Serious Games for Training in Patient Flow Management in Emergency Departments: State of the Art and Perspectives

Charlotte Blot[1,*], Katia Weickert[1,*], Arthur Payros[1,*], Marta Avalos-Fernandez[1,2], Cédric Gil-Jardiné[1,4]

[1]University of Bordeaux, Bordeaux Population Health Research Center, UMR U1219, INSERM, F-33000, Bordeaux, France
[2]SISTM team Inria BSO, F-33405, Talence, France
[4]University Hospital of Bordeaux, Pole of Emergency Medicine, F-33000, Bordeaux, France
{first name.last name}@etu.u-bordeaux.fr, {first name.last name}@u-bordeaux.fr

Abstract

Emergency departments (EDs) face significant challenges in providing timely care due to the increase in patient volume and limited resources. To improve patient flow management, new strategies based on artificial intelligence, machine learning, computer modeling, and simulation have been developed, including serious computer games and virtual reality. We performed a systematic review of the use of serious games and virtual reality to train healthcare professionals in the ED.

Introduction

Emergency departments (EDs) around the world are facing an increasing problem of overcrowding, with the majority of EDs operating at or near maximum capacity. The phenomenon affects patient safety, privacy, confidentiality, and staff frustration. Improving patient flow in EDs is essential to reducing crowding and increasing the quality of care. Intrinsic factors affecting patient flow include department layout, staffing levels, waiting times, slow investigation turnaround times, and delays in disposition decisions. Extrinsic factors include exit block, lack of inpatient bed availability, and surges in patient demand. To improve patient flow in the ED, several strategies have been proposed, such as doctor triage, rapid assessment, point-of-care testing, and effective collaboration between medical services and providers (Ortiz-Barrios and Alfaro-Saiz 2020; Jarvis 2016). Recently, strategies based on artificial intelligence (Rosemarin, Rosenfeld, and Kraus 2019; Liventsev, Härmä, and Petković 2021; Lee and Lee 2020; Arnaud et al. 2022; Cho et al. 2022), machine learning (Alenany and Ait El Cadi 2020; El-Bouri et al. 2021; Wang et al. 2021; Terning, Brun, and El-Thalji 2022), and computer modeling and simulation (Mohiuddin et al. 2017; Tuominen et al. 2022) have been developed.

These strategies also include serious computer games and virtual reality (VR) for training healthcare professionals in the ED. Serious games are computer-based games designed for training purposes. Also, there is a growing interest in using virtual, augmented and mixed (merging real and virtual) reality in healthcare for improving the quality of care. Factors motivating the incorporation of simulation into medical education include the provision of standardized, repeated practice and specific feedback, allowing adaptation to the user's skill level, and enabling flexibility in the time and location (Wang et al. 2015; Lu and Kharrazi 2018; Condino et al. 2022). This is particularly interesting for training in the management of a specific pathology or a particular technical procedure. However, the configuration of an ED requires the ability to respond to several simultaneous tasks, and this aspect of the training still seems to be underdeveloped through these games.

The aim of this study is to review the use of simulation software, tools, serious games, virtual, augmented or mixed reality to enrich the training of healthcare professionals in ED with a focus on the management of patient flow.

Methods

We conducted this systematic review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Four items were required: serious games, teaching methods, training of health professionals and emergencies. We used HeTOP (Health Terminology/Ontology Portal) to search for synonyms. Studies were required to deal with simulation-based learning tools with digital support and aimed at health professionals in intra-hospital emergency medicine services. PubMed and Scopus were queried using the search terms:

- Pubmed: (((”train*”[Title/Abstract] OR ”teach*”[Title/Abstract] OR ”educat*”[Title/Abstract] OR ”learn*”[Title/Abstract]) AND (”serious game*”[Title/Abstract] OR ”virtual realit*”[Title/Abstract] OR ”simul*”[Title/Abstract] OR ”virtual patient”[Title/Abstract] OR ”mixed reality”[Title/Abstract] OR ”augmented reality”[Title/Abstract]) AND (”comput*”[Title/Abstract] OR ”numeric*”[Title/Abstract] OR ”digital*”[Title/Abstract]) AND (”emergenc*”[Title/Abstract] OR ”critical care”[Title/Abstract] OR ”first aid”[Title/Abstract] OR ”resuscitation”[Title/Abstract])) NOT (”covid-19”[Title] OR ”surger*”[Title] OR ”e-learning”[Title])) AND (2010:2023/04/01[pdat])
- Scopus: (TITLE-ABS (train* OR teach* OR educat* OR learn*) AND TITLE-ABS (”serious game*” OR ”virtual realit*” OR simul* OR ”virtual patient*” OR ”mixed reality” OR ”augmented reality”) AND TITLE-ABS (comput* OR numeric* OR digital*) AND TITLE-ABS (”emergency unit” OR ”emergency service” OR ”emergency staff” OR ”emergency department” OR ”emergency ward” OR ”emergency room” OR ”emergency personal” OR ”critical care” OR ”first aid” OR resuscitation) AND NOT TITLE-ABS-KEY (”covid-19” OR surger* OR ”e-learning”)) AND PUBYEAR ¡ 2024 AND (LIMIT-TO (LANGUAGE , ”English”) OR LIMIT-TO (LANGUAGE , ”French”))

*Equal contributors

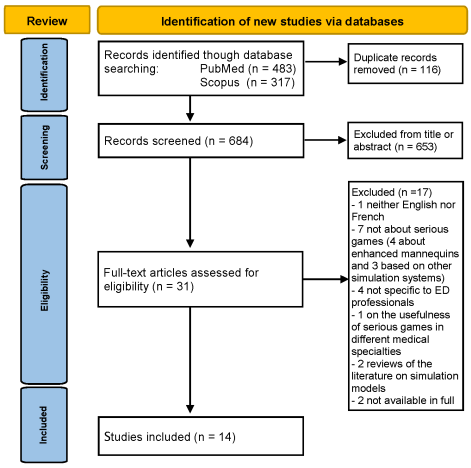

Figure 1: PRISMA flow diagram summarizing our search results and study selection for the systematic review.

All types of publications reported in English or French and published online by April 1st, 2023, were included. We excluded articles published before 2010 because of the technology involved. Finally, all articles that did not deal with in-hospital emergency medicine or resuscitation, tools that did not use digital training, and that targeted a population other than ED students or professionals were excluded.

The import was performed with Zotero software. The relevance of the titles and abstracts of the articles was assessed. A transfer of the remaining articles was done on the Raayan software. Three members of the team independently gave their opinion on each article. A confrontation of the conflicts was then carried out to bring out a consensus of the articles to be kept. Then an analysis and summary of the full texts of the articles were carried out using reading sheets.

Results

We identified 31 papers, 14 of which (from 10 countries) were selected from the full text (Fig 1):

- MicroSim (Bonnetain et al. 2010): A high-fidelity patient computer screen simulator in a cardiac arrest simulation.
- Computer-based 3D simulation (Krange, Moen, and Ludvigsen 2012): A trauma team simulation environment.
- Lsim (Karakus and Azenyer 2014): Training of final year medical students in the emergency setting.
- Malpractice cases (Karakus et al. 2014): Simulation tool for the management of pathologies such as drug allergies.
- Sepsis fast Track (Ribeiro et al. 2016): Serious game to train on the Sepsis Fast Track protocol.
- First2actweb (Borg Sapiano, Sammut, and Trapani 2017): 3 scenarios of clinical deterioration of a patient in the ED.
- EMERGE (Middeke et al. 2020): Management of 10 simultaneous clinical cases.
- VitalSigns™ (Luu et al. 2020): Pediatric ED with 7 beds and a waiting room and changes in vital signs or results.
- Virtual Doc (Perron et al. 2021): VR to teach pediatric cardiopulmonary resuscitation skills to students.
- Guideline adherence (Raupach et al. 2021): Serious game related to the management of virtual patients in the ED.
- eHBB VR (Ezenwa et al. 2022): Mobile VR in neonatal resuscitation training in a low-resource environment.
- Oxford Medical Simulation (Mahling et al. 2023): Simulation as a physician in a virtual ED in 4 scenarios.
- DIANA (Bardelli et al. 2022): Serious game in neonatal resuscitation, 4 phases theoretical and interactive part.
- VR for Basic life Support training (Figols Pedrosa et al. 2023): 5 scenarios in simulation on the platform LUDUS.

Discussion

Computer-based simulations require much less material and human investment than role-playing simulations. They may be useful in mitigating bias in medical decision making (Sader et al. 2021), a problem from which the ED is not exempt. More recently developed, serious games have the potential to be useful educational tools that could benefit the training. The ability to conduct serious games at home would be a significant advance in skill development. It should be noted that the learning objectives and assessment are different (Chan et al. 2020).

Among the studies, first2act places learners in a situation of clinical deterioration and deliberately introduces elements of stress into the scenario. In 3D simulation, a whole team is confronted with the clinical deterioration of a patient, the learning objective is related to communication between professionals. DIANA deals with neonatal resuscitation. VitalSigns™ allows the learner to manage several pediatric patients simultaneously whose clinical situation may deteriorate. However, they are not fully developed computationally and/or further testing is needed to link to meaningful benefits. EMERGE allows for multiple management of adult patients. In the scenario, students navigate through imaging, laboratory, and clinical exams or patient interactions. Unfortunately, this game is only available in German. These serious games therefore pose several problems for their actual use. First of all, they require a significant financial investment for their implementation, while their effectiveness is not fully proven. Moreover, they are still very few in number and do not benefit from communication that would allow them to be disseminated to a wider public, whether they are academic or industrial productions. Finally, most were built around pedagogical objectives that do not entirely correspond to the reality of the field.

Yet, ED flow data (which we are now able to collect, store and analyze) could be used to model patient flows as close to reality as possible and thus create collaborative serious games to train students and professionals in the management of several patients simultaneously as well as in communication between them. This type of tool could be easily accessible via interfaces such as digital tablets that have become a common everyday tool for most people. Furthermore, these tools could also be applied to imagine the ideal ED based on patient flows, human resources and architectural constraints.

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