

Serious Games in Health Care: a Survey

C. Gaudet-Blavignac, A. Geissbuhler

Division of eHealth and Telemedicine, Geneva University Hospitals and Geneva University, Switzerland

Summary

Objective: to present an overview of existing serious games in healthcare designed for patients, and the evaluation of their effects. Such games, aiming to help patients better understand their condition or treatment, to foster healthy behaviors, or even to participate in therapies, are expected to grow in parallel with the importance of the videogaming industry.

Methods: references were searched in Medline and through recursive browsing of their citations.

Results: 21 papers were identified and analyzed. Serious games are used to increase knowledge and control, foster preventive behaviors, or can be used in therapies. Their positive effects on improved patient understanding, adherence, and engagement, although documented mostly in preliminary studies, calls for the development and more thorough evaluation of these tools.

Keywords

Serious games, patient-centered healthcare software

Yearb Med Inform 2012;30:3

Introduction

Today, seventy-two percent of American households play computer or videogames [18]. Games represent one third of the 15 billion applications that have been downloaded for IOS-based devices. The videogame industry weighs more than 50 billion USD, twice as much as the recorded-music industry, and almost two-thirds of the film industry. It is expected to become the fastest growing mass-media during this decade.

If the main purpose of videogames is to entertain, some of these games have other functions, and these are called "serious games". A serious game can be any type of game, board game, card game, quiz game, but videogame is a lot more common due to the huge development of this medium in the last thirty years. It can serve different functions, the main ones being information diffusion (educational, preventive or advertising), training (a type of serious game commonly known as "exergaming") and exchange (data, money or objects).

Those different functions can target very different fields. Education is a major area with all the educational games released for the kids. Advertising is another, with the multiplication of small games on the internet pages of various cultural properties (movies, books or videogames).

Healthcare has also been an interesting side of serious gaming development. From "Packy and Marlon" [12] a videogame about two diabetic elephants, to Roxxi the hero of "Re-mission" [4, 11], a game about child cancer, there has been progress made in the technical side of videogames but also in the use of such games in a serious, educational, preventive or therapeutic purpose.

Although serious videogames have been used for years in healthcare, little

is known about their efficacy and usefulness. A thorough review was made by Adams in 2010 [1].

This survey paper reviews existing papers focusing on serious videogames developed for patients, describes these games, and details how serious videogames can be used, and analyses what is known about their actual impact.

Methods

References in MEDLINE were searched using the terms "serious game", "serious gaming", and "serious video game". Only those papers focusing on serious games used by patients were considered for analysis. Additional papers were identified in the citations of the retained papers (i.e., snowballing). The selected papers were examined from two main perspectives: usage and impact.

Results

Literature Search

The initial MEDLINE search provided 21 references. Of which 14 were excluded because they weren't about serious videogames aiming at patients (they were aiming at health professionals, or about a non-video game project or they were theoretical works without a game project). A further 7 papers were identified by reading through references of the selection. One article from 2007 was an alpha testing of two developing games, so a search was made on MEDLINE combining the names of the games ("Nanoswarm" and "Escape from Diab") and another clinical trial on the final version of the games was added to the selection.

The papers spread over 14 years (from 1997 to 2011), 11 of them (73%) have been published during the past 5 years, suggesting that there the field of serious gaming is in expansion.

On the 15 papers in the selection, 4 were about randomized trials, 7 were feedback after testing of the games or of a preliminary version of the game, one was a presentation of the conceptual model to create a serious game, one was a short presentation, one was about the development of a game, and one was a review of three games and trials about those three games.

In total, 12 serious videogames are mentioned in this selection of articles. Of these 12 games, 5 of them are about health prevention, four aim at an improvement in adherence, knowledge and self-managing of the disease among patients, two are therapeutic games, and one is a decision-support tool.

Types of Serious Games

There are various fields for the use of serious videogames in health care. The main three categories represented in the article selection are: prevention, increase in control and knowledge for the patients and therapeutic intervention.

Increase in Control and Knowledge

Chronologically, the first paper, published in 1997, is a randomized clinical trial about "Packy and Marlon" [12], a videogame designed to improve health-care among children with type-1 diabetes. "Packy and Marlon" was the subject of a 6-month randomized controlled clinical trial on 59 young people aged from 8 to 16 years. By the end of the 6 month, the treatment group experienced a 77% drop in diabetes related urgent visits by month compare to the baseline and an improvement in diabetes related self-efficacy, communication with their parents about diabetes and in daily diabetes self-care.

At the same period, another videogame was designed to help children with asthma to control their condition:

"Bronkie the Bronchiasaurus" [12] was a very similar game, with similar graphics, gameplay and targeted age group. "Bronkie the Bronchiasaurus" was the subject of a randomized comparison with an asthma educational videotape on 14 pediatric asthma patients aged from 8 to 13. The patients in the videogame group reported higher level of enjoyment than the videotape with similar knowledge improvement.

Another project for knowledge and self-efficacy improvement in chronically ill patients is "Re-mission" [4, 11]. This project, created in 2006 by HopeLab, a non-profit organization, was a 3D computer game with up-to-date technology and modern graphics about cancer among the children. The game was about Roxxy, a nanobot looking like a girl, fighting in the body of children with cancer to destroy cancerous cells and infections. This game has been the subject of a large randomized controlled clinical trial on 375 patients aged from 13 to 29 years with baseline, 1 month and 3 month assessments. The results of this trial showed a significantly greater increase for the intervention group in cancer related knowledge assessed by a 18-items questionnaire (7% versus 3%), a greater increase in self-efficacy scores for the intervention group (4.9% against 1.2%) and a 16% increase in adherence for intervention group compare to the control group.

The "Insulot" [2] project also deals with pediatric diabetes. It is a cellular phone-based game, whose purpose is to teach the relation between plasma glucose, insulin and alimentation. This game has been evaluated by 30 diabetic patients (12-24 years) and 80% of those agreed that the game was useful as a learning tool.

"Time after time" [13], a decision aid tool for patients with localized prostate cancer, gets patients to rate each potential side effects of prostate cancer treatment in order to help them to choose a treatment option. The game is split in two parts, one being a card game and the other a slot machine game. The game has been evaluated by focus groups composed by patients with localized prostate

cancer and the overall result was that a majority of the study participants believed that "Time after Time" represents a valuable step in the development of an appropriate decision tool for localized prostate cancer [12].

Prevention

There are five games targeting prevention in the selection.

In "Rex Ronan" [12], the player controls the eponymous young surgeon, who gets miniaturized to clean the body of a sick smoking patient, cleaning vessels or bronchi and killing precancerous cells. The game has been given to children ages 10 and 11 for a week and the general feedback was an intensification of their resolution not to smoke.

Two games focus on diet and physical activity among children and adolescents in prevention of type 2 diabetes: "Escape from Diab" [3, 6, 15, 16, 17] and "Nanoswarm: Attack from Inner Space" [3, 6, 15, 17]. The first is a third person game where an healthy boy has to escape a town where fruits, vegetable and physical activity is forbidden, and the latter is a first person game where the character has to eat healthy food and do physical activity in order to keep a sick friend alive. Both of those games have been the subject of a randomized controlled trial on 133 children aged from 10 to 12 years, resulting in an increase in fruits and vegetables consumption by the children by about 0.67 servings per day but not in physical activity or water intake.

"Happy farm" [9] aims at increasing young people's awareness of the risks connected to psychoactive substance use. A character is at a party, makes choices along the night and sees the consequences of consumption of various psychoactive substances. It was tested by a total of 175 young people and the feedback was that the game was easy to play (89.4% of the participants) with credible story (65.6%) and credible drug consumption effect (75.9%) although no feedback on the effect on prevention has been given.

"Reach Out Central" [7, 14] uses principles of cognitive behavior theory to

improve mental health and wellbeing among young people. The game starts with a character having just moved to a new town, with choices to make and consequences on the mood. The purpose of the game is to teach to young people life skills, problem solving strategies and optimistic thinking in a real life scenario. An independent online evaluation of "Reach Out Central" including 266 people aged from 18 to 25 years was conducted. The survey included several psychological scales and questions about help seeking, mental health or program satisfaction. The results showed that *"although some inconsistencies between genders were noted, [Reach out central] appears to enhance protective factors for the prevention or early intervention of mental health disorders"* [14].

Therapeutic Intervention

Therapeutic serious games attempt to implement practices and exercises used in psychotherapy into videogames.

"Personal investigator" [8] is a 3D game using a "goal oriented, strengths based model of psychotherapy called Solution Focused Therapy" [8] to help adolescent engage in psychotherapy, a challenge in this age group. The patient controls a personal investigator (in analogy to a private investigator) in a detective academy. *"The overall goal is to learn how to find solutions to personal problems and graduate from the Detective Academy as a Master Detective"* [8]. During the game, the patient will learn how to cope with situations and how to find solutions for personal problems. A pilot study was completed by three therapists with four adolescents. The therapists' feedback was *"unanimous agreement that the use of Personal Investigator helped increase adolescent engagement in therapy and helped therapists develop therapeutic relationship with their clients"* [8]. The patients' feedback was that the game was easy to use and *"very helpful in assisting them to think about and solve a personal problem"* [8].

"Treasure Hunt" [5] is meant to support psychotherapeutic treatment of chil-

dren. It is based on principles of cognitive behavior modification and targets eight to twelve year-old children. The player has to help the captain of an old ship find sea stars to complete a treasure map. Each task's reward is a sea star and, ultimately, treasure. An example of a task is a shooting mini game with fish where the child has to hunt unhelpful thoughts and replace them by helpful ones. The game is designed to be used under supervision of the therapist with the possibility to give the child personal homework to do. Several therapists used pilot version of the game with patients gave general feedback. *"All therapists reported positive reactions of the children in treatment and liked to work with the game themselves."* [5] The pilot also showed that the game was useful to structure therapy sessions and to explain cognitive-behavioral concepts to children.

Impact of Serious Games

Effect of Serious Videogames in Knowledge and Adherence Improvement

The positive results of the randomized trials about "Packy and Marlon" [12] and "Re-Mission" [4, 11] show that well designed serious videogames can increase medical knowledge of young patients. "Insulot" [2]'s evaluation is similar. The small trial about "Bronkie the Bronchiasaurus" [12] shows that serious game maybe a better way to improve knowledge than informational video.

According to Thomson, *"entertainment and learning are tightly bound"* [15]. The possibility of repetition and rehearsal of videogames is a key feature allowing increase in knowledge and adherence: *"[videogames] can provide players with unlimited opportunities to rehearse skills receive immediate feedback on performance, [...] and develop the confidence and ability to carry out new skills in their daily lives"* [10].

Engagement

The positive feedback of the "Personal Investigator" [8] and "Treasure Hunt" [5]

shows that serious videogames can improve engagement of young and adolescent patients in treatment. *"The game world is a simulation and as such is a safe environment in which to experiment and most importantly, in which to fail."* [8]. Virtual reality is being explored as a way to improve engagement in various healthcare situations, but little is known currently about the efficacy of this type of games on other type of patients.

Conclusion

This review differ from Adams' work [1] by focusing less on practical considerations and more on which benefit can be awaited with the use of serious games for the patients. It also focuses on the results of the available trials on the subject and their impact on each fields of improvement for the patient (knowledge, compliance, prevention). Due to the disparity in evaluation methods, a precise analysis of these data is compromised, but general considerations can be made.

Glossary

Cellular phone-based game: video games developed especially to be played on cellular phones.

Exergaming: a serious game developed to be played to exercise and train specific skills.

First person game: a video game where the graphical perspective of the game shows to the player the visual field of the playing character.

Gameplay: specific way in which the player interacts with the video game.

Graphics: the visual rendering of a video game.

IOS-based devices: portable devices functioning on Apple's mobile operating system IOS (essentially iPhones, iPods and iPads).

Shooting mini-game: short video game with a gameplay based on the aiming and shooting mechanism.

Third person game: a video game where the graphical perspective shows the playing character, the player being external to it and able to manipulate it.

The multiplication of papers and projects about serious videogames in the past five years shows that it is a developing field in health promotion and healthcare. The overall promising results of trials and evaluations of those projects show that those games can improve some specific fields like knowledge, adherence, prevention and therapy. Virtual reality, repetition and rehearsal possibility are key features of videogames that can be used to improve those fields. However, there is lack of large trials and general concepts are difficult to define with such small groups and fractionated data.

However, despite the overall positives results of trials and evaluations, more studies are needed. Sizeable randomized trials are still missing, as solid conclusions are not possible with small, non-randomized evaluations. Such evaluations should also help understand how the efficacy of these tools vary according to the type of patients, thus enabling more precise targeting.

References

- Adams SA. Use of "serious health games" in health care: a review. *Stud Health Technol Inform* 2010;157:160-6.
- Aoki N, Ohta S, Okada T, Oishi M, Fukui T. Insulot - A cellular phone-based edutainment learning tool for children with type 1 diabetes. *Diabetes Care*, 2005;28(3):760.
- Baranowski T, Baranowski J, Thompson D, Buday R, Jago R, Griffith MJ, et al. Video game play, child diet, and physical activity behavior change a randomized clinical trial. *Am J Prev Med* 2011;40(1):33-8.
- Beale IL, Kato PM, Marin-Bowling VM, Guthrie N, Cole SW. Improvement in cancer-related knowledge following use of a psychoeducational video game for adolescents and young adults with cancer. *J Adolesc Health* 2007;41(3):263-70.
- Brezinka V. Treasure Hunt - a serious game to support psychotherapeutic treatment of children. *Stud Health Technol Inform* 2008;136:71-6.
- Brown SJ, Lieberman DA, Gemeny BA, Fan YC, Wilson DM, Pasta D. Educational video game for juvenile diabetes: results of a controlled trial. *Med Inform (Lond)* 1997;22(1):77-89.
- Burns JM, Webb M, Durkin LA, Hickie IB. Reach Out Central: a serious game designed to engage young men to improve mental health and wellbeing. *Med J Aust* 2010;192(11 Suppl):S27-30.
- Coyle D, Matthews M, Sharry J, Nisbet A, Doherty G. Personal Investigator: A therapeutic 3D game for adolescent psychotherapy. *Journal of Interactive*

Synoptic table of the projects

Name	Year	Theme	Purpose	Description
Bronkie the Bronchiasaurus	1995	Asthma	Patient education	A dinosaur has to avoid asthma triggers
Time after time	2010	Prostate cancer treatment choice	Patient education	Card game and slot machine game to help prostate cancer treatment choice
Escape from Diab	2008	Diabetes	Prevention	An healthy boy has to escape a town where fruits, vegetable and physical activity is forbidden
Happy farm	2009	Drug abuse	Prevention	A character in a party has to make choice and avoid drug abuse
Insulot	2005	Diabetes	Patient education	Cell-phone based slot machine to learn relationship between insulin, food and glycaemia
Nanoswarm : attack from inner space	2008	Diabetes	Prevention	A character has to eat healthy food and do physical activity in order to keep a sick friend alive
Packy and Marlon	1995	Diabetes	Patient education	Two diabetic elephants have to clean a diabetes summer camp of rat invasion while keeping glycaemia in normal range
Personal investigator	2005	Psychotherapy	Therapy	A personal investigator has to learn how to find solutions to personal problems and graduate from the Detective Academy as a Master Detective
Reach out central	2010	Depression	Prevention	A character having just moved to a new town has to make choice and learn how to feel good in this new environment
Re-mission		Cancer	Patient education	A nanobot has to kill cancerous cells and infections inside the body of children with cancer
Rex-Ronan: Experimental Surgeon	1994	Smoking	Prevention	A young surgeon gets inside a smoker's body to clean it from all the damages cigarette has made.
Treasure hunt	2008	Psychotherapy	Therapy	The player has to help a captain to find sea stars in order to complete a map and find a treasure

- Technology & Smart Education 2005(2):73-88.
- Gamberini L, Marchetti F, Martino F, Spagnoli A. Designing a serious game for young users: the case of happy farm. *Stud Health Technol Inform* 2009;144:77-81.
- Howell K. Games for health conference 2004: issues, trends, and needs unique to games for health. *Cyberpsychol Behav* 200; 8(2):103-9.
- Kato PM, Cole SW, Bradlyn AS, Pollock BH. A video game improves behavioral outcomes in adolescents and young adults with cancer: a randomized trial. *Pediatrics* 2008;122(2):e305-17.
- Lieberman DA. Management of chronic pediatric diseases with interactive health games: theory and research findings. *J Ambul Care Manage* 2001;24(1):26-38.
- Reichlin L, Mani N, McArthur K, Harris AM, Rajan N, Dacso CC. Assessing the acceptability and usability of an interactive serious game in aiding treatment decisions for patients with localized prostate cancer. *J Med Internet Res* 2011;13(1):e4.
- Shandley K, Austin D, Klein B, Kyrios M. An evaluation of 'Reach Out Central': an online gaming program for supporting the mental health of young people. *Health Educ Res* 2010; 25(4):563-74.
- Thompson D, Baranowski T, Buday R. Conceptual model for the design of a serious video game promoting self-management among youth with type 1 diabetes. *J Diabetes Sci Technol* 2010;4(3):744-9.
- Thompson D, Baranowski T, Buday R, Baranowski J, Thompson V, Jago R, et al. Serious Video Games for Health How Behavioral Science Guided the Development of a Serious Video Game. *Simul Gaming* 2010;41(4):587-606.
- Thompson D, Baranowski T, Buday R, Baranowski J, Juliano M, Frazier M, et al. In pursuit of change: youth response to intensive goal setting embedded in a serious video game. *J Diabetes Sci Technol* 2007;1(6):907-17.
- http://www.theesa.com/facts/pdfs/ESA_EF_2011.pdf

Correspondence to:
 Christophe Gaudet-Blavignac
 Division of eHealth and Telemedicine
 Geneva University Hospitals
 1211 Geneva 4, Switzerland
 E-mail: chrisgaubla@gmail.com