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Serious Games in Healthcare: Results from a Systematic Mapping Study

TANJA KORHONEN & RAIJA HALONEN

Abstract There is a need to understand, on a large scale, the role that serious games (SG) in healthcare can play in empowering citizens or patients. This systematic mapping study aims to identify how SG in healthcare is perceived and approached in the literature. A total of 408 studies from 2005-2016 were found, and after screening and exclusion, 83 studies were analysed. This study found that case studies with solution approaches that described design or development and literature reviews were the most popular methods used to analyse SG in healthcare. The biggest demographic groups targeted by SG that were described in these papers were children, the elderly, and patients with certain diseases. According to the results, the top five SG subjects in healthcare are education, exergaming, cognitive rehabilitation, psychology, and physical rehabilitation. The results suggest that the next focus will be on developing general guidelines for SG developers in healthcare, focusing on validation of SG and research of SG maturity models to improve level of development. Future studies should integrate the gaming industry and healthcare professionals.

Keywords: • Serious Games • SG • Health Games • Systematic Mapping Study •

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1 Introduction

The current study analysed how earlier studies have approached and presented serious games (SG) in healthcare. The term serious game, or applied game, is used to classify a game in which its main purpose is something other than pure entertainment (Djaouti, Alvarez, Jessel & Rampnoux, 2011; Susi, Johannesson & Backlund, 2007; Zyda, 2005). This group includes several subgroups, including edutainment, advergaming, edumarket games, political games, and training and simulation games, to educate, train, advertise, and influence people (Alvarez et al., 2007). Games can work as motivators or to help change players' behaviour (Baranowski et al., 2013; Ryan, Rigby & Przybylski, 2006).

Healthcare services are looking for new functions to empower their customers. SG in healthcare can provide methods for maintaining and developing health in different age groups. The goal can be to provide a new kind of model for self-help or rehabilitation. (Kemppainen, Korhonen & Ravelin, 2014.)

Play and entertainment can be effective foundations for serious interventions in healthcare. Nevertheless, there is a need for more research studies that show a causal link between playing video games and health outcomes. (Kato, 2010.)

We wanted to understand how SG are seen by researchers. The main research question was:

How are serious games in healthcare perceived and approached in the literature?

To get the answer, three supplementary questions were presented:

- (RQ1) Which journals include papers on serious games in healthcare?
- (RQ2) What are the most investigated areas of serious games in the health sector and how have these changed over time?
- (RQ3) What research type and methods are most frequently applied?

A method of systematic mapping (Kitchenham & Charters, 2007) was selected for getting a broad overview of the chosen area. Systematic mapping study is a proper method to reveal whether there is research evidence on a topic, and to provide any indication of the quantity of evidence (Kitchenham & Charters, 2007). The guidelines provided by Petersen et al. (2008); Petersen, Vakkalanka, and Kuzniarz (2015); and Kitchenham, Budgen, and Brereton (2011) were applied. Existing criteria on research approaches given by Wieringa, Maiden, and Roland (2006) were utilised in the evaluation.

This paper presents a systematic mapping study of SG in healthcare and is organised into four major sections: background and related work on SG, research approach, mapping results, and conclusions.

2 Background and Related Work

The concept of serious games was introduced in the 1970s when it referred to an activity among two or more independent decision-makers seeking objectives in a limited context. In that time, SG were focused on educational functions (Ricciardi & De Paolis, 2014). The concept involves a digital game whose main purpose is something other than pure entertainment and is designed to be used in training, education, and healthcare (Loh, Sheng & Ifenthaler, 2015).

Zyda (2005) defined a serious game as:

> a mental contest, played with a computer in accordance with specific rules that use entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives (p.25).

Susi, Johannesson & Backlund (2007) defined SG as:

> games that engage the user and contribute to the achievement of a defined purpose other than pure entertainment (whether or not the user is consciously aware of it) (p.5).

Fullerton (2014) described a digital game as a system in which the whole is greater than the sum of its parts. A digital game creates a structured conflict and provides an entertaining process for players to resolve that conflict (Fullerton, 2014). Game design combines psychological aspects (Rigby & Ryan, 2011) with mechanical and artistic aspects (Fullerton, 2014). Game designers empathise with players, and their main task is to ensure that the game will be entertaining (Adams, 2013.) Juul (2011) defined video game as a game played using computer power and a video display that can be a computer, cell phone, or console game. Video games not only can tell stories, but also allow players to live them (Rigby & Ryan, 2011). Figure 1 illustrates aspects of SG design.

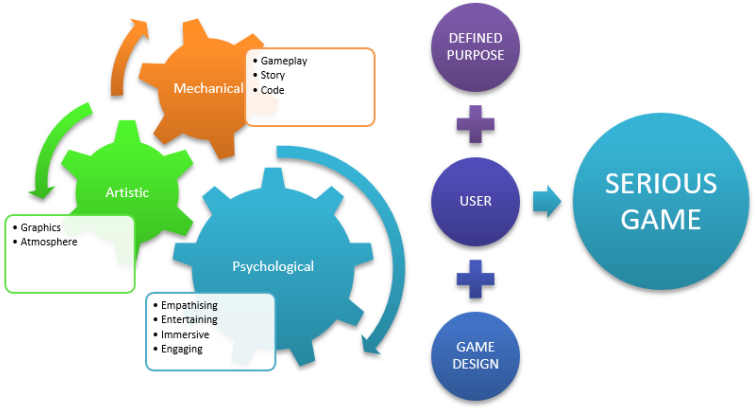

Figure 1: Aspects of Serious Game Design

Research on player motivation is founded on knowing what psychological needs games satisfy and how different games fulfil those needs, and immersion, in which a player is transported to a fictional world through storytelling is a valuable asset. This provides information about both positive and negative experiences within games. (Rigby & Ryan, 2011.) In the early 2000s, Rollings and Adams (2003, p.201) defined gameplay as 'One or more causally linked series of challenges in a simulated environment', and Adams (2013) later described gameplay as:

> the challenges presented to players and the actions players are permitted to take, both to overcome those challenges and to perform other enjoyable activities in the game world (p.511).

The healthcare sector has strong interests in using new technologies related to health. SG in the health sector can be divided into game-based education of health professionals and improving therapeutic outcomes of patients. Today's increasing challenges with aging populations and chronic diseases suggest that serious games in healthcare may be one strategy to help with survival (Arnab, Dunwell & Debattista, 2013).

Health games can be classified also by their main purpose, type of players, and the stage of disease of patients. The stages of disease of patients include stage of susceptibility (healthy non-patients with the possibility of certain illnesses), pre-symptomatic stage (patients feeling healthy with specific illness), stage of clinical disease (patients or professionals), or stage of recovery or disability (patients or professionals), as divided by Wattanasoontorn, Hernandez, and Sbert (2014), who indicated three main purposes for health games:

1. Games that are designed originally for entertainment and in which a health purpose comes secondary, but can be found in the games.

2. Games that include a health topic to pass on knowledge or skills.
3. Training games with medical purposes, including simulations.

The classifications by Wattanasoontorn et al. (2014) also divide health games by player, as in patient player (health monitoring, detection, treatment, rehabilitation, education for self-care) and non-patient player (wellness, simulation games). Furthermore, health games can be classified in the areas of physical fitness, education in health, training and simulation, rehabilitation (recovery, therapy), diagnosis and treatment of mental conditions, cognitive functioning and self-control (Susi et al., 2007). Figure 2 illustrates these classifications.

Figure 2: Classification of SG in healthcare (Wattanasoontorn et al., 2014; Susi et al., 2007)

There are many different stakeholders in the health-game market, such as hospitals, clinics, private-practice physicians (including therapists and personal trainers), government, corporations, other organizations, and individual consumers (Susi et al., 2007). Social Security systems and healthcare providers differ significantly among different countries and on a global scale, with each market area having its own methods to facilitate a healthy lifestyle (Kaleva, Hiltunen & Latva, 2013). Significant changes should be expected, for example, in medical simulations, serious games, and mobile serious games, and an increased need for serious-game analysis is already present (Loh et al., 2015).

Supporting players' motivations and enhancing behavioural changes are essential in health-game design (Rigby & Ryan, 2011). Design includes using game elements such as surprise and simulation to engage players and enable immersion (Adams, 2013). On the other hand, developing a health game requires a multi-disciplinary team to work together successfully (Kemppainen et al., 2014). It is important to define both the target group and main objective, then design a game accordingly using sound game-design principles in collaboration with health professionals and involving patients as early as possible (Brox, Fernandez-Luque & Tollefsen, 2011). Braad, Folkerts, and Jonker (2013) describe the health-game design process as a game-based intervention process. Their human-centred design method consists of four phases: analysis, design, development, and evaluation.

Like Braad et al. (2013), Friess, Kolas, and Knoch (2014) and Deen et al. (2014) use similar processes in SG development in the health sector. They all include strong research and analysis phases at the beginning, and involving different stakeholders is essential. Iterative development processes or the use of prototyping are among their development methods. The game-development process then ends usually with user-group testing and evaluation or validation phases.

In the design of SG in health games, the target group should be considered during the development process (Brox et al., 2011; Braad et al., 2013; Friess et al., 2014; Deen et al., 2014). A multi-disciplinary team is necessary to develop a successful and effective health game, and professional knowledge is an essential part of the development process (Kemppainen et al., 2014; Merry et al., 2012).

3 Research Approach

To get an overview of SG in healthcare studies, the guidelines for a systematic mapping process (presented in Chapter 3.1, Fig. 1) were followed. This chapter describes the chosen research method and how it was applied.

3.1 Overview of Systematic Mapping Study

A standard systematic literature review is usually conducted over a specific research question that can be answered by empirical research (Kitchenham et al., 2011). A mapping study, on the other hand, aims to provide an overview of a topic area through multiple research questions (Kitchenham et al., 2011). Mapping questions are about what we know with respect to a specified topic (Petersen et al., 2015). The results of a systematic mapping -- presented as a visual summary, the map -- help determine in which areas to conduct a conventional systematic literature review (Kitchenham et al., 2011; Petersen et al., 2008).

A systematic mapping process (Fig 3) defined by Petersen et al. (2008) consists of the following process steps: definition of research questions, conducting the search for

relevant papers, screening of papers, keywording using abstracts, and data extraction and mapping. The categories used in a mapping study are usually based on publication information such as authors' names, authors' affiliations, publication source, publication type, publication date, and/or information about the research methods used (Kitchenham et al., 2011).

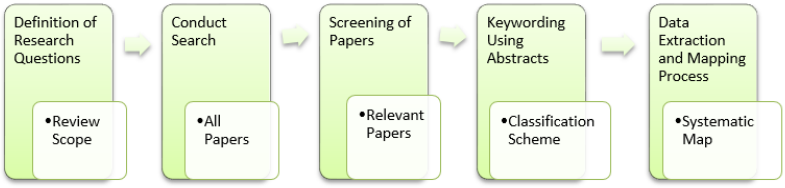

Figure 3: Systematic mapping process (Petersen et al., 2008).

Mapping questions often are formulated around what we know with respect to a specified topic and include questions regarding venues, research methods, and trends (Petersen et al., 2015). The search is conducted in relevant databases for all papers in the research field, and, as recommended by Kitchenham and Brereton (2013), the use of IEEE and ACM, as well as two indexing databases, is sufficient. A search string is defined based on the research questions (Petersen et al., 2008).

The third step in the systematic mapping process is the screening of papers. Inclusion and exclusion criteria are needed to find relevant papers that answer the research questions (Petersen et al., 2008). Inclusion and exclusion criteria can be related to the relevance of the topic of the article, venue of publication, period considered, requirements for evaluation, and restrictions with respect to language (Petersen et al., 2015). The selection of papers is performed on titles and abstracts, thereby building a classification scheme first, then later reading is extended to introductions and conclusions (Petersen et al., 2015).

For classifying the type of research, Kitchenham et al. (2011) and Petersen et al. (2008,2015) recommended using a classification system developed by Wieringa et al. (2006) with six categories:

1. Validation research, which concerns evaluating novel techniques not yet deployed in industry
2. Evaluation research, which concerns evaluating industrial practices
3. Solution proposals, which discuss new or revised techniques
4. Philosophical papers, which structure the field in new ways, such as taxonomies
5. Opinion papers
6. Experience papers, which discuss how someone did something in practice

In the data-extraction phase, relevant articles are sorted into a scheme, such as an Excel spreadsheet. The mapping process ends with a presentation on the frequencies of publications for each category using maps for visualization (Petersen et al., 2008).

3.2 Research Questions

To get a broad overview on how serious games in healthcare are perceived and approached in the literature, the following supplementary questions were asked:

- RQ1: Which journals include papers on serious games in healthcare?
- RQ2: What are the most investigated areas of serious games in the health sector and how have these changed over time?
- RQ3: What research types and methods are most frequently applied?

The objective of RQ1 was to identify the forums of discussion. The objective of RQ2 was to discover trends in research and possible gaps. The objective of RQ3 was to determine the methods of research used.

3.3 Search and Screening of Papers

To get a broad overview of the research area, searches were first conducted on these scientific databases: IEEE, ACM, Scopus, Web of Science, and Google Scholar. At the second stage, the database of Web of Science was left out of the process due to technical problems with remote access. The search string was formulated by considering the properties of each database.

Search string: Search for serious games in healthcare, i.e. ‘serious games’ OR ‘serious game’ OR ‘applied game’ AND ‘health’ OR ‘healthcare’ AND ‘design’ or ‘development’.

The search strings used for each database and number of search results per database are presented in Table 1. Without the design and development elements of the search parameters, the number of papers filtered out would have totaled 2,199.

Table 1: Search strings and number of results in databases

Database	**IEEE**	**ACM**	**Scopus**	**Web of Science**	**Google Scholar**	**Total**
Search string Refined search to design, development	(('Document Title':'Serious games' OR 'Document Title':'serious game' OR 'Document Title':'health game' OR 'Document Title':'applied game') AND 'Document Title':'health' AND (p_Title:'development' OR 'Document Title':'design'))	(('Serious games') OR ('serious game') OR ('health game') OR ('applied game')) AND (('development') OR ('design')) AND ((health) OR ('healthcare')))	TITLE-ABS-KEY('Serious games' OR 'serious game' OR 'health game' OR 'applied game' AND (('development') OR ('design')) AND (('health') OR ('healthcare'))) AND (LIMIT-TO(DOCTYPE,'cp') OR LIMIT-TO(DOCTYPE,'ar')) AND (LIMIT-TO(SUBJAREA,'COMP') OR LIMIT-TO(SUBJAREA,'ENGI')) AND (LIMIT-TO(LANGUAGE,'English'))	(('Serious games') OR ('serious game') OR ('health game') OR ('applied game')) AND (('development') OR ('design')) AND ((health) OR ('healthcare')))	-	
	93	**95**	**276**	**108**	**79**	**651**

The following inclusion criteria were applied to titles in the screening of papers (reading through titles and abstracts):

- Topic of study focuses on serious games in healthcare.
- Studies are in the field of software engineering or information systems.

The following exclusion criteria were applied to titles in the screening of papers:

- Studies presenting summaries of conferences/editorials
- Studies presenting non-peer-reviewed material
- Studies not presented in English

- Studies not accessible in full text
- Books and grey literature.
- Studies that are duplicates of other studies.

This yielded a total of 479 papers, of which 71 were found to be duplicates, leading to a final total of 408 papers (see Table 2).

Table 2: Number of included papers.

Database	**IEEE**	**ACM**	**Scopus**	**Web of Science**	**Google Scholar**	**Total**
After screening of papers, exclusion of papers outside of focus area.	60	90	221	75	33	479
Duplicates						71
Total						**408**

3.4 Keywording and Study Selection

The basic information in papers, such as authors, titles, years published, source titles, abstracts, digital object identifiers (DOIs), and links were exported into an Excel spreadsheet. This table was used in keywording to find the classification scheme as follows: Abstracts from ACM, IEEE, and Scopus search results were downloaded as text from the Excel spreadsheet to TagCrowd (www.tagcrowd.com) to create an overview of used keywords in the filtered-out abstracts. These keywords are presented in Figure 4 to visualise the volumes of used words in the abstracts.

The classification schemes were formed based on the chosen keywords and included research articles. From these keywords and connecting the information with research questions, the following classification schemes were formed:

1. Source Title (RQ1)
2. Aim/target and focus (RQ2), Year (RQ2): using keywords such as behaviour change, cognitive, education/learning, rehabilitation, therapy, exergaming, design/development, user/patient, interaction, persuasive, usability
3. Research type: validation, evaluation, solution, philosophical, opinion, experience (RQ3), and research method (RQ3)

Figure 4: Frequencies of keywords/index terms.

The frequencies of keywords or index terms of 'serious games in healthcare' are presented in this order: ACM (upper left), IEEE (upper right), and Scopus (lower left) in Figure 4.

3.5 Data Extraction and Mapping Process

To answer research questions, the data was sorted on an Excel spreadsheet (data-extraction form) with basic identification information from papers such as identification number (ID), authors, titles, years published, source titles, DOIs, and links. The classification schemes were added: aim/target and focus, research type, and research method.

Since the search results totaled up to 408 papers, it was decided that RQ1 and, partly, RQ2 would be based on the whole body of articles. On the other hand, to be able to answer RQ2 and RQ3 required reading through papers and gathering needed information in classification schemes. It was decided that this would be done in publications that have 10 or more papers in each source publication, restricting the upper limit of read papers to 112. Each of these papers was read to find the above information, which was added to the spreadsheet. At this phase, 18 papers were considered to be not fully in the realm of health games and thus were excluded, and 11 were not available as full text, which brought the number of papers down to 83. If information was not available on the abstract, or the paper was not accessible in full text, it was excluded at this point. Papers were arranged in ascending order by publication time.

The analysis of the results focused on presenting the frequencies of publications for each category.

The quality of the sample of studies selected in the inclusion/exclusion process, generalizability of the results of the mapping, and reliability of the conclusions drawn in relation to the data collected were identified as possible threats to the validity of the research.

4 Analysis and Interpretation

This chapter is structured with the help of the assisting research questions.

4.1 Venues of Publication (RQ1)

To find out which journals include papers on SG in healthcare, the distribution of papers in different publications is visualised in Figure 5, and the publications that have 10 or more papers in each publication are listed in Table 3. The papers were published in 163 different publications, which indicates quite a vast distribution over different sectors; 93 publications included only one (1) paper in this area.

Table 3: SG in Healthcare publications with 10 or more papers.

Name of Publication	Number of Papers
IEEE International Conference on Serious Games and Applications for Health (SeGAH)	41
Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	31
International Conference on Pervasive Computing Technologies for Healthcare	15
Studies in Health Technology and Informatics	15
Games for Health Journal	10
Total	112

The most popular publication was IEEE SeGAH Conference, with 41 papers, the Lecture Notes in Computer Science came in second, with 31 papers. The research area of SG in healthcare covered many research disciplines. Most of the papers were from conferences.

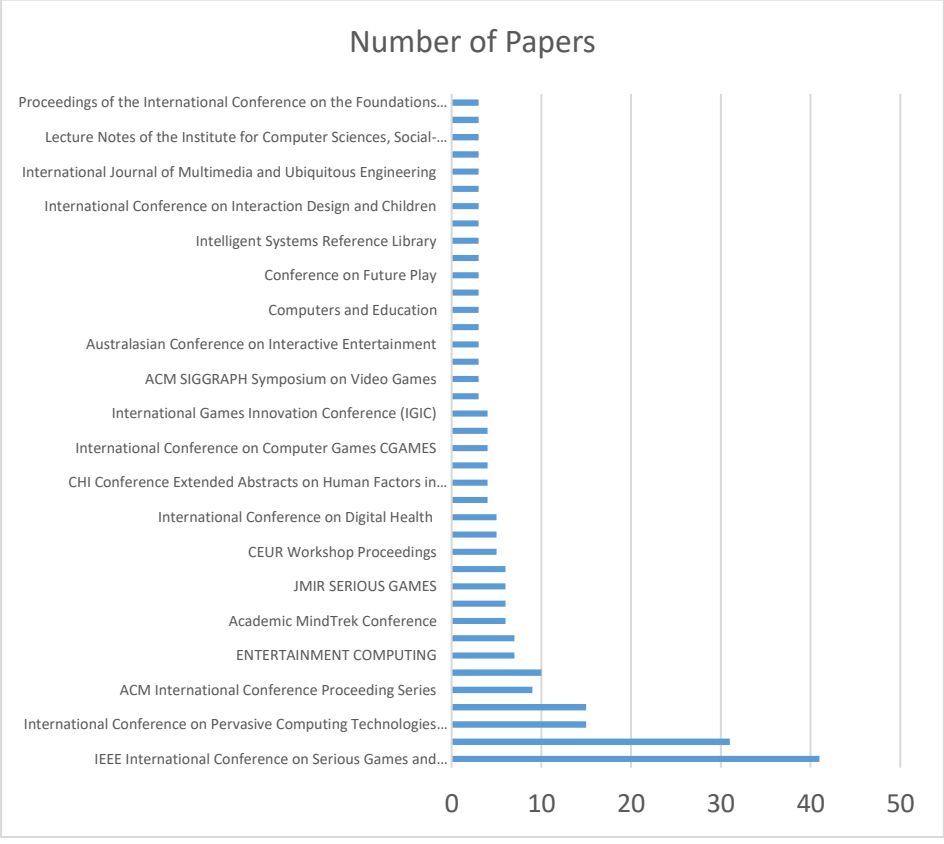

Figure 5: SG in Healthcare source publications and number of articles with three or more papers.

4.2 Topics and Frequency of Publication (RQ2)

To analyse the annual distribution of SG articles in healthcare, the annual distribution was calculated between the years 2005 and 2016. Some of the papers were published in 2017, but those were excluded due to the scheduling of the study. Figure 6 shows the number of papers over the years, and the trend has been increasing until 2014. After that, there was a gap in 2015, and it went back up to 82 in 2016.

Figure 6: Number of papers on SG in healthcare between 2005 and 2016.

According to a content analysis of 83 papers, the most investigated areas of serious games in the healthcare sector regarding games' aims are presented in Figure 7. The five top subjects of serious games were:

- Education (14)
- Exergaming (8)
- Cognitive rehabilitation (6)
- Psychology (6) and
- Rehabilitation (6)

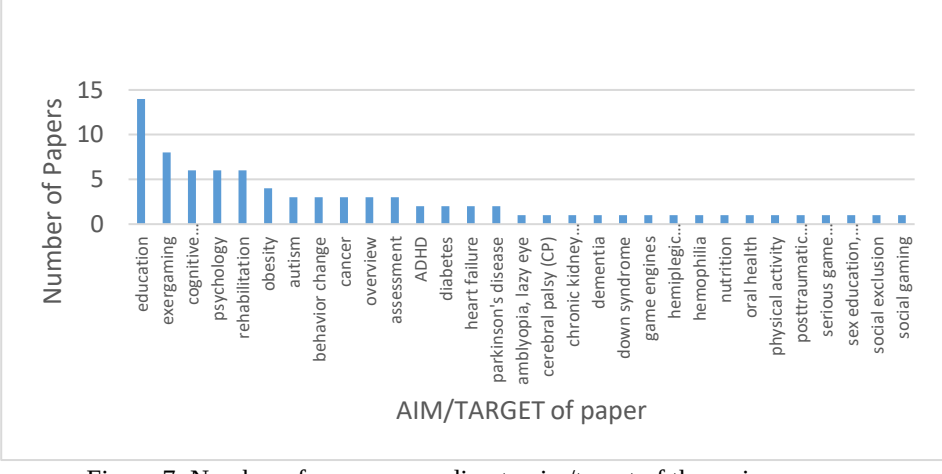

Figure 7: Number of papers according to aim/target of the serious game.

Most of the papers focus on describing design and development of a serious game (28). The next most popular focus areas were user-centred design (6) and participatory design (5). This is presented in Figure 8.

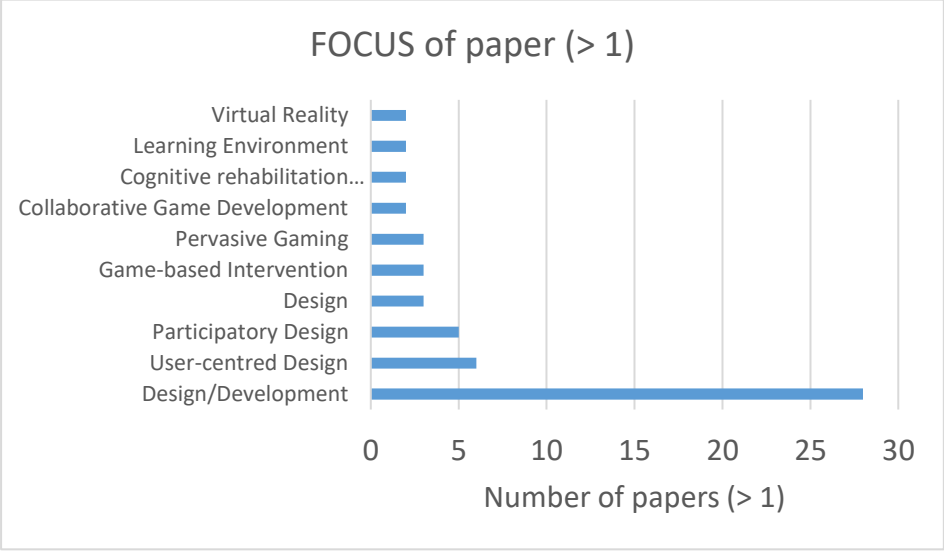

Figure 8: Number of papers grouped by focus of the paper.

One way to categorise the most investigated areas of health care was to analyse the target group of developed games. As illustrated in Figure 9, the targeted demographic groups of most serious games in these papers were children (20), the elderly (15), and patients of certain diseases (8).

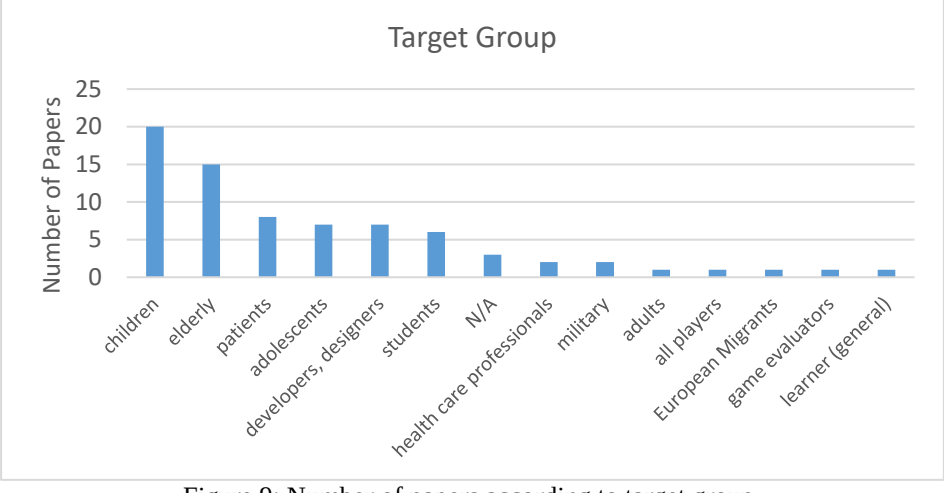

Figure 9: Number of papers according to target group.

4.3 Research Types and Methods (RQ3)

To analyse the research type and methods, the papers were categorised according to the research types in the classification system by Wieringa et al. (2006). None of the analysed papers were considered Opinion or Experience research. 55% of them were categorised as Solution Research, 19% Philosophical, 15% Validation, and 11% Evaluation Research, which is presented in Figure 10.

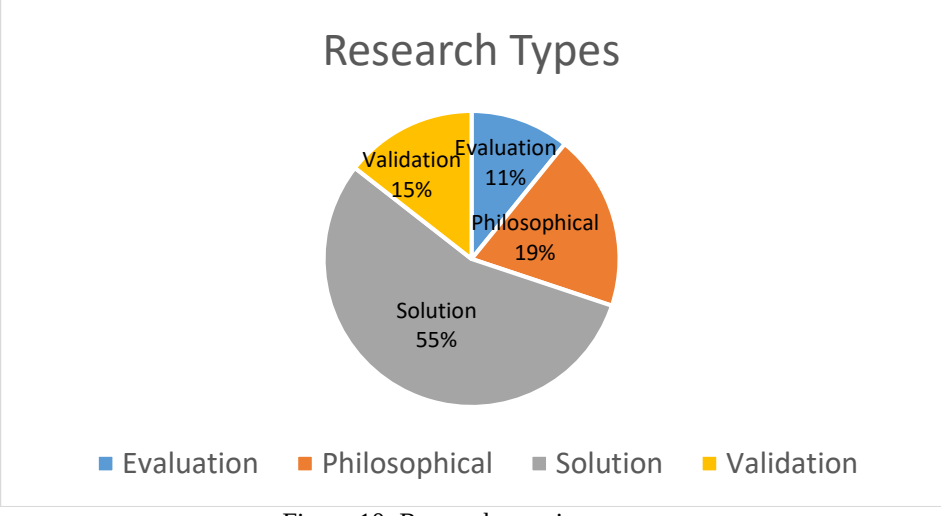

Figure 10: Research type in papers.

Research methods in analysed papers are presented in Figure 11. Most of the papers were classified under case studies and literature reviews/studies.

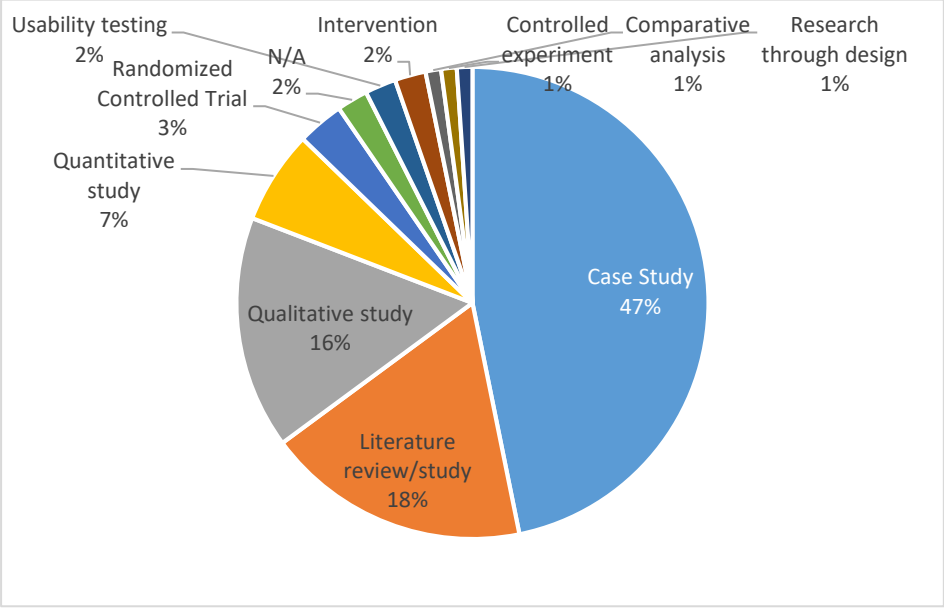

Figure 11: Research methods of papers.

5 Conclusions

The purpose of the study was to analyse how SG in healthcare are perceived and approached in the literature. To solve the research problem, systematic literature mapping was applied in the study. A total of 408 studies from 2005-2016 were found, and after screening and exclusion, 83 studies were analysed. The results of this systematic mapping could be used to identify gap areas in research of SG in healthcare.

Although the concept of serious games is from the 1970s (Ricciardi & De Paolis, 2014), we found out that there were just a few publications who wrote about the phenomenon before 2009. The number of publications increased until 2014, after which there was a gap in 2015, then the number increased again in 2016. Most of the analysed papers came from conferences. The most popular forum of discussion was the IEEE SeGAH conference, with the Lecture Notes in Computer Science coming in second. Since the development of SG in healthcare is multi-disciplinary (Kemppainen et al., 2014; Merry et al., 2012), some of these papers were published in medical journals and thus were not included in this study.

Wattanasoontorn et al. (2014) classified health games by their main purpose, types of players, and patients' stage of disease. The biggest target groups of SG described in this mapping study were children, the elderly and patients with certain diseases. In the analysed studies, the main purpose and type of player were easily found, but none used classifications for stages of disease. The five top topics of SG in healthcare were

education, exergaming, cognitive rehabilitation, psychology, and physical rehabilitation. In educational games, the players were 1) healthy people (informative, preventive approach) of a certain group: children, adolescents, the elderly, etc. 2) patients with certain diseases (informative, educative) or 3) students and professionals in a certain medical area (educative, training, or simulation).

Considering the focus and methods of research, the most common approach was to describe design or development of SG by using a case study. Most of these were considered solution proposals as defined by Wieringa et al., thereby discussing new or revised techniques. The focus of most studies was in using user-centred, participatory, and collaborative design models. This supports prior research involving different stakeholders in SG development (Brox et al., 2011; Braad et al., 2013; Friess et al., 2014; Deen et al., 2014). Also, there were some literature reviews that were deemed to be philosophical papers, structuring the research field in new ways. Kato (2010) brought up the need for validation of SG in healthcare, but it was not seen as a topic in many papers. One RCT and a controlled experiment were found, as well as a couple of intervention studies. Few papers covered guidelines for assessment of SG. Many described prototypes of SG were tested with focus groups, but there were no further studies found. There were just a few papers focusing generally on SG design or providing guidelines for SG developers in healthcare, even though there were plenty of cases described.

The study unearthed new knowledge on the topic of how serious games in healthcare are perceived and approached in the literature. The results provide a foundation for deeper analysis of the use of SG in the health sector, and suggest that the next focus will be on developing general guidelines for SG developers in healthcare, focusing on validation of SG and research of SG maturity models to improve level of development.

The study points to future avenues of research integrating both the gaming industry and healthcare professionals. There are limitations to the study of research mapping, and further studies should be conducted to validate and further extend the knowledge of SG in healthcare.

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