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Review

Serious Games and Gamification in Healthcare: A Meta-Review

Robertas Damaševičius [1,*], Rytis Maskeliūnas [2] and Tomas Blažauskas [1]

[1] Department of Software Engineering, Kaunas University of Technology, 44249 Kaunas, Lithuania
[2] Department of Multimedia Engineering, Kaunas University of Technology, 44249 Kaunas, Lithuania
* Correspondence: robertas.damasevicius@ktu.lt

Abstract: A serious game is a type of game that is designed for a primary purpose other than entertainment. Instead, serious games are intended to achieve specific goals, such as education, training, or health promotion. The goal of serious games is to engage players in a way that is both enjoyable and effective in achieving the intended learning or behavior change outcomes. Recently, several systematic reviews on the development and application of serious games and on the application of gamification techniques have been published, which indicate high activity and ongoing progress in this area of research. Such an extensive body of review papers raises the need to analyze and extract the current state and the prevailing trends of the serious games and gamification (SGG) domain by analyzing and summarizing the systematic review articles. This study presents a systematic meta-review, i.e., a review of the 53 survey papers on the domain of serious games and gamification. The systematic review follows the PRISMA guidelines, while constructive and cross-sectional methods are used to analyze and present the results. Finally, this study identifies the future trends and challenges for the domain. As a result, the meta-review helps the reader to quickly assess the present status of SGG and serves as a reference for finding further information on each technology utilized in SGG. Using the criterion of the citations, the meta-review analysis provides insight into the quantity and academic relevance of the published SGG articles. Moreover, 53 articles published in journals were selected as important surveys in the research field. The study found that serious games and gamification techniques are increasingly being used for a wide range of health conditions and the focus is shifting towards the use of mobile and digital platforms, virtual reality, and machine learning to personalize and adapt interventions. The existing research gaps include the lack of standardization in development and evaluation, insufficient understanding of underlying mechanisms of action, limited understanding of integration into existing healthcare systems, limited understanding of specific game mechanics and design elements for promoting health behaviors, and limited research on scalability, adoption, and long-term effects. These research gaps highlight the need for further research to fully understand the potential and limitations of serious games and gamification for health and how to effectively apply them.

Keywords: gamification; serious game; healthcare; meta-review

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1. Introduction

A game is a structured activity that is typically conducted for entertainment or leisure purposes but can also be used for educational or training purposes [1]. Games can take many forms, including physical games, board games, card games, video games, and online games. There are various meanings of the term "game", all of which have some similarities but also significant distinctions. Several definitions tend to lump other activities into the same class as games, while others exclude a few games based on various criteria (for example, "artistic motive"). For the sake of this evaluation of digital game reviews, we selected Smed and Hakonen's view on games [2]. This definition considers the digital character of games while defining games based on factors directly connected to game-like traits, rather than creative or economic decisions adopted during development. Another definition states that a game is a collection of goal-oriented actions carried out by following

the predetermined rules [2]. Games are distinguished from profession simulators and virtual reality (VR) apps by their goal-oriented character, which drives the player. Simultaneously, the rules provide difficulties, and unexpected random actions or unpredictable human players can cause conflicts, preventing participants from reaching their aim. The game's depiction makes the game more concrete for the player and matches to the game's regulations. Digital games are played on computers and mobile phones with the help of digital equipment [3].

A serious game is a type of game that is designed for a primary purpose other than entertainment [4]. Instead, serious games are intended to achieve specific goals, such as education, training, or health promotion. Serious games can take many forms, such as simulations, role-playing games, and educational games, and can be used in various settings, such as classrooms, workplaces, and healthcare settings. The goal of serious games is to engage players in a way that is both enjoyable and effective in achieving the intended learning or behavior change outcomes [5]. Initially, serious games were adopted in the educational domain to promote interest and support motivation in learning [6,7]. The concept of utilizing serious games to improve healthcare outcomes has attracted support from an increasing group of academic scholars, developers, and healthcare practitioners [8]. Many people are now aware of the need of developing evidence-based games which are specifically geared to treat physical and mental health issues that end users suffer with [9]. Game-based therapies are increasingly being used in healthcare to promote motivation, engagement, and the overall sustainability of health habits [10]. Gamification and serious games are the most common forms of game-based treatments in healthcare studies.

Gamification is the process of incorporating game design elements into non-game contexts, such as business, education, or healthcare, to engage and motivate people to achieve their goals [11]. Gamification can take many forms, such as adding points, badges, or leaderboards to a task or activity, or incorporating game-like challenges and feedback into a process or system. The goal of gamification is to increase engagement, motivation, and participation in the task or activity, and to improve outcomes such as learning, productivity, or health [12]. Gamification is a comparatively recent concept that shines a spotlight on using game principles in non-game environments to attract audiences and insert the elements of entertainment into monotonous work while also providing motivational and cognitive advantages [1]. While many industries, such as business [13], marketing [14], work [15], and education [16], have taken advantage of gamification's potential, the digital healthcare sphere has begun to do so as well. However, it is fascinating to observe that gamification has entered the mainstream, whereas serious games have remained on a small scale, regardless of how outdated the idea of serious games is.

Recently, there has been an upsurge in research into the usefulness of digital games, with multiple individual and systematic reviews that present the top level of research evidence in the field [3–5,12,16]. There are several reasons why there is a need to research games, serious games, and gamification methods. Firstly, games and gamification are being increasingly used in various fields such as education, health, business, and government, and there is a need to understand their effectiveness in achieving specific goals and outcomes. Research can help to identify the most effective game mechanics and design elements for different contexts and populations, and to understand how these interventions can be integrated into existing systems and processes. Secondly, the use of games and gamification is rapidly growing and evolving, and there is a need to keep up with the latest developments and trends in the field. Research can help to identify new and emerging technologies and techniques, and to understand how these can be used to achieve specific goals and outcomes. Thirdly, games and gamification have the potential to make a positive impact on people's lives, and there is a need to understand how these interventions can be used to promote positive health outcomes, improve education and training, and increase engagement and motivation in different fields. Research can help to identify the most effective ways of using these interventions to achieve specific goals and outcomes. Lastly, the field of games, serious games, and gamification is still relatively new, and there is a need to

establish a strong evidence base to support the use of these interventions in different fields. Research can help to establish the best practices, guidelines, and standards for the use of games and gamification, and to identify areas for further research and development. As a result, a summary and assessment of the quality of these data published in systematic evaluations and reviews would be useful for building future serious games and guiding future gamification research.

A previous meta-review in the areas related to the development and use of serious games included the works of Radu et al. [17] and Parisod et al. [18]. Radu et al. [17] discussed augmented reality (AR) as an educational medium, which also included educational games. The study examined 26 prior studies that contrasted student learning in AR against non-AR apps. The meta-review of Parisod et al. [18] examined digital games that are good for promoting kids' health. This evaluation of reviews was conducted with the intent of evaluating the quality of systematic reviews, summarizing the evidence in those studies that focused on the usefulness of games in supporting and promoting healthy lifestyle, and identifying knowledge gaps.

The purpose of this study is to provide an overview of the topic of using serious games and gamification (SGG) in various fields. It serves as a meta-review, offering a comprehensive understanding of what gamification can offer without delving into detailed comparisons of methods or outcomes. The aim is not to suggest a single optimal strategy for using SGG, but rather to provide a complete evaluation to help academics and practitioners to understand the research gaps and potential of this approach.

The goal of this study is to conduct a systematic analysis of SGG research using a well-defined data search process and coding scheme to answer the following questions:

1. What are the most common health conditions that serious games and gamification techniques have been used to address?
2. What are the most common game mechanics and design elements used in serious games and gamification for health?
3. What is the evidence for the effectiveness of serious games and gamification in promoting positive health outcomes?

The following are the primary contributions of this study:

- A curated collection of SGG surveys over the last five years.
- Based on citations to publications discovered in chosen surveys, an analysis of the present situation of the SGG research field.

Section 2 of the study begins with an overview of the methodology for performing a systematic review and describes the process of the performed review. Section 3 presents and discusses the results of the meta-review on SGG for health. Section 4 discusses the selected review studies, as well as the issues that come with it and conducts a thorough examination of 53 surveys to obtain insight into the works' academic effect. Section 5 presents the findings of this study with regard to research questions and limitations. Section 6 discusses research gaps, trends, challenges, and future directions. Finally, Section 7 concludes with concluding remarks.

2. Methodology

Academic publication has accelerated in recent years, both in terms of quantity and pace of publication. Simultaneously, new venues for publishing are fast-emerging, such as conference proceedings, scientific blogs, and a plethora of scientific journals, which allow the researchers to report their work in a variety of places. To keep up with the explosion of systematic reviews across fields, new methodological techniques for synthesizing this information have been created. In sectors where a rising number of systematic reviews are available, conducting reviews of previous systematic reviews has turned into a reasonable next step in presenting research evidence.

When many systematic reviews on comparable or related subjects already exist, overviews or umbrella reviews are most typically utilized to gather, assess, and synthesize

the results of relevant systematic reviews [19]. As a result, evidence from several reviews or survey papers is compiled into a review of reviews or an umbrella review. The analysis of formerly published systematic reviews may use other terms such as "summary of systematic reviews", "review of reviews", "synthesis of reviews", and "meta-review" [20]. Reviews of reviews are made to compile evidence from multiple review papers into a single document that is accessible and useful for researchers. They present the best evidence possible by summarizing the evidence for several solutions, describing the quality of the evidence, and discussing the advantages of the conclusions [20].

2.1. Literature Search

We followed a PRISMA methodology for systematic reviews in this study. We carried out a literature search on 24 March 2022, from the Scopus database, which is represented in Table 1. The authors predetermined the inclusion criteria for this review of reviews. Only reviews that reported conducting a literature search and systematic reviews (including meta-analyses) were included. The focus of the chosen literature had to be on video games. The review articles that solely focused on subjects other than digital games (e.g., simulation, VR apps, nondigital games) were disregarded. Digital games were referred to by the keywords "video game", "computer game", "electronic game", "mobile game", or "app". The inclusion and exclusion criteria set beforehand were followed when systematically screening the findings. Two impartial reviewers checked the titles and abstracts (R.D. and R.M.). Disparities were addressed and resolved using the previous criteria after the initial screening. Fifty systematic reviews and reviews were selected for analysis because of the screening. A follow-up search in the Web of Science (WoS) bibliographic database was conducted using the same procedure as the updated search in August 2022. Three new systematic reviews were added as a result.

Table 1. Summary of the search.

Bibliographic Database	**Scopus**
Article title	"serious game" OR gamif *
Search within results	health * OR medical OR rehabilitation
Years	2017–2021
Document type	Review
Source type	Journal
Language	English
Search query	(TITLE ("serious game")) AND (TITLE-ABS-KEY (health * OR medical OR rehabilitation)) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017)) AND (LIMIT-TO (DOCTYPE, "re")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j"))

Symbol "*" is a part of search query and denotes any symbol.

The search yielded 45 studies. Forward snowballing yielded 1 additional study. Backward snowballing yielded 7 additional studies. The total number of studies selected for further analysis was 53. Figure 1 demonstrates the selection procedure using the PRISMA flowchart.

2.2. Assessment of Quality

All the reviews included in the study were assessed using the AMSTAR (http://amstar.ca/, accessed on 1 October 2022), a technique for assessing the quality of systematic reviews and meta-analyses. There were 11 items on the checklist, which included inquiries about the literature search, paper selection, and analysis, as well as summarizing the systematic review's findings. The checklist was solely utilized as a guiding device and no inferences

regarding the quality of selected articles were drawn based on the AMSTAR ratings. Two reviewers separately scored and evaluated the quality of the work.

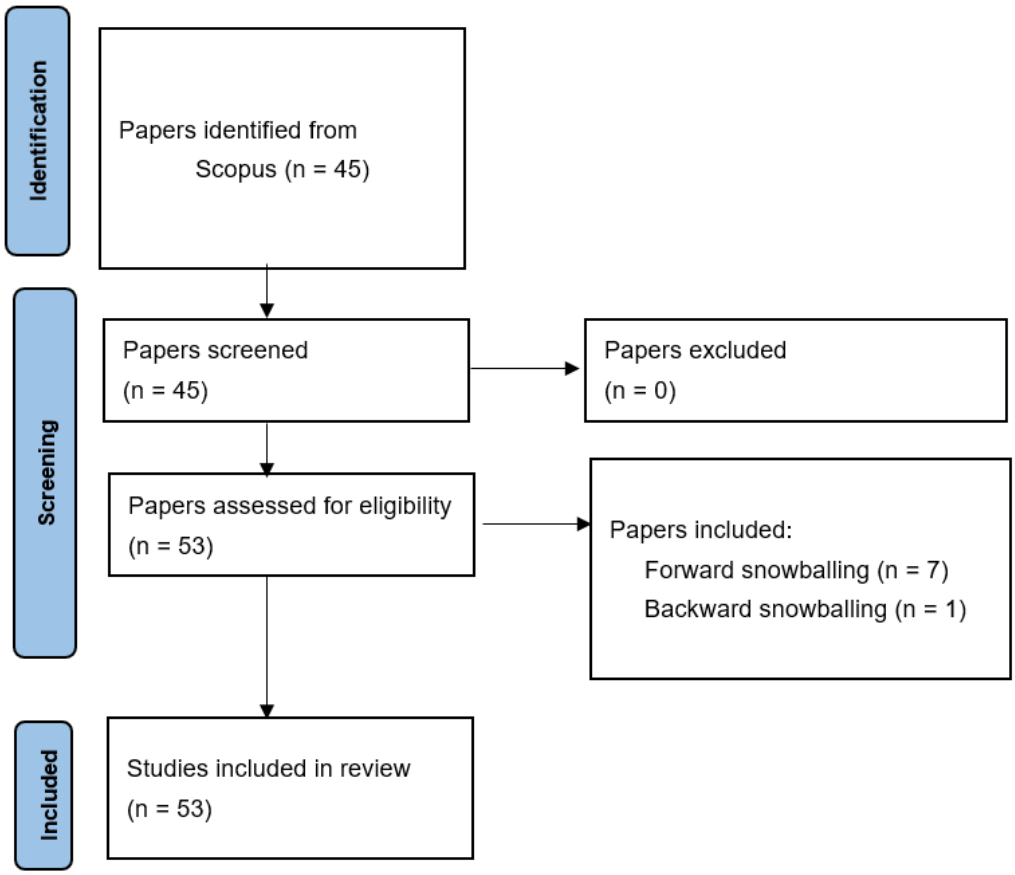

Figure 1. PRISMA flowchart of the review selection process.

2.3. Quantitative Evaluation

We used several metrics that could be used to analyze the bibliographic characteristics of studies included in a systematic review:

- Publication year helped to identify publication trends over time and to understand how the research field has evolved.
- Subject area helped to identify the specific field or discipline in which the studies were conducted and was useful in helping to understand the broader context of the research. The analysis of subject area also helped to identify any overlaps or gaps in the literature and to identify new areas of research that may have been relevant to the specific field or discipline.
- Journal provided information on the quality of the journal, the impact factor, and the reach of the journal.
- Author provided information on the number of authors, the authors' affiliations, and the authors' publication history, which were useful when identifying the most influential authors in a certain area of research.
- Number of citations included information on the number of times the study was cited by other papers, which was used as an indicator of the impact and influence of a study within its field. Studies with a high number of citations are often considered to be highly influential and important in the field. In this study, all citation counts were retrieved from the Scopus bibliographic database.
- Distribution of keywords helped to identify the most common terms used in the studies and to understand the language used to describe the research, which was of further help to identify key areas in the research field. This information can be useful

for researchers, to identify gaps in the literature and to understand the latest trends in the field. It can also be used by practitioners to understand the current state of the field and to identify new areas of research that may be relevant to their work.

These metrics were used to provide an overview of the studies included in the systematic review, and to identify patterns or trends that may have been relevant to the research questions.

3. Analysis of Meta-Review Results

3.1. Preliminaries

A descriptive analysis of the scientific publications is presented. A total of 53 research publications (review articles), which were published between 2017 and 2021, were included in the descriptive analysis. The aims of the analysis were formulated as follows:

- Analyze, describe, and present the relevant literature's relationships (such as the number of publications per year and research topic, etc.).
- Present information on current research trends in SGG as well as a critical examination of the issues that have been found.
- To help us to visualize the various study methodologies employed in the scientific literature up to this point regarding the propagation of SGG review papers.

3.2. Results and Their Analysis

The remaining portions of this paper's findings are primarily based on 53 SSG-related papers [21–73] that were published between 2017 and 2021. We did not consider surveys that just referenced gamification techniques or games in passing or whose material was not accessible online. The number of the chosen surveys and their annual citation numbers are shown in Table 2. The number of citations of a study is the number of times other authors mention a study in their work. In Table 2, we give a total number of citations for all analyzed review studies in each year. The number is provided according to the Scopus bibliographic database. Most review papers were published in 2020, while the number of citations demonstrated a consistent growth from 2017 with the highest number reached in 2021 (Figure 2). As a result, research in the field of SGG has significantly risen during the previous five years. This growing trend illustrates SGG's current public and policy effect.

Table 2. Distribution of the selected surveys and their total number of citations (according to Scopus) by publication year.

Year	2017	2018	2019	2020	2021
Papers	10	8	9	15	11
Citations	15	75	237	386	545

The 53 systematic studies and miscellaneous reviews in total satisfied the inclusion requirements. Table 3 lists the characteristics of the literature that were included according to subject area (research topic). The list of categories is based on the classification of papers into subject areas used in the Scopus bibliographic database. Most of the review papers were published in the subject areas of medicine (42), computer science (15), health professions (15), and engineering (15), which faithfully reflects the intertwining of the problem domain of healthcare and the solution domain of games developed using computer science methodology. Note that some papers are listed in multiple domains.

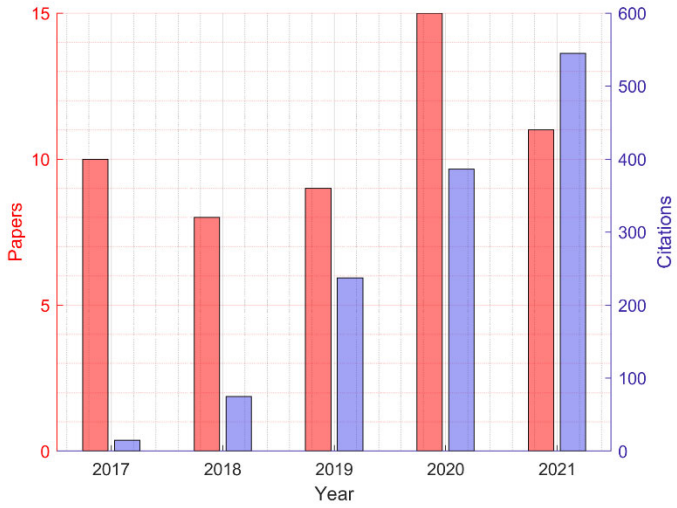

Figure 2. Scopus search results using Scopus collection database: Left: number of publications from 2017 to 2021. Right: Citation report of these publications throughout the years.

Table 3. Distribution of papers by subject area (more than one study).

Subject Area	Number of Papers	References
Medicine	41	[21–25,27,31,32,35–38,42–44,46–56,58,60–72]
Computer Science	15	[22,24,26,27,31,38–40,48,57,60,62,70,72,73]
Health Professions	15	[21,23,24,42,44,47,51,55,56,61,63,65,67–69]
Engineering	15	[21,23,24,30,40,42,47,51,55,60,61,63,65,67–69]
Social Sciences	10	[22,27,29,31,38,45,48,53,70,72]
Nursing	4	[28,33,34,44]
Psychology	2	[26,66]
Others	6	[26–28,36,53,60]

The analysis of published surveys by venue shows (Table 4) that most articles were published in the *JMIR Serious Games* journal (11), followed by *Games for Health Journal* (6), which are currently the leading publication venues for health-related serious games and gamification techniques. *JMIR Serious Games* is a multidisciplinary journal devoted to computer, mobile, and VR applications that incorporate elements of gaming and gamification, or novel hardware platforms such as VR headsets to solve serious problems in the health domain. *Games for Health Journal* is the peer-reviewed journal dedicated to gaming research, technology, and applications for human health and well-being.

Table 4. Distribution of papers by venue of publication (more than one study).

Venue	Number of Papers
JMIR Serious Games	11
Games for Health Journal	6
Journal of NeuroEngineering and Rehabilitation	2

The analysis of the distribution of papers by countries and affiliations of authors shows (Table 5) that the leading countries in SSG research are USA (7), Brazil (6), and Canada (6), followed by Germany (5) and the Netherlands (5). The researchers representing the top universities and medical institutions, such as Harvard Medical School and Massachusetts General Hospital, have contributed.

Table 5. Distribution of papers by countries and affiliations of authors (more than two studies).

Country	Universities or Institutes	Number of Papers
USA	Harvard Medical School, Johns Hopkins Bloomberg School of Public Health, University of Pittsburgh, University of Wisconsin School of Medicine and Public Health, Northeastern University, Massachusetts General Hospital, Boston College, Michigan State University, University of Wisconsin–Madison	7
Brazil	Universidade de São Paulo, Universidade Federal de São Carlos, Universidade Brasil U.B. Fernandópolis, Universidade Federal do Rio Grande do Sul, Universidade Federal de Pelotas, Universidade Federal de Uberlândia, Universidade Federal do Triangulo Mineiro, Universidade Estadual do Ceará	6
Canada	University of Montreal, Royal Alexandra Hospital, Edmonton, Institut de Cardiologie de Montreal, University of Alberta	6
Germany	Uniklinik Köln, Technische Universität Braunschweig, FOM University of Applied Sciences (Essen), Technische Universität Kaiserslautern, Technische Universität Darmstadt, Medizinische Hochschule Hannover (MHH), Karlsruher Institut für Technologie, Peter L. Reichertz Institut für Medizinische Informatik (Braunschweig)	5
The Netherlands	Universiteit van Amsterdam, Vrije Universiteit Amsterdam, Universitair Medisch Centrum Groningen, Delft University of Technology, Universiteit Utrecht, Rijksuniversiteit Groningen, Medisch Centrum Leeuwarden, Amsterdam Public Health	5
Portugal	Universidade Nova de Lisboa, Alcoitão Centre for Rehabilitation Medicine, Universidade da Beira Interior, Universidade de Aveiro, Instituto de Engenharia Electrónica e Telemática de Aveiro, Universidade Católica Portuguesa, University of Coimbra	4
Spain	Universidad de Murcia, Universidad de Deusto, Universitat de les Illes Balears, Universidad de Burgos	4
Australia	Deakin University, University of Melbourne, The University of Western Australia	3
Belgium	Erasmus University College Brussels, Université Catholique de Louvain, Cliniques Universitaires Saint-Luc	3
Singapore	Nanyang Technological University, Singapore Institute of Mental Health, National University of Singapore, Singapore General Hospital	3

The most cited systematic reviews are summarized in Table 6. The top two papers were published in 2017 and over five years were cited 347 [62] and 1160 [52] times. Study [62] presented a systematic review of gamification in e-Health, and it was published in the *Journal of Biomedical Informatics*.

Table 6. Most cited (over 100 times) systematic reviews (up to 23 October 2022).

Reference	Authors	Year	Journal	Citations
[62]	Sardi, L., Idri, A., Fernández-Alemán, J.L.	2017	*Journal of Biomedical Informatics*	347
[52]	Lau, H.M., Smit, J.H., Fleming, T.M., Riper, H.	2017	*Frontiers in Psychiatry*	140
[73]	Zhonggen, Y.	2019	*International Journal of Computer Games Technology*	115
[70]	Villani, D., Carissoli, C., Triberti, S., (. . .), Gilli, G., Riva, G.	2018	*Games for Health Journal*	108
[45]	Gorbanev, I., Agudelo-Londoño, S., González, R.A., (. . .), Yepes, F.J., Muñoz, Ó.	2018	*Medical Education Online*	103

The selected review publications were cited 1474 times. The average number of citations for a work is 27.83. Most of the publications were cited between 10 and 99 times (54.7%), while five papers were cited over 100 times (Table 7). The citation distribution might indicate that (1) the surveys are highly precise and scarcely intersect in substance, (2) the recommended solutions, identified trends, and presented recommendations in the survey papers remain relevant for the research in the domain.

Table 7. Number of citations of non-survey works.

Citations	Number of Papers (Percentage)
0–9	19 (35.8%)
10–99	29 (54.7%)
>100	5 (9.5%)

The selected survey papers cited 2944 references in total. The most cited references (Table 8) were the *Diagnostic and Statistical Manual of Mental Disorders* [74] and *Statistical Power Analysis for the Behavioral Sciences* [75], which describe commonly used statistical analysis methods employed for presenting medical-related research results, while ref. [76] refers to the PRISMA methodology.

Table 8. Top cited references cited by the analyzed systematic reviews on SSG (up to 23 May 2022).

Reference	Authors	Year	No. of Citations
[74]	American Psychiatric Association	1994	193,348
[75]	Cohen	1988	118,898
[77]	Folstein et al.	1975	68,934
[78]	Ajzen	1991	41,588
[76]	Moher et al.	2009	37,389

The analyzed survey paper most often used PUBMED (25), Web of Science (15), and Scopus (12) databases as the main sources of bibliographic information (Table 9). PubMed®, maintained by the National Center for Biotechnology Information (NCBI), has more than 34 million citations for biomedical papers from MEDLINE, life science journals, and online books. Web of Science gives access to many databases that provide reference and citation data from academic journals, conference proceedings, and other materials in various academic subjects. Scopus is a bibliographic database managed by Elsevier that covers the subjects of biological sciences, social sciences, physical sciences, and health sciences.

Table 10 shows the characteristics of survey papers including the number of included studies, the range of studies, and the keywords (or a search query) used for identifying the relevant articles. The largest study, published in 2021, analyzed 206 relevant articles on serious games and gamification, respectively, published in the *Journal of Medical Internet Research* (JMIR).

The domain-oriented distribution of the 53 review publications included in our study is shown in Figure 3.

After the analysis of the abstract and text of the selected reviews, we identified seven common study topics of interest, as follows: general health (16), rehabilitation (11), virtual reality (8), video games (8), education (8), mental and cognitive disorder (6), and learning (5). Here, mental and cognitive disorders include intellectual impairments and conditions such as anxiety, depression, Parkinson's disease, Alzheimer's autism spectrum disorder (ASD), etc. Education is related to all aspects of teaching, and the use of games in the pedagogical context to improve the engagement of students and the delivery of professional knowledge in a formal environment. Rehabilitation is focused on actions meant to enhance functioning and minimize impairment in people with health issues (such as after traumas

or chronic disease) as they interact with their environment. General health focuses on maintaining health and well-being throughout the lifetime by practicing exercise, diet, preventative health checks, oral hygiene, etc. Virtual reality (VR) is a computer-generated environment featuring realistic-looking images and objects which immerse the viewer in their surroundings using specialized equipment (VR headset) with visual feedback. Video games are any electronic games that are based on interaction and visual feedback. Note that the topics are naturally overlapping. Moreover, several review articles which do not fall into any of the categories highlight the interdisciplinary nature of the SGG domain.

Table 9. Commonly used databases (more than once) used in review studies.

Database	Number of Papers
PUBMED	25
Web of Science	15
Cochrane Central Register of Controlled Trials	12
MEDLINE	11
IEEE Digital Library/IEEExplore	10
Scopus, EMBASE	9
ScienceDirect	8
PsycINFO, CINAHL (Current Index to Nursing and Allied Health Literature)	6
Google Scholar	5
LILACS	3
ACM Digital Library, Taylor & Francis, Springer, ERIC (Education Resources Information Center), Wiley	2

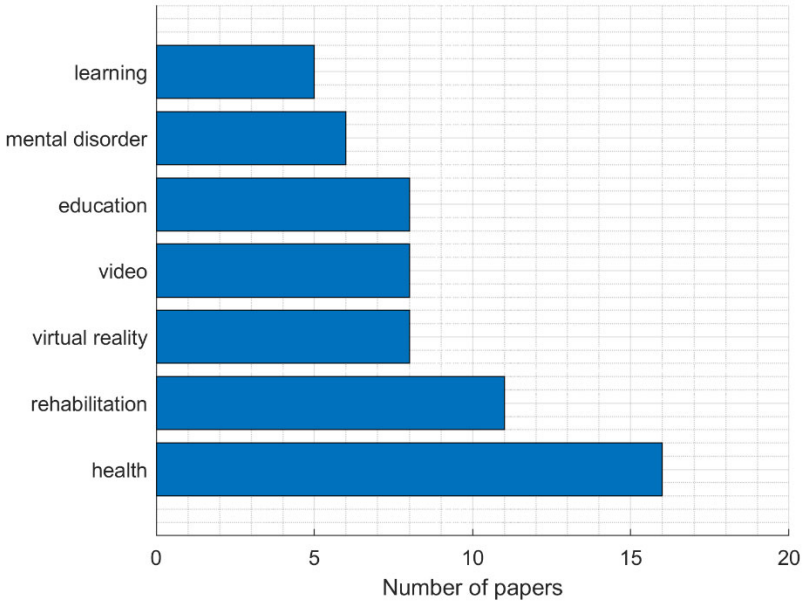

Figure 3. Most common terms used in keyword abstracts.

Table 10. Characteristics of the systematic reviews and reviews and the studies included within them.

Reference	Year of Study	Number of Included Studies	Year Range of Included Studies	Databases	Keywords (Search Query)
[73]	2019	46	2009–2018	Web of Science (WoS)	"serious game", "serious gaming", "education", "learning"
[66]	2019	34	1990–2018	CINAHL Plus (EBSCOhost), Embase, ERIC (Proquest), Medline, PsychInfo	"autism", "social", "emotion", "computer"
[62]	2017	46	2010–2015	ACM, IEEE-Xplore, Springer, Wiley Interscience, ScienceDirect, PubMed, Google Scholar	software (app, framework, system, electronic) AND health (PHR, HER, medic, clinic, patient) AND gamification (game elements, game, game mechanics)
[37]	2017	12	1980–2015	PubMed, EMBASE, Cochrane Library, PsychInfo, WoS	serious games, videogame, gaming AND asthma
[45]	2017	21	2011–2015	WoS, Scopus, ProQuest, Ebsco Host, OvidMedline	computer-based, medical education, technology-enhanced, medical students, learning, physicians, e-learning, education, m-learning, mobile phone, smartphone, mobile app, app, game *, serious games, gamification
[30]	2021	38	2011–2021	WoS, Scopus, PubMed, Bireme, ScienceDirect, IEEE Digital Library, ACM DL, Google Scholar	"serious game", "Parkinson"
[55]	2021	34	2015–2020	PubMed, Scopus, Wiley, Taylor & Francis, Springer, PsycINFO, PsycArticles, WoS, Science Direct	(serious game OR video game OR applied game OR computer game OR mobile game OR online game OR gaming) AND (children OR adolescent OR childhood OR adolescence) AND (cognitive behavioral therapy OR cognitive training OR anxiety treatment OR anxiety disorder OR mental health OR depression OR stigma OR helping behavior OR meditation)
[28]	2019	43	2019	Medline (Ovid), Scopus, PSYCINFO	(gamification OR serious game OR game * OR gaming) AND (child * OR kid) AND (eating behavior OR food preference * OR intake OR food acceptance OR food attitude OR liking OR consumption)
[71]	2021	206	–2020	Journal of Medical Internet Research (JMIR) website	gamification (search terms: gamification, gamified, gamifying, or gamify) or serious games (search terms: serious AND games, serious AND gaming, or serious AND game)
[33]	2018	6		Public Medline, WoS, Science Direct, Latin American and Caribbean Health Sciences Literature, Health Game Research, Cumulative Index to Nursing and Allied Health Literature	video games and obesity

Table 10. *Cont.*

Reference	Year of Study	Number of Included Studies	Year Range of Included Studies	Databases	Keywords (Search Query)
[46]	2019	25	1996–2019	ERIC, Education Source, PsychINFO, Global Health, CINAHL, WoS, Medline	(“serious game *”) AND (educate * OR train * OR teach *) AND (medical OR medicine OR surge * OR surgical OR physician OR healthcare OR doctor * OR nurse * OR “allied health”)
[43]	2019	21	–2019	PubMed, Google Scholar, Cochrane Central Register of Controlled Trials, CINAHL, WoS, EMBAS	“neonatal”, “delivery room”, “infant”, “baby”, “neonatal resuscitation”, “serious game”, “computer game”, “board game”, “video game”, “virtual reality”, “screen-based simulation”, “table-top simulation”
[56]	2018	12		PubMed, EMBASE, Cochrane Library, Current Index to Nursing and Allied Health Literature	wearable, serious game, videogame or mobile application, and rehabilitation, exercise therapy, physiotherapy
[23]	2021	83	2012–2019	PubMed, PEDro, IEEE Xplore, ScienceDirect, ACM DL, Mary Ann Liebert, Taylor & Francis Online, Wiley Online Library, Springer	serious game and framework
[44]	2020	4	–2019	PubMed, Google Scholar, Cochrane Central Register of Controlled Trials, CINAHL, WoS, EMBASE	“RETAIN”, “neonatal resuscitation”, “resuscitation training”, “healthcare professionals”, “digital simulation”, “neonatal”, “infant”, “baby”, “serious game”, “computer game”, “board game”, “video game”, “virtual reality”, “table-top training simulator”
[51]	2017	9	–2016	PubMed, Scopus, ERIC, PsycINFO, Information Science and Technology Abstracts, EMBASE	(video games OR game OR games OR gaming OR computer simulation *) AND (software design OR design) AND (fidelity OR fidelities OR transfer * OR behavior OR behavior)

Table 10. *Cont.*

Reference	Year of Study	Number of Included Studies	Year Range of Included Studies	Databases	Keywords (Search Query)
[64]	2020	115	2009–2019	PubMed/MEDLINE, LILACS, Scopus, CINAHL	(Students OR Student OR "School Enrollment" OR "Enrollment, School" OR "Enrollments, School" OR "School Enrollments") AND ("Video games" OR "Game, Video" OR "Games, Video" OR "Video Game" OR "Computer Games" OR "Computer Game" OR "Game, Computer" OR "Games, Computer") AND ("Serious Game") ("Video games" OR "Game, Video" OR "Games, Video" OR "Video Game" OR "Computer Games" OR "Computer Game" OR "Game, Computer" OR "Games, Computer" AND "Serious Game") AND (Learning OR Phenomenography OR "Memory Training" OR "Training, Memory") AND ("Cardiopulmonary Resuscitation" OR "Resuscitation, Cardiopulmonary" OR CPR OR "Cardio-Pulmonary Resuscitation" OR "Resuscitation, Cardio-Pulmonary" OR "Code Blue" OR "Mouth-to-Mouth Resuscitation" OR "Mouth to Mouth Resuscitation" OR "Mouth-to-Mouth Resuscitations" OR "Resuscitation, Mouth-to-Mouth" OR "Resuscitations, Mouth-to-Mouth" OR "Basic Cardiac Life Support" OR "Life Support, Basic Cardiac").
[34]	2017	17	2009–2014	Lilacs, Medline, WoS	video games, serious games and obesity
[70]	2018	23	2007–2017	PsycINFO, Scopus	"emotion regulation" and "videogames"
[25]	2019	86	2007–2019	WoS, PubMed	"serious games", "motor rehabilitation", "Kinect", "vision-based", "virtual reality"

Wildcard "*" is a part of search query; it means any characters.

3.3. Quality Evaluation Using AMSTAR

We used a revised version of AMSTAR (a measurement tool to assess systematic reviews), which is a popular instrument for critically appraising systematic reviews. It is a validated tool that assesses the quality of a systematic review by evaluating the process of conducting the review, rather than the quality of the primary studies included in the review. It is divided into 16 items that cover various aspects of the systematic review process, such as the transparency of the search strategy, the reporting of potential biases, and the use of a systematic approach to data extraction and analysis.

To carry out AMSTAR-2, the review was assessed against each of the 16 items using a yes/no/can't answer format. A score of 1 is given for a "yes" answer, a score of 0 is given for a "no" answer, and a score of 0.5 is given for a "can't answer" answer. The total score ranges from 0 to 11, with a higher score indicating a higher quality systematic review.

A score range was created for categorizing the systematic reviews into critical low (0–4 p), low (5–8), moderate (9–11), and high categories based on the original AMSTAR method (12–16). Separately, two researchers assessed the studies. Discussions were held to settle any differences and come to a consensus agreement on the final score. The final consensus score was 11.75, which indicates a moderate quality of the systematic reviews.

4. Analysis and Discussion of the Systematic Reviews on SSG

In this section, the selected review articles are discussed. For convenience, the articles are grouped by research topics identified in Section 3 via lexical analysis of titles and abstracts of publications and the categorization presented in Figure 3 was followed.

4.1. Games for General Health

Study [32] assessed the influence of serious games on smoking start, cessation, and behavioral variables. The study found 15 studies that evaluated 14 different serious games, which combined different gaming aspects. General and sporadic incentives, theme and genre aspects, and penalties were the most used. Eight factors were identified to have statistically significant beneficial impacts in six trials on smoking avoidance (e.g., attitude, knowledge, intention). Five of the seven studies on quitting smoking indicated favorable, statistically significant benefits on quitting or status. Six determinants demonstrated statistically significant beneficial impacts in these trials (e.g., self-efficacy, attitude, intention). Stronger game designs are needed to illustrate, measure, and comprehend the impacts of serious games, as most of the research had significant methodological shortcomings.

Study [47] examined the usage of gamification approaches in stress treatment applications, as well as their coexistence with evidence-based stress management and behavior modification tactics. Seventeen gamification tactics, 15 stress management techniques, and 26 behavior modification approaches were evaluated in 62 stress management applications from the Google Play Store. A taxonomy of gamification strategies was developed and put into practice. There are no links between the adoption of gamification tactics and behavior modification or stress management strategies, according to the findings. As a result, stress management app designers do not employ gamification tactics to influence user behavior and responses. Furthermore, the app creators fail to see the value of mixing gamification approaches with behavior modification theories.

Study [48] analyzed the impact of serious games on chronic illness outcomes in children. Self-efficacy, adherence, knowledge, theory application, parental participation, and study quality were all investigated. The review includes a total of eighteen papers. Cerebral palsy, asthma, diabetes, developmental coordination difficulties, and eye abnormalities were among the health issues treated. Psychosocial variables such as self-efficacy (i.e., an individual's belief in their ability to control their own actions and affect change in their environment) and knowledge were studied in the analysis. The potential for games to benefit young people's health is demonstrated in this study. The mixed results imply, however, that more serious gaming treatments should be well-developed and extensively researched to support their influence on improving health outcomes.

Study [51] focused on game-like interventions for health. There were 15 studies that were relevant. Transfer (i.e., the ability of a patient to apply the skills or knowledge learned in the game to real-life situations) is seen as a desired consequence but not as a design concept in studies on game-like treatments for health and healthcare. Studies on game-like health treatments seldom explain design decisions or give design principles. Games and simulations for health are based on first-class transfer (i.e., direct application of skills or knowledge learned in the game to real-life situations), although second-class transfer (i.e., the application of skills or knowledge learned in one situation to a related but different situation) is rarely used.

Study [63] undertook a scoping assessment of the development and assessment of serious instructional games for healthcare workers, patients, and healthy users. The authors found 161 studies. The findings revealed a positive trend in broadening the scope of health teaching games beyond a single clinical condition. The findings point to the necessity for health education game creation and acceptance in poor nations, as well as the need of interdisciplinary cooperation in the production of effective educational serious games for health. In order to provide evidence of long-term efficacy, future health games should include longer follow-up assessments and extend the duration of the game itself. This would allow researchers to track the progress of patients over a longer period of time and to see if the benefits of the game continue to be evident even after the game has been completed.

Study [68] aimed to (1) identify and analyze the needs, suggestions, and guidelines offered by SSG for health in the scientific literature, and (2) build a consensus framework to help researchers, game developers, and healthcare professionals in developing evidence-based SSG for health. This interdisciplinary, iterative, and interactive evaluation revealed five high-level criteria and 20 low-level requirements provided by the SGH community. The authors propose a framework for developing theory-driven, evidence-based SGH that include quantitative trials to assess whether SGH achieve the intended outcomes, and follow-up monitoring to enable SGH stakeholders to use them in a wide range of projects, regardless of discipline, healthcare segments, or focus.

Study [71] presented the state of SSG conceptualizations in healthcare research. There were 206 papers evaluated theoretically in the *JMIR* and its sibling publications that contained phrases linked to gamification, serious gaming, or both. The authors created the GAMINGs (game-based intervention reporting guidelines) for researchers reporting on game-based treatments, which consist of 25 elements organized into four categories of focus, contribution, awareness, and individual concepts. Following the GAMINGs can help writers present research outcomes of game-based therapies more rigorously.

Study [72] gave a summary of serious games designed for the training of oral health professionals or for oral health promotion. A total of 19 investigations (25 publications) were chosen. Games were separated into two categories: instructional games and games that promote oral health. Most of the research involved students in the oral health professions or school/preschool children. In terms of increasing oral health outcomes, interactive serious games were just as successful as traditional noninteractive techniques. Participants expressed a higher degree of satisfaction with learning through games in their feedback. The use of serious games in oral health is restricted, and there is little reliable scientific evidence to back up their efficacy.

4.2. Games for Rehabilitation

Study [22] assessed the state of the art in terms of interaction modes utilized in games for the rehabilitation of upper limbs. There were 33 articles examined. Almost half of the experiments (42.4%) employed vision systems as an interaction modality and collected body motions using the Kinect sensor (48.48%). Lighting conditions have the potential to alter the device performance of vision systems and supplementary vision systems. Not many studies have been conducted on the use of serious games for finger rehabilitation and

treating injuries, or on how to combine multiple sensor data to improve the way people interact with the game. These research gaps may be promising topics for future study.

Study [23] reviewed the benefits of utilizing a software engineering methodology in serious games for physical rehabilitation. For this investigation, 83 publications were chosen. Eight of the eighty-three publications examined employed a software engineering framework to construct their work. Most of them concentrated on one or more factors, such as data collection and processing, game levels, incentive, and therapist monitoring. This comprehensive examination reveals that most serious games are not developed using software engineering. As a result, development systems ignore various factors and lack a consistent approach, resulting in the omission of critical implementation elements that affect the patient's recovery period. For example, the lack of proper assessment and feedback can lead to a lack of progress or even deterioration in the patient's condition. If there is no feedback provided to the patient, they may not be aware of their progress or areas where they need to improve, which can hinder their recovery. Another important element is lack of engagement and motivation. Games that are not engaging or motivating may not hold the patient's interest, which can lead to poor compliance and a lack of progress. The omission of the proper integration with other treatment methods can lead to a lack of continuity in the patient's treatment, which can impede progress.

Study [30] determined and assessed the situation of using serious games in the rehabilitation of people with Parkinson's disease (PD). The evaluation looked at the type of game, interface, device, rehabilitation procedure, technique for measuring the game's effectiveness, symptoms cured, and implementation in real patients. Most studies suggest creating exergames, using VR as an interface technology, capturing body motions with Leap Motion and Microsoft Kinect, and treating bradykinesia and gait problems. The findings show that high scientific rigor is required for the solutions provided, as well as the extension of the instrument to medical practice. Serious games for people with PD should be adaptable to the unique needs and abilities of each individual player, easy, and intelligent. This could include options to adjust the game's difficulty level, control options, and other settings to accommodate for the physical and cognitive limitations that may be associated with PD. The games should also be easy to understand and navigate, with clear instructions and simple interfaces to minimize confusion and frustration. This can help to ensure that players are able to focus on the therapeutic aspects of the game rather than struggling with the mechanics of playing. Finally, serious games for Parkinson's Disease should be intelligent, using data and analytics to track progress and adjust the game's difficulty level or other aspects as needed. This can help to ensure that players are challenged at the appropriate level, and that the game continues to be effective over time as the player's condition changes. Additionally, these games should also be able to provide feedback to the therapist or caretaker, so that they can monitor the player's progress and adapt their treatment accordingly.

Study [35] assessed the effectiveness of serious games for stroke rehabilitation. In addition, independent of the device utilized, we looked at whether adhering to neurorehabilitation principles affects the efficacy of games especially intended for rehabilitation. When compared to traditional therapy, a meta-analysis of 42 studies with 1760 individuals found that serious gaming interventions had greater results. This meta-analysis found that rehabilitation using serious games, aimed towards recovery after stroke, results in superior gains in three International Classification of Functioning, Disability and Health (ICF-WHO) components compared with standard therapy. Serious games are more effective when they conform to a unified set of neurorehabilitation principles, regardless of the technology instrument employed. The collected set of neurorehabilitation principles should be considered in the future development of stroke-specific rehabilitation therapies.

Study [38] analyzed serious games in psychotherapy and psychosomatic rehabilitation. Publications that did not include empirical evidence on efficacy were not included. The results of N = 15 research satisfied the inclusion criteria based on this systematic literature review. They largely used cognitive behavioral approaches, which may be used to treat

a variety of mental illnesses. Serious games work well as a standalone intervention or as part of psychotherapy, and they appeal to patients of all ages and genders. Serious games were found to have a beneficial therapeutic component. However, the findings are inconclusive, and further study is needed to better understand the usefulness of serious games for psychotherapy.

Study [41] analyzed new data on the efficacy of exergaming for PD rehabilitation and presents an overview of current research on exergame-based therapy in PD patients. There were 64 publications chosen. The results of the last review revealed that potential improvements in motor abilities had occurred. Microsoft Kinect and the Wii Balance Board were found to be safe and feasible in pilot trials. Both devices' balance and gait data were shown to be reliable in technical studies. Related meta-analyses and systematic reviews back up these claims, highlighting the necessity for patient skill adaption as well as the use of novel input devices and sensors as discovered gaps. Exergame-based therapy has been shown to be viable, safe, and successful in the treatment of PD.

Study [42] analyzed engagement and muscle training, with virtual training software for upper limb prosthetic rehabilitation either focused on game design elements or on a realistic portrayal of prosthetic training activities to encourage task-specific skill transfer. Previous research has shown that without a transfer-enabling task structure, muscle training alone does not result in enhanced prosthesis control. However, there has been a significant increase in the number of game-based prosthesis training aids, which emphasize participation rather than skill transmission. The availability of commercially available acquisition devices and publicly available game development tools for creating serious games for prosthesis training impacted this flood.

Study [59] described the key results from the evaluation of current games for stroke recovery, including meaningful play, failure handling, emphasis on difficulty, and the need of feedback. The authors conclude with a set of design suggestions for future serious game creators to think about when creating interfaces for stroke victims. This study shows that using gaming technology for stroke rehabilitation is an effective interactive approach. Serious games provide the possibility of fully customizable and contextualized gaming. The analysis also argues that encouraging challenge and recovery from errors are useful characteristics to have in serious games for rehabilitation.

Study [60] gave an examination of the influence of SG on neurorehabilitation therapy and patient opinions on rehabilitation. This evaluation included 47 papers that looked at the use of experimental serious games and commercially produced serious games (CSGs) for rehabilitation in a variety of neurological diseases. The Nintendo Wii was used by the majority of CSGs as a supplement to traditional therapy. In 35 investigations, significant improvements in key outcomes such as motor performance, balance, executive, and cognitive functions were identified. In addition, 17 pieces of research revealed patient viewpoints on rehabilitation. According to the findings, SGs are effective exergame instruments.

Study [56] examined the effects of wearable technologies and serious games used in the rehabilitation of individuals with severe bone and soft tissue injuries on functional results and treatment adherence. Only two pieces of research revealed that serious games had favorable benefits when compared to traditional therapy. In one of five experiments that looked at treatment adherence, the gaming group had a statistically significant benefit over traditional physiotherapy. The pooling of data was not possible due to differences in research design and outcome measures. After catastrophic bone and soft tissue injuries, serious games appear to be a safe alternative or a supplement to traditional treatment. Their validity and efficacy in rehabilitation therapy, as well as their cost-efficiency and influence on treatment adherence, should be investigated more in the future.

Study [69] examined the association between the qualities of serious games (SGs) and the therapeutic outcomes of trials that used games to help patients who had cerebral palsy or multiple sclerosis or had had strokes. They found 12 studies that evaluated motor, sensory, and functional functions, as well as overall health outcomes in certain cases. Upper-limb motor rehabilitation was achieved by game-based interventions. Six

games from casual SGs, one combination of casual, simulation, and exergaming SGs, and two mixed sports and simulation SGs all showed substantial gains in at least one clinical assessment. Casual games with a first-person perspective, no visible player character, single-player mode, and non-immersive VR had the greatest therapeutic effects.

Study [61] investigated the use of serious games in the rehabilitation of people with neuromotor impairments of the upper limb resulting in 38 research papers. This study examines 35 distinct gaming systems. Only eight of the thirty-eight publications in this evaluation completed a clinical trial, and only twenty-one of them reported benefits in the target population after using the games and platforms. As a result, in the rehabilitation sector, a new paradigm is emerging, characterized by the systematic use of electronic gaming platforms with serious games in/for rehabilitation. Serious games and gaming platforms for upper limb rehabilitation are ushering in a new rehabilitation paradigm. More research is needed to fully integrate these technologies in the rehabilitation industry.

Study [65] studied game design aspects to aid in the rehabilitation of patients with shoulder musculoskeletal problems. There were 31 articles in total, published between 2006 and 2019. Points, tasks, and avatars were the most-often-utilized game components. Collections and teams, which are more complicated game components, were rarely employed. There were just a few systems that used game design aspects to assist subjects with musculoskeletal illnesses of the shoulder in rehabilitation. Exergames allow self-exercising in almost all application platforms. Patients' unique characteristics are frequently overlooked. Motivational game design components that are incorporated into a game to encourage players to engage and continue playing (such as points, levels, achievements, and leaderboards) based on patient-specific characteristics are necessary as part of a holistic strategy to improve rehabilitation adherence.

Study [62] outlined the present state of knowledge on gamified e-Health applications, investigated the various gamification tactics used in e-Health, and discussed the pros and drawbacks of this new field. After, 46 studies from various sources were evaluated. Most of the publications included in this study discussed SSG in health and well-being areas such as chronic illness rehabilitation, physical exercise, and mental health. In this sector, there is still a scarcity of reliable empirical evidence. Furthermore, most of the e-Health apps and serious games studied have been shown to provide only short-term engagement through explicit reinforcement. To realize the full capabilities of gamification, e-Health solutions must be built on well-founded theories that harness the fundamental experiences and psychological consequences of game mechanics.

Study [66] examined the use of serious game principles in social emotional computer-based interventions (CBI) for autistic people and assessed the effectiveness of these concepts in improving social emotional outcomes. Database searches turned up 34 papers on social emotional CBI, with 17 controlled studies. The five serious game concepts were used to summarize the qualities of each CBI: compelling plot, goal-directed learning, incentives and feedback, escalating levels of difficulty, and individualization. The findings indicated that autistic people have a limited (45%) integration of serious game concepts in social emotional CBI. The serious game design framework can help to guide the development of social emotional CBI, which can help autistic people to improve their social emotional abilities.

4.3. Virtual Reality Games

Study [25] examined how visionary serious games and VR technologies are used in motor rehabilitation programs. There were 86 studies found. The most often utilized technology in exploring the impact of vision-based serious games and VR systems on rehabilitation is Kinect. The findings also imply that patients with cerebral palsy and who have had strokes are the primary target categories, with an emphasis on older individuals in this category. Most of the research focused on posture control and upper limb workouts, and they employed a variety of metrics to assess them. Despite the increased interest in this field among researchers, many studies lack adequate clarity and are not standardized.

In study [49], the current cognition tests, VR apps, and serious games in cognitive assessment and therapy for neurocognitive disorders were analyzed to evaluate the current state of the art in cognitive assessment for major neurocognitive disorders (NCDs), such as Alzheimer's disease (AD), the most common geriatric major NCD, and then it briefly looked ahead at the potential applications of VR technologies in NCD assessment and cognition training in a simulated 3D environment, and for the alleviation of cognitive disorder symptoms. The VR-based technologies, we feel, offer enormous potential in cognitive evaluation and non-pharmacological treatment for severe NCDs.

Study [57] examined and classified the influence of VR technology on 46 gamified apps with serious goals. Our findings imply that immersive VR enhances simulation outcomes, such as learning acquisition and information retention, as well as clinical rehabilitation outcomes. It does, however, have drawbacks, such as motion sickness and limited access to VR devices. The study contributed by providing clearer knowledge of the benefits and constraints of utilizing VR technology in serious simulations, a taxonomy for categorizing them, and a discussion of whether methodologies and participant profiles impact results.

Study [24] examined the history and quality of clinical research on VR-based serious games. The adoption of serious VR games has demonstrated efficacy in improving upper limb telerehabilitation (TR) following strokes, although the evidence quality is still poor due to a lack of randomized controlled trials (RCTs), few subjects, and diverse samples. VR games are a potentially useful technique for supplementing traditional rehabilitation, but further research is needed to reinforce the proof of success and encourage the spread of the proposed solutions.

4.4. Video Games

Study [28] analyzed and evaluated game-based dietary treatments for children. The focus was on whether the game-based techniques helped young people to improve their eating habits, what the most effective game elements were, and how game-based techniques help young people to alter their eating habits. There are 43 pieces of research that have been discovered which improve fruit and vegetable consumption, change snacking behavior, stimulate food discovery, and promote healthy eating. Serious games that focus on food education can help children to develop healthy eating habits by increasing their knowledge and positive attitudes towards fruits and vegetables. These games can also encourage children to try new foods and reduce picky eating habits. On the other hand, games that promote unhealthy snacks may lead to an increase in unhealthy snack consumption among children. To inspire and involve young people in developing good eating habits, a mix of story context, feedback, progress, and challenge was widely employed.

Study [33] investigated the effectiveness of serious games in improving knowledge and/or behavioral improvements in overweight and obese young people. The final sample included six studies. The articles aimed to encourage gamers to make positive behavioral changes, such as increased physical activity and better eating habits. Using serious games as a technique can be effective in promoting healthy behaviors and coping strategies for children and adolescents who are struggling with obesity. Serious games are an alternate way to give health education to children, and research in this subject is an increasing and promising technique.

Study [34] analyzed serious games to treat and/or prevent childhood obesity. The search yielded 466 studies, with 17 being chosen for examination. Serious games for health promotion might have a good impact on children's health, induce behavior changes, and promote healthy behaviors. Serious games can be a useful technique for children's health education. Given children's usage of technology, these tools may modify the public's behavior with relation to juvenile obesity.

Study [40] investigated the application of various artificial intelligence algorithms linked to decision making and learning. To classify 129 papers that matched the inclusion requirements, a classification system was created and defined. The authors used this classification system to reach some findings about how intelligent serious games are really

used. The authors believe that enough information has been acquired in recent years to design new intelligent serious games that consider not only the end goal but also the technology and tactics employed to give players a virtually genuine experience. However, to ensure that produced serious games accomplish their intended goals, researchers may need to enhance their testing approach.

Study [70] examined the research on the effects and modalities of using video games for emotional regulation (ER). The review comprised 23 papers, which were divided into three categories: (1) cross-sectional and qualitative studies, (2) studies on the impact of videogame experience on ER, and (3) ER intervention using serious games. A limited time of playing, such as that enabled by serious games, gave less potential for ER improvement than frequent gaming with commercial games (connected to gameplay and pleasure of fictitious properties). This field of study is still in its infancy; thus, results should be evaluated with caution. Moreover, future evaluations should include clinical populations. Video games provide a variety of ER options as well as a challenge for educational and psychosocial solutions.

4.5. Games for Education

Study [21] sought to find serious games that educate patients on the issues of medication adherence, education, and safety, as well as theoretical frameworks for developing serious games for medication use and sample frames for assessing serious games on medication usage. There were 16 trials with 12 serious games containing elements of medication adherence, education, and safety. Existing evaluations investigate serious games that focus on disease management, such as diabetes, HIV, and asthma, as well as the beneficial impact of serious game teaching. Serious games should specify the theoretical framework included into game design, and success should be measured by the player's ability to retain learning objectives.

Study [37] analyzed articles about serious games developed to teach patients and the public on asthma and evaluated their influence on patient knowledge, behavior, and asthma disease outcomes. Twelve articles were identified as being relevant, each describing ten serious games. Eight games for children with asthma and two for school-based intervention were included in the serious games. Most of the serious games were linked to high levels of enjoyment and knowledge improvement in young people. Seven studies compared the effects of serious games on medical outcomes to control groups and discovered no significant differences, while few changes in behaviors or medical outcomes have occurred.

Study [44] examined the evidence for using the RETAIN serious game to improve newborn resuscitation instruction. There were three articles and one conference proceeding found. The RETAIN board game was described in two studies, while the RETAIN computer game was described in two investigations. RETAIN was described as therapeutically useful and relevant. RETAIN also served as a summative evaluation and enhanced the knowledge of newborn resuscitation. RETAIN is a tool that may be used to teach and assess experienced neonatal resuscitation clinicians.

Study [43] reviewed the existing literature on serious games and how they might help neonatal healthcare workers retain information and abilities. This review includes twelve serious games (five video games, four board games, and three VR games). The RETAIN board game and neonatology game both showed improvements in knowledge. To improve theoretical and practical learning, serious games are more commonly being introduced into medical school curricula. Serious games can increase healthcare personnels' knowledge, abilities, and adherence to the resuscitation protocol, as well as improve access to SBE in both resource-rich and resource-poor settings. Important clinical outcomes in newborns should be the focus of future study.

Study [45] explored the educational tactics used by game developers while building medical education games, and how good the evidence is for the effectiveness of games. Even though game creators say that games are great teaching aids, the data are mixed. Games are complementing tools that do not supplant classical pedagogical methods, and

behaviorism and cognitivism remain the most common instructional approaches. Medical educators do not require the use of complex games in their courses, preferring simulations and tests that focus on information retention and skill improvement via repetition. The real-life use of games is contingent on the quality of the evidence supporting their success.

Study [46] evaluated the efficacy of serious games for professional health education in 25 studies. Sixteen students had both a pre- and post-test, and all of them improved significantly in their learning scores after using serious games. Eighteen studies published controlled trials, whereby fourteen of which found that following serious games, post-test results were considerably higher than with traditional teaching approaches. The study found a lack of integration of emotional learning with other abilities, and a requirement for serious games prepared people for postgraduate education. Serious games appear to be effective for short-term learning. Before making generalizable conclusive assertions, additional competences and health professionals must be addressed across the school continuum.

Study [53] synthesized the evidence on the efficacy of SGs in increasing engagement and enhancing learning outcomes in healthcare profession education. Between January 2005 and April 2019, 37 randomized controlled trials (RCTs) were discovered, with 29 of them being included in random-effect meta-analyses. SGs did not result in longer time spent with the intervention, higher information acquisition, cognitive and skills development, attitude change, or behavior change when compared to other educational interventions, but there was minimal evidence for SGs with regard to boosting skill confidence.

Study [54] evaluated and synthesized the best available information on the effectiveness of SGs and the influence of DEs on healthcare professionals' and students' involvement and educational results.

Study [55] collected papers on SSG published between 2015 and 2020, with an emphasis on their applications: detection, prevention, therapy and awareness, to study tool deployment, development, and evaluation for trends, strengths, and flaws. The following criteria were used to filter the papers: SSG for personal computer (PC), smartphone, or VR; for children and adolescents; and for depression, anxiety, or both. SSG for PC, smartphone, and VR devices were created in 34 pieces of research and tested in adolescents and children. Most games are used for prevention and treatment. Anxiety is more prevalent in childhood, whereas depression is more prevalent in adolescence. More awareness and detection games that include awareness, prevention, detection, and therapeutic applications are needed. Games should appeal to people of all ages. SSG development and assessment should be harmonized.

Study [58] discussed the adoption of serious games to teach young people about mouth hygiene, as well as hunted for applications that served the same objective. Twelve articles were chosen, 11 games were designated as serious games focused on oral health, and 284 applications were found on the Play Store, with a majority surrounding interventionist action in dental clinics with the primary plots being pain, tooth cavity, and trauma. There are just a few apps dedicated to oral hygiene instruction. There is a large presence of a children's audience among the intended audience. Despite the paucity of publications on the issue, investigating electronic resources as instructional choices for children's oral hygiene suggests a field of study with academic promise and prospective public health implications.

Study [64] reviewed the scientific data on the use of serious games to teach cardiopulmonary resuscitation to health students. The authors found eight studies and divided them into two categories: the study's purpose in relation to cardiopulmonary resuscitation using serious games, and the serious game's approach to teaching cardiopulmonary resuscitation (CPR). The primary target for serious game learning is medical students, and the games' primary goals are to evaluate their effectiveness with regard to established approaches and information retention.

Study [73] analyzed articles related to the adoption of serious games in education and discussed numerous elements that impacted the effects of serious-gaming-assisted learning.

The main portion discussed the benefits and drawbacks of using serious games in teaching. Attitudes about the application of serious games in education, as well as the new growth of serious game usage in education, were investigated. The study underlined the need for interdisciplinary collaboration in future theoretical and practical exploration.

4.6. Games for Mental Disorders

Study [29] aimed to provide a complete picture of the evidence of serious games for health-aimed behavioral change in adolescents and children. There were 34 studies that investigated the effectiveness of serious games in promoting mental health and changing health-related behaviors in children and adolescents. The data evidencing the use of serious games in adolescents and children for the promotion of health remain limited. Given the publication bias, these results should be viewed with care. Before we can make firm conclusions, we need more research that is properly conducted and that examines well-defined serious games.

Study [31] analyzed how end-user engagement in the design and decision-making process affects game effectiveness. Users are introduced in all phases of the process, including planning, creating, and testing the serious game, in user-centered design or participatory design. The goal of this study was to see how many published studies of serious games that are intended to prevent or cure depression and anxiety have used the participatory design framework.

Study [50] examined clinical research that focused on the adoption of serious games in children with developmental impairments. The bulk of the 145 pieces of research was on autism spectrum disorder (ASD), and related intellectual impairments. A randomized design was reported in 30 of the 145 investigations. The authors found encouraging outcomes in the areas of anxiety reduction, stress management, emotion identification, and rehabilitation. Currently, there is a paucity of clinical evidence that serious games can aid children with neurodevelopmental issues.

Study [39] studied serious games for persons with mental illnesses, including Alzheimer's, ADHD, ASD, dementia, MCI, PTSD, and schizophrenia, as well as the many ways utilized to make the games available to the intended players. To avoid the player being disoriented, the basic aim is to reduce the quantity of stimuli present at the same time. Reducing stimuli should be inherent to the game (by presenting a very basic game), and it should be adjustable (through a menu of selections), and dynamic (by adjusting the quantity of stimuli, or a system that adjusts itself automatically).

4.7. Other Games

Study [26] synthesized and integrated all previous research and material on gamification and serious games, appraising the present state of the art in the area, and filling a gap in the literature on the subject. The most important determinants of intention to adopt in gamification are attitude, enjoyment, and utility. The most important determinants of a brand's attitude toward gamification are intent, enjoyment, and utility. The findings enable us to propose a theoretical model that will aid future gamification research.

Study [52] studied the impact of severe games on signs of mental illness. The review contained ten papers that fulfilled the inclusion criteria, while the meta-analysis comprised nine pieces of research. The investigations were conducted on people aged from 7 to 80 years. The serious games employed goal-oriented and cognitive training games to address symptoms of depression (2), post-traumatic stress disorder (2), autistic spectrum disorder (2), attention deficit hyperactivity disorder (1), cognitive functioning (2), and alcohol-consuming disorder (1). The findings show that gaming therapies might help those with disorder symptoms. More research is sought to have a better understanding of the usefulness of games for certain mental diseases and their long-term impacts.

Study [67] explained the conceptual aspects of the current research on serious games aiming to promote cognitive and behavioral outcomes in individuals with chronic diseases. The review includes a total of 38 papers. The present landscape of serious game research

for health focusing on behavioral and cognitive outcomes in people with chronic illness is defined in this scoping study. A wide range of patient demographics and patient outcomes have been studied. To further explain the active components and processes of serious games, researchers that want to improve upon the present study should incorporate theoretical models into the intervention and trial design process.

5. Findings

5.1. Answers to Research Questions

RQ1. What are the most common health conditions that serious games and gamification techniques have been used to address?

Serious games and gamification techniques have been used to address a wide range of health conditions. The most common health conditions that have been studied include the following:

1. Chronic conditions such as diabetes [21,48], heart disease, and cancer, which often require long-term self-management and lifestyle changes.
2. Mental health conditions such as depression [31,49,52,55] and anxiety [31,50,55], which often involve addressing negative thoughts and behaviors.
3. Physical rehabilitation, especially for patients with trauma injuries [22,42,56] or neurological conditions [60,65] that affect their mobility.
4. Substance abuse, especially in terms of addiction to alcohol [32] and drugs.
5. Smoking cessation [32].
6. Eating disorders [28,33] and obesity [33,34].
7. Geriatric care, especially in terms of promoting healthy aging and preventing cognitive decline (e.g., due to Alzheimer's disease) [49].
8. Pain management, especially in terms of chronic pain patients [56].
9. Asthma and COPD management [21,37].

RQ2. What are the most common game mechanics and design elements used in serious games and gamification for health?

The most common game mechanics and design elements used in serious games and gamification for health include the following:

1. Points, badges, and leaderboards which are used to provide feedback on progress, and to create a sense of competition and accomplishment [54].
2. Quests and challenges which are used to create a sense of purpose, and to provide structure for the player's experience [28].
3. Storytelling and narratives which are used to create a sense of immersion, and to provide context and meaning for the player's actions [28,54,66].
4. Virtual rewards and incentives which are used to motivate players to engage in desired behaviors, such as exercising or taking medication [28].
5. Personalization and tailoring which are used to adapt the game or gamification experience to the specific needs and preferences of the player.
6. Social connections and collaboration which are used to create a sense of community and to foster social support [55,66].
7. Feedback and coaching which are used to provide guidance, information, and feedback to help players to improve their skills and knowledge [23,28,66].
8. Virtual reality and immersive technologies which are used to create a sense of immersion and to provide an engaging experience for the players [24,25,30,44,49,55,57,69].
9. Game-based assessments and adaptive testing which are used to assess players' skills, knowledge, and progress [44,49].
10. Gamified environments and settings which are used to create a sense of immersion and to provide an engaging experience for the players [54,62].

Note that the effectiveness of these game mechanics and design elements for different health conditions and populations may vary and more research is needed to fully understand their potential and limitations.

RQ3. What is the evidence for the effectiveness of serious games and gamification in promoting positive health outcomes?

The evidence for the effectiveness of serious games and gamification in promoting positive health outcomes is still emerging, but it is growing. Studies have shown that serious games and gamification techniques can be effective in promoting positive health outcomes, such as improved physical activity [62], healthy eating [28], and smoking cessation [32], as well as improved mental health outcomes, such as reduced depression [31] and anxiety [31,55].

Studies have also shown that serious games and gamification techniques can be effective in promoting medication adherence [21], the self-management of chronic conditions [67], and rehabilitation outcomes [22–25,27,30,35,41,42,56,60,61,65,69].

Note that the effectiveness of serious games and gamification for promoting positive health outcomes can vary depending on the specific health condition, population, and the design of the game or gamification intervention. Additionally, it is important to note that while some studies have shown positive results [29,32,46,48,56,60,69], other studies have not found significant effects [37,66].

As a result, more research is needed to fully understand the underlying mechanisms of action of serious games and gamification in promoting positive health outcomes, and to identify the specific game mechanics and design elements that are most effective for different health conditions and populations.

5.2. Limitations

The review study's selection procedure and data extraction are two possible restrictions. Even if a systematic search and further searches were conducted, it is probable that not all relevant material was discovered. Because it was impossible to examine the results linked to health and digital games independently, some material had to be eliminated. These choices may have resulted in a loss of critical data. There was considerable overlap between the systematic reviews and reviews that were included, which may have had a significant impact on our findings.

Finally, the meta-analysis reveals that a few publications which analyzed the survey papers were disruptive (i.e., challenged existing paradigms, introduced new ideas or methods, or fundamentally changed the way we think about a particular field) [79] and had a significant impact on subsequent developments in the research field. Between 2017 and 2021, there were just a few articles with moderate impact (approximately 100–200 average citations per year since publication).

6. Research Gaps, Trends, Challenges, and Future Directions

6.1. Research Gaps

The field of serious games and gamification for health is a rapidly growing and dynamic area of research; however, there are still several research gaps that need to be addressed. The current research gaps in this field include:

1. Lack of standardization [23,25,59] in the development and evaluation of serious games and gamification applications for health, making it difficult to compare and replicate studies and leading to inconsistent results and conclusions.
2. Insufficient understanding of the underlying mechanisms of action [62,67] of serious games and gamification in promoting positive health outcomes.
3. Limited understanding of how to effectively integrate serious games and gamification into existing healthcare systems [47,61,66] and how to measure the effectiveness of the integration.
4. Limited understanding of the specific game mechanics and design elements that are most effective for promoting different health behaviors and outcomes [31,54,56,70,72].
5. Insufficient evaluation and validation of serious games and gamification applications for health, particularly in terms of determining the optimal dosage and duration of treatment [30,65].

6. Limited research on the scalability and sustainability of serious games and gamification for health and how to increase their adoption by healthcare providers and patients. Here, scalability is understood as the ability of the game platform to support a large number of players. Sustainability is understood as the ability of the game to sustain player interest in healthy behaviors and motivate him/her to continue playing [71].
7. Limited research on the effectiveness of serious games and gamification for specific population groups, such as marginalized communities [80].
8. Limited research on the ethical and legal implications of serious games and gamification for health, and the potential risks and benefits of these interventions [81,82].
9. Limited research on the cost-effectiveness and economic benefits of serious games and gamification for health [56].
10. Limited research on the long-term effects of serious games and gamification on health outcomes [28,35,52,63].

These research gaps highlight the need for further research to fully understand the potential and limitations of serious games and gamification for health and how to effectively apply them in different settings and for different health conditions.

6.2. Current Research Challenges

There are several current research challenges in the field of serious games and gamification for health.

One major challenge is the lack of standardization in the field [23,25,59]. There are currently no widely accepted guidelines or standards for the development and evaluation of serious games and gamification applications for health. This makes it difficult to compare and replicate studies, and can lead to inconsistent results and conclusions.

Another challenge is the lack of robust evaluation and validation of serious games and gamification techniques for health [30,65]. While there is a growing body of evidence to suggest that these types of interventions can be effective, there is still much work to be done in terms of understanding the underlying mechanisms of action, identifying the most effective design elements, and determining the optimal dosage and duration of treatment.

Additionally, there is a lack of understanding of how serious games and gamification can be effectively integrated into existing healthcare systems and how to measure the effectiveness of the integration [47,61,66]. Moreover, there is still a lack of understanding of the specific game mechanics and design elements that are most effective for promoting different health behaviors and outcomes. For example, some researchers have found that certain game mechanics, such as rewards and social comparison, can be effective in promoting physical activity, while others have found that other mechanics, such as storytelling and simulations, are more effective.

Lastly, serious games and gamification applications are still not widely adopted by healthcare providers and patients [63]. There is a need for more research on how to increase the adoption of these interventions and how to ensure that they are used in a way that is consistent with the best practices in healthcare.

6.3. Current Trends of Research in Serious Games and Gamification for Health

The field of serious games and gamification for health is a rapidly growing and dynamic area of research. Based on review studies analyzed in this paper, some of the main trends in the field include:

1. An increasing use of serious games and gamification techniques for a wide range of health conditions, including chronic conditions such as diabetes [21,48] or asthma [21,37,48], as well as mental health conditions such as depression and anxiety [31,52].
2. Growing recognition of the potential of serious games and gamification to promote healthy behaviors and prevent the onset of chronic health conditions, such as through promoting physical activity [62,67], healthy eating [28], and smoking cessation [32].

3. A shift towards the use of mobile and digital platforms for delivering serious game and gamification interventions [55], as these platforms are increasingly accessible and convenient for patients and healthcare providers.
4. An increasing use of virtual reality and other immersive technologies in serious games and gamification [24,25,30,43,49,55,57,69], as these technologies have the potential to enhance engagement and immersion for players.
5. A growing use of machine learning and other advanced technologies [40] to personalize and adapt serious games and gamification interventions to the specific needs and preferences of individual players.
6. Increasing recognition of the need for rigorous evaluation and validation of serious games and gamification techniques for health, to understand their effectiveness, the underlying mechanisms of action, and the optimal duration of treatment [55].
7. A growing need for more research to identify and understand the most effective game mechanics and design elements for promoting healthy behaviors and outcomes [31,54,56,70,72].
8. An increasing focus on understanding how serious games and gamification can be effectively integrated into existing healthcare systems and how to measure the effectiveness of the integration [47,61,66].
9. The emergence of serious games and gamification applications in preventative healthcare [32,55], with a focus on promoting healthy behaviors, preventing illnesses and chronic conditions, and empowering patients with self-management tools [65].

These trends highlight the ongoing progress and the potential of this field to make a positive impact on the health of patients and communities.

6.4. Future Research Directions

The field of serious games and gamification for health is a rapidly growing and dynamic area of research. The results of this systematic meta-review indicate that there are several promising directions for future research in this area.

One important area for future research is the development of more effective and engaging serious games and gamification applications for a wide range of health conditions. There is a growing body of evidence to suggest that these types of interventions can be highly effective in promoting positive health outcomes, such as improved patient adherence to treatment regimens, reduced symptoms of certain conditions, and increased physical activity [21,35,37,65]. However, there is still much work to be done in terms of developing games and gamification applications that are tailored to the specific needs of different patient populations and that can be easily integrated into existing healthcare systems.

Another important area for future research is the use of serious games and gamification techniques to promote healthy behaviors and prevent the onset of chronic health conditions [48,67]. For example, there is a growing body of evidence to suggest that serious games and gamification can be effective in promoting healthy eating, physical activity, and smoking cessation. However, there is still much work to be done in terms of identifying the most effective game mechanics and design elements for promoting these behaviors, as well as in understanding how these interventions can be scaled up to reach large populations.

Additionally, there is a growing need for rigorous evaluation and validation of serious games and gamification applications for health. While many studies suggest that these types of interventions can be effective [48,51], there is still much work to be done in terms of understanding the underlying mechanisms of action, and identifying the most effective game design elements and gamification techniques.

Finally, the ethical and privacy implications of serious games and gamification for health are an important research direction [83,84] that needs to be addressed in the future. One ethical implication is the protection of players' privacy and sensitive information [81]. Serious games and gamification for health often require players to provide personal information, such as health data, and it is important to ensure that this information is protected and used in a responsible and transparent manner [82]. Another ethical implication is the

potential manipulation of players' behavior using game mechanics and design elements. It is important to ensure that these interventions are designed to promote positive health outcomes rather than to exploit players for commercial or other purposes. Related issues to be addressed are informed consent and the right to autonomy. Players should be fully informed about the potential risks and benefits of the intervention, and should have the freedom to choose whether or not to participate. Furthermore, there are implications related to the accessibility [39], inclusive design, and cultural appropriateness of serious games and gamification for health. It is important to ensure that these interventions are accessible to a wide range of players, including those with disabilities, and that they are culturally appropriate for different population groups, including the marginalized communities.

7. Conclusions

This systematic meta-review aimed to analyze and extract the current state and the prevailing trends of the field of serious games and gamification (SGG) for health by analyzing and summarizing 53 survey papers on the topic. The review followed the PRISMA guidelines and used constructive and cross-sectional methods to analyze and present the results. This review study has found that serious games and gamification techniques have been used to address a wide range of health conditions, including chronic conditions, mental health, physical rehabilitation, substance abuse, smoking cessation, eating disorders and obesity, geriatric care, pain management, asthma management, and preventive care. The most common game mechanics and design elements used in serious games and gamification for health include points, badges, leaderboards, quests and challenges, storytelling and narratives, virtual rewards and incentives, personalization and tailoring, social connections and collaboration, feedback and coaching, virtual reality and immersive technologies, game-based assessments and adaptive testing, and gamified environments and settings.

The review has also found that there is evidence to suggest that serious games and gamification can be effective in promoting positive health outcomes; however, more research is needed to fully understand their potential and limitations, as well as the specific game mechanics and design elements that are most effective for different health conditions and populations. Additionally, the review revealed that there are ethical and legal implications related to serious games and gamification for health such as players' privacy, the manipulation of behavior, compliance with regulations, informed consent, accessibility, inclusive design, and cultural appropriateness.

There are several current research challenges in the field of serious games and gamification for health, including the lack of standardization, lack of robust evaluation and validation, lack of understanding of how to integrate these interventions into existing healthcare systems, lack of understanding of the specific game mechanics and design elements that are most effective for promoting different health behaviors and outcomes, and lack of adoption by healthcare providers and patients.

In conclusion, the field of serious games and gamification for health is a rapidly growing and dynamic area of research with a lot of promise. There are a number of exciting directions for future research, including the development of more effective and engaging serious games and gamification applications for a wide range of health conditions, the use of these techniques to promote healthy behaviors and prevent the onset of chronic health conditions, and the rigorous evaluation and validation of these interventions.

However, it is important to note that the field of serious games and gamification for health is still a relatively new research area, and further research is needed to fully understand their potential and limitations in healthcare-related applications.

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