The use of serious games as an innovative educational strategy for learning cardiopulmonary resuscitation: an integrative review

Utilização do serious game como estratégia educacional inovadora para aprendizagem da ressuscitação cardiopulmonar: revisão integrativa

Uso del juego serio como una estrategia educativa innovadora para aprender la reanimación cardiopulmonar: revisión integradora

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ABSTRACT

Objective: To analyze the scientific evidence available in literature on the use of serious games for health students to learn about cardiopulmonary resuscitation.

Methods: Integrative review in PubMed / MEDLINE®, LILACS, Scopus and CINAHL databases. Included primary studies, in Portuguese, English or Spanish, from January 2009 to August 2019. The Rayyan software was used for study selection.

Results: We identified 115 studies, and 8 composed the sample, categorizing two domains: : Intention of the study with regard to cardiopulmonary resuscitation through the serious game, and method used by the serious game to teach CPR.

Conclusion: Medical students are the main audience for serious game learning, and the main intentions of the games are to compare their effectiveness with traditional methodologies and knowledge retention. The method adopted is the description of a cardiorespiratory arrest for training. The serious game proved effective for learning cardiopulmonary resuscitation.

Keyword: Cardiopulmonary resuscitation. Students. Education. Video games.

RESUMO

Objetivo: Analisar as evidências científicas disponíveis na literatura sobre a utilização de *serious game* para a aprendizagem sobre ressuscitação cardiopulmonar de estudantes na área da saúde.

Métodos: Revisão integrativa nas bases de dados PubMed/MEDLINE®, LILACS, Scopus e CINAHL. Incluídos estudos primários, em português, inglês ou espanhol, de janeiro de 2009 a agosto de 2019. Utilizou-se o aplicativo *Rayyan* para seleção.

Resultados: Identificou-se 115 estudos e 8 compuseram a amostra, categorizando-se dois domínios: Intencionalidade do estudo quanto a aprendizagem por meio do *serious game* para a Ressuscitação Cardiopulmonar e Método utilizado pelo *serious game* para aprendizagem.

Conclusão: O graduando de medicina é o principal público para aprendizagem com *serious game*, e as principias intenções são a comparação da sua efetividade com metodologias tradicionais e a retenção de conhecimento. O método adotado é a descrição de uma parada cardiorrespiratória para treinamento. O *serious game* demonstrou-se efetivo para aprendizagem da ressuscitação cardiopulmonar.

Palavras-chave: Reanimação cardiopulmonar. Estudantes. Educação. Jogos de vídeo.

RESUMEN

Objetivo: Analizar la evidencia científica disponible en la literatura sobre el uso de juegos serios para aprender sobre la reanimación cardiopulmonar de estudiantes de salud.

Métodos: Revisión integradora en bases de datos PubMed / MEDLINE®, LILACS, Scopus y CINAHL. Incluyeron estudios primarios, en portugués, inglés o español, de enero de 2009 a agosto de 2019. La aplicación Rayyan se utilizó para la selección.

Resultados: Identificamos 115 estudios y 8 compusieron la muestra, categorizando: Intencionalidad del aprendizaje a través del juego serio para la Reanimación Cardiopulmonar y Método utilizado por el juego serio para el aprendizaje.

Conclusión: El estudiante de medicina es el público principal para el aprendizaje serio del juego, y las principales intenciones son comparar su efectividad con las metodologías tradicionales y la retención de conocimientos. El método adoptado es la descripción de un paro cardiorrespiratorio para entrenamiento. El juego serio demostró ser efectivo para aprender la reanimación cardiopulmonar.

Palabra clave: Reanimación cardiopulmonar. Estudiantes. Educación. Juegos de video.

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■ INTRODUCTION

Recently, a new generation was identified: the "Y" generation, capable of naturally handling technology and, as a result, classified as a group of "digital natives", standing out due to their creativity, curiosity, and restlessness with regards to learning[1]. In order to change the traditional teaching methods that are still used and guide this generation, active teaching strategies have emerged in the 20th century which have an effective participation of the students [2–4].

One of the technological strategies for learning, which has been standing out, involves the serious games[5–6], especially in the field of health. These are educational games, developed to stimulate learning in an interactive and intuitive way, accelerating critical thought to deal with clinical complications and plan assistance[7–9]. A variety of themes in health, which can be taught using serious games, can be identified, among which cardiopulmonary resuscitation (CPR) stands out[10].

The worldwide incidence of cardiopulmonary arrest (CPA) varies from 20 to 140 per 100 thousand people, and nearly 1.6 in each thousand hospital admissions progress into CPA[11–12]. The survival rate post CPA varies from 2% to 11% in hospitals, which shows that the processes and the implementation of new teaching and learning strategies is necessary[12].

Different studies evaluated the learning of CPR, and the results indicate that the abilities become less sharp within 3 to 6 months after the initial training[13–15]. Therefore, developing techniques to update and maintain the knowledge related to CPR is as important as teaching it. In this context, the serious games can be adequate tools, since they are not only used to complement learning, but also to expose students to new situations during the teaching of CPR, thus updating the knowledge[16].

Considering the important of teaching and learning CPR, and the use of innovative technologies for the development of professional competence in the field of health with regards to this science[17–19], and understanding, from the above, that serious games are educational technologies that can promote this articulation (innovation/teaching of CPR), studying the theme in depth can contribute for the understanding of this tool, for the understanding of its use in the current settings, and its adoption by health educators. This premise instigated us to ask the following guiding questions: What are the main intentions of serious games, when targeted at cardiopulmonary resuscitation, considering the teaching and learning process, and what is the teaching method used to reach this objective? Considering this context, the objective of this study is analyzing scientific evidences available in literature about the use of serious games for health students to learn about CPR?

■ METHODS

This is an integrative literature review about the application of a digital, proactive, and innovative technology, the serious game, targeted at teaching CPR. To reach this objective, the following stages were followed: selection of the research question, definition of the sample, definition of the characteristics of the primary research, analysis of the findings, interpretation of the results, and reproduction of the review[20].

The searches were carried from February to April 2019. Primarily, the guiding question of the review was elaborated through the use of the PICO strategy (Patient-Intervention-Comparison-Outcomes). The P, in the acronym, refers to the patients, that is, to the population addressed, made up by health students; the letter I refers to the intervention, that is, the use of the serious games; the letter O, in turn, referred to the outcome, which here is the learning of CPR. The letter C in the acronym was not used in this study. As a result, the following question was elaborated: What are the evidences available in literature with regard to the use of serious games to teach CPR to health students?

With regard to the stages described above, more specifically, the second and third ones, sample definition and definition of the characteristics of the primary research, the search strategies were specified for the databases selected, which were PubMed® and Scopus. The descriptors used, which were from the Medical Subjects Headings (MESH), were "Cardiopulmonary Resuscitation"; "Students, Health Occupations", and the keyword was "Serious Game". The search strategy use was: (Students OR Student OR "School Enrollment" OR "Enrollment, School" OR "Enrollments, School" OR "School Enrollments") AND ("Video games" OR "Game, Video" OR "Games, Video" OR "Video Game" OR "Computer Games" OR "Computer Game" OR "Game, Computer" OR "Games, Computer") AND ("Serious Game") ("Video games" OR "Game, Video" OR "Games, Video" OR "Video Game" OR "Computer Games" OR "Computer Game" OR "Game, Computer" OR "Games, Computer" AND "Serious Game") AND (Learning OR Phenomenography OR "Memory Training" OR "Training, Memory") AND ("Cardiopulmonary Resuscitation" OR "Resuscitation, Cardiopulmonary" OR CPR OR "Cardio-Pulmonary Resuscitation" OR "Resuscitation, Cardio-Pulmonary" OR "Code Blue" OR "Mouth-to-Mouth Resuscitation" OR "Mouth to Mouth Resuscitation" OR "Mouth-to-Mouth Resuscitations" OR "Resuscitation, Mouth-to-Mouth" OR "Resuscitations,

Mouth-to-Mouth" OR "Basic Cardiac Life Support" OR "Life Support, Basic Cardiac").

In the databases Cumulative Index to Nursing and Allied Health Literature (CINAHL), the descriptors, identified in "Títulos" (Titles), were: "Resuscitation, Cardiopulmonary"; "Students, Health Occupations"; "Education, Health Sciences" and the keyword was "Serious Game", with the following strategy: (Students OR "Students, College") AND ("Video Games" OR "Exergames") AND ("Serious Game") ("Video Games" OR "Exergames") AND ("Serious Game") AND (Knowledge OR "Health Knowledge") AND ("Resuscitation, Cardiopulmonary").

For the research in the database Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS), descriptors came from the Descritores em Saúde (Health Descriptors - DeCS), and were: "Reanimação Cardiopulmonar", "Estudante". The keyword was "Serious game", coupled with its equivalent terms in English and Spanish. The following search strategy was used: (Estudante) AND ("Jogos de Video") AND ("Serious Game") AND (Aprendizagem) AND ("Ressuscitação Cardiopulmonar") (Estudiantes) AND ("Juegos de Video") AND ("Serious game") AND (Aprendizaje) AND ("Reanimación Cardiopulmonar") (Students) AND ("Jogos de Video") AND ("Serious game") AND (Learning) AND ("Cardiopulmonary Resuscitation")

The term "serious game" was used as a keyword so that the results of the research would be intrinsically related to games specific for learning, since finding researches that were related to the objective of this study proved to be challenging.

All scientific researches found were included, including quantitative or qualitative ones, published in any discipline connected to health, and containing data regarding teaching strategies, learning, serious games, and cardiopulmonary reanimation, published from 2009 to May 2019, a time period selected because 2009 was the year with the first scientific publications about serious games in the teaching of CPR, be it in Portuguese, English, or Spanish, considering those that were published in scientific journals and available in electronic form. Literature reviews, editorials, reviews, experience reports, case studies, theoretical reflections, dissertations, theses, monographs, abstracts from the annals of events, publications in websites, ads, articles, and abstracts that were not available online were excluded. The same was done to all gray literature, documents produced by governments, universities, companies, and industries, in print and without the control of editors.

There were three stages in the selection of the studies. The first involved the triage of the articles. Titles and abstracts were evaluated by two professionals using the Rayyan software, which makes the initial triage process of abstract and title reading faster, using a semi-automated process and incorporating a high level of usability in this process[21]. During the second stage of the selection, it was verified whether the studies selected by the researchers were the same, which led 15 investigations to be sent to a third party, responsible to make the final decision about their inclusion or exclusion. In the last stage, the works were read in full, to determine the final sample. An instrument[22] was used, specifying the following items: identification of the article, title, authors, country of origin, language, and year of publication, objectives, method, and results. The method for the development of the serious game was also identified, as well as its target-audience and the effectiveness of the game for the teaching-learning process of CPR. Finally, the level of evidence of the studies was classified[23]. The articles were selected according to Figure 1[24].

RESULTS

The next stages were the interpretation of results and review reproduction. Eight primary studies were considered eligible to make up the sample of this integrative review. Chart 1, below, characterizes the studies according to their identification number, country of origin, language, and classification of the level of evidence.

Chart 2 shows the objective, methodological design, effectiveness, and the teaching-learning method adopted by the serious game, considering the studies that were part of the sample of this research.

DISCUSSION

The scientific production on the use of serious games as innovative strategies to learn CPR in the field of health is still incipient, but has grown in the period under study, though mostly distributed in the international educational setting.

The serious games found in the study were, in most cases, directed at medicine students, followed by those targeted at nursing students. A smaller number was targeted at other health professionals. This could be explained due to the increase in the use of educational technologies for teaching in medicine graduation schools, when compared to traditional methods, coupled with the expressive growth in the number of computer strategies available for medical education throughout the world[33–34].

The experimental and quasi-experimental designs were the most frequent in this review, standing out with levels of evidence of 2 and 3, respectively. This could be related to the need to compare the effectiveness of different methodological teaching strategies regarding CPR, for the choice of better practices[35].
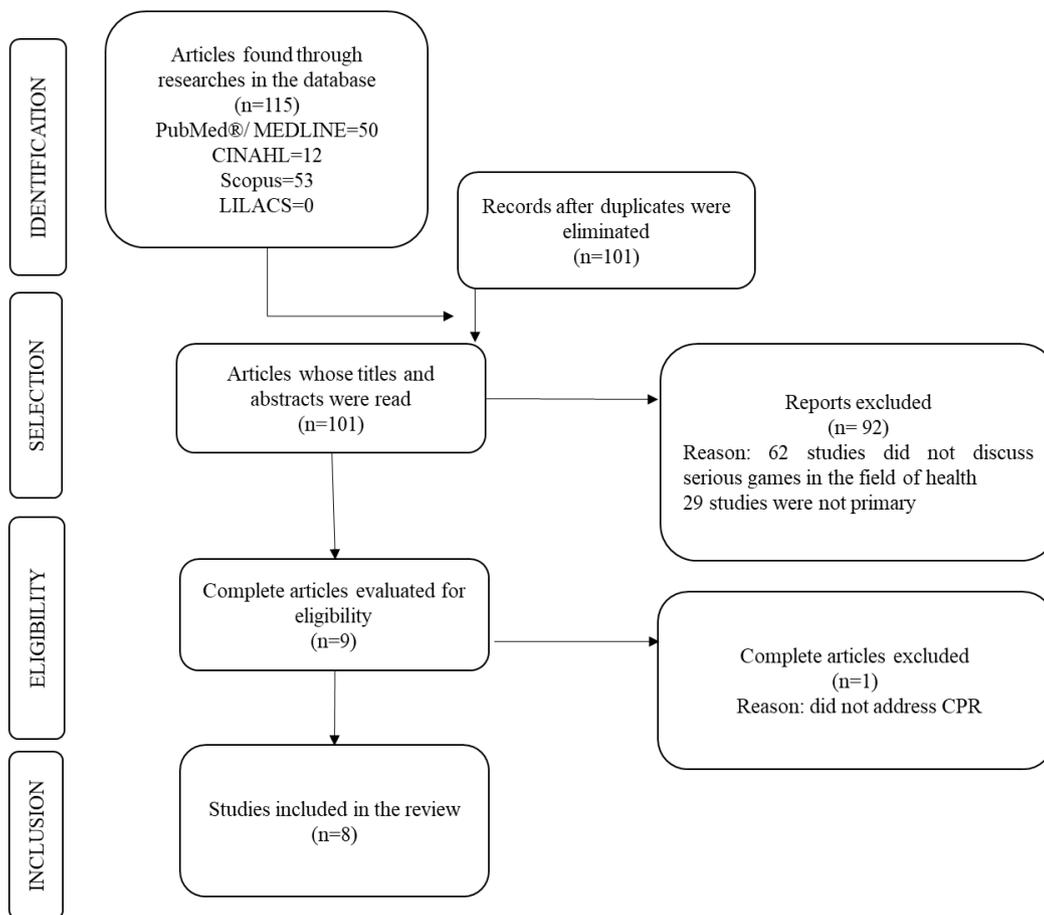
Figure 1 – Flowchart of the process of identification, selection, and inclusion of the studies, elaborated according to the PRISMA recommendations.
Source: Research Data, 2019.

Study	Origin	Language	Level of evidence
Boada et al.[25]	Spain	English	II
Creutzfeldt et al.[26]	Escandinávia	English	III
Creutzfeldt et al.[27]	Suécia	English	III
Buttussia et al.[28]	Italy	English	III
Cook et al.[29]	Inglaterra	English	II
Drummond et al.[30]	France	English	II
Sena et al.[31]	Brazil	English	II
Cutumisu et al.[32]	Canadá	English	III

Chart 1 – Characterization of studies that made up the sample
Source: Research Data, 2019.

Study	Intentionality	Design	Effectiveness	Teaching-learning method
Boada et al.[25]	Comparing the efficiency of the serious game LISSA and that of a traditional CPR teaching method.	Randomized clinical trial, carried out with 109 nursing students from a Spanish university. Three groups were taught by a classic teaching strategy and five used the LISSA. Target-audience: nurses	Students who used the LISSA had better scores for learning than those who used the traditional teaching method. The LISSA is effective for CPR.	An emergency situation (CPA) out of a hospital, in which the player has to save the victim through BLS using CPR. The player starts with 100 points and wrong decisions make this score drop.
Creutzfeldt et al.[26]	Verifying whether medicine students trained through the serious game "Multiplayer Virtual World" can retain CPR knowledge and abilities.	Quasi-experimental study, with 30 medicine students separated in tree groups. Two groups (intervention) received a conventional CPR training and the serious game, while the other group only received a conventional training. Target-audience: physicians.	The intervention group retained more information regarding CPR than the control one. The serious game Multiplayer Virtual World CPR was effective.	Consists in four settings in which the subjects attend to a victim with PCA in an extra-hospital environment, using BLS.
Creutzfeldt et al.[27]	To investigate the influence of the serious game Massively Multiplayer Virtual Worlds in the retention of CPR knowledge in medicine students.	Mixed-method study with 12 medicine students exposed to the CPR serious game. Target-audience: physicians.	Most subjects reported liking the training and approved it. However, it was found that they had trouble retaining the knowledge after six months.	The participants interact with the role of the victim and of the paramedics in 4 scenarios, using BLS.
Buttussia et al.[28]	To evaluate the efficacy of a serious game called Emergency Medical Services for the disAbled for the learning of ALS.	Quasi-experimental study for 40 ALS instructors, with two cardiac arrest scenarios and a test, which was applied immediately and three months later. Target-audience: professionals who participate in the ALS	There was a significant retention of knowledge. The game was considered effective for the retention of CPR knowledge and abilities.	The participants play as the leader of an ALS team, which must rescue a patient with CPA. The scenarios can be a living room or a train station, and the ALS must be used.

Chart 2 – Characterization of the studies with regards to their intentions for learning Cardiopulmonary Resuscitation through the serious game, methodological path, effectiveness, and method used by the serious game for the process of CPR teaching-learning.

Study	Intentionality	Design	Effectiveness	Teaching-learning method
Cook et al.[29]	Evaluating the impact of a serious game called *Plataforma para Graduação em Educação de Apoio à Vida* (PULSE - Platform for Graduation in Life Support Education), involving the performance of nursing students for BLS.	Randomized clinical trial. Carried out with 34 nursing students divided in a control group (traditional BLS teaching) and an intervention group (game). Target-audience: nurses.	There was a statistically significant difference between the control group and the group exposed to the serious game. The PULSE is effective to develop abilities in CPR.	BLS scenarios, which gradually increase the difficulty level, and must be concluded within a specific time frame. There is an initial score, which decreases with each error.
Drummond et al.[30]	To compare a traditional on-line course done through a lecture via PowerPoint to the serious game Staying Alive, in medicine students.	Experimental randomized trial with 82 medicine students using an on-line course (control group) and the serious game (intervention). Target-audience: physicians.	Regarding learning, there were no significant differences between the traditional method and the serious game.	In Staying Alive, the player enters in a medical office and finds a man undergoing CPA and, as a result, must apply BLS techniques.
Sena et al.[31]	To compare the effects of a serious game for training CPR with a video on-line course, in medicine students.	Randomized clinical trial. 45 students were distributed in two groups. Group A watched a video lecture about the cardiac arrest in adults, while group B used the serious game. Target audience: physicians.	This serious game was as effective as the traditional teaching strategy used.	The game is developed in an environment outside the hospital, in which the player must identify a CPA victim and apply the BLS.
Cutumisu et al.[32]	Examining the retention of knowledge about neonate CPR through the game RETAIN.	Quasi-experimental study, in which 50 health professionals in Canada used a serious game involving resuscitation scenarios. Target-audience: nurses, neonate nurses and physicians.	The serious game was related to an improvement regarding the development of critical actions during attention.	RETAIN takes place within a hospital, presenting scenarios for the advanced support of neonate life.

Chart 2 – Cont.
Source: Research Data, 2019.
LISSA: Life Support Simulation Activities; RCP: ressuscitação cardiopulmonar; SBV: Basic Life Support Suporte Básico de Vida; SAV: Suporte Avançado de Vida

The findings were categorized in two domains: Intention of the study with regard to Cardiopulmonary Resuscitation through the serious game, and method used by the serious game to teach CPR.

The first category took into account the main objectives of the studies that used serious games to teach CPR, among which stood out the need to compare traditional teaching strategies[25,29–31]. The identification of the positive results of the serious game for learning CPR[25,29] and in uncertain results with regards to their effectiveness in the retention of knowledge[30,31], showing variability in the outcomes.

A study carried out in the Descartes University, in Paris, aiming to compare a traditional CPR course and the effectiveness of a serious game with 82 medicine students, did not find the game to have statistically superior results when compared to the traditional course[30]. On the other hand, a study with 109 undergraduate nursing students in the University of Girona, in Spain, compared the use of a serious game to teach CPR with a classic teaching methodology, made up by self-directed learning, and found statistically significant differences between the groups tested, with a better performance of the students who used the serious game[25].

Further investigation on this subject is clearly needed, through well-designed clinical trials that can offer more conclusive outcomes about the adoption of serious games for the learning of CPR to be effective[36].

Still in this context, this research strongly showed another objective of using serious games to teach CPR, that is, the retention of cognitive knowledge[26,27,32]. In the case of most serious games identified, the knowledge was not retained by the players[26,32]. Corroborating this statement, a study carried out in Sweden with 12 medicine students, to investigate the influence of the use of a serious game to teach CPR, showed that there was a loss in the cognitive performance related to the retention of knowledge as time progressed[26].

A recent systematic review concluded that, to promote the retention of knowledge in the teaching-learning of CPR, different validated teaching strategies must be combined, preferably with the inclusion of popular music and feedback, and applied every 3 to 6 months, although further investigations are necessary to determine an exact period[37].

The method used by the serious game for CPR learning was also addressed as a category for this study. The extra-hospital setting for CPA attention was addressed in most studies[25–28,31], also emphasizing the teaching of Basic Life Support[25–27,30,31].

The choice of this environment may be justified by two main reasons: first, two thirds of the total CPA cases take place outside the hospital, requiring a fast attention from the Basic Life Support, meaning this primordial stage of CPR should be valued; and, secondly, due to how complex it is to include all peculiarities of Advanced Life Support in the serious game, which is a shortcoming in the education about this subject[38].

Only one study addressed the teaching of neonate CPR[32]. Although many serious games have been developed to make the teaching of adult CPR easier, those focused on the CPR of neonates are still scarce[32].

Didactically, most serious games presented in this review[25,28–32] describe a CPA situation, which leads the player to attend to the victim by applying CPR. The player starts with 100 points and loses points with every wrong decision. They only go to the next stage when the student answers the question correctly. Following this methodology, only two serious games were not more effective than the traditional teaching strategy to which they were compared[17,31]. Although serious games have been proved useful as educational tools in many domains, there is still a lack of reliable, automated, and repetitive methodologies to measure their efficacy, and most of them are evaluated by questionnaires, going against the current trends in the videogame industry[39].

■ CONCLUSION

The scientific evidences found in literature with regard to using the serious game in the teaching-learning process of students in the field of health, with regard to cardiopulmonary resuscitation, indicated that the main target audience of these games are medicine undergraduate students. The main objectives of the researches were comparing the effectiveness of these games with traditional teaching methodologies and evaluating how well the cognitive knowledge is retained. The method that most serious games use to teach CPR is describing CPA scenarios, asking the player to attend to the victim. The players start with 100 initial points and, as they make mistakes, they lose points. They only go to the next stage when the student answers the question correctly. Serious games were shown to be effective to teach cardiopulmonary resuscitation, but further scientific studies still need to be made so that more conclusive results may be found, due to the variety in the outcomes found with regards to retaining knowledge. Extra-hospital environments and Basic Life Support were addressed widely, and few studies showed intra-hospital scenarios or taught Advanced Life Support.

The main limitations of this study were the scarcity of up-to-date studies that could answer the guiding question, and the lack of methodological specifications with regard to the use of the serious game, which made it more difficult to analyze its effectiveness. It stands out that this

study contributes for the teaching, research, and assistance in the field of cardiopulmonary resuscitation, since it identifies the contribution of serious games as innovative CPR teaching-learning strategies, as well as their effectiveness and pedagogical methodology, delineating a framework of knowledge that can give support to the adoption of this praxis in the teaching of health.

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