

# Serious games for health

Voravika Wattanasoontorn(A,B), Imma Boada(A), Rubén Jesús García Hernández(A), and Mateu Sbert(A)

A Institut d'Informàtica i Aplicacions, Universitat de Girona, Spain

B Faculty of Technology and Environment, Prince of Son

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## Abstract

Maintaining and restoring health is a basic aspect of well being. On the other hand, serious games is an emerging technology growing in importance for specialized training, taking advantage of 3D games and game engines in order to improve the realistic experience of users. Thus, according to the advancement of technology and the desire to achieve good health using an interesting and enjoyable way, different serious games for health have been proposed during the last few years. In this paper, we present the core process of serious games and explain their functionalities. Then we survey more than one hundred serious games for health and propose new classifications in four different aspects. Finally, we use fifteen relevant characteristics to classify all the surveyed games and present them with plenty of graphs and charts with corresponding discussion.

**Keywords:** Serious Games ; Healthcare ; Medical information system ; Interactive learning

## 1. Introduction

Today, the term serious game is becoming increasingly popular. Even though there is currently no single definition of the concept, most researchers and developers agree that serious games are games used for purposes other than mere entertainment. They inherit gameplay characteristics from entertainment games, but the main focus may be learning or training, and the lessons learnt are expected to be used in real-life work environments (Michael & Chen, 2005; Sawyer & Smith, 2008; Zyda, 2005).

Serious games are present in many areas of knowledge, including military, health, manufacturing, education and medicine. Focusing on the field of health, the use of serious games can provide an additional mean to increase interest in training, education and evaluation of user performance. For instance, serious games can be designed to educate and train health care professionals to avoid medical errors (Gostin, 2000; Kost, 2001) or in rehabilitation processes, to reproduce the repetitive tasks that have to be done by the patient (Deponti, Maggiorini, & Palazzi, 2009; Red Hill Studios, 2011). The purpose of this paper is to review serious games for health.

Health is one of the main issues that affects people the most in every stage of life (from infancy to old age). In Maslow's hierarchy of needs (Maslow & Frager, 1987), see Figure 1, health is represented in the second lowest level after basic needs required for life are fulfilled. Health is then a very basic need, and maintaining health should therefore be a priority. Additionally, the desirable human characteristics located in higher levels of Maslow's pyramid which are needed for a functioning, peaceful society are negatively impacted by lack of health in the population. For our purpose, the first issue to be taken into account is which games are considered

for health.

World Health Organization (2006) defined health in its broader sense as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity. Other definitions simply require being free from illness or injury (Waite & Hawker, 2009). If we use the stricter definition, we may only consider games dealing with the different phases of illness development, both doctor training and patient familiarization with his illness. However, the use of the WHO definition allows us to consider a third variety of games which has had a big success recently: games dealing with healthy habits such as exercise (including dancing and fitness games), so we shall use this broader definition to select the games.

In this paper, which is an extended version of Wattanasoontorn, Garcia, & Sbert (2012), the aim is to survey the serious games that are related to health. We present new classifications regarding their different aspects, additionally analyzing each game based on the functionalities described in the classifications. The paper has been structured as follows. Section 2 presents concepts and related work. Section 3 explains the method and scope of the study. Section 4 presents all the surveyed serious games ordered by year of publication from January 2004 to December 2012. Section 5 details the different ways in which serious games in health can be classified. Then we present the characteristics of all games according to different parameters in section 6. A summary of their main characteristics, a comparison table, graphs and a discussion of the results is presented in Section 7. Finally, Section 8 concludes the paper.

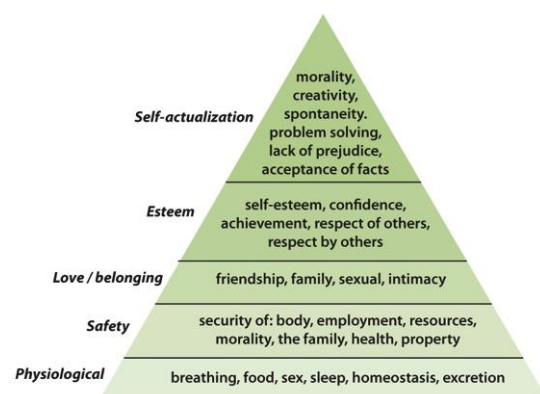


Fig. 1. Maslow's Pyramid

## 2. Concept and Related work

In this section we will focus on serious games, describing their main components and also the core processes involved in the development of a serious game. To end the section, we will review previous surveys about serious games for health.

### 2.1. Serious games

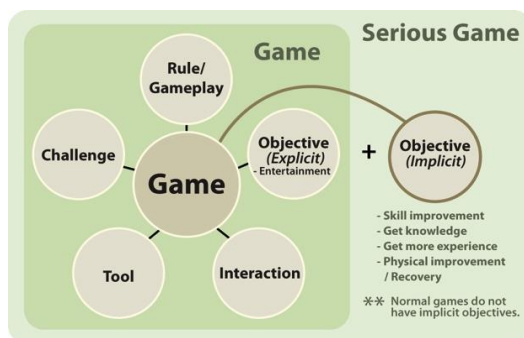
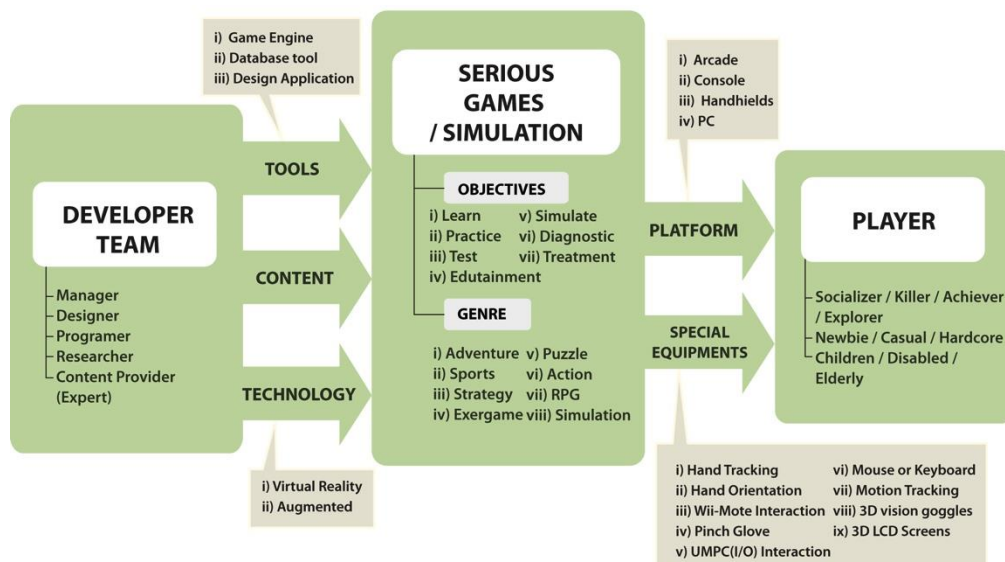


Fig. 2. The Functions of Serious Games

A game is a physical or mental contest with a goal or objective, played according to a framework, or rules, which determines what a player can and cannot do inside a game world (Huizinga, 1955). All games, including computer games, can be specified by means of five different components (see Figure 2). The first component is the *rule or gameplay*, that is the pattern defined through the game rules which connects the player and the game. The second component is the *challenge*, that determines the bonuses to reward the good actions or the obstruction and barriers that avoid the player reaching the game goal easily. Challenges are used to create the different levels of difficulty of the game in order to encourage enjoyment and motivate the player to spend more time with the game. The third component is the *tool*, which is related to the interaction component. It represents equipment or accessories that are connected to the games to give input information to the system. For example, the player may use a Wii balance board as a tool in an exercise game to improve his or her motor skills after operation; in this case the interaction is the gesture performed during the play. The fourth component is the *interaction* which represents the way the player communicates with the game. Interaction refers to any action that is done by the player to start some actions. Interaction can be visual, listening, physical (typing, mouse, touchpad, button pressing), dialogue exchange, etc. The last component is the *objective* which is defined as something that one's efforts or actions are intended to attain or accomplish. Two types of objectives can be distinguished: explicit and implicit. While the explicit objective is only entertainment, nature of every game, the implicit objective includes increasing skills and abilities, gaining knowledge or acquiring experience. The type of objectives can differentiate computer games (with only explicit objectives) from serious games (with include both implicit and explicit objectives).

## 2.2. Serious games core components

The creation of a serious game involves different processes, technologies and specialists. In Figure 3 we illustrate how they are related. A first component is the developer team which may consist of managers, 2D and 3D graphic designers, programmers, researchers and content providers. In a small team one person may be assigned to more than one position; also in medium or big development teams other positions will be added (Eurogamer expert, Ltd., 2012) such as game designer, game tester, level designer, animator, software engineer, interface artist, simulation analyst, etc. The number of people in the team depends on the budget, time, and size of the serious game. In the case of serious games, special attention has to be paid to the content provider who provides not only the information related to the game but also shares his expertise to develop any module in the game including the level of difficulty, the proper rewards and obstructions, etc. Generally, content providers are professionals and experts in serious games. To create the serious game, the developer team has to determine the tools, the technologies and the contents which have to be used in the game. Focusing on these elements we have to take into account that:



**Fig. 3.** Core Components of Serious Games

- *Tools* can be separated into three main groups, the game engine, the database and the design software application. All of them are working together. Every input information is gained through a graphic user interface (GUI) (made from the design software application); then, feedback action is generated by the game engine which is connected to the database. The database maintains all the data and information required by platform including player information, score, game object, animation, etc. The game engine is one of the most important components. It contains the specific code that controls how the system on each game operates. When the application is launched, the game engine dictates what the GUI will present to the user. It also defines the set of rules that determine the win conditions, i.e., the necessary steps that a user must take to compete the game. The engine receives the user inputs, interprets what the user is attempting to do and describes the proper outputs. When the win conditions are satisfied, the interface for the database is utilized and the game scores are recorded for future reference.
- *Content* can be defined as a significant information which will be delivered to the players when the serious game is played. Content is provided by experts and converted to useful information according to the objective of the serious game.
- *Technology* is the branch of knowledge that deals with the creation and the use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, etc. In this context, two outstanding technologies are virtual and augmented reality (Liarokapis, Macan, Malone, Rebolledo-Mendez, & Freitas, 2009; Stone, Panfilov, & Shukshunov, 2011). Virtual reality refers to computer-simulated environments that can simulate physical presence in places in the real world, as well as in imaginary worlds (Zyda, 2005). It is commonly associated with immersive technology which provides perceptually-real environment by special equipment such as holography, head-mounted displays (HMDs), haptic tactile equipment, etc. Augmented reality is a technology which allows computer generated virtual imagery to exactly overlay physical objects in real time (Zhou, Duh, & Billinghamurst, 2008).

These three components (tool, content and technology) are fundamental in the games developing process. To select the best ones we need to identify the game objective and the game genre. Both are described below.

- *Game objective*, in the case of serious games, is mainly focused on education, training and informing in an effective and incisive manner (GENIOUS Interactive, 2012; Janarthanan, 2012; Riedel & Hauge, 2011; Yi, 2011). Other objectives can be practice, testing, simulation, diagnosis and treatment. A serious game can contain more than one objective. For example, serious games which are related to health purpose are not only focused on edutainment but they also show many good results on diagnostic and treatment purposes as well.
- *Game genre* is used to categorize video games based on their gameplay (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). Some of the proposed game genres are: Adventure games which involve exploration of, and interaction with, the environment as a main facet of gameplay; Sport games, like the name implies, are games based on sports which emulate traditional physical sports such as basketball, golf, football, etc.; Strategy game in which the players often autonomous decision-making skills have a high significance in determining the outcome; Exergame which is a term combining exercise and gaming, by merging exercise equipment with video games, aims to encourage people to exercise more by making the activity more fun; Puzzle games are short but addictive graphical games that usually require the player to solve a puzzle such as a maze, logical problem or positioning different pieces together; Action games which players are required to have good reflexes, hand-eye coordination and quick reaction times in order to overcome challenges such as combat, avoiding traps, jumping, running, completing tasks within a pressing time limit, etc.; Role Playing Games in which the player's character has skills and abilities represented by statistics. Gameplay involves the characters exploring and completing quests that build up their statistics and possessions. The game can be single or multi-player; and Simulation games that attempts to realistically mimic the conditions of a particular environment or activity.

To specify the target player is one of the important parts of the game development process. The objectives are to create the most satisfactory game for the intended users and also the most efficient results on an implicit

objective as mentioned in Section 2.1. The player can be designated by various contexts such as playing style (socializer, killer, achiever and explorer), playing skill (newbie, casual and hardcore) and status of player (children, disabled and elderly). To provide the serious game to the players, last two components have to be considered:

- *Game platform*, also called a video game platform or video game system, refers to the specific combination of electronic or computer hardware which, in conjunction with software, allows a video game to operate. Game Platform can be separated into four types: Arcade (Large devices normally found in commercial game centers); Console (Nintendo NES, PlayStation3, Wii, Xbox360, etc.); Handhelds (Game Boy, iPad, iPhone, Nintendo DS, PSP, Mobile, etc.); Personal Computers (Desktop, Laptop).
- *Special equipment* or interface devices used in virtual environments serve as portals into a virtual world. The data input devices perform special interaction purposes such as gesture recognition or performance capture. For example, hand tracking, hand orientation, Wii-mote, pinch glove or motion tracking. On the other hand the special devices for data output devices such as 3D vision goggles or 3D LCD screens are used for vision based image control on serious games.

As Figure 3 shows all described processes and elements have to be considered together since they are related to each other.

### 2.3. The use of serious games to promote health

In the last decade, many serious games in the field of e-health have been developed (Roubidoux, Chapman, & Piontek, 2009). These deal with a wide variety of aspects such as surgeon training, radiology operation, cardiopulmonary resuscitation (CPR) and patient care. Different surveys on serious games for health have been published. Watters et al. (2006) explored the use of games for children with long term treatment regimes, where motivation for compliance is a key factor in the success of the treatment. Papastergiou (2009) reviewed 34 articles on the use of computer and video games in health education and physical education and presented a synthesis of the available empirical evidence on the educational effectiveness of them. Kato (2010) summarized the scientific literature of commercially available and tailor-made games used for education and training with patients and medical students and doctors; her classification is based on diseases. Rego, Moreira, & Reis (2010) proposed a classification designed to properly distinguish and compare eight serious games for rehabilitation systems with respect to their fundamental characteristics. They also described a particular serious game for rehabilitation, RehaCom, as a case study. Lopes & Bidarra (2011) presented the state of adaptability in general games and simulations focusing on the purposes, targets and methods from both academia and industry. Bartolome, Zorrilla, & Zapirain, 2011 presented a systematic review of 21 serious games for health and education, described at scientific papers, and projects from the 7<sup>th</sup> Framework Program.

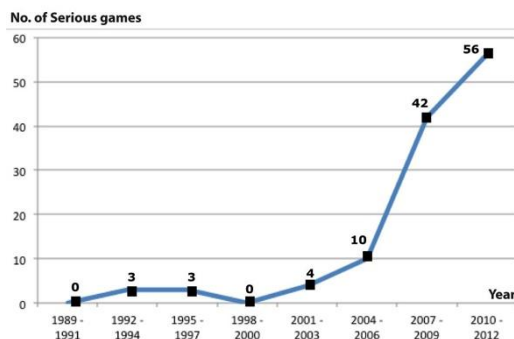
Regarding our survey, the novelties of our study, with respect to the reported ones, are new classifications of serious games which particularly regard health. Moreover 108 serious games from January 2004 to December 2012 are presented and grouped into each classification.

## 3. Method and Scope of study

In this survey we have considered not only serious games that have been described and evaluated in peer-reviewed publications but also commercial games (consoles and PCs), online games, games on mobile platforms and games running on specialized platforms in clinics, hospitals and patients homes.

To carry out our research, we have considered the following sources: The international online bibliographic databases of Science Direct, Association for Computing Machinery (ACM), Institute of Electrical and Electronics Engineers (IEEE) of Computer Society Digital Library (CSDL), Cambridge Journals Online, Oxford University Press (journals), NRC Research Press, The CINAHL database, BioMed Central and Emerald. We have searched with Google and Google scholar. Our searching key words have been "game", "video games", "play", "serious games", "simulation", "virtual", "reality", "game based learning", "training", "health", "clinical", "treatment", "rehabilitation" and "medicine". Some specific keywords may have been

derived from a previous search: such as "Role play game" or "RPG", "exergame" and "edutainment". All the terms have been addressed in conjunction to increase the efficiency of possible outcomes.



**Fig. 4.** Numbers of surveyed serious games for health according to the year of publication

If we focus on the number of serious games for health according to the year of publication from January 1989 to December 2012 which we present in Figure 4, we can see that before 2004 few games were proposed while from 2004 until now the production increases. Therefore we decided to take into consideration only the serious games for health published since January 2004 to December 2012. To be included in this review, papers must show an empirical evidence related to the main objective of this paper (serious games for health and their many aspects).

The result of our search is presented in Section 5 but before, in the next section, we present the proposed four new classifications of serious games for health.

#### 4. Review of serious games for health

In what follows, we review the work developed in the health area, including additional games from commercial or online sources. We provide a short summary of each game, indicating their most relevant characteristic by year of publication.

**Table 1.** Review of serious games

Developer/Author	Game name	Description
Johnston & Duskin (2004)	Ben's Game	A serious game designed to help kids fight against cancer. The game was initiated by Ben Duskin, nine years old, who is in remission from Leukemia.
MIT Teacher Education Program (2004)	Outbreak @ MIT	A handheld game occurring within the premises of MIT that aims at exploring an epidemic of avian influenza being triggered in college.
Montreal Science Centre (2004)	Sleep: A to Z	A serious game which aims to present the operation and the importance of the different stages of sleep by a set of mini games.
Respondesign (2004)	MayaFit	An exergame dedicated to physical training. Many fitness exercises are offered by virtual coach.
Nintendo (2005)	Brain Age 2	A serious game that evaluate the brain age, between 20 to 80, by determining approximately the range of brain's responsiveness.
Archimage, Inc. (2006)	Escape from Diab	An adventure game in healthy eating and exercise that focuses on obesity and type 2 diabetes prevention. The game guides the player through goal setting, problem solving, energy balance, and other game-play activities.
Believe in Tomorrow National Children's Foundation, Ltd. (2006)	FreeDive	A serious game that helps chronically ill children cope with pain and anxiety by distracting them while they undergo painful medical treatments.
Gameloft (2006)	Brain Challenge	A collection of serious games aiming to exercise the brain and keep intellectual muscles in shape. It also checks the performance and monitors the overall results of the brain activity with the daily follow-up. The game is based on four subjects: logic, math, memory and visual.
Janomedia (2006)	Terveellinen Ateria	A serious game aiding practical nurses (PN) and school staff train in the practical aspects of preparing meals for people with different nutritional requirements.
McGill University (2006)	Grow Your Chi	A serious game designed to increase self-esteem by displaying a positive ability



or function of the player.

**Table 1.** Review of serious games (continued)

Developer/Author	Game name	Description
BreakAway, Ltd. (2007)	Pulse!! The virtual clinical learning lab	An immersive virtual learning space where health care professionals can train their clinical skills by dealing with injured patients, bioterrorism or other catastrophes (Alhadeff, 2007).
Edheads (2007)	Virtual Knee Replacement Surgery	A science game for patients and their caregivers to take on the role of a surgeon and complete a knee replacement surgery while learning about the procedure, the technology, and health risks and benefits.
Fatworld.org (2007)	Fatworld	A videogame that explores the relationships between nutrition, obesity and socioeconomic factors in the contemporary U.S. Budgets, subsidies, regulations and physical world characteristics are taken into account.
Intelligent System Co., Ltd. (2007)	Otona no DS Kao Training	A brand game released only in Japan. The training software instructs the user on how to perform several facial exercises that have a goal of keeping your face healthy looking and wrinkle free.
Nintendo EAD (2007)	WiiFit	An exercise game consisting of activities utilizing the Wii Balance Board peripheral. Wii Fit Plus, an enhanced version of the original Wii Fit, was launched in 2009 by adding new exercises and tools to personalize the exercise routine.
Nordic Innovation Centre (2007)	Valion Energiasummaaja	A nutrition game aimed to build a healthy and balanced meal. The effects of the meal on blood sugar are shown, and possible improvements in the meal are suggested.
	MC Urho	A game that contains information regarding lifestyle effects on health and aims to teach young people about the effects of smoking, high blood pressure and cholesterol.
	MoFun Circus	An exergame in which players cycle to capture falling objects in the game. A camera is used to follow the users and display the activity on-screen.
SEGA Corporation (2007)	Mind Quiz (Nounenrei)	Series of 16 mini-games for mental training, aiming to measure and improve particular parts of the player's brain, such as one's brain age and its brain stress degree.
Anderson (2008)	-	A simulation game was created to help nursing students to identify the roles and responsibilities of a multidisciplinary team of professionals when caring for a Maternal-Child Health (MCH) patient and family in crisis.
Glasgow Caledonian University (2008)	Nurse Education	A virtual learning environment in Second Life, a massively multiplayer online role playing game (MMORPG), for use in nurse education.
Hatfield D. (2008)	My Stop Smoking Coach	An educational game for smokers to quit immediately and permanently. The game is run on several platforms including iPhone, Mobile (Java ME) and Nintendo DS.
Imperial College London. Faculty of Medicine (2008)	Game-based Learning for Virtual Patients	A region in Second Life provides a learning space where virtual patients suffering five different respiratory illnesses (such as lung cancer or pneumonia) can be diagnosed, investigated and treated by players wanting to perform roleplaying learning activities under the feedback and guidance of medical staff.
Mili, Barr, Harris, & Pittiglio (2008)	VI-MED	A virtual training to be used as a precursor and as a supplement to real practical training.
Sliney & Murphy (2008)	Medical Simulation Training Program (JDoc)	A computer-aided junior doctor simulator used for training and teaching junior doctors their interpersonal, communication and decision making skills, and to ease the transference of the medical information available to them.
The Partnership for Food Safety Education (2008)	The Food Detectives	A web base game for 8-12 year old kids to learn about foodborne illness.
TruSim (2008)	Fight BAC game	A serious game to train in triage, the process of prioritizing the treatment of multiple casualties based on the severity of their injuries.
	Triage Trainer	
Vermont department of health (2008)	Khemia	A serious game designed to help people quit smoking. The game provides both a distraction from cigarette cravings and personalized support for quitting through the integrated MyQuitKit tool.
Warner Bros. Entertainment, Inc. (2008)	Pamoja Mtaani	A video game that simulates real life settings in Kenyas capital Nairobi aims to teaching Kenyan youth how to avoid contracting HIV.
BBG Entertainment GmbH (2009)	Train Your Brain With Dr. Kawashima	A brain-exercising game with 30 specifically designed and scientifically tested exercises. Along with the goal of the game, it explains how the brain will be activated and developed by the training.
Blitz Games Studios, Ltd. (2009)	The Biggest Loser	A health and lifestyle game. Based on the hit NBC reality TV show, USA. The game mirrors the format of the show by featuring intense training routines, weekly challenges, nutritional goals and information and the iconic weekly weigh-in and elimination from the show.

**Table 1.** Review of serious games (continued)

Developer/Author	Game name	Description
Burke, McNeill, Charles, Morrow, & Crosbie (2009)	Arrow Attack	A serious game developed for bimanual rehabilitation (both arms).
	Catch task	A serious game for upper limb stroke rehabilitation (focused on bilateral rehabilitation).
	Rabbit Chase	A serious game developed for single arm rehabilitation (either right or left arm).
	Whack a Mouse	A serious game designed to encourage movement and to improve the accuracy and speed of the users upper limb movement.
	Virtual Vibraphone	A serious game that uses Nintendo Wii remote controllers for wrist and arm rehabilitation.
Collision Studios (2009)	Daisy Fuentes	A fitness game of Pilates exercise, a system of exercise created in the 1920s by Joseph H., features a 3D Avatar of Daisy Fuentes who performs the exercises with the player.
Deponti, Maggiorini, & Palazzi (2009)	DroidGlove	A ubiquitous game therapy for wrist rehabilitation. The exercise has to be done while holding the smartphone in the hand. The performance will be automatically recorded for the doctor supervision.
Hopelab (2009)	Re-Mission	A video game with 20 levels that takes the player on a journey through the body of young patients with different kinds of cancer. The main aim is to engage young cancer patients through entertaining game play while impacting specific psychological and behavioral outcomes associated with successful cancer treatment.
Keele University (2009)	-	A system which aims to train pharmacists by using a virtual patient. Traits such as race, age and gender are taken into account in the treatment of patients to let learners understand the clinical significance.
Kim JA, Kang, Yang, & Kim D (2009)	A Sensory Gate-Ball Game	PC-based 3D graphics game designed for aged people; it uses a realistic gate-ball stick and balls as interfaces. In the game, players use the same stick and ball as the real gate-ball.
Laikari (2009)	Fitness Adventure	A location-aware fitness game which takes advantage of a variety of mobile phones, location information and Bluetooth GPS receivers; combines mobile games with exercising outdoors.
Learning Games Lab (2009)	Science Pirates: The Curse of Brownbeard	An adventure game allowing the child to learn about food safety and the underlying scientific principles. The adventure is made up of different challenges: problem solving, scavenger hunt, etc.
Lightning Fish Games (2009)	NewU Fitness First Personal Trainer	A fitness game featuring both structured exercise programs and nutrition programs. The fitness programs are designed by the Fitness First gym chain, the nutrition programs are in association with the You Are What You Eat television series.
Mckanna, Jimison, & Pavel (2009)	21 Tally	A collection of 2D games used to detect divided attention unobtrusively, by using performance on a computer game designed to force players to attend to different dimensions of attention simultaneously in order to succeed.
Persuasive Games LLC (2009)	Killer Flu	A game about seasonal and pandemic flu attempting to explain how flu really mutates and spreads, and how challenging it can be for a deadly strain to affect a large population geographically. The player takes the role of the flu itself, trying to mutate and then spread in a variety of conditions.
QOVEO (2009)	Prevenir la gripe A H1N1	A serious game to raise public awareness about H1N1 virus prevention. It is a shooting game where player have to destroy viruses. However, in order to reload the weapon players have to answer questions related to the virus.
RANJ Serious Games (2009)	The Great Flu	A serious game aims to raise the awareness of similar outbreaks by having the player control the deadly Gamers Flu. The goal of the game is to control a possible pandemic by select options to apply actions or assign research teams in order to stop the flu.
Raylight S.r.l. (2009)	Train Your Senses	A serious game to train the visual and aural senses through 22 exercises. The game lets the player try first on his weaknesses and improve his skills through targeted training.
Succubus Interactive (2009)	Happy Night Club	A serious game which aims to sensitize teenagers about the risk of over-alcohol and binge drinking. Player performs as a secret agent sent on a mission in a night club he needs to investigate without drinking too much, in order to stay clear enough to fulfill the mission.
Virtual Heroes, Inc. (2009)	Zero Hour: Americas Medic	A 4.8 million dollar serious game, designed by George Washington University's office of homeland security and Virtual Heroes, Inc., which aims to train and exercise first responders to respond to mass casualty incidents such as earthquakes and terrorist attacks.
Vtnen & Leikas (2009)	Virku - Virtual Fitness Centre	A system that allows users to exercise in a virtual environment. The game is controlled by a user interface based on an exercise cycle, and users may practice individually or in a group.



**Table 1.** Review of serious games (continued)

Developer/Author	Game name	Description
Anchor Bay Entertainment (2010)	10 Minute Solution	An exergame which allows players to construct their own workout regimens based on 10 minute exercise sessions. Exercises are organized into 3 major categories: Cardio Boxing, Mixed Games, and Aerobics, each featuring several different workout games to choose from.
Atkinson & Narasimhan (2010)	-	A medical diagnostic gaming environment that is used to gather Parkinson's patient information in a casual environment. The system employs the novint falcon human interface device (Novint Technologies, Inc., 2011) to guide a patient within the game.
Bartolome, Zorrilla, & Zapirain (2010)	-	A serious game to analyze the behavior and promote certain social skills (conversation, negotiation, etc.) of people with Neurological development Disabilities.
BreakAway, Ltd. (2010) & Medical College of Georgia School of Dentistry faculty and students (2010)	Virtual Dental Implant Training Simulation Program	A 3D virtual environment for students to train in the correct decision-making protocol to determine patient preparation (both physical and mental) for dental implant surgery.
Clawson, Patel, & Starner (2010)	DITS	A mobile phone game similar to Dance Dance Revolution (DDR). Instead of using a dance pad, DITS uses wireless 3-axis accelerometers that are worn around the player's ankles and uses a mobile phone to control the game and to display graphics.
Electronic Arts, Inc. (2010)	EA Sports Active	An exergame focused on cardio exercise. Players can choose from three week or nine week programs which are rigidly guided systems that track players through the range of weeks selected.
Finkelstein, Nickel, Barnes, & Suma (2010)	Astrojumper	A stereoscopic virtual reality exergame for children with autism. During the game, virtual space-themed objects fly forward toward the user who must use their own physical movements to avoid collisions.
Fishing Cactus (2010)	R.O.G.E.R	A serious game for patients who has a lack of logic and organizational skills (typically post-stroke patients, Alzheimer, hemi-negligent patients, etc.).
Gago, Barreira, Carrascosa, & Segovia (2010)	Nutri-Trainer	A collection of serious games about nutritional health following professional recommendations, cooperating with doctors and nutritionists to give coherence to the information collected in the nutritional databases.
Grau, Tost, Campeny, Moya, & Ruiz (2010)	-	A neuropsychological rehabilitation game that allows patients to navigate through the virtual environment and perform cognitive tasks.
HopeLab (2010)	Zamzee	An online rewards program and game-like experience powered by your physical activity. Players wear a device with an accelerometer that monitors their movement and translates it to points that can be then redeems with both digital and real-world rewards.
Innovation in Learning, Inc. (2010)	CliniSpace	A medical training game for healthcare professionals focusing on clinical diagnosis and patient management. Players in the role of a doctor who may consult medical records to a patient, plan an operation or provide a clinical consultation.
KTM Advance (2010)	Alphega Game	An education game to train pharmacists focus on patients observation by counseling with the virtual patients in game.
Miller (2010)	Market Virtual Patient Care Simulation (MUVE)	Patents simulations for students and professionals (nurses, pharmacists, paramedics, emergency medical technicians, social workers, etc.) training.
Sabri et al. (2010)	-	A serious game designed to train orthopedic surgical procedures to orthopedic surgical residents.
Skills2Learn, Ltd. (2010)	Nursing and Midwifery	A program that helps nurses and midwives increase their ability to assess patients. The interactive scenario is based on the simulation of the 36 weeks of pregnancy realistically.
TruSim (2010)	Patient Rescue	A serious game which supports health professionals to recognize the signs of patient deterioration, use set protocols to assess a patient's condition and intervene effectively.
Ubisoft Divertissements, Inc. (2010)	Your Shape: Fitness Evolved	This console game focuses entirely on fitness routines led by virtual trainers, and is divided into structured personal training, pick-up fitness classes, and active gym games.
Vidan, Chittaro, & Carchietti (2010)	EMSAVE	A serious game for training in emergency medical procedures concerning disabled patients. It allows users to experience emergency situations involving disabled persons.

**Table 1.** Review of serious games (continued)

Developer/Author	Game name	Description
Visual Imagination Software (2010)	Chirurgie Simulator	A surgery simulation in which players take on the role of a surgeon at a hospital. The surgical procedures include operating on fractures, removing an inflamed appendix or tonsils, treating infected gall bladders, attending to varicose veins, repairing hernias, restoring vision in cataract procedures and dealing with the injuries of a road traffic accident.
Wang, Sourina, & Nguyen (2010)	Brain Chi and Dancing Robot	The EEG-based concentration games named Brain Chi (2D) and Dancing Robot (3D) are developed for concentration level control
Zumba Fitness LLC (2010)	Zumba Fitness	An interactive exercise program helps to perform high calorie-burning workouts. The game concept is based on calorie-burning dance fitness-party. Zumba Fitness is available in PlayStation 3, Wii and Xbox 360 platform.
Association RMC / BFM (2011)	Staying alive	A 3D simulation aiming to teach how to deal with emergency situation of cardiac arrest.
Botella et al. (2011)	-	A mobile phone game for the treatment of cockroach phobia. The objective is to reduce the level of fear and avoidance.
CCCP (2011)	LudoMedic	An educational game aims to teach children to prepare for an MRI, have surgery, or undergo chemotherapy.
De Bortoli & Gaggi (2011)	PlayWithEyes	This serious game aims to test children eyes while they are having fun playing with Lea symbols and images taken from popular cartoons, using a touch interface.
Diehl et al. (2011)	-	A serious game for training doctors and medical students about insulin management for the treatment of diabetes mellitus.
Fuchslocher, Niesenhaus, & Krmer (2011)	Balance	A health game developed to optimize the self-management of teenagers with diabetes mellitus type-I.
Imbeault, Bouchard, & Bouzouane (2011)	-	A serious game created specifically for patients suffering from Alzheimer; advances in the field of artificial intelligence such as activity recognition and guidance to offer optimal experience through the training sessions.
Lakeside Center for Autism (Microsoft) (2011)	Kinetix Academy	A series of several games for autism by using Kinect in order to stimulate: motor development, use of language and comprehension, use of different cognitive processes and social interactions.
Lin (2011)	-	An augmented reality serious game for facilitating the patients to execute rehabilitative activities without any geographical or time limitations.
Moya, Grau, Tost, Campeny, & Ruiz (2011)	-	A 3D virtual environment for neuro-rehabilitation of the upper limb. Patient wears a special suit with sensors integrated to move one of their arms trying to simulate concrete daily actions, such as grasping a bottle, opening a door or putting a book on a shelf.
Nauta & Spil (2011)	-	A educational diabetes game which aims to enhance a healthy lifestyle by educating and coaching self monitoring, reinforcements and observational learning.
Public Health Agency of Canada (2011)	Buffet busters	A game developed for grade 5 educators and students to promote infectious disease awareness and to introduce concepts related to food and waterborne infectious diseases as well as basic principles of epidemiology.
Queiros et al. (2011)	-	A low-cost laparoscopy simulator, for novice surgeons training, which is able to monitor and assist the trainee's laparoscopy surgical movements.
Red Hill Studios (2011)	-	A collection of therapeutic games for Parkinson's disease patients to increase their balance, designed by Red Hill Studios and the School of Nursing, University of California San Francisco. The games are played by performing movements which are known to be beneficial for balance control and the movements are captured and processed by the system.
Scarle et al. (2011)	Match-3	A serious game designed to combat childhood obesity. The Wii-mote is being used for a rowing action which propels the vehicle forward, while direction is altered by leaning left and right on the Wii balance board.
Schnauer, Pintaric, Kosterink, & Vollenbroek (2011)	-	A chronic pain rehabilitation game provides multimodal interaction including full body motion capture by the use of Kinect, and other bio-signal capture devices. Patients can manage their state and train physically on their own.
The Diablotines (2011)	L' Affaire BIRMAN	This educational game aims to help patients treated by insulin to practice the technique of functional insulin therapy.
Urturi (2011)	-	A serious game for Autism Spectrum Disorder (ASD), oriented to first aid education: what to do in certain situations, basic knowledge about healthcare, medical specialties, etc.

**Table 1.** Review of serious games (continued)

Developer/Author	Game name	Description
Van E, Peper, van A, & Salverda (2011)	-	A set of computer games to help children with spastic cerebral palsy (CP) to loosen the coupling between their hands. Patients were challenged to move both hands simultaneously in various phase relations.
Vazquez (2011)	-	A serious game to promote hand hygiene among health care professionals and citizens. The correct hand hygiene practice and its indications depends on the health care typology, the environment, and the clinical task, focusing specially on five moments for hand hygiene.
Applied Research Associates, Inc. (2012)	HumanSim	An immersive world where doctors and nurses train to learn the nuances of complex, unusual or other error-prone tasks until they become experts.
Cagatay, Ege, Tokdemir, & Cagiltay (2012)	-	A 3D game developed for speech and language disordered children. The game is used during the treatment process of Turkish children with language disorders.
Chan, Qin, Chui, & Heng (2012)	-	A computer based surgical simulator which aims to train an ultrasound-guided needle placement which is a key step in a lot of radiological intervention procedures such as biopsy, local anesthesia and fluid drainage.
e-Learning Studios (2012)	The iSpectrum	This serious game aims to improve the work based social skills and relevant work skills of people with high functioning Autistic Spectrum Disorders (ASD) and Asperger's disorder.
EMCO3 (2012)	MD Advisor	A serious game that allows medical students to test their skills as future doctors such as performing the differential diagnosis in a virtual doctor's office.
GENIOUS Interactive (2012)	Voracy Fish	A serious game for the upper limb rehabilitation. Movements are captured by Kinect, the player dives into a sea universe looking for some treasures and evolves while devouring other fish to become the strongest.
IKARE (2012)	MUCOPlay	A learning game to help caregivers, sufferers and families on cystic fibrosis. The game provides information about the right gestures and the means to validate their knowledge about cystic fibrosis and its care required.
Milo Foundation (2012)	Miloland	A serious game for children with a language delay, aged 9-11 years old but with a mental age of 5-6 years, i.e. starting literacy.
MIRROR project (2012)	CLinIC	The serious games focused on difficult communication between nursing career staff and patients/residents. These games aim to foster reflection around difficult dialogues and to maximize learners ability to self-regulate their training.
Nike + Kinect Training (2012)	Nike+ Kinect Training	An exergame that combines fitness with gaming elements focusing on personalizing training and providing statistics.
SAIC, Inc. (2012)	OLIVE	This serious game aims to train the medical professionals with a set of training data with different scenarios in a virtual hospital.
University Medical Center Utrecht (2012)	Air Medic Sky 1	The interactive bio-feedback game consists of mini-games and lectures which describe the basic concepts required for efficient communication and teamwork resulting in patient safety.
Verduin et al. (2012)	-	A computer simulation designed for alcohol use disorders (AUDs) to practice relapse prevention skills.

## 5. Classification of surveyed serious games for health

Among the literature reviews, which were studied and presented in Section 2.3, Sawyer and Smith (2008) presented an interesting taxonomy on game for health categorized by a set of users (personal, professional, research / academic and public health) cross related with set of serious games objectives (preventive, therapeutic, assessment, educational, and informatics) (Sawyer & Smith, 2008). Compared with their assortment, our survey deals with all their game objectives but for the scope of users, as our study identifies the users as someone who play serious games in order to affect their personal health and therefore, we do not mention the research and academia field of study as users in our survey. According to the divergence in scope and objective of our study, in this section we propose new parameters to categorize serious games for health which leads to four different classifications.

As it is illustrated in Figure 5, our classifications are based on three related subjects: serious game, health and player. Focusing on serious game subjects, we can classify by game purpose and game functionality. For health subject, we can classify by state of disease. Finally, focusing on player subject, two types of players can be considered (player / non player and professional / non professional), and both are included into the same classification. More details of each classification are given below.

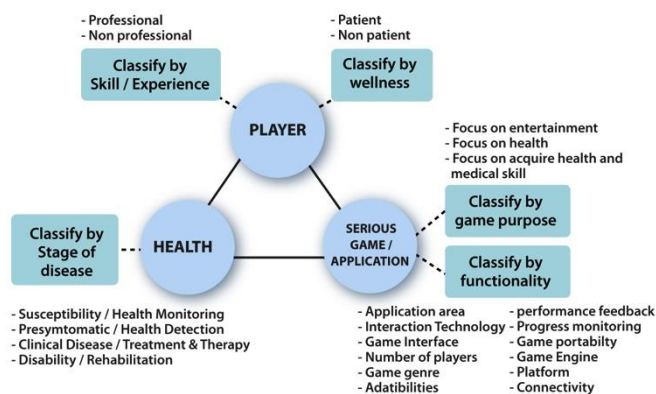


Fig. 5. Classifications of Serious Games for Health

### 5.1. Classification by game purpose

There are three main categories of serious games for health according to their main purpose. We can consider games:

- *Focused on entertainment (FE)*, in this case, in addition to entertainment there is a need to move some parts of the body so the wellness is obtained as a bonus. As an example we can consider Dance Dance Revolution (DDR) ([www.ddrgame.com](http://www.ddrgame.com), 2012) which is the pioneering series of the rhythm and dance genre in video games. The commercial exercise games became famous since Wii (Nintendo, 2012) was released by Nintendo on November 19, 2006. The motion control over the avatar by various accessories inspired people to exercise with the video games.
- *Focused on Health (FH)*, in this case, the main goal is health but the game is used as a tool to pass on knowledge and or skills. To use the capability of the game engine, various serious health contents are conveyed to players. For example, Fatworld ([fatworld.org](http://fatworld.org), 2007), Re-Mission (Tate, Haritatos, & Cole, 2009), Air medic sky 1 (University Medical Center Utrecht, 2012) and many other games described in Section 4.
- *Focused on health acquisition and medical skills (FA)*, in this case, the game has serious use in health purpose regarding to a need of virtual viewpoint or simulation to avoid or concern the risk, safety, budget, etc. Most of the games in this category are simulation games with virtual reality or augmented reality technology such as Virtual dental implant training simulation program (Medical college of Georgia school of dentistry, 2009), Emergency medical services for the disabled virtual environment (EMSAVE) (HCI Lab, University of Udine, 2011), Olive: 3D hospital training (SAIC Inc., 2012), etc.

### 5.2. Classification by functionality

Rego et al. (Rego, Moreira, & Reis, 2010) identify some criteria for the classification of serious games for health. We build upon their criteria and add some more characteristics which we found interesting (some of them have already been defined in Section 2.2). The descriptions of our classification system are based on:

- *Application area* or domain, describes the part of the real world being modeled by the software. In serious games for health, we will distinguish two main aspects: cognitive skills (Cog) such as memory, attention span, concentration and reasoning and motor skills (Mot) such as general coordination or re-learning to walk after injuries.
- *Interaction technology* has the different paradigms for establishing communication between humans and computers. Both hardware and software interfaces are included. Traditionally, mouse and keyboard have been used; newer means of interaction include virtual reality (using head-mounted displays), computer monitors, haptic or pseudo-haptic devices such as gloves or pens, or tracking devices. Webcams and web applications are also common. Patients can affect virtual objects in real-time using a variety of senses

(vision, hearing and touching).

- *Game interface* is related with the virtual world inside the game which can simulate the real world in three-dimensions (3D) or provide a top-bottom or sideways perspective of a simpler world with two-dimensions (2D).
- *Number of players* concurrently using the world of the game. In general, we distinguish single player games (for one person) and multiplayer games (for two or more people).
- *Game genre* is a categorization according to gameplay; we can distinguish adventure, strategy, simulation, sports and puzzles, among others. In games for health, the games which evaluate coordination and movement are common in rehabilitation; other genres are also used for different tasks.
- *Adaptability* (Yes/No) represent adaptability of the difficulty according to the skill of the player, in order to increase playability and enjoyment. Traditional games which to have a fixed level of difficulty, which could either be programmed or chosen before the game started. In health, adaptability is an excellent trait because it allows the patient to test and separate his limits in a controlled manner.
- *Progress monitoring* (Yes/No) is an advantage function for patient evaluation; having logs of the patients actions inside the game can be an invaluable asset. We call this feature progress monitoring, since it allows the doctors to monitor the progress of the patients as a function of time.
- *Performance Feedback* (Yes/No) are the indications of the game dealing with showing the users their status and abilities. They allow patients to feel confident they are progressing and to detect and fix their failures. The feedback can be audio, visual or haptic.
- *Game portability* (Yes/No) refers to being able to physically move the game hardware. In particular, we distinguish games located at a hospital or clinic, and games which can be used at home or which can be held portably by the user.
- *Game engine* is a platform which provides commonly used functionality in games, so that game developers can focus on higher level game design and functionality. The engine provides an API to access lower level functionality and a set of predefined models and materials and scenes (Cheng-yong & Wei-ming, 2010).
- *Platform* means hardware the game runs on. This may include personal computers (PCs), commercial game consoles (Nintendo Wii, Microsoft Xbox), portable consoles or custom hardware.
- *Connectivity* is an ability to link to and communicate with other computer systems, electronic devices, software, or the Internet. Games might require an internet or network connection (online) or they may be played in standalone computers (offline).

### 5.3. Classification by stage of disease

This classification is based on the stage of the disease the game is focused on. Following the classification proposed by Merrill (2010), we can consider the four different categories, represented in Figure 6, together with the purpose of the game, as described below.

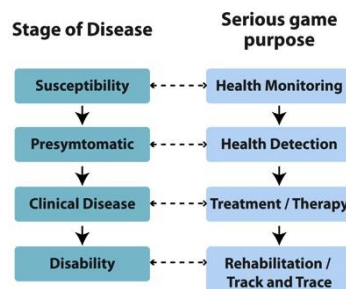


Fig. 6. Serious games purpose relate to stage of disease

- *Susceptibility Stage*: This is the first stage, in which the person is still healthy. A serious game in this stage helps the user to familiarize with monitoring procedures, and with illnesses that he or she could develop later in life. Environmental risks or unhealthy surroundings can also affect the probability of developing illnesses.



- **Pre-symptomatic Stage:** In this stage, people still feel healthy although the illness is already present. For example, the number of virus particles may still be too small to produce a response in the body, or a failing organ may still be able to cope with the added pressure of the illness with no external indications. The beginning of this stage may be discovered by the periodic checkups mentioned above. In this stage, the specific illness is now known, and the chances of developing it are very high, so more focused serious games can be used to show the patient the relevant aspects of his illness and his treatment. EEG-based serious games (Wang, Sourina, & Nguyen, 2010) and PlayWithEyes (Bortoli & Gaggi, 2011) are an example.
- **Clinical Disease Stage:** In this third stage, the symptoms of the illness are already manifest in the patient. If the illness was not detected in the previous stages, serious games can be used to familiarize the patients with the expected progression of their illness, and the treatment procedures. Alternative treatments can also be shown using games. Games intended to be played by doctors or other medical staff usually focus on this stage as well. The examples are Social skills (Bartolome, Zorrilla, & Zapirain, 2010), Speech disorder children therapy (Cagatay M, Ege, Tokdemir, & Cagiltay N, 2012) and Improve bimanual coordination in children with spastic cerebral palsy (Loon, Peper, Rijt, & Salverda, 2011).
- **Recovery, Disability Stage:** In this last stage of the illness, two different outcomes are possible: the illness may be cured, returning the patient to health or to another stage of susceptibility, or it may have serious effects on the patient's health, making them unable to function at previous levels (disability). Serious games in this stage normally deal with the rehabilitation procedure, or helping the patient cope with their disabilities such as Neuropsychological rehabilitation (Grau, Tost, Campeny, Moya, & Ruiz, 2010), Chronic pain rehabilitation (Schnauer, Pintaric, Kosterink, & Vollenbroek, 2011), Upper limb rehabilitation following stroke (Burke et al., 2009), After Parkinson's disease (Red Hill Studios, 2011).

#### 5.4. Classification by player's wellness (patient/non-patient)

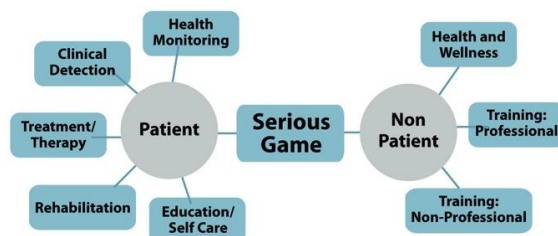


Fig. 7. Classification of Serious Games for Health by player

Regarding the definition of health, referred in Section 1, which covered both patients and non-patients, we classified serious games according to these two target players (see Figure 7) and described as following.

##### 5.4.1. Serious games for patients

Serious games for patients can be classified according to the use into five different categories which are:

- **Health Monitoring** aims to keep an eye on patient health by monitoring the bio-signal. Mostly use the application software with the help of the networking technology such as Heart failure telemanagement system (Finkelstein, Wood, Cha, Orlov, & Dennison, 2010), Healthcare monitoring (Fergus, Kifayat, Cooper, Merabti, & Rhalibi, 2009) and the U-health monitoring system (Lee, Kim, Kim, Lee, 2009).
- **Detection** focuses on analysis or trace the irregularity symptom of the patient. For example Unobtrusive health (Mckanna, Jimison, & Pavel, 2009), EEG-based serious games (Wang, Sourina, & Nguyen, 2010) and PlayWithEyes (Bortoli & Gaggi, 2011).
- **Treatment** or therapy is used to remedy a health problem. The examples are Match-3 (Scarle et al., 2011), Diagnosis and management of Parkinson (Atkinson & Narasimhan, 2010) Social skills (Bartolome, Zorrilla, & Zapirain, 2010) and Speech disorder children therapy (Cagatay, Ege, Tokdemir, & Cagiltay, 2012).
- **Rehabilitation** is a restoration of health and life skills after illness such as Neuropsychological rehabilitation (Grau, Tost, Campeny, Moya, & Ruiz, 2010), Chronic pain rehabilitation (Schnauer,



Pintaric, Kosterink, & Vollenbroek, 2011) and Upper limb rehabilitation following stroke (Burke et al., 2009).

- *Education* for self/directed care to increase understanding about the disease or health problems and learning how to get and stay more healthy with them. The examples are Re-Mission (Tate, Haritatos, & Cole, 2009), Serious game for diabetes (Nauta & Spil, 2011), First aid education for autism spectrum disorder (Urturi, Zorrilla, & Zapirain, 2011) and Cognitive training for Alzheimer (Imbeault, Bouchard, & Bouzouane, 2011).

#### 5.4.2. Serious games for non-patient

Serious games for non-patient can be classified according to the use into three different categories which are:

- *Health & wellness* focuses more on lifestyle issues and their relationships with functional health. We have surveyed the serious games regarding to the Alameda county study (Housman & Dorman, 2005) which suggested that people can improve their health via 1) exercise, 2) enough sleep, 3) maintaining a healthy body weight, 4) limiting alcohol use, and 5) avoiding smoking. The examples are Sensory gate-ball game (Kim, Kang, Yang, & Kim, 2009), Dancing in the streets (DITS) (Cheng-yong & Wei-ming, 2010), Fitness adventure (Laikari, 2009), Virku (Vtinen & Leikas, 2009) and Mo-Fun circus (Nordic Innovation Centre, 2007).
- *Training and Simulation for professional* are serious games used as learning and practicing tools for the professional in health and medical career such as doctors, nurse, etc. The examples are HumanSim(Preview) (Applied Research Associates, Inc., 2012), Virtual dental implant training simulation program (Medical College of Georgia School of Dentistry faculty and students, 2009; BreakAway, Ltd., 2010), Nursing and midwifery (Skills2Learn, Ltd., 2010), Pulse: the virtual clinical learning lab (Alhadeff, 2007) and Emergency medical services for the disabled (EMSAVE) (HCI Lab, University of Udine, 2011; Vidani, Chittaro, & Carchietti, 2010).
- *Training and Simulation for non-professional* are games used for layperson to learn to improve their healthcare. In this group here are games such as Fatworld (Fatworld.org, 2007), The food detectives fight BAC! game (The Partnership for Food Safety Education, 2008), Hand hygiene training (Vazquez, Santana, Skodova, Ferrero, & Torres, 2011) and Nutri-trainer (Gago, Barreira, Carrascosa, & Segovia, 2010).

To complete all the classifications above, next we are going to present the serious games for health using the characteristics of our classifications in this section.

## 6. Results

In this section, we present the surveyed games with respect to the different classifications proposed earlier. To better present the results, we create Table 2 that collect the information of games designed for patients and non-patients. All tables have the same column structure. From left to right, column (1) contains the name or the author of the game together with the publication year and column (2), presents the disease related to the game (or general health if no specific disease is mentioned). Column (3) presents purpose, following the classification of Section 5.1, where FE represents focused on entertainment, FH focused on health and FA focused on health acquisition and medical skills. From columns (4) to (15), we present the information according to the classification by functionality (see Section 5.2). Column (4) is the application area which can be motor (Mot) or cognitive (Cot). Column (5) shows the tool that players use to connect to the game. Column (6) is game interface that can be 2D or 3D. Column (7) represents the number of players: single or multi player. Column (8) is the game genre that can be action, puzzle, simulation, etc. From columns (9) to (12), we represent adaptability, progress monitoring, feedback and portability. These columns are filled with three symbols (Y, N and -), where Y and N represent yes and no, and (-) represents that this feature is not mentioned in the game description. Columns (13) and (14) represent the engine/tool and the platform, respectively. Finally, column (15) shows connectivity that can be online (On) or offline (Off). The tables have a different row structure. In Table 2, rows have been grouped according to the classification by player's wellness for patients (see Subsection 5.4.1), from top to bottom, which are health monitoring, detection, treatment,

rehabilitation, and education for self/directed care (self-education). We continue with the classification by player's wellness for non-patients (see Subsection 5.4.2). In this case, we consider three different categories, from top to bottom, health & wellness, training and simulation for professional and finally, training and simulation for non-professional.

**Table 2.** Classification and Comparison of Health Games form our survey

Author	Disease	Purpose	Application Area	Interactive tool	Interface	Players	Genre	Adaptability	Progress Monitoring	Feedback	Portability	Engine / Tool	Platform	Connectivity
<b>Detection (Patient)</b>														
Mckanna et al. (2009)	Alzheimer	FH	Cog	Mouse	2D	Single	Puzzle	Y	Y	N	Y	-	PC	Off
Wang et al. (2010), Brain Chi	Neurofeedback	FH	Cog	EEG	2D	Single	Action	-	-	-	N	-	PC	Off
Wang et al. (2010), Dancing Robot	Neurofeedback	FH	Cog	EEG	3D	Single	Action	-	-	-	N	-	PC	Off
De Bortoli and Gaggi (2011)	Eye Test	FH	Mot	Touch	2D	Single	Puzzle	Y	Y	Y	Y	SDK	iPad	Off
<b>Treatment (Patient)</b>														
Johnston and Duskin (2004)	Cancer	FA	Cog	Mouse	3D	Multi	Adventure	Y	-	Y	Y	-	PC	Off
Believe in Tomorrow (2006)	Chronic painning	FH	Cog	VR Headset	3D	Single	Action	-	-	Y	Y	Tailor-Made	PC	Off
Hatfield (2008)	Quit Smoking	FH	Cog	Mix	2D	Single	Action	Y	Y	-	Y	-	Mix	On
Vermont department of health (2008)	Quit Smoking	FH	Cog	Mouse	3D	Single	Action	Y	Y	-	Y	Unity3D	PC	On
Akinson and Narasimhan (2010)	Parkinson	FH	Cog	Novint	2D	Single	Action	Y	-	-	Y	SDK	PC	Off
Bartolome et al. (2010)	Neuro-disability	FH	Cog	Wiimote	3D	Single	RPG	Y	Y	Y	Y	Director	PC	Off
Finkelstein et al. (2010)	Autism	FH		VR	3D	Single	Exergame	Y	Y	Y	Y	Tailor-Made	PC	Off
Botella et al. (2011)	Cockroach phobia	FA	Cog	Camera	3D	Single	Puzzle	Y	Y	Y	Y	J2ME	Mobile	Off
Lakeside Center for Autism (2011)	Autism	FA	M+C	Kinect	3D	Single	Simulation	Y	Y	Y	Y	-	Xbox360	Off
Scarle et al. (2011)	Obesity	FH	Mot	WiiFit	3D	Single	Adventure	Y	-	Y	Y	-	Wii	Off
Van Loon et al. (2011)	Cerebral palsy	FH	Mot	External	-	Single	Action	Y	Y	Y	Y	D-Flow	PC	Off
Cagatay et al. (2012)	Speech disorder	FH	Cog	Mouse	3D	Single	RPG	Y	Y	Y	Y	Unity3D	PC	Off
e-Learning Studios (2012)	Autism	FH	Cog	Mouse	3D	Single	RPG	Y	Y	Y	Y	Unity3D	PC	Off
<b>Rehabilitation (Patient) (continuing on next page)</b>														
Edheads (2007)	Knee Surgery	FH	Cog	Mouse	2D	Single	Action	N	Y	N	Y	Flash	PC	On
Burke et al. (2009), Arrow attack	Stroke	FH	Mot	Webcam	2D	Single	Action	Y	Y	Y	Y	XNA	PC	Off
Burke et al. (2009), Catch task	Stroke	FH	Mot	VR	3D	Single	Action	Y	Y	Y	Y	ORGE	PC	Off
Burke et al. (2009), Rabbit chase	Stroke	FH	Mot	Webcam	2D	Single	Action	Y	Y	Y	Y	XNA	PC	Off
Burke et al. (2009), Virtual vibraphone	Stroke	FH	Mot	Wiimote	2D	Multi	Action	Y	Y	Y	Y	-	PC	Off
Burke et al. (2009), Whack a mouse	Stroke	FH	Mot	HMDs	3D	Single	Action	Y	Y	Y	Y	-	PC	Off
Deponti et al. (2009)	Wrist injury	FH	Mot	Mobile	2D	Single	Exergame	Y	Y	Y	Y	-	Android	Off
Fishing Cactus (2010)	Organizational Problem	FH	Cog	Kinect	3D	Single	Puzzle	Y	Y	Y	Y	-	Xbox360	Off

**Table 2.** Classification and Comparison of Health Games form our survey (continue)

Author	Disease	Purpose	Application Area	Interactive tool	Interface	Players	Genre	Adaptability	Progress Monitoring	Feedback	Portability	Engine / Tool	Platform	Connectivity
<b>Rehabilitation (Patient) (continuing from last page)</b>														
Grau et al. (2010)	Nero illness	FH	Cog	Mouse	3D	Single	RPG	Y	-	Y	Y	-	PC	Off
Lin (2011)	General Health	FH	Mot	Webcam	3D	Single	Puzzle	Y	Y	Y	Y	ARToolKit	PC	On
Moya et al. (2011)	Upper limb injury	FH	Mot	Sensor	3D	Single	Action	Y	Y	Y	Y	-	PC	Off
Red Hill Studios (2011)	Parkinson	FH	Mot	Sensor	2/3D	Single	Mix	Y	Y	-	Y	Tailor-Made	PC	-
Schnauer et al. (2011)	Chronic pain	FH	Mot	Kinect	3D	Single	Adventure	Y	Y	Y	N	Unity3D	PC	Off
GENIOUS Interactive (2012)	Upper limb rehabilitation	FH	Mot	Kinect	3D	Multi	Adventure	Y	Y	Y	Y	-	Multi	On
Milo Foundation (2012)	Language Disabilities	FH	Cog	Touch	3D	Single	Adventure	Y	Y	Y	Y	Unity3D	iPad	Off
<b>Education (Patient)</b>														
Hopelab (2009)	Cancer	FH	Cog	Mouse	3D	Single	Adventure	Y	Y	Y	Y	-	PC	Off
CCCP (2011)	General Health	FH	Cog	Mouse	2D	Single	Simulation	Y	Y	Y	Y	Flash	PC	On
Fuchslocher et al. (2011)	Diabetes	FH	Cog	Mouse	2D	Single	Adventure	Y	Y	Y	Y	-	PC	-
Imbeault et al. (2011)	Alzheimer	FH	Cog	Mouse	3D	Single	Action	Y	Y	Y	Y	Torque	PC	Off
Nauta and Spil (2011)	Diabetes	FH	Cog	Mouse	3D	Single	Adventure	N	Y	N	Y	Flash	PC	On
The Diablotines (2011)	Diabetes	FH	Cog	Mouse	2D	Single	Adventure	Y	Y	Y	Y	-	PC	Off
Urturi (2011)	Autism	FH	Cog	Mobile	2D	Single	Quiz	Y	Y	Y	Y	-	Mobile	On
IKARE (2012)	Cystic Fibrosis	FH	Mot	Mouse	3D	Single	Puzzle	Y	Y	Y	Y	-	PC	On
Verduin et al. (2012)	AUDs	FH	Cog	Mouse	2D	Single	Puzzle	Y	Y	Y	Y	-	PC	-
<b>Health and Wellness (Non-Patient) (continuing on next page)</b>														
Montreal Science Centre (2004)	General Health	FH	Cog	Mouse	2D	Single	Puzzle	N	N	Y	Y	Flash	PC	On
Respondesign (2004)	General Health	FH	Mot	Kinect	3D	Single	Exergame	Y	Y	Y	Y	Unity3D	PC	Off
Nintendo (2005)	Brain Health	FH	Cog	Button	2D	Single	Puzzle	Y	-	Y	Y	-	DS	Off
Gameloft (2006)	Brain Health	FH	Cog	Mix	2D	Single	Puzzle	Y	-	Y	Y	-	Mix	Off
McGill University (2006)	Chi	FH	Cog	Mouse	2D	Single	Puzzle	Y	-	Y	Y	Flash	PC	On
Intelligent System (2007)	Face Exercise	FH	Mot	Camera	2D	Single	Action	-	Y	-	Y	-	DS	Off
Nintendo EAD (2007)	General Health	FH	Mot	Wii Balance Board	3D	Multi	Exergame	Y	Y	Y	Y	-	Wii	On
Nordic Innovation Centre (2007)	General Health	FH	Mot	Camera	2D	Multi	Action	-	Y	-	N	-	PC	Off
SEGA (2007)	Brain Health	FH	Cog	Button	2D	Single	Mix	Y	-	Y	Y	-	DS	Off
BBG Entertainment GmbH (2009)	Brain Health	FH	Cog	Mouse	2D	Single	Puzzle	Y	Y	-	Y	-	PC	Off
Blitz Games Studios (2009)	General Health	FH	Mot	Wii Balance Board	3D	Single	Exergame	Y	Y	-	Y	-	Wii	Off
Collision Studios (2009)	General Health	FH	Mot	Wii Balance Board	3D	Single	Exergame	Y	Y	-	Y	-	Wii	Off
Kim et al. (2009)	General Health	FH	Mot	Sensor	3D	Single	Sport	Y	Y	Y	N	-	PC	Off
Laikari (2009)	General Health	FH	Mot	RFID	2D	Single	Exergame	Y	Y	Y	Y	SMAC	Mobile	On

**Table 2.** Classification and Comparison of Health Games form our survey (continue)

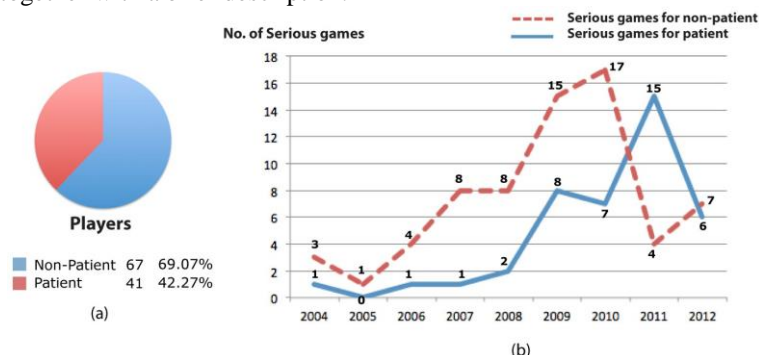
Author	Disease	Purpose	Application Area	Interactive tool	Interface	Players	Genre	Adaptability	Progress Monitoring	Feedback	Portability	Engine / Tool	Platform	Connectivity
<b>Health and Wellness (Non-Patient) (continuing from last page)</b>														
Lightning Fish Games (2009)	General Health	FH	Mot	Wii Balance Board	3D	Single	Exergame	Y	Y	Y	Y	-	Wii	On
Raylight (2009)	Eyes and Ears Health	FH	Mot	Mouse	2D	Single	Puzzle	Y	Y	Y	-	-	DS	Off
Succubus Interactive (2009)	Over Alcohol	FH	Cog	Mouse	2D	Single	Adventure	Y	Y	N	Y	Flash	PC	On
Vtnen and Leikas (2009)	General Health	FH	Mot	Cycle	3D	Single	Exergame	Y	Y	-	N	-	PC	Off
Anchor Bay Entertainment (2010)	General Health	FH	Mot	Wii Balance Board	3D	Single	Exergame	Y	Y	Y	Y	-	Wii	Off
Clawson et al. (2010)	General Health	FH	Mot	Sensor	2D	Single	Exergame	N	Y	N	Y	-	Mobile	Off
Electronic Arts (2010)	General Health	FH	Mot	Mix	3D	Multi	Exergame	Y	Y	Y	Y	-	Mix	Off
HopeLab (2010)	Obesity	FH	Mot	Accelerometer	2D	Single	Exergame	N	Y	N	Y	-	Multi	On
Ubisoft Divertissements (2010)	General Health	FH	Mot	Kinect	3D	Multi	Exergame	Y	Y	Y	Y	-	Xbox360	Off
Zumba Fitness (2010)	General Health	FH	Mot	Kinect	3D	Multi	Action	Y	-	Y	Y	-	Mix	On
Nike + Kinect Training (2012)	General Health	FH	Mot	Kinect	3D	Single	Exergame	Y	Y	Y	Y	-	Xbox360	On
<b>Training for Professional (Non-Patient) (continuing on next page)</b>														
BreakAway (2007)	Injuries	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Tailor-Made	PC	Off
Anderson (2008)	Maternal Child Health	FH	Cog	Mouse	-	Single	RPG	Y	Y	Y	Y	-	PC	Off
Glasgow Caledonian University (2008)	General Health	FA	Cog	Mouse	3D	Single	Simulation	-	-	-	Y	Second Life	PC	On
Imperial College (2008)	Respiratory illness	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Second Life	PC	On
Mili et al. (2008)	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	-	PC	On
Sliney and Murphy (2008)	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Torque	PC	On
TruSim (2008), Triage Trainer	Triage	FA	Cog	Mouse	3D	Single	Simulation	-	Y	Y	-	TruSim	PC	Off
Keele University (2009)	General Health	FA	Cog	Voice Record	3D	Single	Simulation	Y	Y	Y	Y	-	PC	On
Virtual Heroes (2009)	General Health	FH	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Unreal	PC	-
BreakAway (2010)	Dental	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Tailor-Made	PC	Off
Innovation in Learning (2010)	General Health	FA	Cog	Mouse	3D	Multi	Simulation	-	Y	Y	Y	-	PC	Off
KTM Advance (2010)	General Health	FA	Cog	Mouse	3D	Single	Simulation	-	Y	-	Y	Flash	PC	On
Miller (2010)	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	-	PC	On
Sabri et al. (2010)	Knee Replacement	FA	Cog	Mouse	3D	Multi	Simulation	Y	Y	Y	Y	Tailor-Made	PC	On
Skills2Learn (2010)	Pregnancy	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	-	PC	Off
TruSim (2010), Patient Rescue	General Health	FA	Cog	Mouse	3D	Single	Simulation	-	Y	Y	-	TruSim	PC	Off
Vidani et al. (2010)	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	NeoAxis	PC	Off
Visual Imagination Software (2010)	General Health	FA	Cog	Mouse	3D	Single	Adventure	Y	Y	-	Y	Star Force 3D	PC	Off

**Table 2.** Classification and Comparison of Health Games form our survey (continue)

Author	Disease	Purpose	Application Area	Interactive tool	Interface	Players	Genre	Adaptability	Progress Monitoring	Feedback	Portability	Engine / Tool	Platform	Connectivity
<b>Training for Professional (Non-Patient) (continuing from last page)</b>														
Diehl et al. (2011)	Diabetes	FH	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Flash	PC	Off
Queiros et al. (2011)	General Health	FA	Cog	Laparoscopic	3D	Single	Simulation	Y	Y	Y	Y	XNA	PC	Off
Applied Research Associates (2012)	General Health	FA	Cog	Touch	3D	Single	Simulation	Y	Y	Y	Y	Unreal	iPad	Off
Chan et al. (2012)	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Tailor-Made	PC	Off
EMCO3 (2012)	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	-	Multi	Off
MIRROR project (2012)	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Unity3D	PC	Off
SAIC (2012)	General Health	FA	Cog	Mouse	3D	Multi	Simulation	Y	Y	Y	Y	-	PC	On
University Medical Center Utrecht (2012)	General Health	FA	Cog	Bio-Feedback	3D	Multi	Simulation	Y	Y	Y	Y	-	PC	On
<b>Training for Non-Professional (Non-Patient)</b>														
MIT Teacher Education Program (2004)	Avian influenza	FH	Cog	Button	2D	Single	Action	-	-	Y	Y	-	Pocket PC	On
Archimage (2006)	Diabetes	FH	Cog	Mouse	3D	Single	Adventure	Y	-	Y	Y	-	PC	Off
Janomedia (2006)	Nutrition	FH	Cog	Mouse	2D	Single	Action	Y	-	Y	Y	Flash	PC	On
Nordic Innovation Centre (2007), MC Urho	General Health	FH	Cog	Mouse	2D	Single	Puzzle	Y	N	-	Y	Flash	PC	On
Nordic Innovation Centre (2007), Valion Energiasummaaja	General Health	FH	Cog	Mouse	2D	Single	Quiz	Y	Y	-	Y	Flash	PC	On
Fatworld.org (2007)	Obesity	FH	Cog	Mouse	2D	Single	RPG	Y	Y	Y	Y	Flash	PC	Off
Food Safety Education (2008)	General Health	FH	Cog	Mouse	2D	Single	Puzzle	Y	Y	N	Y	Flash	PC	On
Warner Bros. (2008)	AIDS	FH	Cog	Mouse	3D	Single	Adventure	-	Y	-	Y	-	PC	Off
Learning Games Lab (2009)	General Health	FH	Cog	Mouse	2D	Single	Adventure	Y	Y	N	Y	Flash	PC	On
Persuasive Games (2009)	Flu	FH	Cog	Mouse	2D	Single	Action	-	Y	N	Y	Flash	PC	On
QOVEO (2009)	H1N1	FH	Cog	Mouse	2D	Single	Action	N	Y	N	Y	Flash	PC	On
RANJ Serious Games (2009)	Flu	FH	Cog	Mouse	2D	Single	Strategy	N	Y	N	Y	Flash	PC	On
Gago et al. (2010)	General Health	FH	Cog	Touch	2/3 D	Single	Puzzle	Y	Y	Y	Y	WPF	Mobile	On
Association RMC / BFM (2011)	Cardiac arrest	FH	Cog	Touch	3D	Single	Simulation	Y	Y	Y	Y	-	Multi	On
Public Health Agency of Canada (2010)	Epidemics	FH	Cog	Mouse	2D	Single	Adventure	N	N	N	Y	Flash	PC	On
Vazquez (2011)	General Health	FH	Cog	Mouse	2D/3D	Single	Action	Y	Y	Y	Y	Flash	PC	On

## 7. Discussion

The information collected from Table 2 has been used to compare the characteristics of the surveyed serious games with respect to different parameters. Below, from Figures 8 to 24, we present the obtained results by a graphical summary together with a brief description.



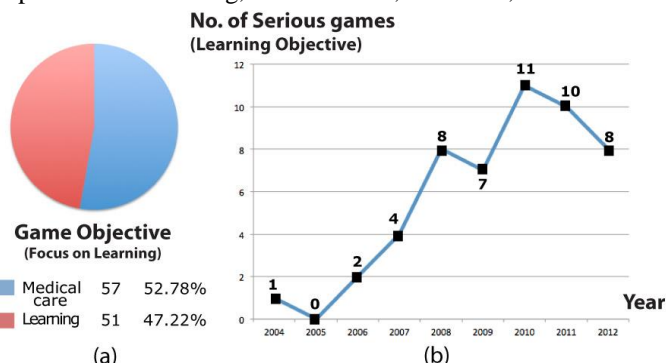
**Fig. 8.** Breakdown of the "Players" values present in our survey (a) and number of serious games designed for patients and non patients according to the year of publication (b)

Figure 8 shows the production of games according to the player (patient, non-patient). In Figure 8(a) we illustrate the number of games for patients with respect to games for non patients. We observe that serious games for non patient are about twenty seven percent more common than serious games for patient. In Figure 8(b), we present the evolution of game production, according to the year of publication, distinguishing between games for patient and non patient. We will see that the maximum of the production is reached in 2010. Then in 2011, the interest on serious games for patient increases. The intersection point in 2010-2011 indicate that the interest in serious games for patient may be higher than that of serious games for non patient in the future.



**Fig. 9.** Breakdown of the "Game Objective" values present in our survey

Focusing on the objectives of serious games developed (Figure 9), we can see that their objectives are quite varied, but an emphasis can be seen on professional training and health & wellness (almost a quarter) followed by serious games for non professional training, rehabilitation, treatment, education and detection respectively.



**Fig. 10.** Breakdown of the "Serious Games Objective" values focus on "learning" (a) and number of serious games objective focus on learning according to the year of publication (b)



We classified serious games for the learning purpose (professional training, non professional training and self education) from medical care as illustrated in Figure 10. We see that number of serious games for learning in our survey is almost half of them (Figure 10(a)). The trend of serious games focused on learning objective is moving up even though the graph shows the fluctuation of the number of serious games published per year until now, see Figure 10(b).

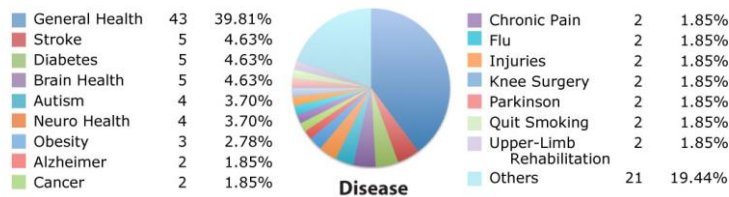


Fig. 11. Breakdown of the "Disease" values present in our survey

Figure 11 presents the distribution of serious games according to the disease for which they have been designed. The chart shows the wide variety of the use of serious games in many different diseases. About forty percent of the serious games are designed for general health. With specific disease, stroke is the most commonly addressed disease followed by diabetes, brain health and autism respectively. We notice that most all of serious games for health & wellness and training for nonprofessional are made for general health purposes. On the other hand, there are no serious games for general health presented in patient detection and treatment purposes.

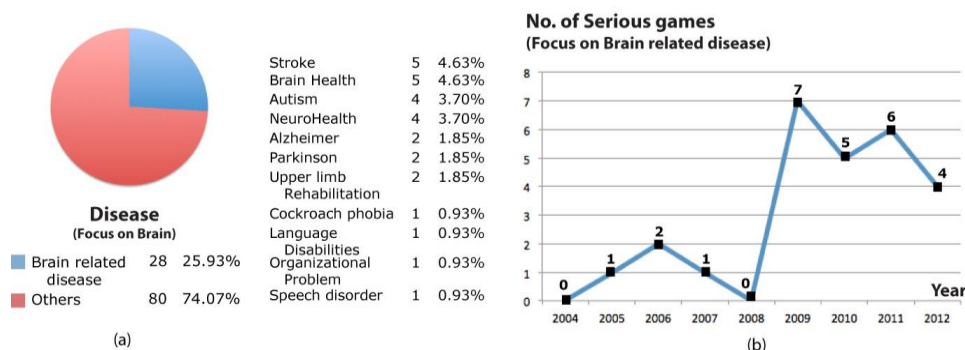


Fig. 12. Breakdown of the "Brain's Disease" values present in our survey (a) and numbers of surveyed serious games for health according to Brain's Disease according to the year of publication (b)

Figure 12 presents the production of the serious games focusing on the diseases related to the brain which amount to a quarter of all games, see Figure 12(a). We observe that the interest in brain related disease became higher during the year 2009 and the number of games published fluctuates every year.

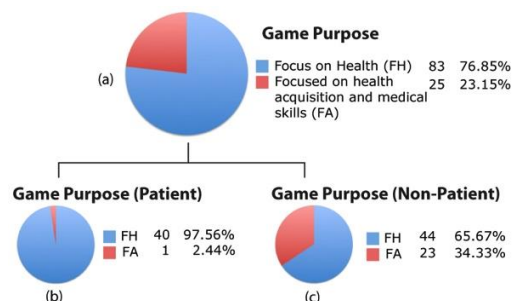
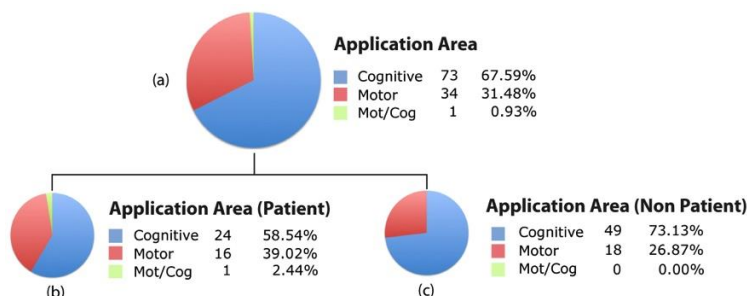


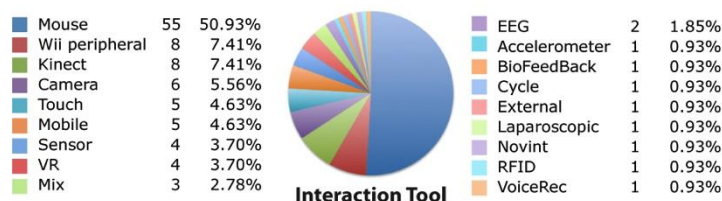
Fig. 13. Breakdown of the "Game Purpose (a)", "Game Purpose for patient (b)" and "Game Purpose for non-patient (c)" values present in our survey

Focusing on the game purpose by the classification in Section 5.1, Figure 13 presents the distribution of serious games according to its purpose. In the top chart, Figure 13(a) we can see that an amount of three quarter of serious games focused on health while a quarter focus on health acquisition and medical skills; 88 percent (23 out of 26) of serious games for professional training are in this group. Furthermore, we classified game purpose according to the player (patient and non patient) as shown in Figures 13(b) and (c), we will see that almost all serious games for patient are focused on health. On the other hand, serious games for non patient focused on health are approximately thirty percent more than the one focused on health.



**Fig. 14.** Breakdown of the "Application Area (a)", "Application Area for patient (b)" and "Application Area for non-patient (c)" values present in our survey

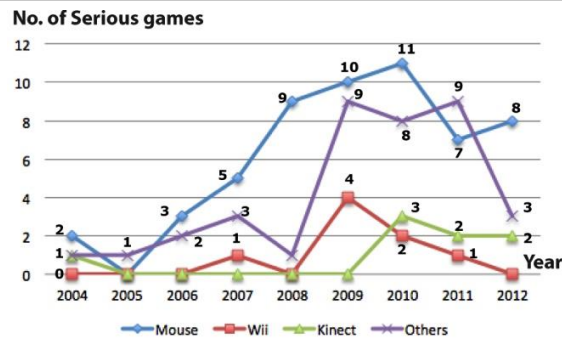
Focusing on application area, Figure 14 shows that both motor and cognitive abilities are well represented in our survey. An amount of two third of serious games are for cognitive improvement while one third serious games for motor improvement and only one of the a hundred and eight surveyed has been designed to improve both cognitive and motor skills. Almost all (50 out of 51) of the serious games for education purpose (self education, training for both professional and non-professional) are focused on cognitive skills. On the other hand two third (18 out of 25) of the serious games for health & wellness purpose are designed for motor skills. From Figures 14(b) and (c) which present the number of application area for patient and non patient, we will see that the number of motor improvement games for patient (16) and non patient (17) is similar.



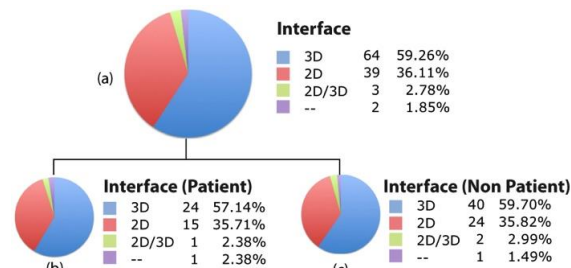
**Fig. 15.** Breakdown of the "Interaction Tool" values present in our survey

Figure 15 presents the distribution of surveyed serious games according to interaction tools. The results are quite varied, however the standard mouse interface is used in about half of the games, followed by Wii peripheral, Kinect, camera and touch screen respectively.

Additionally, if we focus on Figure 16 where we show the distribution of games according to the top four interaction tools and the year of publication we will see that mouse is in the leader position except in the year 2011 which was led by other tools.

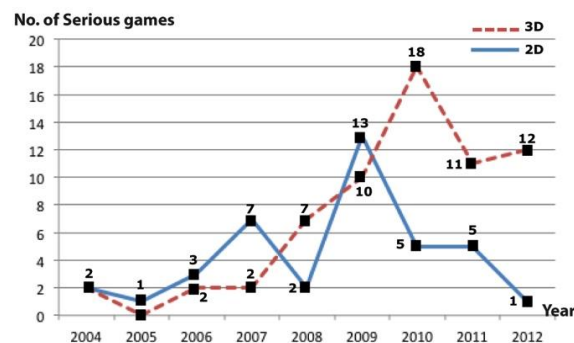


**Fig. 16.** Numbers of surveyed serious games for health according to "Top four Interaction Tool" according to the year of publication



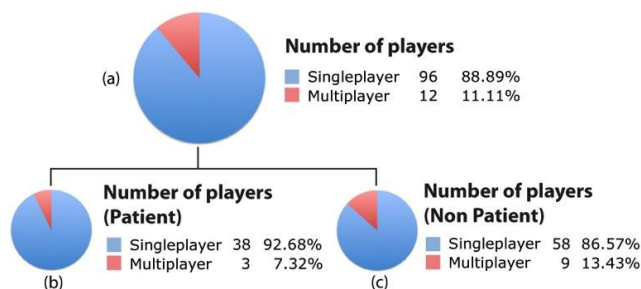
**Fig. 17.** Breakdown of the "Interface (a)", "Interface for patient (b)" and "Interface for non patient (c)" values present in our survey

Focusing on the graphic user interface, Figure 17(a) presents that 2D and 3D interfaces are both well represented in the surveyed games. However, the number of 3D games is twenty five percent more than 2D games. We also observe that almost all (24 out of 26) of the interface for professional training have a 3D interface. The 3D interface also shows major amounts in both serious game for patient and non patient which can be seen in Figures 17(b) and (c).



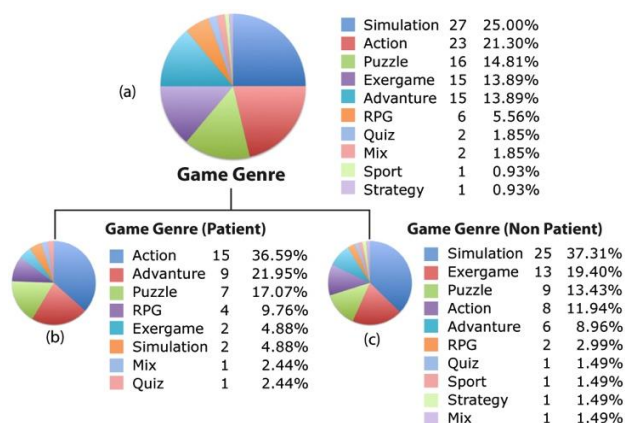
**Fig. 18.** Number of "2D and 3D Interface" in our survey according to the year of publication

Figure 18 presents the evolution of both 2D and 3D interface in our surveyed serious games according to the year of publication. We see that the trend of 3D interfaces is growing up in average since 2007, with the maximum value on year 2010. At the same time, the 2D interface graph fluctuated from 2007 to 2009 then dropped since year 2009. We can say that the interest in 3D interfaces overcame 2D interface since 2010.



**Fig. 19.** Breakdown of the "Number of players (a)", "Number of players for patient (b)" and "Number of players for non patient (c)" values present in our survey

Figure 19 reports the distribution of our surveyed serious games according to the number of players. We will see from Figure 19(a) that most of the games (9 out of 10) are currently single player. Multi player is presented in the health & wellness game most, follow by serious game for professional training. Figures 19(b) and (c) show that multi player are represented in serious games for non patient rather than serious games for patient.



**Fig. 20.** Breakdown of the "Game Genre (a)", "Game Genre for patient (b)" and "Game Genre for non patient (c)" values present in our survey

Figure 20 illustrates the distribution of the surveyed serious games according to game genre. Figure 20(a) shows that the Simulation and Action genres dominate, followed by Puzzle, Exergame and Adventure respectively, although there is a large variety of other genres. Almost all of serious games for professional training are 3D simulation genre (24 out of 26). Although action game is used for many objectives (treatment, health & wellness, etc.) the most important one is rehabilitation, as well as an exergame which is prominent genre on serious games for health & wellness. From Figure 20(b), the top three game genres for patient are action, adventure and puzzle. From Figure 20(c) we can see that the top three game genres for non patient are simulation, exergame and puzzle genre.



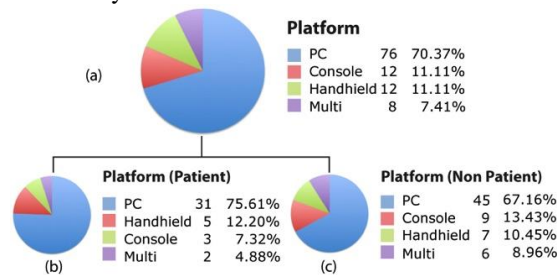
**Fig. 21.** Breakdown of the "Adaptability (a)", "Progress Monitoring (b)", "Performance Feedback (c)" and "Portability (d)" values present in our survey

Figure 21 presents the statistics on our survey (from left to right) in adaptability, progress monitoring, performance feedback and portability respectively. All are an important features, with useful characteristics, and are included in the majority of the serious games as mentioned in Section 5.2. These charts show that each of these functionalities is considered as major (more than three quarters of the surveyed serious games implement them).



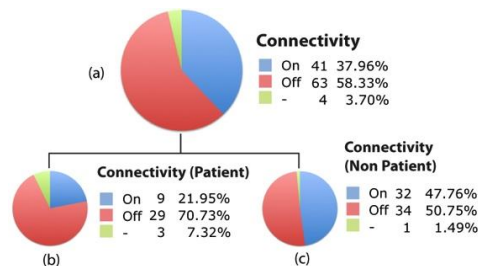
**Fig. 22.** Breakdown of the "Game Engine" values present in our survey

About the production tools, Figure 22 shows a wide variety of engines used in surveyed serious games, although this is not an often reported characteristic. Flash is the engine used most often, by a wide margin, follow by tailor made engines and Unity3D.



**Fig. 23.** Breakdown of the "Game Platform (a)", "Game Platform for patient (b)" and "Game Platform for non patient (c)" values present in our survey

Figure 23 presents the distribution of our surveyed serious games according to game platform. From Figure 23(a) we will see that there are a few used platforms, most of the games (two third) have been designed to run on personal computer followed by console and handheld platform. There are some serious games which were developed for use in multiple platforms, which appear in game for non patient rather than in games for patient. From Figures 23(b) and (c), personal computer is the most often used platform in both serious games for patient and non patient. The console and multiple platform are more common serious game for non patient while handheld platform is present more in serious games for patient.



**Fig. 24.** Breakdown of the "Connectivity (a)", "Connectivity for patient (b)" and "Connectivity for non patient (c)" values present in our survey

Finally, Figure 24 illustrates the distribution of our surveyed serious games according to internet connection. From Figure 24(a) we will see that the internet connection is used in one third of the games surveyed. Figures 24(b) and (c) show that most of the internet connectivity are presented in serious games for non patient (32 out of 41). Most all (13 out of 16) of serious games for non-professional is an online game which aims to be seen by layperson. On the other hand, most all (11 out of 13) of serious games for treatment

are offline. Most of serious games for rehabilitation, patient self education and health & wellness purpose also are offline due to the size of the game which might be huge and difficult to play smooth in an online environment or the games may need some special external tools to perform the tasks given.

## 8. Conclusion

We have studied ninety-seven serious games from academic and commercial environments (including a variety of online games) dealing with health in a broad sense, including medicine, nursing, health care and physical exercise. A short description of each game emphasizing their most relevant characteristics has been given, and the games have been classified according to their main purpose (entertainment, teaching or health), stages of the disease being treated (health monitoring, detection, treatment, rehabilitation and education) and the type of users of the system (general population, patients, health professionals). Additionally, fifteen criteria dealing with the game technology have been selected for a fine-grain classification: application area, interaction technology, platform, game engine, interface, portability, connectivity, adaptability and genre, number of players, performance feedback, progress monitoring and health objective.

Although for most of those criteria there were a wide range of possibilities, which have been explored by at least one game, our results indicate that one of the possibilities in each category has been predominantly chosen by game designers. The average game can therefore be summarized as a portable PC game, using mouse interaction and including progress monitoring, performance feedback and adaptability. The most common genres were simulation and action (which account for half of the games). However, we found little correlation among the characteristics. As an example, only seven of the ninety seven games reviewed have all the characteristics of the average game described. The variability of games is quite large in many aspects.

As a future trend, we expect that the 3D interface in both PC and handheld platform with online connectivity will dominate the serious games for health market, given the increasing capability of handheld devices with PC-like functionality. We also expect the real-time interaction between therapist and player will lead to a powerful tool for patient recovery and treatment.

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