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Gamified eHealth interventions for health promotion and disease prevention in children and adolescents: a scoping review

Pilar Bas-Sarmiento[1,2], Carmen Julián-López[3], Martina Fernández-Gutiérrez[1,2✉], Miriam Poza-Méndez[1,4] & Antonio-Jesús Marín-Paz[1,4]

Gamification, defined as the introduction of game elements in nongame contexts, has shown potential for addressing disease prevention and health promotion through new technologies. The aim of this study was to identify and describe gamified eHealth interventions for health promotion and disease prevention in children and adolescents, the theoretical frameworks that support or endorse these interventions and the key attributes of games with evidence of their effectiveness. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews (PRISMA-ScR). The search was carried out in the PubMed, Scopus, and Science Direct databases. Related data were extracted on the basis of the research questions, and a qualitative content analysis was conducted. We retrieved 930 records, 26 of which met the eligibility criteria, and 15 studies were ultimately analysed. Most of the gamified interventions were based on the implementation of mobile health applications or video games. A high percentage of studies (80%) demonstrated the effectiveness of gamification, which improved the health-related knowledge, motivation, and attitude outcomes of the participants in the intervention group. The theoretical models underpinning the studies were reported in only 40% of the studies. The attributes of game evaluation, conflict/challenge, and rules/goals were included in all the studies analysed and were related mainly to extrinsic motivation. Despite promising results on the use of gamification in the paediatric population, more research is still needed to validate the theoretical models and consolidate the evidence. Gamification should be based on a motivational theoretical model in which the intrinsic motivation of participants is accounted for.

[1] Department of Nursing and Physiotherapy, University of Cadiz, Cádiz, Spain. [2] Biomedical Research and Innovation Institute of Cadiz, INiBICA, Cádiz, Spain. [3] Andalusian Health Service, 29010 Malaga, Spain. [4] University Research Institute for Sustainable Social Development (INDESS), Jerez de la Frontera, Spain. ✉email: martina.fernandez@uca.es

Introduction

Background. Childhood is the critical period for establishing good habits. In terms of health promotion, healthy habits, such as tooth brushing (World Health Organization, 2023) and good sleep habits (Bathory & Tomopoulos, 2017; Matricciani et al., 2019), and the promotion of mental health (Fenwick-Smith et al., 2018; O'Reilly et al., 2018), are essential for children. During childhood, parents play an essential role due to the influence of the family unit on children. However, at this time, unhealthy behaviours are established, such as the consumption of processed foods and drinks that are rich in sugar, a lack of physical activity, and a sedentary lifestyle (Hammersley et al., 2016), with obesity being an obvious consequence of these bad habits. According to the latest report published by the World Health Organization, one in three children in Europe is overweight or obese (World Health Organization, 2022), and overweight and obesity are considered public health problems (World Health Organization, 2024).

In recent years, there has been an increase in the use of new technologies by the population, especially in the early stages of the life cycle (Jo et al., 2020). Therefore, health professionals have begun to address the possibility of combining the use of new technologies with health education through different strategies to promote greater well-being (Mens et al., 2022). As a result, the Shanghai Declaration on Promoting Health in the 2030 Agenda for Sustainable Development established the importance of digital and interactive technologies to promote adequate health literacy in the population (World Health Organization, 2017). Similarly, numerous health applications have been created recently to intervene in modifiable risk factors (Xu et al., 2022; Yau et al., 2022), promoting health education in the family and educational spheres. However, for these applications to be effective, continued use of electronic devices is required to achieve adequate therapeutic adherence; therefore, these applications must include certain features to achieve this goal (Miller et al., 2016).

Games play an essential role in the education sector. Given the motivational properties of games, the application of game design principles (such as competition and cooperation) and other elements/attributes (such as challenges, points, and levels) in nongame environments has emerged as a widespread and powerful technique for shaping behaviour (Mora et al., 2017); this technique is known as gamification. A commonly applied definition of *gamification* is the use of game elements in nongaming contexts (Deterding et al., 2011). Gamification has been shown to be a technique with potential in health education (Edwards et al., 2016). Gamification could effectively encourage participation, which is essential for influencing the acquisition of the knowledge and skills that are necessary to change attitudes and behaviours. This technique provides opportunities for children and adolescents to be engaged, motivated, and to have fun while learning (Behnke, 2015; Kapp, 2012; Landers & Landers, 2014).

However, the design of effective gamified interventions requires theoretical knowledge of hitherto unexplored cognitive, emotional and motivational mechanisms through which the effect of gamification is successfully achieved (Khaleghi et al., 2021). A detailed explanation of the theoretical foundations of gamified interventions is needed to explain, design and evaluate gamified interventions to guide future theoretical and empirical research (Floryan et al., 2019).

In the context of gamification, two theoretical branches exist. The first branch comprises theoretical frameworks related to intrinsic motivation, such as theories of behaviour and motivation (sociocultural learning theory) (Cong-Lem, 2022; Sun & Zhang, 2021; Wang et al., 2019), the Arcs Model of Motivational Design framework (attention, relevance, confidence, and motivation) (Blair et al., 2021; Kawasaki et al., 2021; Keller, 2009), the RAMP model of intrinsic motivation (relationships, autonomy, mastery, and purpose) (Marczewski, 2024.; Sun & Zhang, 2021), self-determination theory (Neal, 2021; Phillips & Guarnaccia, 2017; Ryan et al., 2009; Teixeira et al., 2012; Uriel Stover et al., 2017), and the Transtheoretical Model of health behaviour change (TTM) (Bedwell et al., 2012; Engeström et al., (1999); Prochaska & Velicer, 2016; Rodríguez, 2017; Zimmerman et al., 2000). The second branch consists of theories that constitute the theoretical framework for the research and design of interventions (activity theory) (Engeström et al., 1999; Rodríguez, 2017). Many attempts have been made to define what constitutes games to understand how they engender learning (e.g., why games are engaging and convey knowledge). However, more unity is needed in the approach of these efforts, resulting in complex integrated findings (Bedwell et al., 2012; Klabbers, 2009).

Through the introduction of game mechanics and elements/attributes, many studies have attempted to increase motivation (Da Rocha Seixas et al., 2016), student performance (Yildirim, 2017) and energy savings (Morganti et al., 2017), promote healthy lifestyle habits (Hamari & Koivisto, 2013) or influence consumer habits (Hsu & Chen, 2018). Generally, a gamification-based intervention is based on digital rewards such as points or medals and feedback on the user's progress in the system through rankings or leaderboards, without considering other theoretical aspects. This often results in designs that trivialise games and turn them into simple digital reward systems. However, game design is a complex process for three main reasons: a) gamification is based on game design and requires game thinking; b) gamification involves principles of motivational psychology; and c) games should produce behavioural changes on the basis of the intrinsic motivation of participants (Morschheuser et al., 2017).

Therefore, it is crucial to clarify which game attributes lead to which learning outcomes (Alsofyani, 2022). With an accurate understanding of the key factors influencing the effectiveness of games, these training tools can be harnessed to their fullest potential (Wang et al., 2024). Examinations of game attributes will provide evidence for determining what makes a game appropriate for learning (Cheng & Ebrahimi, 2023) or for modifying inappropriate behaviour, in this case, health-related behaviour (Orte et al., 2023; Sañudo et al., 2024).

Despite the limited evidence currently available, several studies indicate that there are certain positive effects related to personal factors when gamification mechanisms are introduced into mHealth apps to improve therapeutic adherence (Jakob et al., 2022; Tran et al., 2022). In addition, there are results related to new technologies involving gamification, especially in different areas, such as in the treatment and promotion of mental health (Cheng et al., 2019; Litvin et al., 2020), as well as in other stages of the life cycle, such as old age (De Vette et al., 2015; Hurmuz et al., 2022). Therefore, the use of gamification, together with its attributes, can be a fundamental strategy for achieving adequate health promotion and disease prevention (Johnson et al., 2016; Schmidt-Kraepelin et al., 2020).

Objectives. As recommended by Peters et al. (2020), the "PCC" mnemonic (Population, Concept, and Context) was used as a guide to develop the research question and inclusion criteria. The following research question was formulated: *"What is known about gamified eHealth interventions for health promotion and disease prevention in children and adolescents?"*.

The main objective of this study was to identify and describe gamified eHealth interventions for health promotion and disease prevention in children and adolescents. The following specific objectives were determined: (1) to explore current research trends and understand the most commonly used gamification

Table 1 Search strategy in the different databases.

	Databases	Results
Search string 1[a]	PubMed	131
	Scopus	519
	ScienceDirect	58
Search string 2[b]	PubMed	74
	Scopus	103
	ScienceDirect	17
Search string 3[c]	PubMed	15
	Scopus	12
	ScienceDirect	2

[a]Gamification AND (Parents OR Mothers OR Adolescent OR Children OR Paediatric OR Minors).
[b]Gamification AND (Parents OR Mothers OR Adolescent OR Children OR Paediatric OR Minors) AND (Health).
[c]Gamification AND (Parents OR Mothers OR Adolescent OR Children OR Paediatric OR Minors) AND (Health) AND ("Randomised trial" OR "Randomised Controlled trial").

mechanisms; (2) to determine the theories underpinning gamified interventions; (3) to identify the game attributes used; and (4) to analyse the outcomes of gamified eHealth interventions related to health promotion and disease prevention.

Materials and methods

Design. A scoping review was conducted to systematically map the research on gamified eHealth interventions for health promotion and disease prevention in children and adolescents, as well as to identify gaps in knowledge.

The protocol was drafted and revised by the research team using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018) (Supplementary Table S1).

Search methods. To identify potentially relevant documents, the following bibliographic databases were searched in April 2022 (with no date restrictions): PubMed, ScienceDirect, and Scopus. The databases and electronic resources most related to the interdisciplinary structure of research on gamified eHealth interventions were considered: PubMed allows access to bibliographic databases compiled by the National Library of Medicine (MEDLINE). ScienceDirect provides access to a large bibliographic database of scientific, technical and medical publications (Physical Sciences and Engineering, Life Sciences, Health Sciences and Social Sciences and Humanities sections). Finally, Scopus is a multidisciplinary database for scientific research that includes an integrated web search and a suite of patent databases (U.S. Patent and Trademark Office). The increase in new eHealth gamification strategies in recent years recorded in these databases, given their specificity in the health sciences and the integration of numerous journals focused on eHealth, justified the use of these electronic resources.

One of the researchers drafted the search strategies, which were further refined through team discussion. The final search strategy is shown in Table 1. The search strategy was based on the use of the MeSH thesaurus for the index terms "gamification", "health", "adolescent", "children", "paediatric", "minors", "randomised trial", and "randomised controlled trial" via the Boolean operators 'AND' and 'OR'.

The studies with the following characteristics were included: randomised controlled trials; study samples comprising children and adolescents; eHealth interventions with a gamification component; and data on the effects of the intervention on health promotion and disease prevention outcomes or the promotion of healthy habits in individuals with chronic conditions. There was no restriction by language or year of publication.

The exclusion criteria were interventions that did not apply eHealth strategies exclusively for health promotion or report disease prevention outcomes.

The primary data of the studies analysed were obtained via a list of standard verifications included in the research protocol by two authors who filtered the data independently. The Cohen's kappa coefficient for agreement between the two reviewers was 0.91 ($p < 0.001$). Discussions were used to resolve any discrepancies. The reviewers were blinded to article selection and data extraction.

Data abstraction. Three reviewers with extensive experience in the development and evaluation of the effectiveness of mHealth interventions independently extracted the information and chose potentially eligible articles after reading the titles and abstracts. Studies that met the specified selection criteria were read and assessed for final inclusion. A spreadsheet was used as a template, which was identical for all the reviewers.

For data selection, evidence tables were created, and the studies were classified by title, author, date, country, population, learning focus intervention, game attributes, instrument use and variables measurement, and results.

An intercoder agreement rate of 100% ($k = 1$) was used to classify the theoretical foundations identified.

Synthesis. Owing to the differences in the methodology used, such as the wide time range in the different studies and the insufficient provision of information on effect sizes, a statistical analysis could not be performed. Therefore, a qualitative analysis was carried out. The synthesis was based on a detailed analysis of the different theoretical frameworks of gamification that were observed in the selected studies that described it, as well as the game attributes the studies employed and how these game-based learning strategies led to modifications in healthy behaviours.

To identify and classify the attributes/elements used in the different studies in this work, the attribute classification carried out by Bedwell et al. was referenced (2012).

This framework states that all existing game elements can be structured into nine attributes: (a) action language (refers to the method by which players can make their intent clear to the system, e.g., "pick up button", "forward button"); (b) assessment (describes the nature and content of any feedback given to players during a game, e.g., debriefing, scoring, feedback); (c) conflict/challenge (refers to both the presentation of problems in a game as well as the nature and difficulty of such problems, e.g., challenges, conflict, surprises); (d) control (the amount of active control learners have over content or gameplay and the capacity of players for power or influence over elements of the game); (e) environment (defined as the representation of the physical surroundings in which players are immersed); (f) game fiction (describes the nature of the game world and story. Worlds can involve fantasy or mystery. Fantasy refers to elements that are disparate from the real world (Garris et al., (2002); Owen, 2004), whereas mystery is the gap between known and unknown information (Garris et al., (2002)); (g) human interaction (refers to the degree of contact players have with other human agents during the game); (h) immersion (captures a player's perception of their place within a game world, e.g., their judgement of its immediacy and salience); and (i) rule/goals (consist of the degree to which a game has clear rules, goals, and information on progress towards goals; in other words, it constitutes the goal makeup of the game) (Bedwell et al., 2012). Through this theoretical framework, it was possible to test the relationships

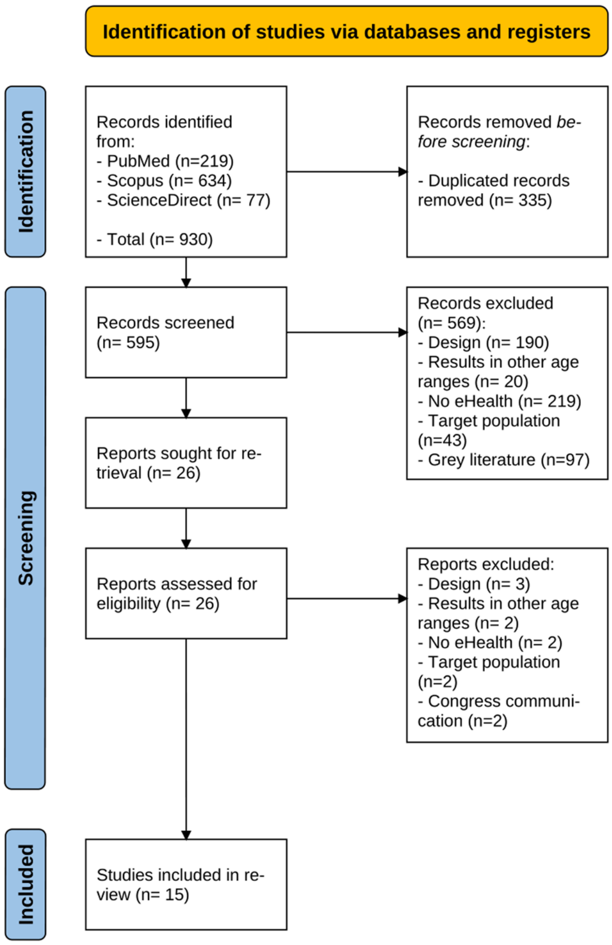

Fig. 1 PRISMA-ScR flow diagram (Tricco et al., 2018).

between these attributes and the outcomes obtained by gamified eHealth interventions that currently lack empirical support.

Results

Synthesis of evidence. Figure 1 (flow diagram) presents the selection process. On the basis of the inclusion criteria, the initial number of identified records was 930. After removing duplicates, 595 studies remained. Second, the inclusion and exclusion criteria were applied with respect to the title and abstract, yielding 26 potentially relevant studies. After a detailed review of each study, 11 studies were excluded (because of the methodological design, the age of the participants, or the use of a non-eHealth intervention). The final sample included 15 articles.

The general characteristics and interventions of the included studies are presented in Table 2. The oldest article dated back to 2015, although most studies were published between 2020 and 2022 ($n = 7$). Most of the studies were conducted in America ($n = 6$); 4 were conducted in Europe, 3 were conducted in Asia, and 1 was conducted in Africa and Australia. The most frequent research topics involved the use of gamified interventions to promote physical activity (González et al., 2016; Melero-Cañas et al., 2021; Patricio et al., 2020; Pyky et al., 2017) and the consumption of fruits and vegetables (Putnam et al., 2018; Vepsäläinen et al., 2022; Wengreen et al., 2021), followed by interest in oral health (Zolfaghari et al., 2021), improved control of type I diabetes mellitus (Alsaleh & Alnanih, 2020; Goyal et al., 2017), drug or sexual education (Cates et al., 2020; Haruna et al., 2018; Stapinski et al., 2018), and finally, the alleviation of preoperative anxiety (Ryu et al., 2018) and other methods aimed at the correct identification of melanoma (Jia et al., 2020).

The use of the theoretical framework. The use of a theoretical framework to explain processes and observed effects was reported in 40% of the studies (Alsaleh & Alnanih, 2020; Cates et al., 2020; Haruna et al., 2018; Melero-Cañas et al., 2021; Pyky et al., 2017; Wengreen et al., 2021). All of the theoretical frameworks were related to motivational frameworks.

Self-determination theory (Phillips & Guarnaccia, 2017; Teixeira et al., 2012; Uriel Stover et al., 2017) was used to inform game design in a gamified educational intervention to engage preteens in the decision to receive vaccination against human papillomavirus (Cates et al., 2020). Despite participants receiving extraextrinsic motivation ($25), only the differences related to increased knowledge between the intervention and control groups were statistically significant. The differences in the behavioural variables did not reach statistical significance.

The combination of the four motivational elements (RAMP) of Marczewski (2024)—relatedness, autonomy, mastery, and purpose—with the teaching personal and social responsibility model led to enhancements in cardiorespiratory fitness, agility and speed-agility among secondary education students (Melero-Cañas et al., 2021).

The MAKE framework, which is based on the Arcs Model of Motivational Design framework and underlines that activity theory, was used in health education programmes via game-based learning and gamification. Both teaching methods effectively improved sexual health knowledge and motivation among secondary school adolescents (Haruna et al., 2018).

The incentive-based approach focused on intrinsic motivation (and its relationship with incentives) was used to promote increased fruit and vegetable consumption among schoolchildren in kindergarten (Wengreen et al., 2021). An increase in fruit consumption and the skin carotenoid concentration was detected.

Finally, the tailored automated health information and feedback messages used in a mobile intervention (Pyky et al., 2017), the aim of which was to increase physical activity, were based on the TTM, and conclusive results on life satisfaction and self-rated health were not obtained (despite the use of extraextrinsic motivation). Nevertheless, the design approach of the study by Alsaleh and Alnanih (2020) was based on the TTM, and the game led to significant changes in the participants' eating behaviours.

Game attributes. Table 3 classifies the game attributes identified in the interventions following the framework of Bedwell et al. (2012). The full characteristics can be found in Supplementary Table S2.

In all the studies, the "assessment", "conflict/challenge", and "rules/goals" game attributes were embedded in the learning environment. Regarding the "assessment" attribute, the feedback provided concerning a player's performance was presented mainly through scores (Alsaleh & Alnanih, 2020; Cates et al., 2020; González et al., 2016; Goyal et al., 2017; Haruna et al., 2018; Patricio et al., 2020; Putnam et al., 2018; Pyky et al., 2017; Stapinski et al., 2018; Zolfaghari et al., 2021), rewards (Haruna et al., 2018; Patricio et al., 2020; Pyky et al., 2017; Ryu et al., 2018; Wengreen et al., 2021; Zolfaghari et al., 2021) or badges (Cates et al., 2020; Haruna et al., 2018; Vepsäläinen et al., 2022). Similarly, most studies with the "conflict/challenge" attribute notably use different tasks (Alsaleh & Alnanih, 2020; González et al., 2016; Haruna et al., 2019; Jia et al., 2020; Melero-Cañas et al., 2021; Ryu et al., 2018; Stapinski et al., 2018; Wengreen et al., 2021; Vepsäläinen et al., 2022) and competition systems (Haruna et al., 2018; Patricio et al., 2020; Pyky et al., 2017; Zolfaghari et al.,

Table 2 General characteristics and methodology of the selected studies.

Study/Year/Country	Population	Learning focus/Intervention
Alsaleh & Alnanih (2020) Saudi Arabia	$N=20$ children (6–12 years old) n CG = 10 n EG = 10	- Children with diabetes mellitus - They played the game without watching the educational video - They played the game after watching the video that presents the nutrients that the body needs, along with the right food to be eaten
Cates et al. (2020) USA	$N=47$ dyads (parents and preteens, 11–12 years old). n CG: 26 n EG: 21	- Sexual Health Education (Human Papillomavirus Vaccination) - Without a video game - *"Land of Secret Gardens"* video game designed to educate preteens about HPV infection and HPV vaccination and to promote conversations with parents and providers and the decision to vaccinate
González et al. (2015) Spain	$N=24$ children (8–12 years old) n CG = 10–15 n EG = 10–15	- Children with overweight or obesity - Intervention: 1. Group sessions (90 min, twice a week), training (30 min), motor games (40 min), and TANGO-H active video game (20 min) twice a week 2. Individual sessions for children at home (45 min, twice a week), Wii Fit Plus video game (30 min) and collaborative multiplayer online video game ("Pirate Island", 15 min) 3. Family training (90 min)
Goyal et al. (2017) Canada	$N=92$ adolescents (11–16 years old) with type 1 diabetes - n CG = 46 - n EG = 46	- Type 1 Diabetes - Any study-related hardware. Usual treatment - *Bant app*, a OneTouch Ultra Mini blood glucose metre, and a Bluetooth adapter allowed for wireless data transmission from the blood glucose metre to *bant*
Haruna et al. (2018) United Republic of Tanzania	$N=120$ adolescent students (11–15 years old) n $CG_{TT}=40$ n $EG_{GM}=40$ n $EG_{GBL}=40$	- Sexual Health Education - *Traditional Teaching-Control Group (TT):* Sexual health education in the classroom (class discussions, group buzzing, group work, and individual assignments) - *Gamification Intervention Group (GM):* Sexual health education in a quiz format using computer platforms offline (Moodle) with gamification plugins - *Game-Based Learning Intervention Group (GBL):* Sexual health education using computer platforms offline (Moodle)
Jia et al. (2020) USA	$N=271$ (high school students) n CG = 135 n EG = 136	- Correct identification of melanoma - Traditional education. Commercially available ABCDE pamphlet - Matching game (they were to identify the correct melanoma image)
Melero-Cañas et al. (2020) Spain	$N=150$ students from secondary schools (13–15 years old) n CG = 37 n EG = 113	- Physical Activity (PA) - 2 Physical Education lessons per week (9 months) using traditional learning methods - 2 Physical Education lessons per week (9 months) using hybridisation of the Teaching Personal and Social Responsibility model -TPRS- and gamification strategies
Patricio et al. (2020) Brazil	$N=65$ (adolescents 15–19 years old) n CG = 28 n EG = 37	- Physical activity in overweight adolescent - Active videogame - Video games associated with a gamified methodology (they had a challenge in each session, virtual prizes, scoring goals, disputes between groups, advancement of stages) through an application called "Arena de Metis"
Putnam et al. (2018) USA	$N=114$ (4–5 years old) n RAE = Not reported n SAE = Not reported n NAE = Not reported	- Healthy eating habits - RAE: Repeated app-exposure ("D.W.´s Unicorn Adventure") - SAE: Single app-exposure ("D.W.´s Unicorn Adventure") - NAE: No app-exposure (control group)
Pyky et al. (2017) Finland	$N=496$ young people (16–20 years) who attended the conscription for military service n CG = 163 n EG = 182	- Physical Activity (PA) - Not access to MOPOrtal - A novel mobile service (MOPOrtal) with automated, tailored health information, exercise, and physical activity instructions
Ryu et al. (2018) South Korea	$N=69$ paediatric patients (4–10 years old) scheduled for elective surgery n CG = 35 n EG = 34	- Preoperative anxiety - Conventional mode of education about the preoperative process - Virtual Reality game where the patient experienced the preoperative process using a three-dimensional virtual environment since first-person perspective (during 5 minutes)
Stapinski et al. (2018) Australia	$N=281$ (school students 14–16 years old) n CG = 133 n EG = 148	- Drug education - Booklet about four drugs (25 min) - They played the videogame "Pure Rush" (10 min) + Booklet about four drugs (15 min)

Table 2 (continued)

Study/Year/Country	Population	Learning focus/Intervention
Vepsäläinen et al. (2022) Finland	$N = 221$ pre-schoolers (3 to 6 years old) n CG = 115 n EG = 106	- Fruit and Vegetable (FV) Consumption - Regular routine in the early childhood education and care centres (ECECs) - Using a food (fruit and vegetables) behaviour and mobile education app (Mole´s Veggie Adventures mobile app) in early childhood education and care centres (ECECs) settings
Wengreen et al. (2021) USA	$N = 1829$ children (5–11 years old) in kindergarten (2016–2017 and 2017–18 school years) n CG = 353 and 625 n EG = 326 and 555	- Fruit and Vegetable (FV) Consumption - No intervention was provided - Field Intensive Trainees—FIT Game—using comic-book formatted episodes filmed throughout lunch
Zolfaghari et al. (2019) Iran	$N = 58$ mother and child (≤ 6 years old) pairs n CG = 29 n EG = 29	- Oral Health Promotion - Simple app (without gamification) to promote oral-health knowledge of mothers (oral hygiene, proper nutrition, fluoride intake, and dental visits) - Gamified version of the App. Tooth brushing for the child, frequency of tooth brushing, application of toothpaste, daily amount of intake of sugar substances were the elements reinforced. Questions about these topics and a reward system

Table 3 Game attributes from selected studies.

Study	Action language	Assessment	Conflict/ Challenge	Control	Environ-ment	Game fiction	Human interaction	Immersion	Rules/ Goals
Alsaleh & Alnanih (2020)		x	x	x				x	x
Cates et al. (2020)		x	x	x	x	x		x	x
González et al. (2016)	x	x	x	x	x	x	x	x	x
Goyal et al. (2017)	x	x	x	x			x		x
Haruna et al. (2018)	x	x	x		x				x
Jia et al. (2020)		x	x						x
Melero-Cañas et al. (2021)		x	x		x	x	x		x
Patricio et al. (2020)	x	x	x				x	x	x
Putnam et al. (2018)	x	x	x	x	x	x		x	x
Pyky et al. (2017)	x	x	x		x		x		x
Ryu et al. (2018)	x	x	x	x	x	x		x	x
Stapinski et al. (2018)	x	x	x	x	x	x		x	x
Vepsäläinen et al. (2022)		x	x		x		x		x
Wengreen et al. (2021)		x	x		x	x	x		x
Zolfaghari et al. (2021)		x	x	x				x	x

2021). The attribute of "rules/goals" was explicitly and implicitly stated to the players because this attribute determines how a player can solve problems in the game.

The next most represented category (77.7%) in the studies was the "environment" attribute, which comprises only the location and provides context for the game. Four studies used metaphors or fantasy settings (Cates et al., 2020; González et al., 2016; Melero-Cañas et al., 2021; Putnam et al., 2018; Vepsäläinen et al., 2022; Wengreen et al., 2021) and real situations (Haruna et al., 2018; Pyky et al., 2017; Ryu et al., 2018; Stapinski et al., 2018). A combination of "environment", "immersion", and "game fiction" attributes was somewhat common (Cates et al., 2020; González et al., 2016; Ryu et al., 2018).

Finally, the "human interaction" attribute was included in 46.6% of the studies. This attribute comprises two types of interaction: interpersonal interaction, which is the relationship between players in real space and time (Melero-Cañas et al., 2021; González et al., 2016; Patricio et al., 2020; Vepsäläinen et al., 2022; Wengreen et al., 2021), and social interaction, which is mediated by technology—voice chat, text chat, etc. (Goyal et al., 2017; Pyky et al., 2017).

Effects of gamified eHealth interventions. Table 4 presents the synthesis of evidence from the selected studies. In terms of evaluating the effectiveness of the intervention, seven studies compared a nongamified intervention with a gamified intervention (Alsaleh & Alnanih, 2020; Cates et al., 2020; Patricio et al., 2020; Putnam et al., 2018; Pyky et al., 2017; Stapinski et al., 2018; Zolfaghari et al., 2021). Five studies reported statistically significant results in favour of the intervention group. In these cases, the clinical variables did not present significant differences, with the level of knowledge and behavioural change showing the most significant results (Alsaleh & Alnanih, 2020; Cates et al., 2020; Patricio et al., 2020; Putnam et al., 2018; Zolfaghari et al., 2021). In the remaining studies, the results were inconclusive (Pyky et al., 2017; Stapinski et al., 2018), as the intervention increased scores in both the control and experimental groups. However, these improvements were not significant in the intra- or between-group measurements.

The other studies analysed the effectiveness of gamified interventions against control interventions that involved traditional training activities (or no activities) (González et al., 2016; Goyal et al., 2017; Haruna et al., 2018; Jia et al., 2020; Melero-

Table 4 Synthesis of evidence from selected studies.

Study	Variables: Instruments	Outcomes
Alsaleh & Alnanih (2020)	Favourite food	EG > CG (50% healthy eating, 40% fruits and vegetables, 10% juice vs. 30% cake and sweets, 20% chocolate, 20% fruits, 20% healthy eating, 10% juice)
	Performance: Maximum number of collected points	EG > CG (91.1% vs. 63.6%)
	Effectiveness: Highest number of badges	EG > CG (8.5 vs. 7.9)
	Efficiency: Maximum number of minutes consumed in the game	EG > CG (17.9 vs. 12.6)
Cates et al. (2020)	*Knowledge Scale*: 5 items scale	EG > CG[a] (2.56 ± 0.34 vs. 2.28 ± 0.41) ($p = 0.03$)
	Self-efficacy and intentions to vaccinate: Vaccination self-efficacy and decisional balance Scales	*Vaccination self-efficacy* CG > EG[a] (1.65 ± 0.35 vs. 1.45 ± 0.35) ($p = 0.05$) *Decisional Balance* Pros: EG > CG (2.44 ± 0.39 vs. 2.31 ± 0.42) ($p = 0.29$) Cons: EG > CG (1.38 ± 0.31 vs. 1.47 ± 0.43) ($p = 0.39$)
	Preteen´s immersion in the story: Physical/Emotional/Narrative Presence Scale–PENS-	>50% preteens called the game boring and not affected emotionally >50% positive scores on game autonomy, ease, and freedom
	Gameplay: Self-reported opinions	86% ($n = 18$) EG participants played the game
	HPV immunisation records	Initiation rate: EG > CG (22% vs. 15%) ($p = 0.31$) Completion rate: EG > CG (9% vs. 2%) ($p = 0.10$)
González et al. (2016)	*Medical area* - Weight: Balance - Height: Stadiometer - Skin folds: Calipers - Bone diameters: Compass - Muscle and body perimeters: Tape measure - BMI - Physiological measurements: Heart rate sensor	*Weight (kg)* $EG < CG_{Pretest}$ (45.26 ± 7.65 vs. 48.12 ± 9.25, $d = 0.11$) $EG < CG_{Postest}$ (45.85 ± 7.62 vs. 49.10 ± 8.88, $d = 0.13$) *BMI* $EG > CG_{Pretest}$ (23.22 ± 1.97 vs. 23.16 ± 1.59, $d = 0.01$) $EG < CG_{Postest}$ (23.08 ± 2.11 vs. 23.32 ± 1.62, $d = 0.04$)
	Interactivity and User experience: Adaptation of the questionnaire on use and attitudes toward video games	Person and structure of activity (50%) Person (15%) Structure of activity and context (21%) Context (9%) Person and context (2%) Person, structure of activity and context (2%) Structure of activity (1%)
	Psychology and pedagogy Interpersonal relationships, relationships with parents, self-esteem, self-confidence: Behaviour assessment system for children and adolescents (BASC) Knowledge: Mediterranean Diet adherence questionnaire (KIDMED)	$EG > CG^{b}_{Postest}$ (8.73 ± 1.48 vs. 6.33 ± 1.41; $t = 3.65$, $p = 0.002$)
Goyal et al. (2017)	HbA_{1c}	*HbA1c (12 months):* CG = EG (8.96 ± 1.2 vs. 8.96 ± 1.3, $p = 0.99$)
	Hypoglycaemic events: Frequency of mild and severe hypoglycaemic events was self-reported by participants or their guardians	*Hypoglycaemic events (12 months):* $CG < EG_{Mild}$ (7.54 ± 7.7 vs. 11.52 ± 10.7, $p = 0.04$) $CG > EG_{Severe}$ (0.48 ± 1.2 vs. 0.16 ± 0.4, $p = 0.13$)
	Self-monitoring of blood glucose (SMGB): 50-day blood glucose metre and/or insulin pump printout	CG < EG (3.39 ± 1.5 vs. 3.49 ± 1.8, $p = 0.42$)
	Self-initiated adjustments: Changes made to the prescribed treatment regimen	CG < EG (1.10 ± 1.3 vs. 1.77 ± 2.7, $p = 0.25$)
	Adherence: Self Care Inventory (SCI)	CG > EG (35.57 ± 6.4 vs. 35.42 ± 5, $p = 0.81$)
	Quality of life: Diabetes Quality of Life for Youth (DQOLY)	*Impact of symptoms* CG < EG (3.16 ± 1.6 vs. 3.33 ± 1.7, $p = 0.15$) *Impact of treatment* CG < EG (2.28 ± 2.2 vs. 2.53 ± 2.1, $p = 0.51$) *Impact on activities* CG > EG (3.42 ± 3 vs. 2.96 ± 3, $p = 0.72$) *Parental issues* CG < EG (4.67 ± 3.6 vs. 5.2 ± 3.6, $p = 0.75$) *Worries about diabetes* CG < EG (4.81 ± 5 vs. 6.84 ± 5.8, $p = 0.17$) *Health perception* CG > EG (2.10 ± 0.6 vs. 1.96 ± 0.7, $p = 0.50$)
	Diabetes Family Responsibility Questionnaire (DFRQ)	CG < EG (36.79 ± 5.7 vs. 37.16 ± 4.3, $p = 0.78$)
	Satisfaction with Bant app	*Engagement level* - Very low: 17 (37%) - Low: 13 (28%) - Moderate: 12 (26%) - High: 4 (9%) *Satisfaction* Satisfied and very satisfied = 76% Usefulness = trending feature (45%); logbook (14%); and the app home page (11%)
Haruna et al. (2018)	*Knowledge*: Adolescent Sexual Health Literacy Test—ASHLT-	$EG_{(GM,\ GBL)} > CG_{TT}^{b}$: F (2,117) = 54.75, $p = 0.001$ $EG_{(GM)} > CG_{TT}^{b}$: $p = 0.001$ $EG_{(GBL)} > CG_{TT}^{b}$: $p = 0.001$ $EG_{(GM)} = EG_{(GBL)}$: $p = 0.970$

Table 4 (continued)

Study	Variables: Instruments	Outcomes
	MAKE Framework: Motivation: - Attention - Relevance - Confidence - Satisfaction Attitude: - Affective - Cognitive Knowledge: - Importance - Effectiveness - Application Engagement: - Emotional - Cognitive	*Motivation* Attention $EG_{(GM)} > CG_{TT}^{b}$: 4.40 ± 0.4 vs. 2.55 ± 1.16 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.43 ± 0.37 vs. 2.55 ± 1.16 ($p = 0.001$) $EG_{(GM)} < EG_{(GBL)}$: 4.40 ± 0.4 vs. 4.43 ± 0.37 ($p = 1.000$) Relevance $EG_{(GM)} > CG_{TT}^{b}$: 4.55 ± 0.41 vs. 2.76 ± 0.73 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.47 ± 0.32 vs. 2.76 ± 0.73 ($p = 0.001$) $EG_{(GM)} > EG_{(GBL)}$: 4.55 ± 0.41 vs. 4.47 ± 0.32 ($p > 0.05$) Confidence $EG_{(GM)} > CG_{TT}^{a}$: 4.42 ± 0.52 vs. 3.65 ± 1.12 ($p = 0.004$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.63 ± 0.32 vs. 3.65 ± 1.12 ($p = 0.001$) $EG_{(GM)} < EG_{(GBL)}$: 4.42 ± 0.52 vs. 4.63 ± 0.32 ($p > 0.05$) Satisfaction $EG_{(GM)} > CG_{TT}^{b}$: 4.56 ± 0.3 vs. 3.67 ± 0.82 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.53 ± 0.38 vs. 3.67 ± 0.82 ($p = 0.001$) $EG_{(GM)} > EG_{(GBL)}$: 4.56 ± 0.3 vs. 4.53 ± 0.38 ($p > 0.05$) *Attitude* Affective $EG_{(GM)} > CG_{TT}^{b}$: 4.84 ± 0.19 vs. 3.64 ± 1.03 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.69 ± 0.35 vs. 3.64 ± 1.03 ($p = 0.001$) $EG_{(GM)} > EG_{(GBL)}$: 4.84 ± 0.19 vs. 4.69 ± 0.35 ($p = 0.351$) Cognitive $EG_{(GM)} > CG_{TT}^{b}$: 4.77 ± 0.22 vs. 3.51 ± 0.94 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.76 ± 0.25 vs. 3.51 ± 0.94 ($p = 0.001$) $EG_{(GM)} > EG_{(GBL)}$: 4.77 ± 0.22 vs. 4.76 ± 0.25 ($p > 0.05$) *Knowledge* Importance $EG_{(GM)} > CG_{TT}^{b}$: 4.84 ± 0.2 vs. 3.13 ± 1.13 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.79 ± 0.23 vs. 3.13 ± 1.13 ($p = 0.001$) $EG_{(GM)} > EG_{(GBL)}$: 4.84 ± 0.2 vs. 4.79 ± 0.23 ($p = 1.000$) Effectiveness $EG_{(GM)} > CG_{TT}^{b}$: 4.88 ± 0.26 vs. 2.85 ± 0.95 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.76 ± 0.34 vs. 2.85 ± 0.95 ($p = 0.001$) $EG_{(GM)} > EG_{(GBL)}$: 4.88 ± 0.26 vs. 4.76 ± 0.34 ($p > 0.05$) Application $EG_{(GM)} > CG_{TT}^{b}$: 4.84 ± 0.28 vs. 3.97 ± 0.85 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.78 ± 0.35 vs. 3.97 ± 0.85 ($p = 0.001$) $EG_{(GM)} > EG_{(GBL)}$: 4.84 ± 0.28 vs. 4.78 ± 0.35 ($p > 0.05$) *Engagement* Emotional $EG_{(GM)} > CG_{TT}^{b}$: 4.67 ± 0.28 vs. 2.77 ± 0.96 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.63 ± 0.33 vs. 2.77 ± 0.96 ($p = 0.001$) $EG_{(GM)} > EG_{(GBL)}$: 4.67 ± 0.28 vs. 4.63 ± 0.33 ($p > 0.05$) Cognitive $EG_{(GM)} > CG_{TT}^{b}$: 4.64 ± 0.37 vs. 2.98 ± 0.79 ($p = 0.001$) $EG_{(GBL)} > CG_{TT}^{b}$: 4.67 ± 0.4 vs. 2.98 ± 0.79 ($p = 0.001$) $EG_{(GM)} < EG_{(GBL)}$: 4.64 ± 0.37 vs. 4.67 ± 0.4 ($p > 0.05$)
	Feedback on experience: Focus group	*CG*: "We are not free during learning as we feel shy and fear to ask questions in the class. As a result, the learning becomes unappealing and boring" (TT-13) and "The way we were taught this subject is too personal and teacher centred and but it is supposed to be more engaging, involving, and attractive" (TT-18) *EG*: "I enjoyed learning, I think even my fellow students felt the same way" (GBL-21). "I wanted to spend more time when the training ended" (GBL-30). In the gamification condition, students reported, "I always am the last students to leave the computer lab and sometimes I was reluctant to shut off my computer" (GM-5)
Jia et al. (2020)	*Percent Accuracy score:* Game logs	$EG > CG^{b}$ (74.2 ± 12.1 vs. 63.5 ± 12.1, $p < 0.001$)
	Confidence Perceived score: Game logs	$EG > CG$ (46.1 ± 22.6 vs. 42.4 ± 20.9, $p = 0.2$)
Melero-Cañas et al. (2021)	*Lifestyle Habits*: Youth Activity Profile Spain (YAP-S)	*PA in school* - Pre-test and Post-test CG^{a}: 2.9 ± 0.73 vs. 3.24 ± 0.86 ($p = 0.005$) - Pre-test and Post-test EG^{a}: 2.86 ± 0.88 vs. 3.04 ± 0.78 ($p = 0.011$) *Afterschool PA (weekday)* - Pre-test and Post-test CG: 3.17 ± 0.79 vs. 3.16 ± 0.85 ($p = 0.912$) - Pre-test and Post-test EG^{b}: 2.71 ± 0.87 vs. 3.04 ± 0.91 ($p = 0.001$) *Afterschool PA (weekend)* - Pre-test and Post-test CG^{a}: 2.95 ± 0.97 vs. 2.65 ± 0.82 ($p = 0.020$) - Pre-test and Post-test EG^{b}: 2.35 ± 0.87 vs. 3.02 ± 1.01 ($p < 0.001$) - $GE > CG^{a}$ ($p = 0.004$) *Afterschool PA (week)* - Pre-test and Post-test CG: 3.08 ± 0.71 vs. 2.96 ± 0.71 ($p = 0.223$) - Pre-test and Post-test EG^{b}: 2.57 ± 0.77 vs. 3.03 ± 0.82 ($p < 0.001$) *Sedentary time* - Pre-test and Post-test CG: 2.46 ± 0.51 vs. 2.64 ± 0.58 ($p = 0.203$) - Pre-test and Post-test EG^{b}: 2.72 ± 0.57 vs. 2.47 ± 0.54 ($p < 0.001$)

Table 4 (continued)

Study	Variables: Instruments	Outcomes
	Physical Fitness (PF): - Cardiorespiratory fitness: 20 min shuttle run test - Speed-Agility: 4 × 10 m speed-agility test - Strength: Standing broad jump - Flexibility: Back sabre sit-and-reach test - Agility: Hexagon test	*Cardiorespiratory fitness* - Pre-test and Post-test CG: 5.08 ± 2.11 vs. 4.70 ± 2.19 ($p = 0.066$) - Pre-test and Post-test EG^{b}: 3.99 ± 2.27 vs. 5.04 ± 2.2 ($p < 0.001$) *Speed-agility* - Pre-test and Post-test CG^{a}: 12.78 ± 1.1 vs. 12.38 ± 1.21 ($p = 0.043$) - Pre-test and Post-test EG^{b}: 13.27 ± 1.29 vs. 11.63 ± 1.53 ($p < 0.001$) - EG < CG^{a} ($p = 0.005$) *Strength* - Pre-test and Post-test CG: 1.57 ± 0.34 vs. 1.61 ± 0.38 ($p = 0.268$) - Pre-test and Post-test EG^{b}: 1.50 ± 0.37 vs. 1.64 ± 0.38 ($p < 0.001$) *Flexibility* - Pre-test and Post-test CG^{b}: 4.38 ± 7.6 vs. 6.03 ± 8.22 ($p < 0.001$) - Pre-test and Post-test EG^{b}: 3.51 ± 7.63 vs. 5.82 ± 7.51 ($p < 0.001$) *Agility* - Pre-test and Post-test CG: 13.69 ± 2.17 vs. 13.30 ± 2.6 ($p = 0.203$) - Pre-test and Post-test EG^{b}: 14.93 ± 2.18 vs. 12.30 ± 1.93 ($p < 0.001$) - EG < CG^{a} ($p = 0.008$)
	Body Mass Index (BMI)	- Pre-test and Post-test CG^{b}: 21.04 ± 4.05 vs. 21.94 ± 3.44 ($p < 0.001$) - Pre-Postest EG: 21.46 ± 4.11 vs. 21.50 ± 4.05 ($p = 0.521$)
Patricio et al. (2020)	*Abdominal circumference*: Measuring tape	*Initial* ($p = 0.081$) EG < $CG_{elevated}$ (8.1% vs. 25.9%) EG > CG_{normal} (91.9% vs. 74.1%) *Final* ($p = 0{,}488$) EG < $CG_{elevated}$ (17.2% vs. 25.0%) EG > CG_{normal} (82.8% vs. 75.0%)
	BMI: Tanita digital scale Stadiometer	*Initial* ($p = 0.013$) EG < $CG^{b}_{obesity}$ (33.3% vs. 66.7%) EG < $CG^{b}_{overweight}$ (67.4% vs. 32.6%) *Final* ($p = 0{,}488$) EG < $CG_{obesity}$ (20.7% vs. 33.3%) EG > $CG_{overweight}$ (72.4% vs. 56.7%) EG > $CG_{eutrophic}$ (6.9% vs. 0%)
	Frequency of physical activity: Questionnaire	*Final* ($p = 0.048$) EG < $CG^{b}_{\leq 25\%}$ (8.1% vs. 25.9%) EG < $CG^{b}_{>30\%\ <75\%}$ (35.1% vs. 44.4%) EG >$CG^{b}_{\geq 75\%}$ (56.8% vs. 29.6%)
Putnam et al. (2018)	*Free recall of healthy and unhealthy items from the app (condition)*: 2-item questionnaire about healthy and unhealthy foods	Free recall of healthy and unhealthy items from the app recall (condition) *Healthy items* ($p < 0.017$) RAE > SAE^{b} (3.09 vs. 1.85 compared to NAE) SAE > NAE^{b} (2.08 ± 1.55 vs. 1.12 ± 1.42; $p = 0.001$) RAE > NAE^{b} (3.47 ± 2.35 vs. 1.12 ± 1.42; $p < 0.001$) *Unhealthy items* ($p < 0.017$) RAE > SAE^{b} (7.69 vs. 3.79 compared to NAE) SAE > NAE^{b} (1.11 ± 1.07 vs. 0.29 ± 0.46; $p < 0.001$) RAE > NAE^{b} (2.25 ± 1.57 vs. 0.29 ± 0.46; $p < 0.001$)
	Children´s liking of the character	Liking: RAE > NAE^{b} (3.58 ± 1.44 vs. 2.73 ± 1.58; $t = -2.41$; $p < 0.018$)
Pyky et al. (2017)	*Life satisfaction (LS)*: Self-reported four-item scale	- Pre-test and Post-test CG^{b}: 7.0 vs. 7.5 ($p < 0.001$) - Pre-test and Post-test EG^{b}: 7.1 vs. 7.9 ($p < 0.001$) - EG > CG ($p = 0.215$)
	Self-rated health: Good, pretty good, average, pretty poor or poor	- Pre-test and Post-test CG: 141 vs. 181 ($p = 1.000$) - Pre-test and Post-test EG: 153 vs. 175 ($p = 0.383$) - EG < CG ($p = 0.654$)
	Physical activity and sitting	- Pre-test and Post-test CG: 9.4 vs. 8.8 ($p = 0.106$) - Pre-test and Post-test EG: 8.9 vs. 9.2 ($p = 0.307$) - EG > CG ($p > 0.05$)
	Weight	- Pre-test and Post-test CG^{b}: 72.9 vs. 74.5 ($p < 0.001$) - Pre-test and Post-test EG^{b}: 73.4 vs. 74.9 ($p < 0.001$) - EG > CG ($p = 0.421$)
	BMI	- Pre-test and Post-test CG: 23.0 vs. 23.5 ($p > 0.05$) - Pre-test and Post-test EG^{b}: 23.2 vs. 23.6 ($p < 0.001$) - EG > CG ($p > 0.05$)
Ryu et al. (2018)	*Anxiety*: Yale Preoperative Anxiety Scale m-YPAS	Baseline: EG > CG (51.7 [46.7–67.5] vs. 50 [43.3–65]) ($p = 0.389$) Preanaesthesia: EG < CG^{b} (28.3 [23.3–36.7] vs. 46.7 [31.7–51.7]) ($p < 0.001$)
	Compliance of patient during induction of anaesthesia: Induction Compliance Checklist–ICC-	EG < CG^{a} ($p = 0.038$) Perfect (0): CG = 19 (54), EG = 27 (79) Moderate (1-3): CG = 13 (37), EG = 7 (21) Poor (>4): CG = 3 (9), EG = 0 (0)
	Behaviour in a stressful medical procedure: Procedural Behaviour Rating Scale–PBRS-	EG < CG ($p = 0.092$)
	Parent/guardian´s satisfaction: *101 NRS*	EG = CG ($p = 0.268$)
Stapinski et al. (2018)	*Knowledge*: 26-item quiz about drug effects, prevalence, risks and harm-minimisation information	EG < $CG_{Pretest}$ (21.9 ± 8.8 vs. 23.0 ± 7.0) EG > $CG_{Postest}$ (28.8 ± 7.3 vs. 28.2 ± 7.1)
	Intentions to use: Life Skills Training Questionnaire (adapted)	EG < $CG_{Pretest}$ (0.6 ± 1.6 vs. 0.8 ± 2.3) EG = $CG_{Postest}$ (1.0 ± 2.6 vs. 1.0 ± 2.4)
	Lesson engagement: Adapted version of the motivation survey developed and validated based on Keller's Model of Motivation	EG < $CG_{Postest}$ (22.5 ± 6.2 vs. 23.4 ± 6.0)
	Enjoyment of the game: Pure rash feedback	$EG_{pretest} < EG_{Posttest}{}^{b}$ (21.9 ± 8.8 vs. 28.8 ± 7.3; $p < 0.001$) $CG_{pretest} < CG_{Posttest}{}^{b}$ (23.0 ± 7.0 vs. 28.2 ± 7.1; $p < 0.001$)

Table 4 (continued)

Study	Variables: Instruments	Outcomes
Vepsäläinen et al. (2022)	*FV acceptance*: Range 0–125	Pre-test and Post-test CG = 70.2 ± 25 vs. 72.4 ± 26.2 Pre-test and Post-test EG = 70.6 ± 25.5 vs. 78.5 ± 30.6 EG > CG (78.5 vs. 72.4)
	FV relative acceptance score: Range 0–5	Pre-test and Post-test CG = 3.77 ± 1.1 vs. 3.75 ± 1.1 Pre-test and Post-test EG = 3.84 ± 1.1 vs. 3.97 ± 1 EG > CG (3.97 vs. 3.75)
Wengreen et al. (2021)	*Vegetable consumption*	EG > CG (26.61 ± 3.94 vs. 17.38 ± 3.92, *p* = 0.096) EG > CG_{3m} (21.36 ± 3.94 vs. 13.73 ± 3.92, p = 0.169)
	Fruit consumption	EG > CG^a (58.57 ± 5.37 vs. 42.24 ± 5.34, *p* = 0.031) EG > CG^a_{3m} (45.85 ± 5.37 vs. 30.82 ± 5.34, *p* = 0.047)
	Combined FV consumption	EG > CG (86.93 ± 11.39 vs. 60.22 ± 11.36, *p* = 0.097) EG > CG_{3m} (66.01 ± 11.38 vs. 43.74 ± 11.35, *p* = 0.166)
	Skin carotenoid concentration	EG > CG^a (35,168 ± 596 vs. 31,628 ± 543, *p* = 0.007) EG > CG^a_{3m} (34,012 ± 600 vs. 30,912 ± 550, *p* = 0.015)
Zolfaghari et al. (2021)	*Oral Health Knowledge of mothers*: 18 items questionnaire	Pre-test and Post-test CG^b = 10.5 ± 2.1 vs. 13.1 ± 1.6 (*p* < 0.001) Pre-test and Post-test EG^b = 11.3 ± 1.9 vs. 14.3 ± 2.0 (*p* < 0.001)
	Self-reported oral health practice of children: 5 items questionnaire	Pre-test and Post-test CG^b = 4.4 ± 2.4 vs. 8.5 ± 1.7 (*p* < 0.001) Pre-test and Post-test EG^b = 4.8 ± 3.2 vs. 8.0 ± 2.2 (*p* < 0.001)
	Plaque Index (PI): Leo & Silness modified dental plaque index	Pre-test and Post-test CG^a = 0.8 ± 0.4 vs. 0.5 ± 0.3 (*p* = 0.006) Pre-test and Post-test EG^b = 1 ± 0.3 vs. 0.5 ± 0.3 (*p* < 0.001)

EG > CG^a: experimental group had significantly better outcomes at 5% significance level; CG > EG^a: control group had significantly better outcomes at 5% significance level; EG > CG^b: experimental group had significantly better outcomes at 1% significance level; Pre-test and Post-test CG^a = Post-test control group had significantly better outcomes at 5% significance level rather than Pre-test control group; Pre-test and Post-test CG^b = Post-test control group had significantly better outcomes at 1% significance level rather than Pre-test control group; Pre-test and Post-test EG^a = Post-test experimental group had significantly better outcomes at 5% significance level rather than Pre-test experimental group; Post-test EG^b = Post-test experimental group had significantly better outcomes at 1% significance level rather than Pre-test experimental group; EG > CG: The results of the experimental group are better than the control group, although findings were not statistically significant ($p > 0.05$); CG > EG: The results of the experimental group are better than the control group, although findings were not statistically significant ($p > 0.05$).

Cañas et al., 2021; Ryu et al., 2018; Vepsäläinen et al., 2022; Wengreen et al., 2021). In these cases, mixed results were obtained. Half of the studies (Melero-Cañas et al., 2021; Ryu et al., 2018; Vepsäläinen et al., 2022; Wengreen et al., 2021) revealed statistically significant differences between gamified interventions and no related interventions concerning clinical or behavioural variables (preoperative anxiety, acceptance of fruits and vegetables, physical activity at school and after school, physical fitness, speed and agility, fruit consumption, and the skin carotenoid concentration, respectively). The study by Goyal et al. (2017) reported unremarkable results, even reporting negative values after the intervention (hypoglycaemia events). In the remaining studies, improvements were observed only in the knowledge variables (González et al., 2016; Goyal et al., 2017; Jia et al., 2020).

Finally, the only study that examined which strategy was more effective, i.e., game-based or gamification-based interventions versus traditional interventions, did not obtain convincing results (Haruna et al., 2018). Although the results show that the game-based intervention was consistently more effective than the traditional method, no significant differences were found in the type of innovative strategy used. Most of the main results (knowledge, motivation, attitudes and engagement) indicated that gamified interventions performed better than game-based interventions did, but these differences were not significant.

Discussion

This scoping review aimed to investigate the current evidence for the use of gamification in eHealth interventions between children and adolescents.

The publication dates of these studies show that this field is in its infancy, although it is expanding. Most of the included studies were performed in American and European schools and used digital technologies to develop and implement gamified eHealth interventions in teaching and learning. With respect to health outcomes, eight studies achieved their main objective (Alsaleh & Alnanih, 2020; Haruna et al., 2018; Melero-Cañas et al., 2021; Patricio et al., 2020; Ryu et al., 2018; Vepsäläinen et al., 2022; Wengreen et al., 2021; Zolfaghari et al., 2021): the intervention group showed positive results compared with the control group. Concerning knowledge outcomes, several studies reported the knowledge variable showed the best improvement (Cates et al., 2020; Haruna et al., 2018; González et al., 2016; Jia et al., 2020; Putnam et al., 2018; Zolfaghari et al., 2021). The remaining studies did not yield conclusive results, as they obtained similar results for both the control and experimental groups (Goyal et al., 2017; Pyky et al., 2017; Stapinski et al., 2018) and were unable to affirm whether the intervention with gamification elements was effective. The results in this direction are shown in the systematic review designed by Yau et al. (2022) to determine the effectiveness of mobile apps in promoting healthy behaviour and preventing obesity, where only 62% of the studies reported significant positive changes in at least one healthy behavioural outcome.

Similarly, Suleiman-Martos et al. (2021) conducted a systematic review and meta-analysis on the effects of gamification on improving diet, eating habits, knowledge, and body composition in children and adolescents. The results revealed improvements in fruit and vegetable intake and increases in the levels of related nutrients. However, most studies do not provide much information on body mass index.

Thus, gamification has positive effects. However, these effects depend mainly on the context in which gamification has been implemented, the design of the game and the characteristics of the users (Hamari et al., 2014). The evidence highlights the importance of good ideation and the tailoring of gamification strategies to the particular context of each application and the types of users involved (García et al., 2017; Haruna et al., 2019; Morschheuser et al., 2018). Like those of Lee et al. (2021), our results reveal populations with a wide age range, including diverse populations (preschoolers vs. adolescents). Thus, the results of the study by Cates et al. (2020) contradict the assessments made by the participants, who described the video game as "boring" on many occasions, which may have significantly influenced the nonsignificant results reported in the study. However, this situation could be because the vast majority of the children interpreted the purpose of the video game, which could detract from their motivation once they discovered the aim of the gamification tool.

These results confirm that gamification is still an emerging field and that we should be cautious in interpreting results, as positive results may be overreported due to publication bias and because few studies with sufficient methodological quality have yet to be carried out (few randomised controlled trials with intergroup analysis). There are still many challenges and open questions for which the answers require the development of empirical research activities that contribute to quality gamification experiences and allow for rigorous evaluation of their results (Marín et al., 2018; Nacke & Deterding, 2017).

On the one hand, in the analysis of the theoretical bases underpinning the design of the interventions evaluated, we observed the lack of a theoretical model in many cases (only 40% of the interventions were based on a theoretical model) and the failure to incorporate these models into the analysis of the results. More methodological proposals and tools that fully support the gamification lifecycle are needed, hindering the application of gamification (Yildirim, 2017). In this context, not all the articles reported which type of motivation (intrinsic or extrinsic) they were trying to use in their interventions.

Consequently, better results were reported by the studies that clarified the approach to the type of motivation (Alsaleh & Alnanih, 2020; Cates et al., 2020; Haruna et al., 2018; Melero-Cañas et al., 2021; Pyky et al., 2017; Wengreen et al., 2021). Therefore, only these studies tried to determine the effects of gamification according to the type of motivation. Other studies, especially those that did not obtain many results with significant differences between groups, focused on the intentionality of motivating the participants through gamification techniques but did not specify the type of motivation (Goyal et al., 2017; Pyky et al., 2017; Ryu et al., 2018; Zolfaghari et al., 2021). Evidence shows that participation in gamified learning experiences may decrease learning, as winning (extrinsic motivation) becomes more critical than internalising knowledge and skills (Reeve & Deci, 1996).

On the other hand, concerning the game elements included in the different interventions (according to the proposed theoretical model), we observed that most of the interventions included combinations of the "assessment", "conflict/challenge", and "goals" attributes. Given that the mechanism by which each person's motivation is increased or decreased is highly individual and particular, a uniform design of the gamification strategy, which is shared by all participants, is not the most appropriate way to maximise the benefits of gamification. Mechanisms that intelligently adapt gamification strategies that consider the characteristics of the tasks to be performed and those of the participants themselves are necessary (Klock et al., 2020; Uskov & Sekar, 2015). Thus, we observed how some game elements ("assessment" attribute), such as scoring and rewards, constitute extrinsic motivation for specific tasks that are not usually rewarded beforehand, which can lead to a loss of interest in the activity once the reward disappears, known as the overjustification effect (Hanus & Fox, 2015; Lameris et al., 2015).

For the other attributes analysed, human interaction has shown how studies that include social interactions can increase feelings of belonging, leadership, and socialisation (González et al., 2016; Goyal et al., 2017; Melero-Cañas et al., 2021; Patricio et al., 2020; Pyky et al., 2017; Vepsäläinen et al., 2022; Wengreen et al., 2021). Similarly, the combination of attributes related to the contextualisation of the experience (immersion, game fiction, and the environment) helps to trigger behaviours/skills that are intended to be modified/incentivized. In this sense, we observed that positive results can be enhanced with virtual reality in terms of behavioural variables (Ryu et al., 2018).

In involving all these elements in the field of health, starting from a robust theoretical model and a careful assessment of the motivation that the gamification strategy can provide for children and adolescents, a more attractive intervention can be achieved, ensuring their long-term commitment and increasing their competitiveness and satisfaction with their achievements, leading to an improvement in health in these age groups (Sardi et al., 2017).

Limitations. With respect to the limitations of this scoping review, although three databases were used, other search engines and MeSH terms could have provided additional studies regarding gamification in this context. Second, another limitation is related to the characteristics of the studies and the nature of the scoping review. The comparative scarcity of studies and the marked heterogeneity in study methodology present challenges for a systematic review or meta-analysis. Finally, the broad nature of this review—although appropriate for a scoping review—limits the ability to provide specific conclusions on the basis of age group, game design, and health outcomes.

Conclusions

This study sought to identify and describe gamified eHealth interventions for health promotion and disease prevention in children and adolescents. Although scientific production has increased in recent years, few solid experimental studies that support the results are emerging.

After evaluating perceived health outcomes and benefits, most studies concluded that gamification was effective compared with no gamification. Thus, gamification can be recommended as a strategy in the development of eHealth resources to improve children's health. In studies that compared gamified versus non-gamified interventions, improvements in the level of knowledge and behavioural changes were reported. The results for the clinical or physiological variables were not promising, perhaps because more time is needed for these changes to be observed. The positive trend of gamified interventions compared with traditional interventions should be studied further in the future. Similarly, the only evidence that analysed the effectiveness of gamified versus game-based interventions is that more studies are required in this regard.

The few theoretical frameworks used in some studies were all based on motivational models, except for the TMM, which was used in two studies, with contradictory results. Gamification must be based on a detailed motivational theoretical model in which the intrinsic motivation of participants is accounted for. A detailed explanation of the theoretical foundations for designing and evaluating gamified interventions and guiding future theoretical and empirical research is needed. Therefore, future research should consider and validate current theoretical frameworks and determine the most effective behavioural models in this field.

Similarly, a future line of research would be to identify the direct effects of the different attributes of games on the different outcomes observed. Analysing how each of the different components affects the results obtained would make it possible to design interventions based on gamification more efficiently.

Data availability

Data generated and analysed during this study are included in this published article and its supplementary information files. The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

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The authors declare no competing interests.

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Ethical approval was not required as the study did not involve human participants.

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Additional information
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Correspondence and requests for materials should be addressed to Martina Fernández-Gutiérrez.