-based simulation games. Pers Psychol. 2011; 64(2):489-528. [DOI:10.1111/j.1744-6570.2011.01190.x]

18. Hu L, Zhang L, Yin R, Li Z, Shen J, Tan H, et al. NEOGAMES: A serious computer game that improves long-term knowledge retention of neonatal resuscitation in undergraduate medical students. Front Pediatr. 2021; 9:645776. [DOI:10.3389/fped.2021.645776] [PMID]

19. Yeo CL, Ho SKY, Tagamolila VC, Arunachalam S, Bharadwaj SS, Poon WB, et al. Use of web-based game in neonatal resuscitation-is it effective? BMC Med Educ. 2020; 20(1):170. [DOI:10.1186/s12909-020-02078-5] [PMID]

20. Min A, Min H, Kim S. Effectiveness of serious games in nurse education: A systematic review. Nurse Educ Today. 2022; 108:105178. [DOI:10.1016/j.nedt.2021.105178] [PMID]

21. Nascimento KGD, Ferreira MBG, Felix MMDS, Nascimento JDSG, Chavaglia SRR, Barbosa MH. Effectiveness of the serious game for learning in nursing: Systematic review. Rev Gaucha Enferm. 2021; 42:e20200274. [DOI:10.1590/1983-1447.2021.20200274] [PMID]

22. Barker TH, Habibi N, Aromataris E, Stone JC, Leonardi-Bee J, Sears K, et al. The revised JBI critical appraisal tool for the assessment of risk of bias for quasi-experimental studies. JBI Evid Synth. 2024; 22(3):378-88. [DOI:10.11124/JBIES-23-00268] [PMID]

23. Barker TH, Stone JC, Sears K, Klugar M, Tufanaru C, Leonardi-Bee J, et al. The revised JBI critical appraisal tool for the assessment of risk of bias for randomized controlled trials. JBI Evid Synth. 2023; 21(3):494-506. [PMID]

24. Bilodeau C, Schmölzer GM, Cutumisu M. A randomized controlled simulation trial of a neonatal resuscitation digital game simulator for labour and delivery room staff. Children (Basel). 2024; 11(7):793.[DOI:10.3390/children11070793] [PMID]

25. Bardelli S, Del Corso G, Ciantelli M, Del Pistoia M, Scaramuzzo RT, Cuttano AJGfHJ. An original remote digital serious game for neonatal resuscitation training: New opportunities from covid-19 era. Games Health J. 2024; 13(6):452-8. [DOI:10.1089/g4h.2023.0197] [PMID]

26. Cutumisu M, Schmölzer GM. The effects of a digital game simulator versus a traditional intervention on paramedics' neonatal resuscitation performance.Children (Basel). 2024; 11(2):174. [DOI:10.3390/children11020174] [PMID]

27. Billner-Garcia RM, Spilker A. Development and implementation of a game-based neonatal resuscitation refresher training: Effect on registered nurse knowledge, skills, motivation, engagement. J Nurses Prof Dev. 2024; 40(1):24-8. [DOI:10.1097/NND.0000000000000953] [PMID]

28. Yang SY, Oh YH. The effects of neonatal resuscitation gamification program using immersive virtual reality: A quasi-experimental study. Nurse Educ Today. 2022; 117:105464. [DOI:10.1016/j.nedt.2022.105464] [PMID]

29. Bardelli S, Del Corso G, Ciantelli M, Del Pistoia M, Lorenzoni F, Fossati N, et al. Improving pediatric/neonatology residents' newborn resuscitation skills with a digital serious game: DIANA. Front Pediatr. 2022; 10:842302. [DOI:10.3389/fped.2022.842302] [PMID]

30. Ezenwa BN, Umoren R, Fajolu IB, Hippe DS, Bucher S, Purkayastha S, et al. Using mobile virtual reality simulation to prepare for in-person helping babies breathe training: Secondary analysis of a randomized controlled trial (the eHBB/mHBS Trial). JMIR Med Educ. 2022; 8(3):e37297. [DOI:10.2196/37297] [PMID]

31. Lu C, Ghoman SK, Cutumisu M, Schmölzer GM. Mindset moderates healthcare providers' longitudinal performance in a digital neonatal resuscitation simulator. Front Pediatr. 2021; 8:594690. [DOI:10.3389/fped.2020.594690] [PMID]

32. Haas JK. A history of the unity game engine [internet]. 2014 [Updated 12 January 2025]. Available from: [Link]

33. Arif YM, Ayunda N, Diah NM, Garcia MB. A systematic review of serious games for health education: Technology, challenges, and future directions. In: Garcia MB, de Almeida RPP. Transformative approaches to patient literacy and healthcare innovation. Hershey: IGI Global; 2024. [Link]

34. Xu M, Luo Y, Zhang Y, Xia R, Qian H, Zou X. Game-based learning in medical education. Front Public Health. 2023; 11:1113682. [DOI:10.3389/fpubh.2023.1113682] [PMID]

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.

357

35. Hassan LJnm, society. Accessibility of games and game-based applications: A systematic literature review and mapping of future directions. 2024; 26(4):2336-84. [DOI:10.1177/14614448231204020]

36. Lamnai A, El mhouti A. Serious games for improving training and skills acquisition in medicine and health professions. In: Motahhir S, Bossoufi B, editors. Digital technologies and applications. ICDTA 2023. Lecture Notes in Networks and Systems, vol 668. Cham: Springer; 2023. [DOI:10.1007/978-3-031-29857-8_96]

37. Johanson C, Piller B, Gutwin C, Mandryk RL. If at first you don't succeed: Helping players make progress in games with breaks and checkpoints. Proceedings of the ACM on Human-Computer Interaction. 2023; 7(CHI PLAY):342-68. [DOI:10.1145/3611033]

38. Shum LC, Rosunally Y, Scarle S, Munir K. Personalised learning through context-based adaptation in the serious games with gating mechanism. Educ Inf Technol. 2023; 28(10):13077-108. [DOI:10.1007/s10639-023-11695-8]

39. Ijaz A, Khan MY, Ali SM, Qadir J, Boulos MNKJEJoBI. Serious games for healthcare professional training: A systematic review. EJBI. 2019; 15(1):14-30. [Link]

40. Damaševičius R, Maskeliūnas R, Blažauskas T. Serious games and gamification in healthcare: A meta-review. Information. 2023, 14(2):105. [DOI:10.3390/info14020105]

41. Schrader C. Serious games and game-based learning. In: Zawacki-Richter O, Jung I, editors. Handbook of open, distance and digital education. Springer: Singapore; 2023. [DOI:10.1007/978-981-19-2080-6_74]

358

Farshid P, et al. Serious Games` Effectiveness in Educating Neonatal Resuscitation. J Pediatr Rev. 2024; 12(4):343-358.