Serious Games for Healthy Nutrition. A Systematic Literature Review

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Abstract

Research indicates that the two main causes of being overweight and obese are living a sedentary lifestyle and unhealthy eating habits. Influencing people to be active and exercise is an active research area that has resulted in the development of several games both commercially available and for free. The area of influencing people to develop healthy eating habits, on the other hand, still has room for growth. In the current paper, I review existing serious games for healthy nutrition over the past five years and summarize the main findings based on three main themes: the design and development of the game, the evaluation of the game, and the findings from the evaluation. My results indicate that most games are designed in collaboration with a team of experts such as nutritionists, psychologists, HCI designers, and software developers. In addition, most of the games for kids are web-based while most of those for adults are mobile-based. Most games used a self-report approach to evaluation which was carried out over a range of period of 30 minutes to 90 days with between 10 to 531 participants. There were mixed results from the evaluations with most games partially achieving their aim. I conclude by suggesting guidelines for developing serious games for influencing healthy nutrition.

Keywords: *Healthy Eating, Serious Games, Literature Review, Nutrition Education*

1 Introduction

Research has shown that adopting a non-sedentary lifestyle and embracing healthy eating habits are the two major ways of improving one's health, reducing weight, and preventing weight gain [1]. A lot of research has been carried out in the area of promoting non-sedentary lifestyles in adults such as the development and promotion of serious games that influence people to be more active. Serious games are games designed for other purposes than pure entertainment [2]. For example, Lentelink et al. [3] developed *Healthy Weight Game*, a mobile game to help people become more active. Similarly, Spikol et al. [4] developed Skattjakt, a serious game to promote physical activity and collaborative problem solving by helping a character in the game solve a mystery. Several commercial games also exist to promote non-sedentary lifestyles such as Wii Fit, Just Dance, My Fitness Coach, Kinect Sports, and Zumba fitness.

The area of influencing healthy eating habits, on the other hand, is still under-researched, particularly the use of serious games to influence healthy eating habits. Healthy eating and healthy nutrition are defined as adopting a healthy eating pattern that includes a variety of nutritious foods and drinks [5]. Serious games have been shown to influence positive behaviour change in their users [6]. Therefore, there is a need to understand the current state-of-the-art in game design and development for healthy nutrition. To contribute to research in this area, a review of the serious games developed for healthy nutrition in the

past five years (twenty articles) was carried out based on three main themes: the design and development of the game, the evaluation, and the findings from the evaluation.

The review of the twenty games indicates that serious games for nutrition are typically developed for specific segments of people such as adolescents with down syndrome to understand healthy eating [7], women to adopt healthier dietary behaviours [8], and pre-school aged children with type 1 diabetes to educate them on healthy food choices [9]. The review also indicates that serious games for nutrition are often based on a theoretical framework to increase their efficacy such as the Self Determination Theory [8], [10] and Social Cognitive Theory [11], [12], [13], [14]. The evaluation period for the studies ranges from half an hour to ninety days using between ten to over five hundred participants. Most of the evaluations were self-reported. The results of evaluating the games indicate that most games were partially successful at achieving their aim.

2 Materials and methods

The quantitative content analysis approach was used in carrying out the systematic literature review. This technique enables one to compare, contrast and categorize data according to various themes and concepts [15]. It is widely used when conducting systematic literature reviews [16].

2.1 Inclusion criteria

Various databases were searched for the literature used in this study including PubMed, Springer, the ACM Digital Library, and IEEE Xplore. The search terms used were: “Serious games and healthy eating”, “Serious games”, and “Serious games and nutrition”. The reference lists of the included studies were scanned through to identify any relevant articles. The search resulted in 913 articles. Articles published before 2015 were excluded because the review period was between 2015 and 2020 to identify the most current trends. Articles written in English were included. Also, only peer-reviewed articles were included. Furthermore, the included articles reported studies that investigate the effects of serious games on nutrition in adults or children. A total of 20 articles met the inclusion criteria and were used in the review.

2.2 Coding scheme

The games described in the articles were analyzed and coded within three broad themes: 1) design and development, 2) evaluation and 3) findings. The coding themes were developed based on the pertinent aspects of game development and previous literature reviews carried out by other researchers [16]. The *design and development* theme describes who the game was developed for, any collaborations that were carried out in the design/development process, the theoretical framework and guiding knowledge that was used to develop the game, the genre the game belongs to, and the technology the game was built with. The *evaluation* theme describes the evaluation method that was used to evaluate the game, how long the evaluation lasted and the number of people that were recruited to evaluate the game. The *findings* theme describes the main findings and results from the evaluation and if the game was successful at achieving the targeted behavioural outcome or not. Table 1 summarizes the coding scheme that was used in this paper.

Table 1. *Description of coding themes used for the current study*

	Themes	Description
1	Design and development	• Who the game was designed for and the age range the game targets, for example, children with diabetes, adult females • The theoretical framework or guiding knowledge that the development of the game was based on • The collaborators who worked to design and develop the game, for example, nutritionists, health researchers • The technology platform used to develop the game, for example, web, mobile, games, desktop applications, etc. • Influence strategies • Number of players (single or multi-player) • Genre of game
2	Evaluation	• Evaluation method, for example, quantitative, qualitative, or mixed, self-reported, the game generated data • Duration of evaluation, for example, years, months, weeks, days, hours • Number of participants recruited to evaluate technology
3	Findings/results	• Successful at achieving a targeted behavioural outcome or not.

3 Results

The results from reviewing the articles based on the three broad themes are presented in the following sections. They are also summarised in Tables 2 and 3.

3.1 Game design and development

Several of the games in the articles reviewed were general nutrition education games for children and adolescents [11], [17], [18], [19], [20], [12]. There were however some games for specific segments of people. For instance, Junk-Food Destroyer [7] was designed to motivate adolescents with down syndrome to adopt a more balanced nutrition. SpaPlay [8] was developed to motivate women to make healthy eating choices and to exercise, and 4KidsDiab was developed to influence pre-school-aged children with type 1 diabetes to eat healthy [9]. Similarly, several games were developed to prevent childhood obesity such as Barty [21], Gustavo in Gnam's Planet [22], Space Adventures [23], DigesTower [18], and NutritionBuddy [13].

Various theoretical frameworks were used in the design and development of the games to increase their efficacy. SpaPlay [8], a game to motivate women to make healthy eating choices and to exercise was developed using the self-determination theory [24]. Similarly, Express Cooking Train [10], a game that aims to build nutrition literacy and food literacy skills, was developed using the self-determination theory. Self-determination theory posits that humans can be self-determined to carry out a behaviour if their needs for connection, competence, and autonomy are fulfilled [24]. The social cognitive theory [25] was used in designing and developing several games including HealthyLunch [11] a game that educates and influences children to adhere to the recommended daily servings of the major macronutrients, Creature 101 [12], a game that helps adolescents acquire the motivation and knowledge to improve their nutrition, NutritionBuddy [13], a game designed to make obese children more aware of the importance of well-balanced foods, and Swiss Foodquiz [14], a multi-player game that supports adults in gaining nutritional knowledge. The social cognitive theory states that in a social context, people learn from others by observing them,

observing the consequences of others' behaviours, and replicating these actions [25]. Table 2 summarises the theoretical frameworks used in the games that were reviewed.

Table 2. *Theoretical frameworks used in the various articles reviewed*

Authors and games	Theoretical frameworks used
Schakel et al. (*ViaNova*),	Theory of reasoned action
Schakel et al. (*ViaNova*),	Theory of planned behaviour
Shiyko et al. (*SpaPlay*), Mitsis et al. (*Express Cooking Train*), Marchetti et al. (*Gustavo in Gnam's Planet*), Majumdar et al. (*Creature 101*)	Self-determination theory
Shiyko et al. (*SpaPlay*)	Player Experience of Need Satisfaction (PENS) model
Mitsis et al. (*Express Cooking Train*), Fuchs et al. (*Swiss Foodquiz*), Espinosa-Curiel et al. (*Healthylunch*), Marchetti et al. (*Gustavo in Gnam's Planet*), Sotiris et al. (*Nutrition buddy*), Majumdar et al. (*Creature 101*)	Social cognitive theory
Espinosa-Curiel et al. (*Healthylunch*)	Cognitive-behavioural therapy
Espinosa-Curiel et al. (*Healthylunch*)	Behaviour change theory
Marchetti et al. (*Gustavo in Gnam's Planet*)	Transtheoretical model of change
Marchetti et al. (*Gustavo in Gnam's Planet*)	Elaboration likelihood model
Hatzigiannakoglou (*Junk-Food Destroyer*)	Theory-action pattern
Hermans et al. (*Feed the Alien*)	Situated and embodied cognition
Mack et al. (*Kids Obesity Prevention*)	Dietary energy density principle

45% of the reviewed games were web-based with access via a web browser while 35% were mobile-based with Android being the most common operating system. 15% of the games were based on motion controllers such as Xbox One and Wii remote while the final 5% is based on Virtual Reality. Most (40%) of the games developed for children and adolescents were web-based while most of the games developed for adults were mobile-based.

Some of the games were designed in collaboration with other experts and the results of their evaluation showed that these games fully or partially achieved positive results. For instance, HealthyLunch [11], a serious game that teaches children about the recommended daily intake of calories, fat, sugar, and salt, was designed and developed by a multidisciplinary team of software developers, graphical designers, a human-computer interaction expert, nutritionists, and psychologists. Most of the participants who played the game found it to be fun, easy to use, and immersive. They perceived the game to stimulate their curiosity and imagination. They also found that the game improved their knowledge and provided personal gratification. Similarly, Creature 101 [12] was designed and developed in collaboration with behavioural scientists, computer scientists, graphic designers, and game developers. The evaluation of the game showed that the intervention participants significantly decreased the frequency and amount of sweetened beverages and snacks that they consumed compared to the control group.

As shown in Table 3, most of the games reported the use of rewards and feedback to motivate participation. Rewards and feedback are common influence strategies in games and have been shown to influence the participation of users [6], [26]. Rewards were offered in various forms including coins [11], points earned from quests [8], and virtual medals [27]. Feedback was used to let players know how they performed in a particular round of the game.

Table 3. *Influence strategies used in the articles reviewed*

Authors and games	Influence strategies used
Baranyi et al. (*NutritionRush*), Schakel et al. (*None provided*), Shiyko et al. (*SpaPlay*), Mitsis et al. (*Express Cooking Train*), Fuchs et al. (*Swiss Foodquiz*), Espinosa-Curiel et al. (*Healthylunch*), Marchetti et al. (*Gustavo in Gnam's Planet*), Hatzigiannakoglou (*Junk-Food Destroyer*), Sotiris et al. (*Nutrition buddy*), Majumdar et al. (*Creature 101*)	Rewards
Schakel et al. (*ViaNova*), Mitsis et al. (*Express Cooking Train*), Fuchs et al. (*Swiss Foodquiz*), Espinosa-Curiel et al. (*Healthylunch*), Marchetti et al. (*Gustavo in Gnam's Planet*), Dias et al. (DigesTower), Hatzigiannakoglou (*Junk-Food Destroyer*), Mack et al. (*Kids Obesity Prevention*), Hermans et al. (*Feed the Alien*), Majumdar et al. (*Creature 101*)	Feedback
Fuchs et al. (*Swiss Foodquiz*), Martin-Niedecken et al. (*The ExerCube*), Espinosa-Curiel et al. (*Healthylunch*)	Leader board/Social comparison
Hermans et al. (*Feed the Alien*)	Praise
Fuchs et al. (*Swiss Foodquiz*), Espinosa-Curiel et al. (*Healthylunch*), Majumdar et al. (*Creature 101*)	Goal setting
Majumdar et al. (*Creature 101*)	Self-regulation
Fuchs et al. (*Swiss Foodquiz*)	Self-monitoring
Baranyi et al. (*NutritionRush*), Martin-Niedecken et al. (*The ExerCube*), Espinosa-Curiel et al. (*Healthylunch*)	Increasing game levels

85% of the games evaluated were single-player games while 15% were multi-player games. Table 4 summarises the games based on the number of players.

Table 4. *List of games characterized as single- or multi-player*

Single or Multi-player	Authors and games
Single-player	Shiyko et al. (*SpaPlay*), Fuchs et al. (*Swiss Foodquiz*), Majumdar et al. (*Creature 101*)
Multi-player	Blackburne et al. (*NoGo*), Baranyi et al. (*NutritionRush*), Schakel et al. (*ViaNova*), Mitsis et al. (*Express Cooking Train*), Martin-Niedecken et al. (*The ExerCube*), Sik-Lanyi et al. (*4KidsDiab*), Espinosa-Curiel et al. (*Healthylunch*), Marchetti et al. (*Gustavo in Gnam's Planet*), Matias et al. (*Ultimate Food Defense*), Gonçalves et al. (*Barty*), Navarro et al. (*Space Adventures*), Dias et al. (*DigesTower*), Hatzigiannakoglou (*Junk-Food Destroyer*), Mack et al. (*Kids Obesity Prevention*), Hermans et al. (*Feed the Alien*), Sotiris et al. (*Nutrition buddy*), Schakel et al. (no name)

Most of the games evaluated belong to the *simulation games* genre. Simulation games replicate complex real-life environments in a simple way, allowing players to experience particular phenomenon through a game [28]. For instance, the game Express Coking Train

[10] simulates a cooking environment. Figure 1 shows the genre of games that were evaluated.

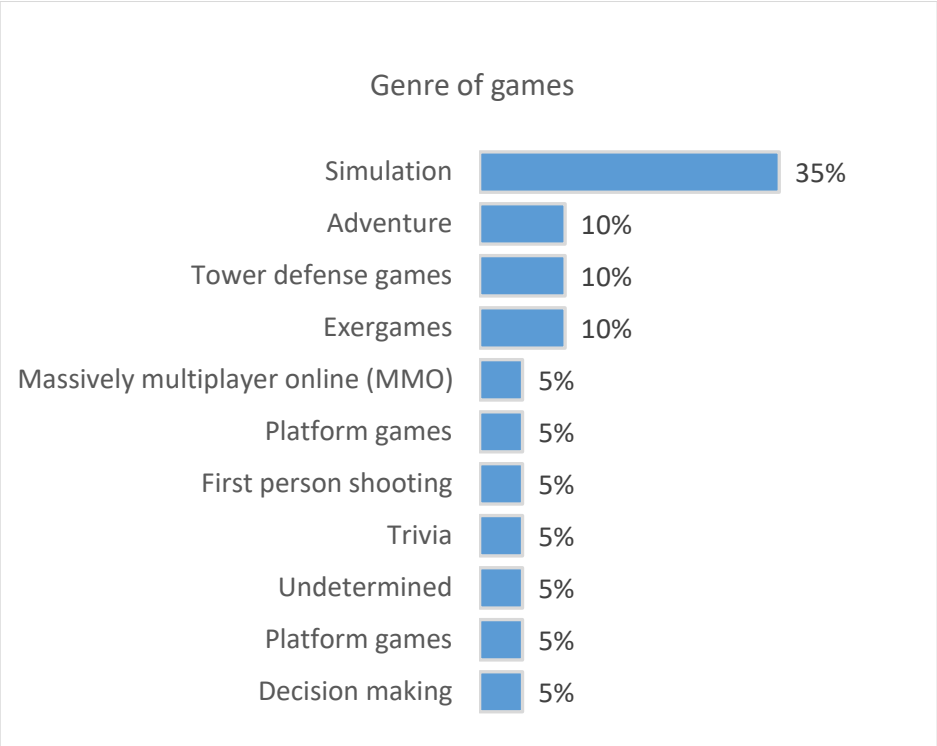

Figure 1. *The trend of serious games by their genre.*

3.2 Evaluation

Of the twenty articles that were reviewed in this study, fifteen were evaluated by the authors. 87% of these were based on self-reported measures while only 13% was based on self-reported measures plus data generated while playing the game [14], [23]. The duration of the evaluations ranged from 30 minutes to 90 days and the number of participants recruited for the evaluations ranged from 10 to 531. The highest number of participants, 531, was used to evaluate Creature 101 [12]. The duration of the evaluation was 210 minutes; participants played the game for seven sessions, of 35 minutes each. The participants were split into a control group that played a different game from Creature 101 and an intervention group that played Creature 101. The participants completed both pre- and post-game questionnaires. Similar to Creature 101, some other games were evaluated using a control group and an intervention group such as Alien Health [20].

Figure 2 shows the trend of articles from 2015 to date, the period of our review. The highest number of articles were published in 2016 and 2018, accounting for 25% each of the total number of articles in our dataset, while the least number of papers were published in 2017 accounting for 5% of our dataset.

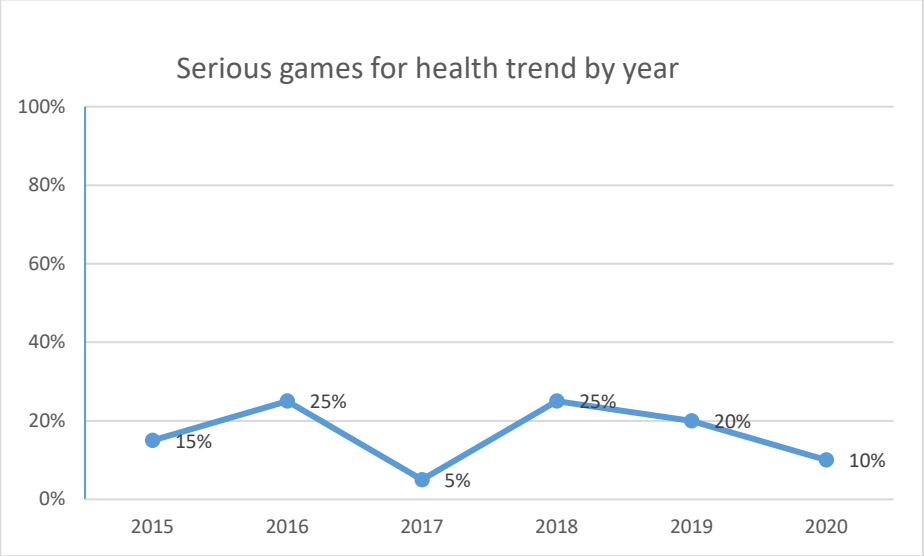

Figure 2. *Percentage of published articles on serious games in health by year of publication.*

The articles were from a broad range of nutrition education. Most of the papers (29%) were related to general nutrition education targeted towards children and adolescents. For instance, "Feed the Alien!"[20] is a nutrition education game to teach elementary school children about nutrition and healthy food choices.

Table 5. *Target areas of articles*

Authors and games	Target Area of Articles
Blackburne et al. (*NoGo*)	Obesity in adults
Baranyi et al. (*NutritionRush*), Schakel et al. (*ViaNova*), Mitsis et al. *(Express Cooking Train*), Fuchs et al. (*Swiss Foodquiz*)	General nutrition education
Schakel et al. (*ViaNova*),	Approach-avoidance training general
Shiyko et al. (*SpaPlay*)	Nutrition education for women
Martin-Niedecken et al. (*The ExerCube*)	Exercise training - general
ik-Lanyi et al. (*4KidsDiab*), Marchetti et al. (*Gustavo in Gnam's Planet*)	Nutrition education - diabetes in children/adolescents
Espinosa-Curiel et al. (*Healthylunch*), Matias et al. (*Ultimate Food Defense*), Dias et al. (*DigesTower*), Mack et al. (*Kids Obesity Prevention*), Hermans et al. (*Feed the Alien*), Majumdar et al. (*Creature 101*)	General nutrition education for children/adolescents
Gonçalves et al. (*Barty*), Navarro et al. (*Space Adventures*), Dias et al. (*DigesTower*), Sotiris et al. (*Nutrition buddy*)	Obesity in children
Hatzigiannakoglou (*Junk-Food Destroyer*)	Nutrition education –downs syndrome

3.3 Findings

The results from the fifteen evaluated studies evaluated by the authors indicate that two main aspects of the games were evaluated. First was the success (or otherwise) of the game at influencing participants to achieve the targeted behavioral outcome [29], [30], [31], [27], [8], [14], [32], [23], [19], [20], [12]. In other words, evaluating if the game achieved what it was designed to achieve such as improving nutrition-related knowledge or increasing fruit and vegetable intake. The second was the evaluation of the game itself, in particular, its

usability [9], ease of use [11], [22], how interesting it was [22]. Most of the games evaluated for achieving their target behaviour had partial outcomes. For example, Creature 101 [12] reported significant decreases in the frequency and amount of sweetened beverages that were consumed. The results also show that the intervention group reported a significant decrease in the number of processed snacks they consumed compared to the participants in the control group. There were no changes for other behaviours that were observed. Similarly, the findings from Alien Health [20] indicate that participants in the intervention group that played the Alien Health game had better knowledge of the five most important macronutrients of food right after playing the game but not in the long term.

Table 6. *Description of articles*

Authors and names of games	***Genre & age range***	***Technology***	***Evaluation type***	***Number of participants & duration of evaluation***
Blackburne et al. (*NoGo*)	Decision making Adults	Mobile phone	A combination of self-reported questionnaires and psychophysiological measures	58 participants 14 days
Baranyi et al. (*NutritionRush*)	Platform Adults	Android mobile devices	Self-reported questionnaire, interviews	14 participants Duration was not stated
Schakel et al. (*ViaNova*)	Simulation Adults	Not stated	Self- reported	81 participants 30 minutes
Schakel et al. (no name)	Simulation Adults	Not stated	Self- reported	120 participants 30 minutes
Shiyko et al. (*SpaPlay*)	Simulation Women	Computer	Self- reported	47 women 90 days
Mitsis et al. (*Express Cooking Train*)	Simulation Adults	Not stated	Not evaluated	Not evaluated
Fuchs et al. (*Swiss Foodquiz*)	Trivia Adults	Android devices	Game data; performance of players in the game	350 participants 2 months
Martin-Niedecken et al. (*The ExerCube*)	Exergames Adults	Virtual Reality	Self- reported	17 participants 10 minutes
Sik-Lanyi et al. (*4KidsDiab*)	Snake game Pre-school age children	Android and Windows	Self- reported	10 participants Duration of evaluation not stated
Espinosa-Curiel et al. (*Healthylunch*)	Simulation 8-10 years	Web-based	Self- reported	29 participants 14 days
Marchetti et al. (*Gustavo in Gnam's Planet*)	Simulation 14-18 years	Web-based	Self- reported	47 participants 1 week
Matias et al. (*Ultimate Food Defense*)	Tower defense game Children	Not stated	Not evaluated	Not evaluated
Gonçalves et al. (*Barty*)	Adventure	Android mobile devices	Not evaluated	Not evaluated

	Children			
Navarro et al. (*Space Adventures*)	Adventure 5-10 years	Computer-based	Self-reported, game generated data	75 participants Duration f evaluation not stated
Dias et al. (*DigesTower*)	Tower defense School-age children	Computer-based	Not evaluated	Not evaluated
Hatzigiannakoglou (*Junk-Food Destroyer*)	First-person shooting Adolescents	Wii remote, Windows-based	Not evaluated	Not evaluated
Mack et al. (*Kids Obesity Prevention*)	Exergame 9-12 years	Motion control interface and tablet	Self-reported	82 participants 4 weeks
Hermans et al. (*Alien health*)	Simulation 10-13 years	Microsoft Xbox One Kinect sensor	Self-reported	108 participants 2 days
Sotiris et al. (*Nutrition buddy*)	Platform game 8-12 years	Android devices	Not evaluated	Not evaluated
Majumdar et al. (*Creature 101*)	Massively multiplayer online (MMO) 11-13 years	Web-based	Self-reported	531 participants 210 minutes (7 sessions of 30 minutes each)

4 Discussion

4.1 Relationship between theoretical framework and efficacy of game

One cannot conclusively state that using behaviour theories to inform the design of games influences their effectiveness in achieving the aims of the game due to the limited number of studies in this review. However, the results suggest that there is a relationship between the use of established theoretical frameworks and the efficacy of the games in achieving positive behaviour change. All the studies that are based on known theories reported partially positive or fully positive results. The social cognitive and self-determination theories were the most commonly used.

4.2 Relationship between influence strategies and efficacy of game

Most of the articles reported using feedback and rewards to motivate participation. It is unclear how successful the other strategies were in motivating participation. The results of the review indicate that all the games that used feedback and rewards reported only partially successful results. Surprisingly, only one game reported the use of praise as an influence strategy [20]. Praise is a common influence strategy used in game development, especially for children's games.

4.3 Relationship between evaluation methods and efficacy of game

While most of the games were evaluated based on self-reported methods, a few were evaluated based on the data generated during gameplay and the performance of the players

during the games. Research indicates that studies that rely solely on self-report measures are prone to response bias which threatens their validity. For example, Steene-Johannessen et al. [33] concluded that there was a significant difference between the time spent in moderate and vigorous exercise using heart-rate and movement sensors compared to self-reported physical activity questionnaires. Similarly, in their analysis of workers' earnings on Amazon Mechanical Turk, Hara et al. [34] showed that there was a difference between the hourly wage of AMT workers shown by the data from AMT and the self-reported hourly wage reported by workers. Self-reported studies, when used alone, are also known to show contradictory evidence compared to other forms of measurements [35]. The games that combined self-reported methods with game data showed positive results. For instance, Swiss Foodquiz [14], a serious game that supports adults in gaining nutritional knowledge, reported high acceptance rates in participants. This was also the case for previously uninvolved participants. The authors also reported a significant increase in nutritional knowledge over the evaluation period with increased performance of participants. Similarly, the authors of Space Adventures, a serious game that aims to prevent childhood obesity [23] reported a significant decrease in sugar and sweets in the food choices of participants, which is the main aim of the game.

4.4 General limitations and recommendations for future research

Specific gaps were identified based on the results of this review. Possible improvements to move the area of games for nutrition forward are suggested:

1. There is a lack of compliance with standards for evaluating games in this area. While some games were evaluated by comparing the pre- and post-performance of participants in intervention and control groups, other games simply compared the performance of participants over time. There is a need for game developers to adopt existing standards for evaluating games.
2. Only a few studies reported a personalization strategy for their game while other games adopted a one-size-fits-all approach; there are no strategies indicated to tailor the game to individuals or groups to similar individuals to increase their efficacy. For instance, [19] required participants to enter their sex, age, height, weight, and activity level which was used to calculate their BMI z-score, energy expenditure, and energy intake while playing the game. The authors of 4KidsDiab [9] also personalized the game by adjusting it according to the player's daily allowable carbohydrate meals. These personalization approaches depend on the player entering the correct information into the game and are not dynamic during gameplay. An approach to personalization that is dynamic and not totally dependent on the player's input would be beneficial to the game development community.
3. The long-term efficacy of the games is unknown since none of the games evaluated their game for more than 3 months. A strategy to evaluate serious games for healthy nutrition over time is needed. This will ensure that the game design can be reviewed and enhanced if necessary. There was also no strategy reported by the articles reviewed to keep the participants interested in the game and not lose interest *over time*. Such strategies are essential to keep users engaged and interested in the game even over time.
4. The influence strategies used in most studies were feedback and rewards. There is a need to explore other strategies to increase the efficacy of games. In addition, while using feedback and rewards, there is a need to explore a more dynamic feedback and reward system so the players can find the game engaging particularly after playing the same game multiple times.
5. The data generated during gameplay usually holds a wealth of information that can inform stakeholders about the players. It also shows how players respond to the different scenarios in the game [36]. With the issues surrounding self-reported approaches to evaluation, there is the need to take advantage of the gameplay data

as a complementary form of evaluation in addition to existing self-reported measures. This will greatly benefit the serious-games development community.

6. Finally, as figure 2 shows, there has been a steady decline in the number of published articles in this area over the last three years. More work has to be done in this area in the coming years as research indicates that games can be used to influence healthier nutrition [36].

4.5 Guidelines for future serious games for healthy nutrition

Although the number of articles reviewed in this study is only twenty, the results form a picture regarding guidelines for the design, development, and evaluation of serious games for nutrition. Based on these results, the recommended guidelines for games to influence healthy nutrition is summarized in Figure 3 and it suggests that games should be:

1. A collective effort with domain experts in various fields including nutrition, human-computer interaction, user experience, and game development [11], [12] in the design of the game.
2. Targeted towards a specific age group and should aim to achieve specific goals such as educating diabetic children or improving nutrition in women.
3. Implemented on mobile and web platforms because they are readily available to users compared to motion controllers.
4. Implemented using influence strategies (not limited to feedback and rewards) to increase their efficacy in achieving positive results.
5. Evaluated using a combination of self-reported and data-driven approaches because of the limitations of self-reported studies.
6. Evaluated over a long period of time.

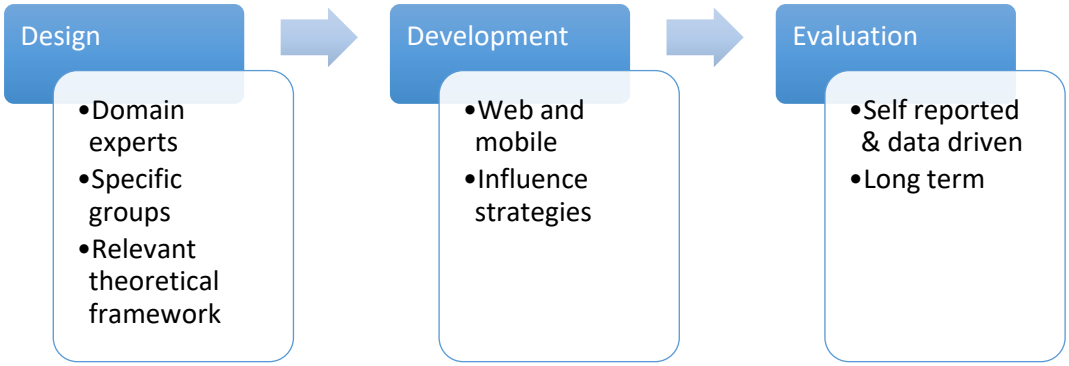

Figure 3. Guidelines for serious games for healthy nutrition

4.6 Limitations of the current study and proposed future work

This study is limited in a few ways. First, the number of articles reviewed is few (twenty). This is primarily because of the short period under review (five years). This study was limited to the last five years in order to identify the *latest* and *current* trends in serious games for healthy nutrition since change rapidly in this domain. This is important to give an up-to-date-account of the state-of-the-art. Second, there are other databases that we did not search for related articles such as Scopus. I believe that there would have been some overlap or duplicate articles. To ensure that all relevant articles are reviewed, the search for articles is ongoing. More databases are being searched for relevant articles. The results from these searches will be analyzed to determine if they are similar to the results presented in this paper. In the future, a framework for the design and development of serious games for healthy nutrition will be developed and evaluated using the results from this paper.

5 Conclusion

Developing healthy eating habits is one way to prevent obesity and being overweight. To determine the current state-of-the-art in this area, a review of existing literature was carried out over the last five years. Twenty papers met the inclusion criteria and were reviewed using three broad themes: design and development, evaluation, and findings. Most of the games with successful outcomes reported being designed with the collaboration of other experts such as nutritionists, behavioural scientists, psychologists, and HCI experts. Most games were also based on existing theories such as the self-determination theory and the social cognitive theory. Most games were developed for specific demography such as children with diabetes and were developed for mostly web and mobile platforms. Feedback and rewards were the top influence strategies implemented by most of the games. The evaluation of the games was carried out over a period of 30 minutes to 90 days with between 10 to 531 participants using a self-reported approach for most games. The results from the evaluations suggest that the games were partially successful at achieving their aims.

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