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# IMPROVING ELDERLY HEALTH CARE BY USING SERIOUS GAMES: A SYSTEMATIC LITERATURE REVIEW

Alemayehu, Tesfa &

Olufuwa, Olumide

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Laurea University of Applied Sciences  
Otaniemi

## Improving Elderly Health Care by Using Serious Games: A Systematic Literature Review

Tesfa Alemayehu  
Olumide Olufuwa  
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Tesfa Alemayehu, Olumide Olufuwa

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The reiterating demographical statistics have been consistent in elaborating the growing rate of the aged population in both developing and developed countries. Currently, steady increase in lifespan of certain populations has been observed which further exacerbates this trend. Governments and other stakeholders in health care have embraced solutions from various disciplines in improving the wellbeing of their elderly citizenry. Serious Games (SGs) are games that have been designed to accomplish other purposes than entertainment such as influencing learning, civic engagement or behaviour change. Limited knowledge, about the application of SGs for elderly, exists in this emerging field. “How have SGs been used in elderly health care?” was our predefined question; the objective of this research is to assess the utilization of SGs in improving elderly health care through a systematic literature review.

A systematic literature search was conducted through Laurea’s electronic library NELLI. The primary search collected 854 articles using the keywords ‘health care’, ‘eHealth’, ‘elderly health care’ in conjunction with ‘Serious Games’. The inclusion criteria (full text articles, English language, published after 1<sup>st</sup> January 2004) were followed by critical appraisal of the articles. A total of seven studies were selected for this review and were analysed through a qualitative inductive process.

The findings showed that SGs have been explored to enhance holistic care, elderly patient’s safety, health care delivery and improve patient autonomy of the elderly. SG applications have been applied across various focus groups, and the potential they have in combination with telemedicine promises positive milestones in the sectors of health care and information technology.

Trustworthiness and ethical issues have been considered throughout the study. From this review, we observed that insufficient and fragmented knowledge of SG utilization in elderly health care exist. Interdisciplinary cooperation is required to accomplish greater strides in this field. Lastly, more extensive and empirical research is recommended to inculcate this new approach into contemporary health care practice.

Key words: Serious Games, elderly health care, eHealth

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## 1 INTRODUCTION

Recent population statistics have demonstrated the growing rate of the aged across developed and developing countries. Finland as an example, has the 6th largest aging population (65 years and above) in Europe. In half a decade, the percentage of its aged population grew from 16.5% in 2008 to a staggering 19.2% by the end of 2013, making it the 2nd highest country in the Nordic region (The World Bank, 2013). In 2012, the official population projection of persons aged 65 or over in Finland was estimated to rise from 18% to 26% by 2030 (OSF 2012).

Clearly, the above growth figures emphatically demand a parallel and steady influx of health care professionals into the health care system- both private and public sectors. Amongst the solutions, geriatric health professionals are pivotal in resolving potential bottlenecks that would be presented by the aging population.

Due to the poor economic outlook for the next consecutive years, looming health care reforms and fiscal budget cuts in the world over, this will undoubtedly present challenges for the health care sector in the nearest future- a future that inversely requires an increase in health spending as a result of the aging population (MSAH 2014). Hence, governments and health care providers are heavily laden with the responsibility of balancing both the financial repercussions of budget cuts and improving the wellbeing of their elderly citizenry using all means available to their disposal- including the strengths and opportunities offered by modern information technology. European and the UK policy makers strongly support initiatives of eHealth and assistive technologies that focus on conserving healthcare resources (Mackenzie and Sakel 2011).

Finland, a society with phenomenal achievements in information technology (IT) has founded successful technological institutions like Nokia, Rovio (Angry birds), and SuperCell (Clash of Clans). The advancement of IT seeks to refine the tripod of our existence where the focus of modern technology has shifted from merely being a source of replacing malfunctioning human parts to a more holistic approach- enhancing human life. In a study conducted by Nielsen Games for Interactive Software Federation of Europe (ISFE) in 2008 among people (UK, Spain and Finland) within the age of 16 and 49 years, 72% play videogames for fun; 57% play as a way to stimulate their imagination; 45% say gaming makes them think. Online games were also found to be a strong secondary motivator for socializing among game players.

The idea of Serious Games; which could be in the form of, computer games, video games, exergames, persuasive games, educational games, etc. dates as far back as the 1970s (Abt 1970). Serious Games (SGs) are games that have been designed to accomplish a beneficial purpose such as influencing learning, civic engagement or behaviour change (Ritterfeld, Cody and Vorderer 2009). SGs can be applied in various fields such as: military, health care, aviation and education. In health care, SGs are classified into two major categories: for professionals and patients. For patients, it addresses topics ranging from healthy lifestyle improvement to prevention of disease, to self-care and self-management. On the other hand, health care professionals utilize these games in teaching and rehearsing clinical skills, diagnosis and delivery of treatment (Lieberman 2012) amongst others.

In the western society there has been a steady increase in total life expectancy (from birth). In Finland for example, the life expectancy grew from 78.8 years in 2005 to 80.6 years by 2012 (The World Bank 2013). As a result, improving and maintaining the standard and quality of health care service offered to the elderly has become a topical agenda in the health sector. The emerging field of SGs offers a unique approach for alleviating this burden on policy makers, governmental organizations and health care centres. The rate at which the design and implementation of SGs for health in improving the wellbeing, rehabilitation and lifestyle of the elderly has gained impressive momentum in recent years.

The aim of this research work is to assess the utilization of SGs in improving elderly health care through a systematic literature review. The primary objective is to assess the current global trend in using SGs to improve the health care of the elderly. It also serves to explore potential areas in which SGs can be applied in elderly health care.

## **2 PURPOSE STATEMENT AND RESEARCH QUESTIONS**

The purpose of this thesis is to describe and discuss the utilization of Serious Games in elderly health care.

### **Research Question:**

How have Serious Games been used in elderly health care?

### 3 DEFINITION OF CONCEPTS

Prior to the conception of this research topic and the consequent undertaking of the thesis work, the homographic and ambiguous nature of the selected MeSH (i.e. Serious Games, eHealth and elderly health care) used in this review implored us to limit the scope of their conventional definition. Therefore, for the sole purpose of this research, we have defined the MeSH only as implied in this research work.

#### 3.1 Serious Games

The concept of a 'Game' has been in existence for centuries. However, the variation in global experience has made the pronouncement of a single definition impractical (Michael and Chen 2005). According to Merriam-Webster English Dictionary (2015), a game is "a physical or mental activity or contest that has rules and that people do for pleasure". The evolution of games has steadily progressed along with the advancement of information technology. As a result, the proliferation of digital games has gained more popularity over the last decades among various audiences and interest groups. Nowadays, digital games have been utilized beyond the primary purpose of entertainment.

Serious Games (SGS) are digital applications specifically adapted for the purpose other than entertaining: such as rehabilitation, training, and education (Robert, König, Amieva, Andrieu, Bremond, Bullock, Ceccaldi, Dubois, Gauthier, Kenigsberg, Nave, Orgogozo, Piano, Benoit, Touchon, Vellas, Yesavage and Manera 2014). Purdy (2007) further defined the term 'Serious Game' as games that have useful outcome or that model real-life situations. Woodrow Wilson Center for International Scholar in Washington, D.C. founded the Serious Games' Initiative in 2002 to establish a formal basis for this rapidly emerging multi-billion industry (Susi, Johanneson and Backlund 2007). In the year 2010, the SGs industry had a market share of 1.5 billion euros and was expected to grow at an estimated rate of 100% annually (Alvarez J. Alvarez A. Djaouti, and Michaud 2010). With medical researchers serving as forerunners, extensive collaboration between the health care communities and investors also led to the inception of 'Games for Health' project in 2004. Its objective was to support community, knowledge and business development efforts to create user-centered games to improve the health and health care (Marin, Navarro and Lawrence 2011).

SGs industry has already widened its scope in education, health care, military and aerospace sectors. In fact, the niche is currently dominated by the military, for example the U.S. military started using SGs as far back as World War II (Laamarti, Eid, and El Saddik 2014) and spends billions of dollars in research and development of SGs at the moment. According to game developers, experts and pioneers of the field, there is a strong belief that the health care industry is the next big growth area for the sector.

Although not yet widely accredited by the medical community for therapeutic interventions due to limited research, insufficient clinical justification and unresolved ethical issues. However, preliminary researches have shown that there is a huge potential to apply SGs in the



following areas: (a) disease prevention and management (b) rehabilitation (c) psychotherapy (d) training (e) patient education and guidance etc. To sum up, SGs can be instrumental in educating and training health care professionals, and delivering an improved health care service for all patients, especially the ever growing ageing population.

### **3.2 eHealth**

eHealth is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology (Reichlin, Mani, McArthur, Harris, Rajan and Dacso 2011).

Despite the clear interest in and apparent marketability of eHealth, it was not evident, what exactly was meant by the term. It had been variously used as a synonym for health informatics, telemedicine, consumer health informatics and e-business, as well as more specific technological applications, but no consensus existed on its conceptual scope and it was unclear whether it indeed represented a new concept, or simply a linguistic change.

The concept of eHealth was first introduced in business environment by industry leaders and marketing experts in late 1990's as e-commerce, e-business, e-solutions, etc. Recently, its scope has been broadened beyond its borders into the health arena (as eHealth). The application of information and communications technology (ICT) in health care has grown exponentially over the last decades and its potential to improve effectiveness and efficiency has gained greater recognition globally (Pagliari, Sloan, Gregor, Sullivan, Detmer, Kahan, Oortwijn, MacGillivray 2005). United by a vision to improve the safety, quality and efficiency of patient care; policy makers, business people, researchers, healthcare professionals and the general public are in search for efficient and effective tools to address the ever evolving health-related problems.

The field of health care has leveraged on the technological potentials offered by eHealth. Of notable areas of application include: facilitating information exchange and communication; online education of healthcare professionals; extending healthcare service beyond traditional boundaries. In addition, it is also useful in empowering patients and materializing remote therapeutic relationship between patients and healthcare providers. However, there is also underlying fact that it poses new challenges and threats to ethical issues such as privacy, informed consent, online professional practice, and equity issues that need to be addressed.

### **3.3 Elderly health care**

Ageing is a privilege and a societal achievement. It is also a challenge, which has an impact on all aspects of the 21<sup>st</sup> century society. The challenge it imposes cannot be addressed by the

public or private sectors in isolation, thus it requires joint approaches and strategies (WHO 2015). The ageing of population is in a dramatic demographic shift that is taking place in both developed and developing countries. By 2050, an estimated 22 percent of the world's population will be over 60 years old and for the first time in history there will be more seniors than children (Lorinc 2008).

The rapid ageing population will lead to changing demands to health care systems. Though ageing is not in itself a disease and old age should not be seen as equal to frailty and sickness, increasing demands on the health sector are inevitable. So, the health care systems should adapt to ever increasing proportions of the elderly people and will be expected to accommodate both the older adults and the rest of the population. This very demanding task nowadays has become top of the agenda at global and national levels. The World Health Organization (2014) emphasized that deficiencies have been reported in elderly health care globally. Many older persons are at risk of maltreatment, where they are deprived of their dignity through insufficient care.

In simple terms, health care is the diagnosis, treatment and prevention of disease, illness, injury, and other physical and mental impairments in human beings. Health care is delivered by practitioners in allied health, dentistry, obstetrics, medicine, nursing, optometry, pharmacology, psychology and other health care professions. It refers to the work done in providing primary care, secondary care and tertiary care as well as public health (Meriam-Webster, 2015). Though there is a notable difference in the structure by which health care is organized, financed, and delivered in rich and poor countries around the globe; the ultimate goal is to provide holistic health care to all regardless of their social, economic, cultural, race and political backgrounds. According to WHO (2006), the WHO Region of the Americas, with 10% of the global burden of disease, has 37% of the world's health workers spending more than 50% of the world's health financing, whereas the African Region has 24% of the burden but only 3% of health workers commanding less than 1% of world health expenditure. The exodus of skilled professionals in the midst of so much unmet health need places Africa and other non-developed regions at the epicentre of the global health workforce crisis. To address this very challenging issue and better health care for all, WHO (2008) has identified five key elements that are instrumental in achieving the goal: reducing exclusion and social disparities in health (universal coverage reforms); organizing health services around people's needs and expectations (service delivery reforms); integrating health into all sectors (public policy reforms); pursuing collaborative models of policy dialogue (leadership reforms); and increasing stakeholder participation. Old age comprises the later part of human life; the period after youth and middle age, usually with reference to deterioration in physical and cognitive abilities. There is no universal consensus on when actually old age begins as it shifts based on context. However, many agree in its common attributes: it is a time of limited regenerative abilities and elderly people are more susceptible to diseases, syndromes, and sicknesses than younger adults. For the purpose of this thesis we regard the term "elderly" as older adults aged 60 years and over.

Elderly health care focuses on prevention and control of health problems of elderly people. The care emphasizes on the social and personal requirements of senior citizens who need assistance with daily activities and health care, who desire to finish course of life with dignity. Elderly care necessitates a multifaceted approach incorporating active collaboration of policy makers, governmental and non-governmental organizations, health care professionals and the public in general. The fulfilment of the special needs and requirements of elderly are unique and encompasses services such as assisted living, adult day care, long term care, nursing homes, hospice and home care.

The health care needs and health related problems of elderly people cannot be viewed in isolation. To bring a significant impact on the quality-of-life of the elderly, we need to adopt a holistic healthcare approach; a comprehensive care that considers their physical, social, economic, and spiritual needs. Though promoting and improving of elderly health care has universal responsibility and accountability, there is a huge difference in content, level and means of delivery of care.

In Finland, the basic principle of the Finnish long term care (LTC) system is that it is a publicly funded, universal system that is open to every citizen. Section 22 of the Finnish constitution (1999) requires that the government ensures the implementation of fundamental and human rights. The rights of particular significance for LTC are equality and social security (Ministry of Social Affairs and Health: Health care act 2010). Thus, in Finland, it is considered to be the obligation of the public sector to provide a decent level of LTC services for the elderly. In the most recent update of the National Framework for High-Quality Services for Older People, the Ministry of Social Affairs and Health (2008) outlined the main ethical principles guiding the delivery of LTC in Finland. Those principles include (1) the right to self-determination, which means that older people must be allowed to make informed choices and obtain the information and help they need to make choices about LTC, (2) equality, which means that consistent principles in granting LTC services should be followed. Equality also means that discrimination should be prevented, and that differences between people should be accepted, (3) participation, which means that efforts should be made to enable older people to influence the development of the society and environment in which they live, (4) individuality, which stresses the importance of seeing people as unique individuals, (5) security, which means ensuring the safety of the home and care environment against fire and other hazards.

This systematic literature review focused only on the application of SGs in elderly health care. For the purpose of clarity, the term 'Serious Games' in this research work refers to games mediated by computer technology (*computer games*) whether they are played on a console, a PC, a mobile phone or in virtual reality.

#### 4 SYSTEMATIC LITERATURE REVIEW

The research methodology adopted for this research followed the step-wise protocols of a systematic literature review as described by Aveyard (2010). It was conducted with aim of synthesizing high-quality scientific literature to resolve the research question- *How have Serious Games been used in elderly health care?* The systematic review process included five steps: literature search using predefined databases; assessing the quality of study; data extraction; data analysis; and presentation of findings.

The focus of this research work was to discuss the overall snapshot of how Serious Games have been used in improving the healthcare of the elderly. Since application of Serious Games in health is generally still at an infant stage, a rigorous systematic review was conducted using all accessible databases as seen in TABLE 1. It is paramount however, to point out that the systematic review process implemented in this research work was not according to Cochrane-style systematic review (Higgins and Green 2008).

The colonial field of medicine, from which nursing science gained its independence, continually structures a set of clinical practice guidelines to assist both medical practitioners and patients with appropriate health care for specific circumstances (Lo and Field 2009). For the most part, these practice guidelines are dependent on experts' experiences and scientific evidences-which are usually subjected to the highly structured scrutiny of systematic reviews or evaluations. Geurden, Stern, Piron and Gobert (2012) defined evidence-based medicine in relation to nursing as: "integrating the best available research evidence with information about patient preferences, nurses' skill level, and available resources to make decisions about patient care". The Cochrane Collaboration and The Agency for Healthcare Research and Quality (AHRQ) have established guidance for conducting systematic reviews using empirical and evidence-based literature.

With over a thousand published systematic reviews on health care topics, the Cochrane Collaboration in 2003 defined a 'Systematic review' as "a review of a clearly formulated question that uses systematic and explicit methods to identify, select and critically appraise relevant research, and to collect and analyze data from the studies included in the review". Systematic review represents a rigorous approach to synthesize and evaluate scientific evidence and related literature by assessing the methodological quality of the included materials; ensuring transparency by detailed documentation of the process; utilizing an analytic framework for extracting key details in response to the research question; presentation of an unbiased inclusion of findings generated by the review process; provision of coordinates where further research activities should be addressed (Lichtenstein, Yetley and Lau 2009).

According to Kitchenham (2004), systematic reviews require substantially more efforts than traditional reviews. It possesses the methodical ability of providing information about the effects of some phenomenon amidst variable environments and empirical methods. If studies provide consistent results, systematic reviews provide evidence that the phenomenon is potent

and transferable. Summarily, upon designing a clear succinct and answerable research question, Kitchenham (2004) asserts that a systematic literature review should feature six aspects: 1. Defined review protocols; 2. Outlined search strategy with aim of detecting as much essential literature as possible; 3. Documentation of search strategy for readers to assess its rigour and completeness; 4. Outlined exclusion and inclusion criteria for assessing the quality of potential primary studies; 5. Specification of information required to be obtained from primary studies; 6. Systematic review also serves as a prerequisite for quantitative meta-analysis.

In line with the methodical approach of a systematic review, a review protocol was pre-defined due to the following: clarity of the review process and allows possible replication of the review by others; to guard against bias among the researchers during the final compilation of the main systematic review; to ensure that only primary studies of robust quality are included in the systematic review (Lipp 2003). The key elements of a protocol include: research objective, research question, research strategy for sourcing for materials, study selection criteria, data extraction strategy, and synthesis of extracted data (Kitchenham 2004). The presentation of the findings will be expatiated upon in the discussion section of this paper.

#### **4.1 Literature search**

A systematic search strategy is pivotal for optimal identification and location of the widest range of published material for the sole purpose of answering the research question in the most comprehensive way (Aveyard 2010). Systematic reviews require a thorough, objective and reproducible search (within resource limits); this carries the heaviest weight when distinguishing between systematic reviews from traditional narrative reviews, and it also helps to minimize bias and therefore assist in achieving reliable estimates of effects (Higgins and Green 2011).

In this study, the data search strategy was developed using systematic review guidelines derived from a text book (Aveyard 2010) as well as in consultation with the school's (Laurea Otaniemi University of Applied Sciences) librarian. The cooperation of the librarian was solicited for because the school's vast electronic library was the most credible, affordable and available resource for the research work.

Again, we are compelled to reiterate that formal recognition of the chosen topic that was reviewed- 'Serious Games'- came into technological limelight a bit over a decade ago (Susi et al. 2007). Thus, the prospect of obtaining sufficient and relevant materials proved to be challenging and required additional measures. After the researchers have fractured the research question into the main concepts - 'Serious Games' and 'elderly health care', further efforts were made to identify synonyms, abbreviations and other related alternative spellings for the main concept. Altogether, the resulting MeSH terms were: 'elderly health care', 'health care' and 'eHealth'. The latter two keywords added to the MeSH terms-'health care' and 'eHealth'- were deemed necessary after a preliminary search using only the two main concepts produced insufficient materials.

For the literature search, the MeSH terms- 'elderly health care', 'health care' and 'eHealth'- were used in conjunction with 'Serious Games'. The search for potential primary studies was accomplished by using the school's electronic library-NELLI. NELLI is a national information retrieval portal in Finland which can be used to direct a search to several different databases (National library of Finland 2015). The robust and rigorous metasearch performed was restricted to 'ALL' available resources in the 'Health and Social Services' database, which produced materials both in English and other languages. The queried online journals and electronic resources include: *T & F Social Science and Humanities Library*, *BioMed Central Journals*, *Aleksi*, *ARTO*, *Medic*, *PubMed*, *Terveyskirjasto*, *Ebrary*, *Julkari - THL:n julkaisuarkisto*, *Itä-Suomen yliopiston verkkojulkaisut*, *Sosiaali- ja terveystieteiden ministeriön julkaisut*, *Helka*, *Melinda*, *EBSCO (CINAHL and Academic Search Elite)*, *Elektra*, *Emerald Journals*, *Ovid (MEDLINE)*, *ProQuest Central Journals*, *PsycARTICLES (ProQuest)*, *SAGE Journals Online* and *Science Direct*.

The total hits obtained from the primary search using the above stated search protocol was 646,808 hits- a figure commensurate to the amount of sources explored (twenty-one). Also, this figure portrays the meticulous nature of the literature search. Higgins and Green (2011) stated that a systematic review requires thorough, objective and reproducible search. Therefore, in adherence to this prerogative and for the demonstration of transparency of this research work, details of the primary search have been illustrated in Table 1. The table shows how the keywords and the main concept were combined during the search for relevant literature. Databases that returned zero hits/records were excluded from the table.

Table 1 Enumeration of the databases and MeSH terms used in the literature search.

Resource/ MeSH combinations	Serious Games + eHealth	Serious Games + Health care	Serious Games + Nursing intervention	Serious Games + Elderly health care
T & F Social Science & Humanities Library	30	26	8	30
BioMed Central	4	0	28	27
Medic	0	7	0	1
PubMed	3	16	4	1
Ebrary	30	30	26	30
Julkari - THL:n julkaisuarkisto	1	27	0	30
Helka	1	2	0	1
EBSCO (CINAHL & Ac- ademic Search Elite)	32	2	43	58
Emerald Journals	6	27	25	30
Ovid (MEDLINE)	3	23	0	0
ProQuest Central	27	26	18	30
Psyc ARTICLES (ProQuest)	6	30	20	30
SAGE Journals Online	1	21	0	2
Science Direct	27	0	0	4

TOTAL: 854

#### 4.2 Inclusion and exclusion criteria

The authors had agreed beforehand the primary study selection criteria while defining the protocol used in section 4.1. Kitchenham (2004) claimed that this practice reduces the likelihood of bias during the selection of potential primary studies. Subsequently, proper documentation of the inclusion and exclusion process was done to reveal the transparency of the selection method.

This research work required multistage processing of the potential primary studies. Firstly, the criteria allows only electronic publications from 1<sup>st</sup> of January 2004 till 2014 should be included. Furthermore, to obtain quality literature, the study should address the research question i.e. focus more on uses of SGs in health. Access to full text of potential primary studies was another

criterion included to enable critical appraisal of the literature and discussed phenomenon; researchers only considered studies documented in English language. The essence of this review was to focus on how SGs have been used in health care, specifically in improving the wellbeing of the elderly patients. Since SGs are fundamentally rooted in the ICT sector, numerous literatures were found based on the design and implementation of SGs; others highlighted computer system requirements and technological platforms where SGs can be deployed. Some studies reflected on the content analysis of SGs that can be used in the health sector. Overall, literatures that were in relation to the research question and fulfilled the criteria were included in the potential primary studies.

Summarily, after the initial collation of a total of 854 potential primary studies, the study selection was done by: excluding literature published before 1<sup>st</sup> of January, 2004 (84); screening of titles and abstracts using the research question (620); availability of full text, double publication and language of the material- English (108). Forty-two potential primary studies were further narrowed down to 7, which were critically appraised for their quality based on their relevance and focus area of study (elderly care). Based on the above criteria, 847 out of 854 (2004-2014) were excluded due to their failure to meet the preset inclusion criteria. Appendix 1 shows the list of 'Selected Primary Studies'. In lieu of the 7 literatures that were selected in relation to the research question, Figure 1 below shows the selection process.



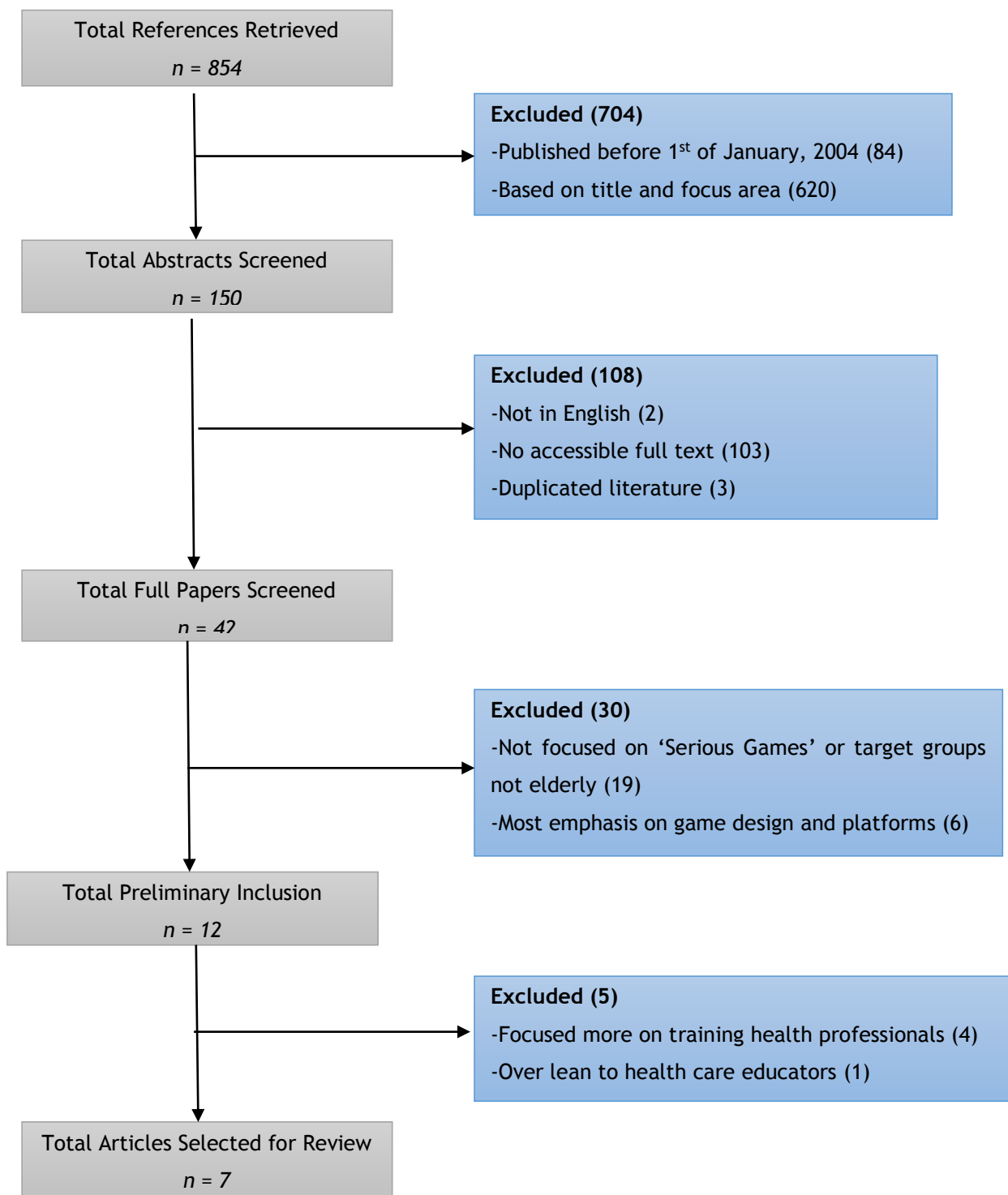


Figure 1 Flow chart of the data selection process.

### 4.3 Data extraction

The main purpose of the data extraction is to extract findings from the selected primary studies in a coherent pattern that enables later data synthesis and interpretation. This stage of the systematic literature review is achieved by designing a data collection form to accurately record the information researchers obtain from the primary studies. It is one of the most important and time-consuming aspects of a systematic literature review (Kitchenham, 2004). Higgins and Deeks (2011) of the Cochrane Collaboration define a data collection form as “a bridge between what is reported by the original investigators and what is ultimately reported by the review authors”.

The functions of a data collection form firstly links directly the review question and criteria for assessing eligibility of studies; provides a clear summary of these that can be applied to identified study reports. Secondly, the data collection form is the historical record of the multitude of decisions (and changes to decisions) that occurs throughout the review process. Thirdly, the form is the source of data for inclusion in an analysis (Meade 1997). A consensus between review authors may be required before the form is modified to avoid any misunderstandings or later disagreements (Higgins and Deeks 2011).

After thoroughly reading the seven selected research articles, the two authors of the thesis discussed and agreed on the contents on the data extraction form (e.g. article’s title, authors, publication details, data code, extracted data). For the purpose of reliability and transparency, data extraction was done independently in three stages in pursuit of a concise data without altering its original meaning.

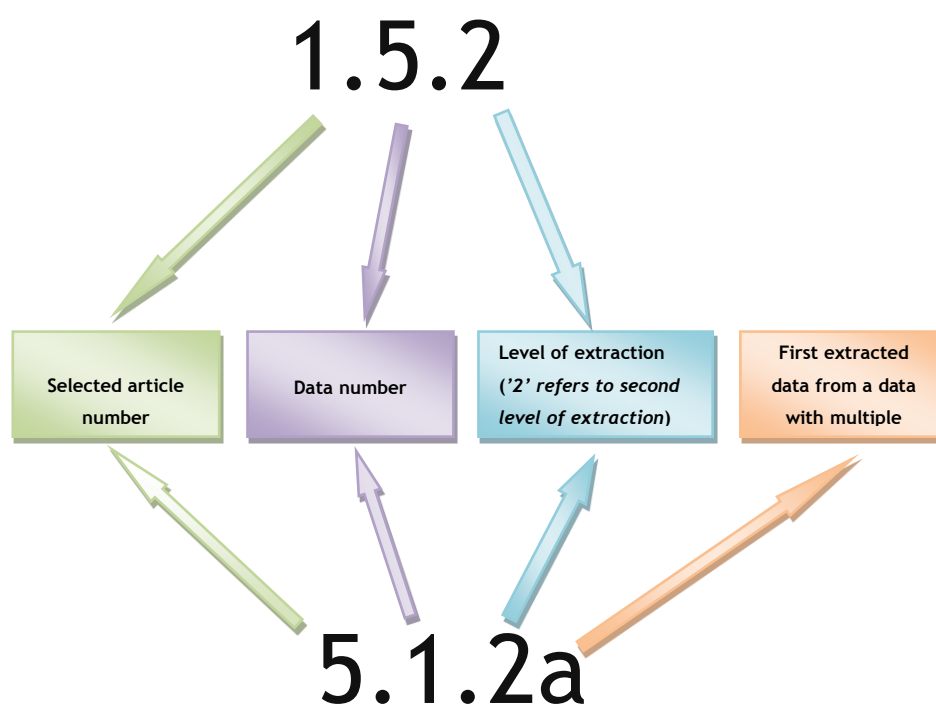


Figure 2 Illustration of the data extraction code

At the end of each stage, a collation of the data was achieved through mutual consensus after in-depth reflections and deliberations (Appendix 1 for 'Data extraction form'). During the data extraction process, utmost emphases have been given to ensure that the data extracted answers directly the research question.

Table 2 Sample table of the three-stage data extraction process

No.	Reference (Author, year, title)	Data code	DATA <sup>1</sup>	Data code	DATA <sup>2</sup>	Data code	DATA <sup>3</sup>
1	<i>Marin et al. (2011). Serious Games to Improve the Physical Health of the Elderly: A Categorization Scheme</i>	1.5	Doyle et al. [26] developed a game to deliver balance and strength exercises. This project aims to help elderly users to improve their motor capabilities in lower limbs in order to avoid falls.	1.5.1	Delivering balance and strength exercises to avoid falls	1.5.2	Exercises to avoid falls
5	Molina et al (2014) Virtual reality using games for improving physical functioning in older adults: a systematic review.	5.1a	Some studies suggest that exercise using VR in elderly patients promotes improvements in mobility [5,6]	5.1.1a	Improves mobility	5.1.2a	Improves mobility

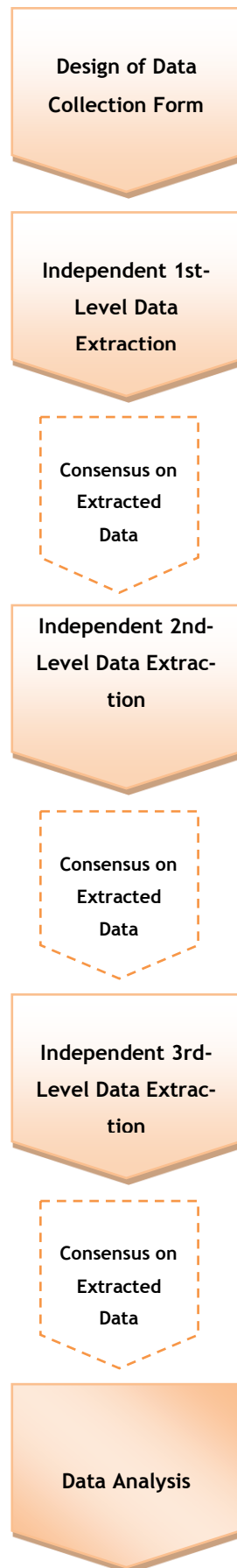


Figure 3 Flow chart of the data extraction process

#### 4.4 Data analysis

Data analysis is the core stage of a systematic literature review process. It usually involves the collation and summarization of the results of the chosen primary studies (Kitchenham 2004). The aim of data analysis is to produce a new and integrative interpretation of findings that is more substantive than those resulting from individual investigations (Finfgeld 2003).

During the literature search of this review on the use of serious games in elderly health care, obtaining substantial and comprehensive primary studies proved difficult. This is mainly attributed to the fact that the idea of utilizing SGs in elderly health care has been sufficiently unexplored. According to Lauri and Kyngäs (2005), if there is a lack of previous knowledge about a phenomenon or if the knowledge is fragmented, an inductive content analysis approach is recommended.

In this paper, the researchers have used an inductive content analysis method. Generally, content analysis is a method that may be used with either qualitative or quantitative data. Through content analysis, it is possible to distil words into fewer content-related categories. It is assumed that when classified into the same categories, words, phrases and the like share the same meaning (Cavanagh 1997). The categories are usually derived from the data in inductive content analysis (Elo and Kyngäs 2008).

The data analysis process involves sorting, grouping and synthesis of data. In the first step the researchers independently read thoroughly the seven selected articles to ground their knowledge and grasp the main ideas presented in the research articles. A rigorous data extraction process (Table 2) was done independently by the researchers and subsequently a coding system (Figure 2) was introduced to maintain data consistency. This process was pivotal in establishing a relationship between the research question and the extracted data. The second step involves independent grouping of the data into sub-categories: individual researchers came up with seven and nine sub-categories. Afterwards, a mutual consensus between the researchers was reached and resulted in 10 sub-categories. Finally, based on the similarity of data content and in line with the research question, the data was grouped into four categories namely: Improvement of patient safety, Enhancement of holistic care, Improvement of patient autonomy, Enhancement of quality health care delivery. An abstraction of the research topic was done by the categories generated from the data.

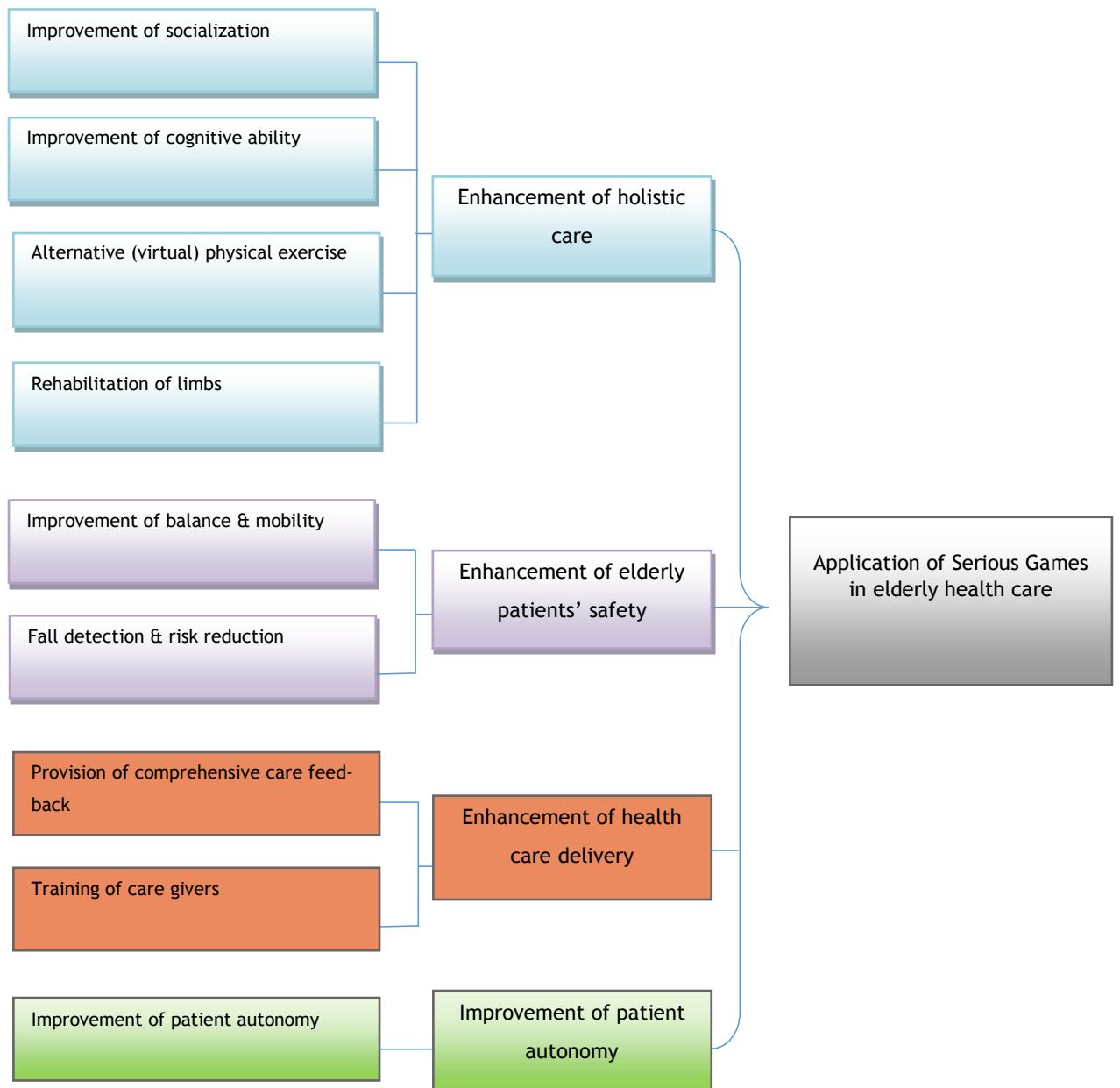


Figure 4 Flow chart of the (four) main themes and the sub-categories.

## 5 FINDINGS

After a thorough inductive content analysis process of the seven critically appraised articles by the researchers of this thesis work, the four categories produced by the data in response to the research question include: enhancement of holistic care, enhancement of elderly patient's safety, enhancement of health care delivery and improvement of patient autonomy. In this section, the findings of our review of the selected articles will be presented in four main themes. Critical appraisal of the selected literatures will also be presented in brief whenever the article is referenced for first time. A copy of the critical appraisal tool can be found in the appendices section (Appendix 1).

### 5.1 Enhancement of holistic care

Webster and Celik (2014) conducted a systematic literature review to assess the use of Microsoft Kinect-based applications in elderly care and stroke rehabilitation. In their analysis, they included 48 peer-reviewed articles from electronic bibliographic databases. They categorized the study into three major themes: elderly care, stroke rehabilitation and serious and exercise games. After examining the various applications of the Kinect in the field of elderly care and stroke rehabilitation, they classified these SG applications into the following groups: (1) fall detection, (2) fall risk reduction, (3) for evaluation of Kinect's spatial accuracy, (4) Kinect-based rehabilitation methods, and (5) serious exercise games. They revealed that exercise games ("exergames") designed for Kinect required body gestures from elderly participants. Though the use of Kinect applications in elderly health care is only at initial stage of development, it has already shown notable potential in making therapy and alert systems financially available and basically beneficial to a large population of elderly and stroke patients. The authors also mentioned the duo-effect of improved mobility and enhanced emotional wellbeing. Additionally, the Kinect-based SG applications create friendly competitions among participants and ultimately increase social activity and enjoyment. The authors of review acknowledge that some significant technological limitations are still present: a fixed location sensor of the Kinect with a range of 10meters; a difficulty in fine movement capture; present applications are less user-friendly for elderly clients.

Robert, König, Amieva, Andrieu, Bremond, Bullock, Ceccaldi, Dubois, Gauthier, Kenigsberg, Nave, Orgogozo, Piano, Benoit, Touchon, Vellas, Yesavage and Manera (2014) from seven countries across two continents analyzed the ideas and recommendations from a co-discovery conference on the use of SGs in people with ADRD (Alzheimer's disease and related disorder) and frailty was attended by academic researchers, health care professionals, patient, and family associations' representative, engineers and companies involved in the development of SGs. From the two-round workshop of the conference, they analyzed the SWOT (Strengths, Weaknesses, Opportunities and Threats) of employing SGs with patients with ADRD. Subsequently, they provided synthesized recommendations for the development and use of SGs in these elderly populations. However, the review does not address the ethical, professional and

cost/benefit issues of using SG in ADRD patients. According to the study, SGs play a key role in promoting social bonding. This includes SGs that require multiple players to be physically present or in groups. Also, they reported that remote serious gaming via internet technologies creates another form of social interaction.

Molina, Ricci, de Moraes and Perracini (2014) have made a systematic literature review on Virtual reality using games for improving physical functioning in older adults. They have studied 13 literatures in which eight of the studies focused on Nintendo Wii gaming console, computer games (2 studies), dance video game with pad (2 studies), and one study on balance rehabilitation. Randomised clinical trials have been conducted to test the application of exergames with Nintendo Wii gaming console in healthy older adults from a local seniors living community, community of dwelling elders at a low-cost income seniors housing facility, community dwelling older adults, at geriatric hospital rehabilitation unit, independent seniors, outpatient geriatric orthopaedic and balance physical therapy clinic, and of healthy elderly living independently. This study has only chosen randomized clinical trials aiming to attain better scientific evidence. However, it resulted in methodological limitations e.g. limited sample size. Consequently, it restricted the capacity for generating evidence regarding the efficacy of elderly health care intervention with virtual reality (VR) games. Regardless of the aforementioned limitations, the authors highlighted that elderly clients were observed to respond positively in terms of enjoyment while playing SGs.

Another literature review by Marston, Greenlay and van Hoof (2013) in their systematic review explored the common uses of the Wii and Kinect in residential care facilities, and their effects on adults aged 60 years and over. English articles from electronic databases and other online sources were systematically searched and six articles were chosen for the review. All articles on Microsoft Kinect consoles were excluded from the review because they did not fit their inclusion/exclusion criteria. The review bordered on the utilization of augmented reality for the design and implementation of exercise strategies via the Wii technology- Wii sport (four studies) and Wii Fit (two studies). It was observed that the environment of care facilities allowed for higher utilization of the multiplayer game mode of the Wii. The review highlighted that there are potential benefits of deploying the Wii games in residential facilities as it enables older adults to implement or maintain physical fitness through a series of programs facilitated by the Nintendo brand (Wii Fit, Wii Sports/Resort). The social benefits documented in their review includes: increase in interpersonal socialization among residents, possibility of inter-generational socialization with younger visitors/guests via gaming, reduction of interpersonal hostility, increased quality of peer-relationships.

Webster and Celik (2014) conducted a systematic review of Kinect applications in elderly care and stroke rehabilitation. They explained that somatosensory video games are useful in improving visual performance and eye-hand coordination in institutionalized older adults. Robert *et al.* (2014) in their Systematic Review of Recommendations for the use of Serious Games in



People with Alzheimer's disease, related disorders and frailty described that SGs has been shown to be able to improve mood, reduce stress, and creates a learning opportunity for elderly people with dementia.

Reichlin, Mani, McArthur, Harris, Rajan and Dacso (2011) in their action research assessed the acceptability and usability of interactive SGs in aiding treatment decisions for patients with localized prostate cancer. The patients usually have the difficult task of choosing a treatment regimen against the background of (1) Health-related quality of life post-treatment, (2) insignificant difference in the treatment efficacy of various clinical trials, (3) varying risks of serious side effects depending on the treatment procedure. An interactive SG 'Time After Time' was developed to assist the men in their prostate cancer treatment decision-making process. The SG translates evidence-based treatment outcome data into an understandable format. The purpose of the game was to raise men's awareness and understandings of the impact of HRQOL (health-related quality of life) issues associated with the major treatment options and also enrich their interactions with health care providers. They stated that SGs can serve as an interactive decision aid by filling the knowledge gap and providing evidence-based education about impact treatments and side effects on elderly men diagnosed with prostate cancer.

The portability, adaptability and mobility of technologies offering SGs have made them appealing to a variety of interest groups from the financial firms, health sectors, to sages in the corridors of academia. Webster and Celik (2014) showed in their literature review of Kinect-based applications that exercise games ("exergames") have recorded health benefits in older adults with disabilities using somatosensory video games.

Jansen-Kosterink, Huis In't Veld, Schönauer, Kaufmann, Hermens and Vollenbroek-Hutten (2013) conducted a pilot study: 'A Serious Exergame for Patients Suffering from Chronic Musculoskeletal Back and Neck Pain'. They aimed at exploring the 'user experience' (usability, satisfaction, level of motivation and game experience) of the patient with the "PlayMancer" SG by selecting ten participants from a focused group of individuals with certain characteristics relevant to the study. The performance indices of the efficacy of this SG were categorized into: user experience, progression of performed motor skills, walking velocity, reach heights and clinical effectiveness. Overall, the study documented that some of the participants experienced the SG as positive. They linked the positive health benefits of the exergames therapy to the motivation received from the SGs.

Marston et al. (2013) in their systematic review explored the common uses of the Wii in care facilities, and their effects on the elderly. Their results showed that Wii provided the opportunity for older adults to virtually participate in activities they were no longer physically able to partake in e.g. tennis, bowling. The Wii provided good motivation for older adults to exercise; Wii and Kinect-based application can serve as a substitution for existing physical exercise. Overall, their results showed that the Wii can have a positive impact on the physical and mental health of older persons in care facilities.

Marin, Navarro and Lawrence (2011) in their literature review about Serious Games to Improve the Physical Health of the Elderly: A categorization scheme, explored that robot monitored arm exercises for the elderly has increased their motivation and ease performance measurements. In their heterogeneous review, they used a concept matrix to ease the classification of the existing games for improving the physical health of the elderly. The total amount of articles included in the review was not clearly stated. However, they classified their study into two major themes: games for balance training and for lower-limbs rehabilitation (3 studies); games for upper-limbs rehabilitation (3 studies). Their study showed a series of low-cost home based webcam games: Rabbit Chase, Bubble Trouble, and Arrow Attack have been developed for upper limb rehabilitation. To increase the effectiveness of these games the authors strongly recommended that the adaptive mechanism that increases or decreases the difficulty of the game should be refined.

Webster and Celik (2014) study showed that serious games have been tailored to assist upper-limb rehabilitation of elderly stroke patients. The Kinect-based applications improved the balance and weight shift management which constitutes a risk of secondary injury for many of stroke patients. Jansen-Kosterink et al. (2013) in their pilot study about patients suffering from chronic musculoskeletal back pain mentioned that the “PlayMancer” exergame namely, “Face of Cronor” improves overhead reach ability. They also showed that, “Three Wind Gods” another type of the “PlayMancer” exergames improves elderly patients’ neck mobility by encouraging them to reproduce sequences of head movements such as: flexion-extension, rotation and lateral flexion-extension. Molina et al. (2014) also in their systematic review on virtual reality using games for improving physical functioning in older adults suggested that exercises using virtual reality increases strength of lower-limbs.

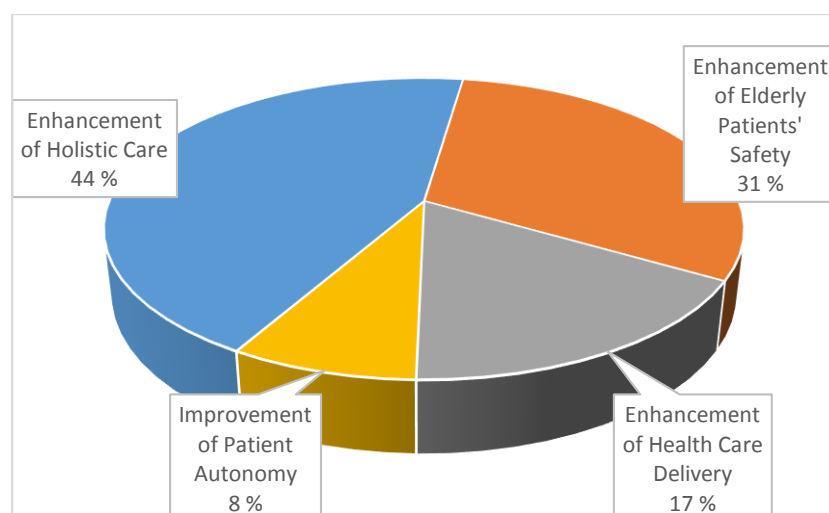


Figure 5 Chart showing the percentage distribution of SGs’ usage in elderly health care.

## 5.2 Enhancement of elderly patient's safety

Molina et al. (2014) have made a systematic literature review on Virtual reality using games for improving physical functioning in older adults. The result unveiled that Wii Fit games improve balance and walking distance of the elderly.

According to Webster and Celik (2014) Kinect-based exergames gaming has a positive effect in enhancing older adults' emotional state. It also allows players to participate in interactive balance exercises with visual feedbacks. Moreover, SGs that functioned by estimating participants' foot locations and then creating two virtual feet on a screen with the game objective of using these virtual feet to step on randomly rising targets that emerged from the floor had a significant impact in improvement of post stroke functionality.

Marston et al. (2013) conducted a systematic literature review on video games consoles (Nintendo Wii and the Microsoft Kinect). The study unfolded that Wii Fit had a significant impact in improving balance and mobility of the elderly. Marin *et al.* (2011) also in their study explored that "Silver Balance", a serious game that uses the Wii Balance board which consist of two single tasks with a simplistic graphic design has been useful for balance training of the elderly.

Webster and Celik (2014) showed that Kinect-based games have been used for the assessment of whole-body kinematics for post postural control and diagnosis purposes with sufficient degree of accuracy. Another study conducted by Molina *et al.* (2014) verified that virtual games improve balance control and prevent falls in older adults.

Additionally, Morin et al. (2011) in their review showed that a modified version of the game 'Dance Dance Revolution' served as a training tool in improving the stepping abilities of the elderly. They also revealed that SGs helped elderly users in improving their motor capabilities of lower-limbs so as to avoid falls.

## 5.3 Enhancement of health care delivery

From the recommendation on the use of SGs in people with Alzheimer's Disease and Related Disorders (ADRD) and frailty by Robert et al. (2014), the consensual findings of their analysis includes: SGs offer care professionals the possibility to record and visualize the patient's activities on-site, and real-time performance measurement; SGs equips the rehabilitation care team with the capacity to provide feedback on performance and on accomplished activities.

Marin et al. (2011) in their review categorized SGs that have been employed to improve the physical health of the elderly. One of the SGs that were developed for rehabilitation of the upper-limbs adopts an assistive robot arm to deliver arm exercises to the elderly, monitoring and providing the user real-time performance feedback.

Reichlin et al. (2011) utilized a SG- 'Time After Time'- in their mixed approach study for assessing the acceptability and usability of an interactive SG in aiding treatment decisions for patients with localized prostate cancer. In addition to using the SG as an education tool by increasing the knowledge of the participants, they found that the SG also encouraged patients

for more active participation in conversation with their medical team. This allowed the patient's health care team to give prompt answers and feedback addressing the patient's concerns.

Robert et al. (2014), in their systematic review: Recommendations for the use of serious games in people with Alzheimer's disease, related disorders and frailty showed that SGs can be employed as an engagement tool to train care givers and provide them with more active information; and helps in providing cheaper and standardized services. Additionally, Jansen-Kosterink et al. (2013) explored another positive aspect of SGs in which SGs assist care givers in designing patient-centred exercise plans, assessment of patient progression so as to better align the game sessions to the needs of the individual patients and also increases transparency of treatment. Finally, it was observed in a study by Reichlin *et al.* (2011), SGs enhances patient education and communication. Marin et al. (2011) also presented SG's usage as a means of monitoring user performance to improve patient-care givers relationships.

#### **5.4 Improvement of patient autonomy**

In the action research study by Reichlin et al. (2011), they assessed the acceptability and usability of interactive SGs in aiding treatment decisions for patients with localized prostate cancer. The researchers reported that participants perceived the evidence-based education received via the SG was beneficial. Consequently, it served as a valuable step in the development of an appropriate decision tool to aid localized prostate cancer treatment decisions. Overall, participants verified that the SG increased their participation in choosing a treatment option for localized prostate cancer.

Molina et al. (2014) systematically reviewed literature on randomized controlled clinical trials of older adults in which SGs were used as the main intervention for the purposes of rehabilitation. The participants responded positively in terms of enjoyment and reported improvement in functional aspects after practicing the exergames.

Marston et al. (2013) in their review of current studies documented the benefits and detriments of Wii in adults in residential facilities. The results from the articles sourced found that the Wii had a positive psychological impact on older persons. It established that some older persons playing on the Wii console had higher self-esteem and better mental well-being than their peers who engaged in traditional care activities. Additionally, the use of self-designed avatars- a virtual projection of a person into a game world- in the SGs on Wii gave the older adults the unique opportunity to interact with other people using on appearance of their own choosing, thus, boosting their self-confidence.

## 6 DISCUSSION

Numerous demographic studies have converged to depict the steady increase in the global growth rate of elderly population. Consequently, this demands a proportional rise in health care spending and presents multiple challenges for governments, health care providers and others sectors of the society at large. In search of an efficient and effective means of addressing the global elderly health care burden given the underlying limited resources, the idea of using SG to improve the health care of the elderly has become pivotal. The advancement and adoption of information technology in health care presents a new approach that will be instrumental in providing better holistic health care for the elderly.

In pursuit of answering the predefined research question (How have Serious Games been used in elderly health care?), we adopted a systematic literature review methodology to synthesize available scientific evidence relevant to the research topic. Since the field of SGs is an emerging one with fragmented and deficient knowledge, it required an inductive content analysis methodology. After we critically appraised the preliminary studies, a total of 7 articles that fulfilled the predefined inclusion/exclusion criteria were selected for this review. The findings of the qualitative content analysis process were grouped into four categories: enhancement of holistic care, enhancement of elderly patient's safety, enhancement of health care delivery and improvement of patient autonomy. In this section, we will discuss various ways by which SGs have been utilized to improve various aspects of elderly health care. An objective interpretation and reflection of our findings will be presented in-depth.

From the selected studies, we considered the diverse ways in which SGs have been used for enhancing elderly health care. Serious Games are digital applications specifically adapted for different purposes other than entertaining such as: rehabilitation, training, and education (Robert et al. 2014). Although the application of SGs in conventional medical or nursing practice is yet to be adopted as a credible therapeutic tool, many of the authors of the reviewed articles highlighted their potential prospects.

In our review, we discovered that SGs are instrumental in enhancing the holistic care of the elderly by improving the physical, social and mental aspects of the care. Many studies outlined that SGs can be applied to enhance the physical health care of the elderly by improving balance, physical fitness and strengthening limbs. (Marin et al. 2011; Marston et al. 2013; Molina et al. 2014; Webster and Celik 2014). The walking velocity and mobility of the elderly was improved in some of the studies using SGs (Jansen-Kosterink et al. 2013; Webster and Celik 2014). Additionally, SGs creates an opportunity for the elderly to participate in virtual sports (e.g. tennis and bowling) which they were no longer physically able to partake in. Thus, culminating into a boost in their emotional wellbeing and positive rehabilitation milestones (Marston et al. 2013). Another aspect of holistic care we deduced in our review was that SGs also improves mood, alleviate stress, and creates a learning opportunity for elderly clients with Alzheimer's disease and related disorders (Robert et al. 2014). Other studies by Jansen-Kosterink et al. (2013) recorded improvement of motor skills in the elderly using SG applications. Similarly, in an effort

to restore functionality to frail and elderly adults, improvement of visual and eye-and-hand coordination has been observed while using SGs (Webster and Celik 2014). As an educational tool, SGs play an important role as an interactive decision aid for elderly clients (Reichlin et al. 2011). Our review shows that holistically, the highest benefits of using SG applications for the elderly were recorded in the improvement of socialization.

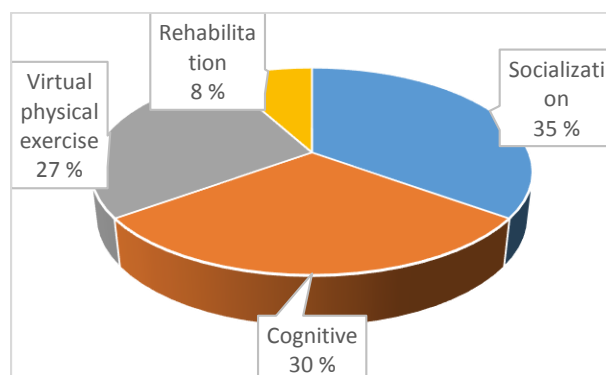


Figure 6 Chart showing areas where SGs are used in holistic elderly health care.

By employing technologies capable of remote connectivity, SGs create an opportunity for another form of social interaction- either being physically present in groups or online connection. This has been observed to improve the quality of enjoyment of the elderly and creates social bonding (Molina et al. 2014; Robert et al. 2014; Webster and Celik 2014). Additionally, SGs have a unique capability to improve the quality of peer-relationships, bridge generational gaps, and creates an opportunity for intergenerational socialization. It also decreases interpersonal hostility among residents of elderly care facilities and boost interpersonal socialization between them (Marston et al. 2013).

Patient safety is a key issue that needs to be taken into consideration whether the elderly clients settle at home or at residential facilities. Various SG applications have been used to assess and improve the safety of the elderly e.g. Microsoft-Kinect and Nintendo-Wii consoles. Other SG applications have also been designed to diagnose the post-stroke functionality of elderly clients (Webster and Celik 2014). SGs have been shown to improve balance and mobility (Marin et al. 2013; Marston et al. 2013; Molina et al. 2014) while others have recorded improvement in walking and distance and stepping abilities (Marin et al. 2011; Molina et al. 2014). It has also been noted that SGs help to prevent falls (Marin et al. 2011; Molina et al. 2014), which would result in reduction of post-stroke complications and fractures. SGs have been utilized as a tool to diagnose and assess the balance, gait and mobility of the elderly. More research is needed to develop technologies as well as SG applications that can assess the postural kinematics in preventing fall.

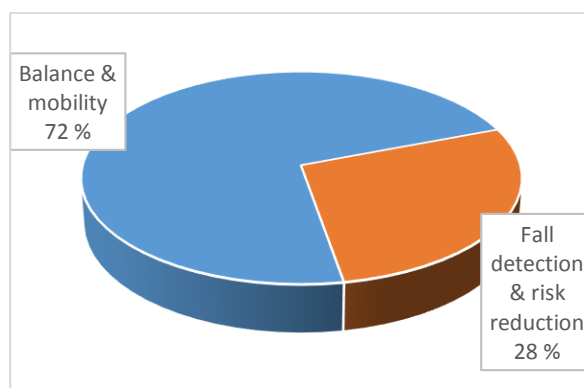


Figure 7 Chart showing the usage of SGs in patient safety.

To improve the quality of services delivered by the three tiers of the health care system- primary, secondary and tertiary, investments in the health care professionals, their clients and the channels of delivery is inevitable. SGs have the capacity to extend health care services beyond traditional boundaries through internet technologies. We discovered that SGs improved the quality of patient-caregiver relationship by providing real-time performance measurements, timely feedback on accomplished activities and promoting transparency (Marin et al. 2011; Jansen-Kosterink et al. 2013; Robert et al. 2014). Additionally, SGs allows health care professionals provide answers promptly to patient's concerns (Reichlin et al. 2011).

From the findings, patient centered care was identified as a key attribute to quality health care delivery of the elderly. It helps to build good patient-caregivers therapeutic relationships and bridges communication gap between patients, care givers and multi-professional teams. We have observed that SGs are very instrumental in designing patient centered exercise plans and assessment of progression (Jansen-Kosterink et al. 2013). Another major theme that we need to look at if we are really determined to enhance health care delivery is training of care givers. Training is key to lay a good foundation for successful health care services. A well trained care giver is equipped with skills, knowledge and tools that are vital for effective and efficient health care interventions. He or she knows patients' rights and is committed to advocate it; takes responsibility and accountability seriously; and adheres to professional and moral values and norms. Many of the authors' of the reviewed literatures share a common view in the utilization of SGs as a tool for training of care givers (Marin et al. 2011; Reichlin et al. 2011; Jansen-Kosterink et al. 2013; Robert et al. 2014). Moreover SGs help to provide cheaper and standardized care for elderly (Robert et al. 2014). The dual balance recorded in Figure 8 below can simply be reflected with the equality and importance of each member in the patient-caregiver relationship.

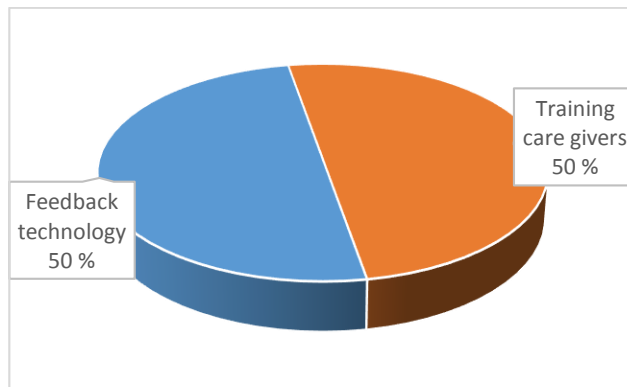


Figure 8 Distribution of SG applications used in improving elderly health care delivery.

It is a universal truth that as the human body ages, our physical and cognitive abilities deteriorate; having limited regenerative abilities, we are more prone to various diseases and sicknesses. The ability of the elderly to make adequate health-related judgments and decisions or regarding other affairs indeed are diminished. However, irrespective of their physical and cognitive frailty, elderly clients cling unto their autonomy- an elixir that fuels their basic rights. Therefore, care givers must take greater caution to adopt and implement an interactive and informed care plan and interventions to boost their self-confidence and improve autonomy. From the findings, improvement of patient autonomy has been identified as one of the key attributes that determine quality elderly life. According to Marston et al. (2013), playing SGs has a positive psychological impact, increases self-esteem, and leads to better mental well-being of the elderly since there is little or no chance to violate their autonomy. Additionally SGs offer the elderly an opportunity to choose their appearance while they play virtual games which boosts their confidence level. Another study highlighted the importance of SGs in improving patients' participation in choosing a treatment option by providing evidence-based education (Reichlin et al. 2011). Overall, SGs presents an opportunity for elderly client to improve and experience elements of their autonomy.

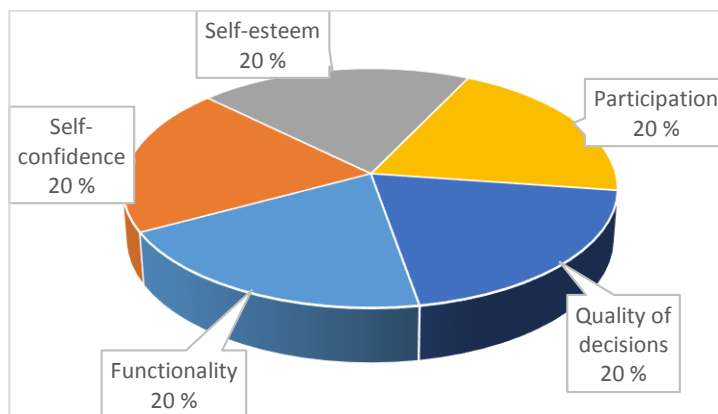


Figure 9 Chart showing aspects of patient autonomy improved through SG applications.



## 6.1 Trustworthiness

Before the commencement of this thesis, a thesis contract and plan was written and accepted by the supervisor. The methodology of the study was deeply studied and understood by the two writers prior to the commencement of this thesis paper. The systematic literature search for potential primary studies was accomplished by using the school's electronic library-NELLI- a national information retrieval portal in Finland. In this study, the data search strategy was developed and implemented using systematic review guidelines derived from a text book (Aveyard, 2010) as well as in consultation with the school's (Laurea Otaniemi University of Applied Sciences) librarian. The robust and rigorous metasearch performed was restricted to 'ALL' available resources in the 'Health and Social Services' database. The queried online journals and electronic resources include: *T & F Social Science and Humanities Library*, *BioMed Central Journals*, *Aleksi*, *ARTO*, *Medic*, *PubMed*, *Terveyskirjasto*, *Ebrary*, *Julkari - THL:n julkaisutarkisto*, *Itä-Suomen yliopiston verkkojulkaisut*, *Sosiaali- ja terveysministeriön julkaisut*, *Helka*, *Melinda*, *EBSCO (CINAHL and Academic Search Elite)*, *Elektra*, *Emerald Journals*, *Ovid (MEDLINE)*, *ProQuest Central Journals*, *PsycARTICLES (ProQuest)*, *SAGE Journals Online* and *Science Direct*. Additionally, the authors of this research scrutinized together the entire literature search and study selection protocol; instances of disagreement were forwarded to the supervising senior lecturer of the research for further clarification.

The aim of trustworthiness in a qualitative analysis is to support the argument that the research findings are "worth paying attention to" (Lincoln and Guba 1985). The seven relevant articles for review have been selected after being refined in a stepwise manner using the predefined selection criteria. To assess the credibility of the articles for the study, we have done critical appraisal (Appendix 1).

After a thorough reading of the selected articles, data were extracted independently in different levels and coded; the coded data were compared against each other to form different themes. Issues of common themes were grouped together during analysis phase. The objectivity of the data have been verified by the two researchers. During the study process data was genuinely analyzed and findings were reported truthfully.

To avoid any form bias and misinterpretation of findings criteria set to guide the process was constantly checked at every stage of the process. Additionally, during the whole process of our thesis work we have used only English language, which is best understood and interpreted by both writers. Thus, any possible misunderstandings have been minimized. To sum up, trustworthiness had been considered in all aspects of this research and we believe this thesis paper produces valuable findings that are directly linked with the purpose statement and answer the research question.

## 6.2 Ethical considerations

During the whole thesis process, we have followed and maintained Laurea's standards and guidelines of academic writing. The research area was chosen after having in-depth discussion

and guidance from our supervisors. We have used only official and trusted academic databases (NELLI) in searching for relevant articles to avoid accessing pirated or unofficial sources. Consequently, copy right violations have been prevented. In all processes of collection, analysing and interpretation of the data, the participants and articles authors' privacy and copyright was highly respected. We attest that the data, concepts, ideas, themes and categories presented in this paper are our original work. Furthermore, by following the guidelines for referencing and citation, and avoiding plagiarism, this final project gives credit to the scientific achievements of the authors' of the systematically reviewed articles. Additionally, in the whole process of data collection, analysis and interpretation, objectivity was maintained and no conflict of interest or bias was present. During the inductive content analysis phase, we independently analysed each set (seven) of articles to obtain unique grouping of the data from the articles. Ethical standards and values such as: mutual respect, accountability and fairness have been practiced by both writers of the thesis project to foster collaborative work. We have been diligently participated, fairly shared the tasks, and were fully committed to the work throughout the whole process. There was also mutual respect and understanding from both parties. We understood the values of ethics and are unconditionally responsible and accountable for our actions. The nature of qualitative methods requires that the researchers remain alert to the possibility of unanticipated ethical dilemmas (Speziale and Carpenter 2007). We have taken in to account ethical considerations in all phases of the thesis project. The data collection process was explained from beginning by strictly following the guidelines of a systematic literature review, thus allowing the readers to follow the process step by step on how the results were generated. Finally, we would like to confirm that there is no conflict of interest involved in this final project.

### **6.3 Limitations and recommendations**

Like every research work in academia, certain limitations were encountered during the period of this thesis work. Kitchenham (2004) refer to publication bias as instances where *positive* results are more likely to be published than *negative* results. Therefore, we acknowledge the possibility of bias in the publications gathered in the process of literature research. In some instances, some of the literatures screened passively mentioned potential side-effects of gaming as a whole. The writers' of the thesis paper acknowledge, due to lack of full access to some of the articles and since we have only selected research articles written in English language; some valuable and relevant data might be missed. Eventually, it could have a negative impact in the quality of our research work to some degree. Another limitation we would like to mention is that; as novice researchers, our lack of in-depth knowledge in various research methodologies encountered during the screening of the preliminary primary studies could possibly reduce the quality of our work. Additionally, during the literature search process of this review on the use

of serious games in elderly health care, obtaining substantial and comprehensive primary studies proved difficult. This is mainly attributed to the fact that the idea of utilizing SGs in elderly health care has been sufficiently unexplored.

We have compiled the following based on our review on improving elderly health care using serious games. It contains our remarks as well as recommendations for relevant future work.

Although the focus group under this thesis work were primarily the elderly, we explored that SGs can be game changing factors and have huge potential to reinforce the health care services our society of any age group. Therefore, we recommend further rigorous studies to be done ensure the utilization of SGs for example in pediatrics, mental health care, etc.

Our existing knowledge about the application of serious games in elderly health care highlighted that little work has been published in the area of understanding what type of activities older adults will like to see in games. Hence, further work is undoubtedly required in this area by multi-disciplinary team to gain greater understanding of the needs and requirements of the elderly. In conclusion, the directions for future work on how to utilize SGs to improve elderly health care is vast and promising. However, key areas such as: cost -benefit analysis of using SGs in elderly health care; ethical dilemmas and considerations for example, privacy, and online professional practices, informed consent and equity issues are hardly assessed or explored. In addition to this questions regarding to the difficulty elderly experience while using SGs; availability viable scientific evidence for to use SGs as a therapeutic tool need to be addressed. Therefore, in order to get justification and to provide stronger scientific evidence and guidance; we suggest that it is compulsory to conduct rigorous future research in this domain.

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Table of Selected literature

ARTICLE NO	AUTHOR/ YEAR OF PUBLICA-TION	TITLE	PURPOSE STATEMENT	METHODOLOGY	CONCLUSION
1	Marin et al. 2011	<b>Serious Games to improve the physical health of the elderly: a categorization scheme</b>	-To provide a snapshot of the current status in the field of serious games for improving the physical health of the elderly. -Goal was to identify how the proper design of SG for elderly could guarantee optimal results.	-Heterogeneous review of literature.	-The SGs that improves the physical health of the elderly were classified according to their specific goal (upper or lower limbs exercising/rehabilitation) and key design elements (interaction, technology, features, home-based, feedback mechanism, target area, progress record).
2	Webster and Celik 2014	<b>Systematic review of Kinect applications in elderly care and stroke rehabilitation</b>	-A review of the most current avenues of research into Kinect-based elderly care and stroke rehabilitation systems -To provide an overview of the state of the art, limitations, and issues of concern as well as suggestions for future work in this direction.	-Systematic literature review on ALL existing data on Kinect based application in elderly care/stroke patients.	-Kinect-based applications in elderly care and stroke rehabilitations were classified in groups of (1) Fall Detection, (2) Fall Risk Reduction, (3) Evaluation of Kinect's Spatial Accuracy, (4) Kinect-based Rehabilitation Methods, and (5) Serious and Exercise Games. -While only in its initial stages of development, the Kinect already shows notable potential in making therapy and alert systems financially accessible and medically beneficial to a large population of elderly and stroke patients; however, some significant technological limitations are still present.
3	Robert et al. 2014	<b>Recommendations for the use of Seri-</b>	-To systematically analyze SWOT of employing SG with patients with ADRD in order to provide practical recommendations	-Organized a two-round workshop ("Innovation Alzheimer 2013"), with stakeholders in	-SG can be considered as useful tools for professionals involved in the care of patients suffering from ADRD.

		ous Games in people with Alzheimer's Disease, related disorders (ADRD) and frailty	for the development and use of SG in these populations.	the field, with the aims of (a) analyzing systematically the employment of SG in frailty and ADRD (SWOT analysis), and (b) gathering recommendations for the development and use of SG targeting these populations. -SWOT analysis of ideas and responses from the conference was done.	-Interdisciplinary cooperation, ethical aspects, efficacy and feasibility should be considered for further research.
4	Jansen-Kosterink et al. 2013	<b>A serious exergame for patients suffering from chronic Musculoskeletal back and neck pain: a pilot study</b>	-The primary aim was to explore the user experience (usability, satisfaction, level of motivation, and game experience) of the patient with the "PlayMancer" exergame. -The secondary aim was to explore the progression of the performed motor skills (walking velocity, overhead reach ability, and cervical range of motion) and the clinical changes (to physical condition, disability, and pain intensity) in a group of patients with chronic musculoskeletal pain using an exergame for 4 weeks.	-A SG- "PlayMancer", was designed for the focus group of participants, including at least 10 people. -Qualitative and quantitative analysis.	-The "PlayMancer" exergame is a potential tool for achieving physical rehabilitation because it motivates patients to perform their exercises and as a result increases their motor skills and physical condition. -It is expected that gaming has a true potential for physical rehabilitation in the future, especially when used in combination with telemedicine applications that enable home-exercising. - By playing the 'PlayMancer' game, patients made a progression in the requested motor skills.
5	Molina et al. 2014	<b>Virtual reality using games for improving physical functioning in older adults: a systematic review</b>	-To investigate the effectiveness of exercises using interactive games (exergames) in improving physical functioning in older adults.	Systematic review of 13 research articles	-Study shows that SG can be viable and well-accepted by older people. Their benefits for physical function in older people remain inconclusive. Further studies are needed in order to achieve better methodological quality, external validity and provide stronger scientific evidence.

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6	Marston et al. 2013	<b>Understanding the Nintendo Wii and Microsoft Kinect consoles in long-term care facilities</b>	<ul style="list-style-type: none"> <li>-To present an overview of the use of commercial video games technology (Nintendo Wii/Microsoft-Kinect) and their respective software (Wii Fit/Sports and Kinect Sports) which has been utilized within long-term care (LTC) facilities.</li> </ul>	<ul style="list-style-type: none"> <li>-Literature review using PRISMA guidelines for analysis.</li> </ul>	<ul style="list-style-type: none"> <li>-All studies on Microsoft-Kinect were excluded from the review because they did not match the inclusion/exclusion criteria.</li> <li>-Results for the Wii display potential for use in older adults in LTC. Further exploration is required to assess the potential of the Kinect in older care, home and clinical environments.</li> </ul>
7	Reichlin et al. 2011	<b>Assessing the acceptability and usability of an interactive Serious Game in aiding treatment decisions for patients with localized prostate cancer</b>	<ul style="list-style-type: none"> <li>-Using SG, aims to raise men's awareness and understanding of the impact of health-related quality of life issues associated with the major treatment options and to enrich their conversations with their health care providers</li> <li>-To determine the acceptability and usability of the SG- Time After Time.</li> </ul>	<ul style="list-style-type: none"> <li>-Action research. Qualitative analysis (13 participants).</li> </ul>	<ul style="list-style-type: none"> <li>-Findings support the use of serious video games as an educational aid on treatment side effects</li> <li>-The SG (Time After Time) has the potential to fill an important need for newly diagnosed patients. Also, it prepares patients for more active participation in conversations with their medical team. Opportunities to improve the game's usability exist.</li> </ul>

Table for critical appraisal tool used for the selected studies included in this review. Appraisal parameters by Aveyard (2010).

ARTICLE NO	REFERENCE	RESEARCH METHODOLOGY	SOURCE	SAMPLING SIZE/ NO OF ARTICLES REVIEWED	DATA COLLECTION METHOD	DATA ANALYSIS TECHNIQUE
1	Marin et al. 2011. Serious Games to Improve the Physical Health of the Elderly: A Categorization Scheme.	Literature review (qualitative)	Academic conference paper	Not mentioned	Electronic database search	Inductive
2	Webster and Celik. 2014. Systematic review of Kinect applications in elderly care and stroke rehabilitation.	Systematic review (qualitative)	Journal of neuro-engineering and rehabilitation ( <i>Impact factor: 2,63</i> )	48 studies reviewed	Systematic search	Inductive
3	Robert et al. 2014. Recommendations for the use of Serious Games in people with Alzheimer's Disease, related disorders and frailty.	Co-discovery action research (qualitative)	Frontiers in aging neuroscience journal ( <i>Impact factor: 2,84</i> )	Round one: 50 participants Round two: 10	Group discussion and web survey	SWOT
4	Stephanie et al. 2013. A Serious Exergame for Patients Suffering from Chronic Musculoskeletal Back and Neck Pain: A Pilot Study.	Action research (qualitative)	Games for health journal ( <i>Impact factor: 5,24</i> )	Focus group: total not specified but at least 10 included	Direct feedback interview	mixed approach: qualitative and quantitative
5	Molina et al. 2014. Virtual reality using games for improving physical functioning in older adults: a systematic review.	systematic review (qualitative)	Journal of neuro-engineering and rehabilitation ( <i>Impact factor: 2,63</i> )	13 studies reviewed	Systematic literature search	PEDro, inductive

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6	Marston et al. 2013. Understanding the Nintendo Wii and Microsoft Kinect consoles in long-term care facilities.	systematic review (qualitative)	Technology and Disability Journal ( <i>H-index: 22</i> )	6 studies reviewed	Systematic literature search	Inductive
7	Reichlin et al. 2011. Assessing the acceptability and usability of an interactive serious game in aiding treatment decisions for patients with localized prostate cancer.	Action research (Qualitative)	Journal of medical internet research ( <i>Impact factor: 4,67</i> )	Focus group: 13 (male) participants	Survey and group discussion	Qualitative



Data extraction form showing all three stages of data extraction

No.	Reference(Author, year, title)	Data code	DATA <sup>1</sup>	Data code	(DATA <sup>2</sup> )	Data code	DATA <sup>3</sup>
1	Marin et al. 2011. <b>Serious Games to Improve the Physical Health of the Elderly: A Categorization Scheme.</b>	1.1	“Overall, the reviewed literature showed that using games as a tool for rehabilitation and training has shown a positive outcome for the elderly.”	1.1.1	Tools for rehabilitation and training	1.1.2	Rehabilitation and training
		1.2	“Found that the most of the games for post rehabilitation did not include enjoyable content for the elderly.”	1.2.1	EXCLUDED	1.2.2	-
		1.3	“Used a modified version of the game Dance Dance Revolution. The main purpose of this game is to provide a tool to train the stepping abilities of the elderly, a common problem experienced by this population.”	1.3.1	For training stepping abilities	1.3.2	Training stepping abilities
		1.4	“Also, the author presents a design for monitoring the user performance by using mobile technology. This aims to enhance cooperation among patients and therapists by sending information about	1.4.1	Monitoring of user-performance for improving patient-client relationship	1.4.2	improving patient-client relationship

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			user performance to the practitioner”				
		1.5	“Developed a game to deliver balance and strength exercises. This project aims to help elderly users to improve their motor capabilities in lower-limbs in order to avoid falls.”	1.5.1	Delivering balance and strength exercises to avoid falls	1.5.2	Exercises to avoid falls
		1.6	“developed a series of webcam games considering the theory for design and rehabilitation (meaningful games, appropriate challenge). This project aims to provide a low-cost tool for upper limbs rehabilitation that can be used at home”	1.6.1	Upper limb rehabilitation tools	1.6.2	Upper limb rehabilitation
		1.7	“implemented an assistive robot to deliver arm exercises for the elderly. This robot monitors the performance of the user and provides motivation to the player promoting an increased range of motion”	1.7.1	Delivering arm exercises along with motivation. Monitoring via a robot	1.7.2	Robot -monitored arm exercises
		1.8	“developed a multi-touch table system to deliver training for upper-limbs. This platform was built under the guidance of occupational therapists, specialists who normally work with patients to	1.8.1	Touch technology for upper limb training	1.8.2	Upper limb training

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			help restore or improve motor functions”				
		1.9	“Some improvements in cognitive processes were observed after conducting trials with elderly patients who played specifically selected computer games.”	1.9.1	Improvement of cognitive process	1.9.2	Cognitive process improvement
		1.10	“...presented a case study where they developed a game for balance training considering the needs of the elderly.”	1.10.1	Games for balance training	1.10.2	Balance training
2	Webster and Celik. 2014. Systematic review of Kinect applications in elderly care and stroke rehabilitation	2.1	“...concluded that, in general, the Kinect has sufficient accuracy for the assessment of whole-body kinematics for postural control and diagnostic purposes.”	2.1.1	Assessment of body kinematics Diagnostic purposes and postural control	2.1.2	Postural assessment and diagnosis
		2.2	“...conducted two studies... the second study then investigated how participants responded to the derived game-based gestures, and concluded that Kinect-based gaming has a positive effect on user’s emotional wellbeing.”	2.2.1	Improvement of emotional wellbeing	2.2.2	Improves emotions
		2.3	“...developed a Kinect-based exergame which allowed players to participate in interactive balance exercises with visual feedback, and explored how Kinect-based balance training exercises influence the balance control ability	2.3.1	Interactive balance exercises	2.3.2	Balance exercises

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			and the tolerable intensity level of a player.”				
		2.4	“examined the health benefits of somatosensory video games specifically related to reaction time and hand-eye coordination on institutionalized older adults confined to wheelchairs”	2.4.1	Reaction time and eye coordination improvement	2.4.2	Improves reaction time
		2.5	“...presented a study which attempted to quantify the health benefits of Kinect-based somatosensory video games to older adults with disabilities. Various physical benefits were noted throughout the study”	2.5.1	Various physical benefits	2.5.2	Physical benefits
		2.6	“...proposed a smart glove extension to their system for concurrent hand and upper limb rehabilitation by requiring a player to actually grasp the virtual gems and place them into a receptacle instead of just hitting them.”	2.6.1	Upper limb rehabilitation	2.6.2	Upper limb rehabilitation
		2.7	“...noted that friendly competition built into a stroke-based serious game can increase social activity and enjoyment”	2.7.1	Increase in social activity and enjoyment via competition	2.7.2	Social activity and enjoyment.
		2.8	“...developed a serious game which functioned by estimating participants’ foot locations and then creating two virtual feet on a	2.8.1	Lower limb rehab for post-stroke	2.8.2	Improves post-stroke functionality

			screen with the game objective of using these virtual feet to step on randomly rising targets that emerged from the floor. The results of this follow-up study involving chronic stroke patients showed improvement on the Berg Balance Scale of 49.00 to 52.13 which was noted by the authors as surpassing standards of post-stroke improvement in functionality previously established...”				
3	Robert et al. 2014. Recommendations for the use of Serious Games in people with Alzheimer’s Disease, related disorders and frailty.	3.1	SG may play a role in promoting social interactions. For instance, there are SG that can be played by multiple players physically co-present, or in groups. Some multi-player SG can be played online by people connected from remote locations.	3.1.1	Promotes social interaction	3.1.2	Social interaction
		3.2	SG offers the therapists (and caregivers) the possibility to record and visualize the activity immediately after it has been recorded, and to measure the patient performance in real-time.	3.2.1	Enables professional client-monitoring	3.2.2	Real-time monitoring
		3.3	In the context of SG, it is possible to provide feedback on perfor-	3.3.1	Provides feedback of accomplished activities	3.3.2	Feedback accomplished activities

			mance and on accomplished activities, which is considered a key element to improving learning and rehabilitation of functional activities				
		3.4	<p>...”Promoting learning processes. When thinking about elderly people and people with dementia, there is a tendency to focus on rehabilitation and recovery of lost functions. However, neuroplasticity can also be improved by learning new things and activities, and by promoting positive affect and stress. SG can be easily employed for this purpose. The employment of ICT when playing a SG represents a learning opportunity and challenge for elderly people and people with dementia-related disorders. Furthermore, SG has been shown to be able to improve mood and to decrease stress...”</p>	3.4.1	Promote learning, improves mood and decrease stress	3.4.2	Mental and cognitive improvement
		3.5	<p>“Contrary to traditional rehabilitation methods that usually rely on costly physical mock-ups owned by specialized centres, SG offers the capacity to produce and distribute cheap and identical “standardized” environments.”</p>	3.5.1	Offers cheaper and standardised services	3.5.2	Cheaper and standardised services

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		3.6	“One of the strengths of rehabilitation programs based on SG is the possibility to collect and analyse performance data in real-time, and to provide the user with rapid performance feedback.”	3.6.1	Provision of real-time performance feedback during rehabilitation	3.6.2	Real-time performance feedback
		3.7	“SG may also be employed as an engagement tool to train caregivers and provide them with more “active” dementia-related information, as opposed to the traditional standard training methods.”	3.7.1	Training of caregivers	3.7.2	training caregivers
4	Jansen-Kosterink et al. 2013. A Serious Exergame for patients suffering from chronic musculoskeletal back and neck pain: a pilot study	4.1	“Patients experienced the “PlayMancer” exergame as positive. They rated the usability of the exergames as good, and the exergames clearly motivated patients to perform their exercises.”	4.1.1	Source of motivation for exercises	4.1.2	Motivation for exercises
		4.2	“Exergames, such as the “PlayMancer” exergame, encourage patients to perform their exercises, so they have the potential to overcome the generally low compliance with the home-based exercise programs”	4.2.1	Duplicate(4.1)	4.2.2	
		4.3	“Another positive aspect of the “PlayMancer” exergame is the availability of game data. These data provide the therapist with	4.3.1	Design of patient-centred exercise plans	4.3.2	Planning patient-centred exercise

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			detailed information on the progression of a patient in terms of the various trained motor skills. By using the available game data, the therapist can better align the game session to the needs of the individual patient, and the transparency of the treatment is increased, which matches the current trend in healthcare.”				
		4.4	“Previous randomized controlled trials have shown the potential of games for helping to rehabilitate stroke patients, patients with acquired brain injury...”	4.4.1	For rehabilitating stroke patients	4.4.2	Stroke patients rehabilitation
		4.5	“The underlying goal of this minigame (Temple of Magupta) is to improve walking velocity and thereby the overall physical conditions of the patients.”	4.5.1	Improvement of walking velocity	4.5.2	Walking velocity improvement
		4.6	“The underlying goal of this minigame (Face of Cronos) is to improve overhead reaching ability.”	4.6.1	improves overhead reaching ability	4.6.2	improves overhead reaching ability
		4.7	“The overall goal of this minigame (Three wind gods) is to improve the patient’s neck mobility.”	4.7.1	improves neck mobility	4.7.2	improves neck mobility



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NO	REFERENCE	DATA CODE	DATA <sup>1</sup>	DATA CODE	DATA <sup>2</sup>	DATA CODE	DATA <sup>3</sup>											
5	Molina et al. 2014. Virtual reality using games for improving physical functioning in older adults: a systematic review.	5.1a	“Some studies suggest that exercise using VR in elderly patients promotes improvements in mobility, in muscular strength of the lower limbs, in cognition, mainly of executive functions, in balance control, in reaction time, helps to prevent falls”	5.1.1a 5.1.1b 5.1.1c 5.1.1d 5.1.1e 5.1.1f	Improves mobility Increase strength of lower limbs Improvement of cognition Improvement of balance control Improvement of reaction time Helps prevent falls	5.1.2a 5.1.2b 5.1.2c 5.1.2d 5.1.2e 5.1.2f	Improves mobility Strengthens lower limbs Improves cognition Improves balance control Fastens reaction time Prevents fall											
								5.2a	“The other studies demonstrated improvements favoring the exergame group in some of the outcomes assessed, such as laboratory outcomes related to gait and posture control, balance, mobility, Self-efficacy for falls...”	5.2.1a 5.2.1b 5.2.1c 5.2.1d	Improves postural control Improves balance Improves mobility Helps prevent falls	5.2.2a 5.2.2b 5.2.2c 5.2.2d	Improves postural control Improves balance Improves mobility prevent fall					
														5.2b	5.2.1b	Improves balance	5.2.2b	Improves balance
								5.3	“In one study with three arms: a group using Wii Fit games, an MOB intervention group and a non-active control group it was observed a balance improvement in all	5.3.1	Improves balance	5.3.2	Improves balance					

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			groups with no difference between them...”				
		5.4a	“The older adults responded positively in terms of enjoyment and their perception of improvement in functional aspects after practicing the exergame	5.4.1a	Increases enjoyment and improves functionality	5.4.2a	higher enjoyment and functional-
		5.4b	“Four articles demonstrated high levels of adherence to the treatments”	5.4.1b	Improves adherence to treatment	5.4.2b	Improves treatment adherence
		5.5	“Within group analyses showed significant improvement after the intervention period on knee extension for both groups. CG had significant improvement on STS and EG for walking distance (6 MW test).”	5.5.1	Improves knee extension and walking distance	5.5.2	Improves walking distance
6	Marston et al. 2013. Understanding the Nintendo Wii and Microsoft Kinect consoles in long-term care facilities.	6.1	“The primary psychological benefits of the Wii came as a result of the console, allowing older adults to virtually participate in activities that they were no longer physically able to take part in.”	6.1.1	Opportunity for virtual exercises	6.1.2	Virtual exercises
		6.2	“...suggest the virtual environment of the Wii gave older adults the unique opportunity to have ownership and control over their	6.2.1	Promotes positive mental state	6.2.2	Improves mental state

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			surroundings, which had a positive effect on their mental state”				
		6.3	“...established that the older persons playing on the Wii console had higher self-esteem and better mental well-being than their peers who engaged in traditional care activities for older adults”	6.3.1	Increase self esteem	6.3.2	Enhances self-esteem
		6.4	“... noted, by allowing players to build their own avatars, the Wii gives older persons the unique opportunity to interact with other people using an appearance of their own choosing, which enhances their confidence”	6.4.1	Enhances confidence via avatars	6.4.2	Boosts self-confidence
		6.5	“The multiplayer focus of the Wii encourages people to play in groups, thus encouraging older persons to interact with people they would not normally associate with, including peers and family members, building upon intergenerational relationships”	6.5.1	Creates social environment and intergenerational relationships	6.5.2	Improves socialization
		6.6	“... observed gaming sessions using the Wii console reduced the hostility between individuals and encouraged greater interaction than traditional residential care activities”	6.6.1	Improves interaction Reduces and interpersonal hostility	6.6.2	Reduces hostility and inspires in- ion

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		6.7	"...concluded the Wii provided a unique opportunity for older persons to interact with younger generations. "	6.7.1	For interaction with younger generation	6.7.2	Intergenerational socialization
		6.8	"Overall, these articles found that the Wii Fit provided good motivation for older adults to exercise"	6.8.1	Provides motivation for exercise	6.8.2	Motivates exercise
		6.9	"...digital game play has the potential to support seniors in creating meaning and enjoying leisure time together or alone, and to train and uphold cognitive and motor abilities"	6.9.1	Creates meaningful and enjoyable leisure time	6.9.2	Quality leisure time
		6.10	"The simulation capability of the Wii enables older adults to experience tennis or bowling past the point where they are physically able to participate in the real sport"	6.10.1	Opportunity for the elderly to participate via virtual sports	6.10.2	Opportunity for virtual sports
		6.11	"...the Wii Fit had a significant impact in improving the balance and mobility of their participants"	6.11.1	Improves balance and mobility	6.11.2	Improves balance and mobility
		6.12	"...results have shown a positive response to the use of the Nintendo Wii console within this environment. In particular, the facilitation of spatial ownership, peer socialization, role creation during game play and enjoyment"	6.12.1	For peer-socialization and enjoyment	6.12.2	Facilitates socialization

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		6.13	“The physical effects of playing Wii games displayed the Wii could be used as a substitution for existing physical exercise programs in care for older persons, and even had the added benefit of providing mental stimulation “	6.13.1	Substitute for physical exercise and mental stimulation	6.13.2	Substitute for physical activity
		6.14	“...show that the Wii can have a positive impact on the physical and mental health of older persons in care facilities”	6.14.1	Improves physical and mental health	6.14.2	Improves physical and mental
7	Reichlin et al. 2011. Assessing the acceptability and usability of an interactive serious game in aiding treatment decisions for patients with localized prostate cancer.	7.1	“Our findings support the use of serious video games as a potential way to enhance education on treatment side effects and prepare patients for more active participation in conversations with their medical team”	7.1.1	Enhances patient education and communication	7.1.2	Patient education and communi-
		7.2	“As an interactive decision aid, Time After Time can fill this knowledge gap by providing men diagnosed with localized prostate cancer with evidence-based education on the HRQOL impacts of treatment side effects.	7.2.1	As a decision aid	7.2.2	Facilitates decision making

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		7.3	Our initial research has made clear that game-based interactive decision aids for localized prostate cancer like Time After Time have the potential to fill an important need for newly diagnosed patients. The 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”	7.3.1	Interactive decision aid	7.3.2	Interactive decision aid
		7.4	“Participants verified that the game meets the goals of increasing focus on HRQOL issues, generating questions for the patient’s health care team, and providing a new educational avenue to augment the patients’ participation in choosing a treatment for localized prostate cancer”	7.4.1	Increases patient’s participation in choosing a treatment	7.4.2	Patient autonomy