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ORIGINAL ARTICLES AND REVIEWS

Serious games in child and adolescent health education campaigns: a systematic review

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Abstract

Background. The use of playful tools to promote children's and adolescents' health in schools is growing. Educational games are proven tools for promoting virtuous behaviours. This systematic review explores the significance of serious games in promoting health education among young audiences, particularly about hand, oral and respiratory hygiene, immunisation, antimicrobial resistance (AMR) and sexually transmitted infections.

Methods. This study was conducted in March 2023 on PubMed, Scopus, Web of Science and Embase using the population, exposure, outcome, and study design framework (PEOS). Articles in English and Italian were published within the past decade regarding campaigns with educational games on hygiene for students aged 3 to 19 years who do not have chronic conditions or disabilities. Final screening resulted in including the study of 40 articles of the 1,577 records initially extracted.

Results. The results indicate that play positively influences the quality of learning. Serious games have been demonstrated to have a high potential in child and adolescent health education campaigns.

Conclusions. Games can effectively engage young individuals, promote healthy behaviors, prevent diseases and enhance health literacy. As serious games continue to evolve, further research and collaboration are needed to utilize their full potential to improve children's and adolescents' health and well-being worldwide.

Key words

- public health intervention
- educational campaign
- health literacy
- gamification
- serious game
- knowledge and awareness
- hygiene
- children and adolescent

INTRODUCTION

In recent years, there has been an increasing acknowledgement of the educational value of games, especially regarding children and adolescents' learning process. Games have been crucial to human culture and social interaction since ancient times. It is known that young people are more likely to become healthy adults when positive early experiences sustain childcare and education [1]. As children and adolescents immerse themselves in games and interactive activities, they acquire essential skills and cultivate curiosity and enthusiasm for learning. This dynamic approach to education transcends conventional methods and supports the innate desire for exploration and discovery that resides within every young learner.

The United Nations Convention on the Rights of the Child (UNCRC) is a fundamental document outlining children's rights and the well-being of children worldwide [2]. Article 31 of the above-mentioned convention emphasises every child's right to engage in play, leisure, and cultural activities, highlighting the crucial role of innovative and interactive approaches in promoting holistic development. For this reason, health campaigns in Italy and Europe have adopted a holistic approach to child and adolescent well-being by recognizing the interconnectedness of various aspects of health. Furthermore, a health-promoting school approach has been promoted globally over the past 25 years. Nevertheless, the aim of a fully sustainable health-promoting school approach system has not yet been achieved [3]. The im-

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portance of games in education and learning has also been a key point for public health as it is known that full involvement in activities leads to improved knowledge and better long-term memory retention of learned information. This represented a change for educational campaigns in public health previously limited to disseminating only information. For the promoted virtuous behaviors to be truly adopted, in fact, it is essential that the audience actively participate in educational campaigns and that engaging tools, such as games, are used for the young population.

Collaboration between stakeholders, including healthcare professionals, educators, policymakers, and parents, has been crucial in implementing comprehensive programs over the past two decades [4]. Quality education is also one of the critical components of the United Nations 2030 Agenda for Sustainable Development. Moreover, as in every other field of learning, even in health education campaigns, technology integration has gained significant attention, offering innovative and engaging approaches to enhance knowledge, promote behavior change, and improve health outcomes among children and adolescents. In this setting, serious games have emerged as a promising tool to send health-related messages in a captivating and interactive way.

For an effective education and to create and consolidate correct behaviors it is essential to intervene already in schools. In this setting, children can easily learn essential skills and attitudes for lifelong healthy habits. However, traditional approaches, such as lectures and pamphlets, often struggle to capture and sustain young audience attention. Serious games use interactive gameplay to educate and empower children and teenagers, promoting health knowledge, positive attitudes, and informed decision-making. By employing elements and mechanics of game design, serious games can create an immersive learning environment where users actively participate, make choices, and face consequences. These games can easily incorporate educational content related to various health topics. Through engaging narratives, challenges, rewards, and real-time feedback, serious games offer a unique opportunity to motivate young learners, stimulate critical thinking, and facilitate behavior change. Since serious games have immense potential, it is essential to rigorously evaluate their impact on child and adolescent health education campaigns. Several frameworks for validation exist, but it is unknown which one is the best [5]. Despite the great interest in serious games and some examples of European health campaign implementation in the past twenty years, such as e-Bug in England [6], the literature lacks a recent systematic review regarding serious games' use in health education campaigns for children and adolescents.

With this review, we would like to contribute to the growing research on serious games for child and adolescent health education campaigns to enhance the impact and effectiveness of health promotion efforts among young populations. Indeed, we believe that using the power of technology and interactive gameplay can potentially revolutionize health education approaches, empowering children and adolescents to make informed decisions and embrace healthier lifestyles for a better future.

Thus, this systematic review aims to synthesize and analyze existing literature to determine the effectiveness and potentiality of serious games in improving health knowledge, attitudes, behaviors, and outcomes among young populations focusing on the following topics: hand, oral and respiratory hygiene, vaccines, antimicrobial resistance (AMR) and sexually transmitted infections (STI).

MATERIALS AND METHODS

Search strategy and data source

This systematic review was constructed and elaborated following the Prepared Items for Systematic Reviews and Meta-Analysis (PRISMA) [7]. Structured electronic searches were performed by referencing four databases: PubMed/Medline, Excerpta Medica Database (Embase), Scopus and Web of Science (WOS). Structured searches were conducted across the four databases on March 16, 2023, using a combination of Medical Subject Headings (MeSH) and free text words. Boolean operators AND and OR were combined to create the search strategy. Filters were also applied. The search strategy was first created in PubMed and then applied to the other databases. The search strategy is presented in *Table S1 available online as Supplementary Materials*.

Inclusion/exclusion criteria

We have decided to include the articles that met the subsequent criteria: (i) written in Italian or English; (ii) population: children and adolescents from 3 to 18 years old (both male and female); (iii) exposure: health education intervention based on serious games; (iv) outcomes: knowledge enhancement (both qualitative and quantitative). In addition, no continent restrictions were imposed.

We have decided to exclude: (i) unpublished articles in Italian or English; (ii) population: <3 and >18 years old or with chronic conditions or disabilities; (iii) exposure: health education intervention based on traditional or other kinds of teaching; (iv) outcomes: improved satisfaction. We also excluded non-original articles (e.g., reviews and meta-analyses) and no full-text articles (e.g., conference proceedings, letters to the editor, commentary notes, abstracts, expert opinions). Inclusion and exclusion criteria are reported in *Table 1*.

Selection process and data extraction

All the studies were collected using Rayyan software [8]. Subsequently, we removed duplicates manually and automatically using Rayyan, under the supervision of one Author (AA). After that, we conducted a two-step screening process. Two team members primarily independently screened all the records (AA and CL) based on titles and abstracts. Afterwards, the eligible studies' full texts were downloaded and double-blindly assessed by two Authors (AA and CL). In every screening step, any discrepancy between the Authors regarding the eligibility of papers was solved through discussion; if the disagreement persisted, it was managed by a third

Table 1
Inclusion/exclusion criteria are based on population, intervention, exposure, outcome, and study design (PEOS) strategy

Search strategy	Details
Inclusion criteria	P: children and adolescents from 3 to 18 years old (both male and female)
	E: health education intervention based on serious games
	O: knowledge enhancement (both qualitative and quantitative)
	S: all original study types
Exclusion criteria	P: <3 and >18 years old; individuals with chronic conditions or disabilities
	E: health education intervention based on traditional teaching
	O: missing data; improved satisfaction
	S: non-original papers; papers without data
Language	English; Italian
Time filter	From January 1, 2013 to March 16, 2023
Databases	PubMed/Medline; Embase; Scopus; Web of Science

PEOS: population, exposure, outcome, study design.

senior reviewer (AM). The Authors used a predefined and standardised Excel spreadsheet (Microsoft Excel® for Microsoft 365 MSO, Redmond, WA, USA, 2019) to extract data from the included articles. At first, the spreadsheet was tested on four randomly selected articles to enhance the Authors' concordance. The Authors agreed to extract the following data: first Author, year of publication, the country where the study took place, number of participants, age, the tool used for knowledge about topics assessment, and the game type.

Strategy for data synthesis

A flow chart was produced to map the included references in every stage of the review process according to the PRISMA 2020 guidelines [7].

RESULTS

Literature search

A total of 1,577 articles were extracted from the databases, of which 617 were from PubMed/Medline, 274 from Embase, 393 from Scopus and 293 from Web of Science. After the first screening, 289 articles were excluded because they were duplicates.

After screening by title and abstract, 102 papers were listed as eligible. Thus, 62 articles were removed after full-text assessment, of which 29 were feasibility studies, 20 were conference abstracts (full text was unavailable), while reading the full text of 5 of the articles, it revealed that they focused on a different population than the stated one and 5 had different outcomes. Moreover, 3 studies were removed because they were written in languages other than Italian and English.

At the end of the screening process, 40 articles were included in the current systematic review. The whole selection process is pictured in detail in *Figure 1*.

Main characteristics of included articles

Table 2 describes the characteristics of the included articles in alphabetical order.

A total of 16 of the 40 included studies had been conducted in Asia [9, 10, 12, 15, 17, 18, 22, 28-30, 34, 41-44, 46], 9 in Europe [11, 13, 19, 23, 27, 31-33, 48], 7 in North America [14, 26, 35, 36, 38-40], 4 in Africa [21, 24, 25, 47], 3 in South America [16, 37, 45], and 1 in Oceania [20]. Among the 40 included studies, 14 involved a game related to oral hygiene [9-11, 18, 22, 26, 28, 29, 34, 41-45], 10 sexually transmitted infections [21, 24, 25, 27, 33, 35, 36, 38-40], 9 hand hygiene [12, 15, 17, 30, 32, 37, 46-48], 4 vaccines [13, 14, 20, 31], 1 respiratory hygiene [16], 1 AMR [23], and 1 concerned vaccination, respiratory hygiene and AMR at the same time [19]. More specifically, 75% (3) of the studies performed on the African continent included games that would enhance participants' knowledge about STIs [21, 24, 25]. Of the 16 Asian studies, 69% (11) focused on oral hygiene [9, 10, 18, 22, 28, 29, 34, 41-44], while the remaining 31% (5) on hand hygiene [12, 15, 17, 30, 46]. The European studies were more heterogeneous: 2 concerned vaccinations [13, 31], 2 STI [27, 33], 2 hand hygiene [32, 48], 1 AMR [23], 1 oral hygiene [11], while 1 study included vaccinations, AMR and respiratory hygiene [19]. 5 of the 7 articles from North America focused on STI [35, 36, 38-40], while the remaining two focused on vaccinations [14], and oral hygiene [26]. The South American articles included games on hand [37], respiratory [16], and oral hygiene [45]. Finally, the only article published in Oceania was about vaccinations [20].

Regarding the average age of the study participants, it was planned to divide them into four age groups corresponding to the school grades: 3-5 years old for kindergarten, 6-10 elementary, 11-13 middle and 14-18 high school. Moreover, to classify the participants of each study into one of the four categories, it was considered the average age of each sample; thus, 9 studies belonged to the 3-5 year range [9, 12, 16, 37, 41, 43-45, 48], 14 into 6-10 [10, 11, 15, 17, 18, 22, 23, 26, 30, 31, 34, 42, 46, 47], 8 into 11-13 [14, 19, 20, 24, 25, 28, 29, 32, 35], and 9 into 14-18 [13, 21, 27, 29, 33, 36, 38-40]. Out of 9 studies that targeted kindergarten children, 4 concerned oral hygiene [9, 41, 43, 44], the same number of hand hygiene [12, 37, 45, 48], and only one respiratory hygiene [16]. For the 6-10 age group, most of the games dealt with oral hygiene [10,

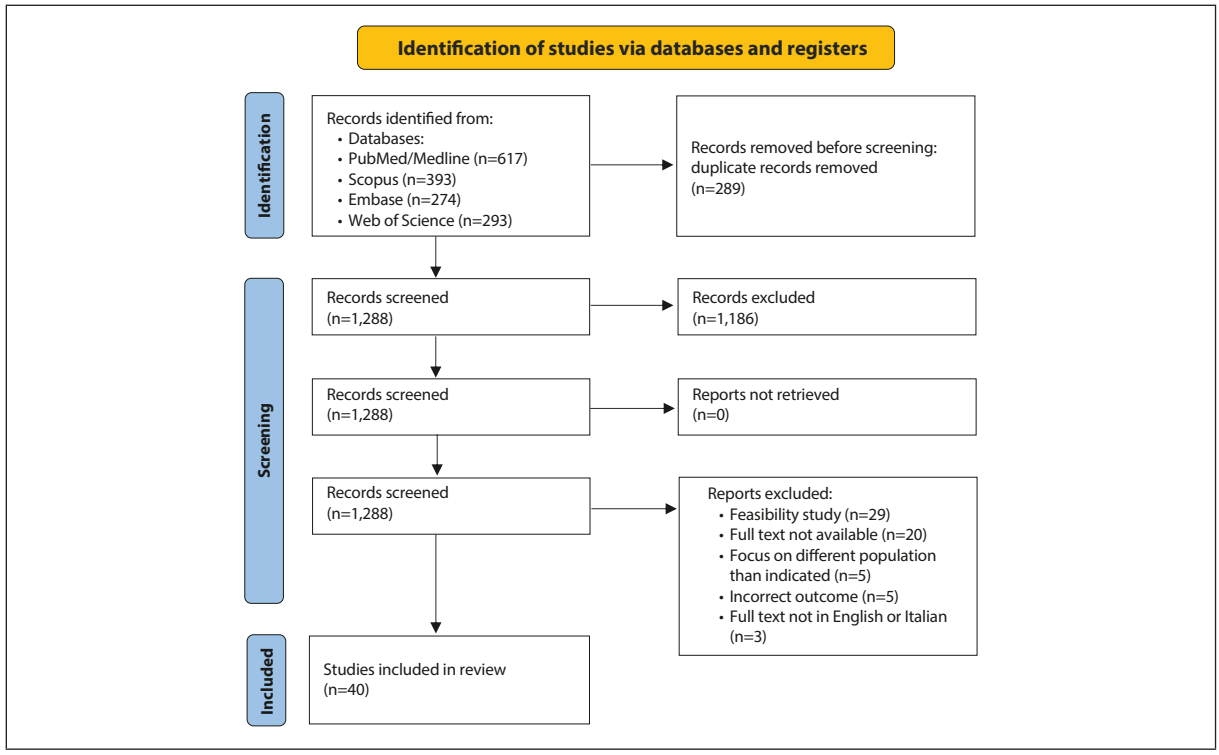

Figure 1
PRISMA flow diagram reporting the selection process.

Table 2
General characteristics of the included studies, in alphabetical order

Author and year of publication	Country	Average age	Topic	Type of game (intervention)	Sample size
Akkaya *et al.*, 2021 [9]	Turkey	5 years	Oral hygiene	Music video	n=100
Aljafari *et al.*, 2022 [10]	Jordan	6.5 years	Oral hygiene	Simulation	n=278
Aljafari *et al.*, 2017 [11]	England	7 years	Oral hygiene	Quiz	n=109
Arbianingsih *et al.*, 2018 [12]	Indonesia	5 years	Hands hygiene	Simulation	n=120
Carolan *et al.*, 2018 [13]	England	14.5 years	Vaccination	Simulation	n=63
Cates *et al.*, 2020 [14]	USA	11.5 years	HPV vaccination	Simulation	n=110
Chen *et al.*, 2022 [15]	Taiwan	8.5 years	Hands hygiene	Board game/Simulation	n=26
Costa *et al.*, 2019 [16]	Brasil	3.5 years	Respiratory hygiene	Card game/Puppets/Simulation	n=39
Devkota *et al.*, 2020 [17]	Nepal	6 years	Hands hygiene	Card game/Manual game/Music video/Simulation	n=50
Effendi *et al.*, 2021 [18]	Indonesia	7.5 years	Oral hygiene	Card game	n=54
Eley *et al.*, 2019 [19]	United Kingdom	11.5 years	Vaccination, Antibiotics, Respiratory hygiene	Role play/Simulation	n=473
Epstein *et al.*, 2021 [20]	Australia	12.5 years	Vaccination	Card game/Simulation	n=3,087
Gaughran *et al.*, 2014 [21]	Kenya	16.5 years	STI	Manual game/Role play	n=42
GeethaPriya *et al.*, 2019 [22]	India	8.5 years	Oral hygiene	Board game/Card game/Theatre	n=360
Hale *et al.*, 2017 [23]	United Kingdom	10 years	Correct use of antibiotics	Role play	n=153
Haruna *et al.*, 2019 [24]	Tanzania	13 years	STI	Role play	n=348
Haruna *et al.*, 2018 [25]	Tanzania	13 years	STI	Quiz	n=120
Jacobson *et al.*, 2019 [26]	USA	5.5 years	Oral hygiene	Music video/Puppets	n=34
Jerlström *et al.*, 2020 [27]	Sweden	15 years	STI	Role play/Theatre	n=826
Kashyap *et al.*, 2022 [28]	India	12 years	Oral hygiene	Quiz	n=160

Continues

Table 2
Continued

Author and year of publication	Country	Average age	Topic	Type of game (intervention)	Sample size
Kumar *et al.*, 2022 [29]	India	13.5 years	Oral hygiene	Music video	n=100
Kusumawardani *et al.*, 2020 [30]	Indonesia	9 years	Hands hygiene	Board game	n=126
La Torre *et al.*, 2020 [31]	Italy	7 years	Vaccination	Board game/Card game/Motion game	n=143
Larsen *et al.*, 2021 [32]	Denmark	11 years	Hands hygiene	Motion game	n=3,127
Macounová *et al.*, 2021 [33]	Czech Republic	16 years	STI	Manual game /Simulation	n=1,210
Malik *et al.*, 2017 [34]	India	10 years	Oral hygiene	Quiz	n=150
Markham *et al.*, 2020 [35]	USA	12.5 years	STI	Simulation	n=4,531
McCammon *et al.*, 2020 [36]	USA	15 years	STI	Board game	n=44
Mendes *et al.*, 2020 [37]	Brasil	3 years	Hands hygiene	Card game/Manual game music video /Puppets	n=126
Peskin *et al.*, 2019 [38]	USA	14.5 years	STI	Simulation	n=1,543
Potter *et al.*, 2016 [39]	USA	14.5 years	STI	Simulation	n=3,143
Rohrbach *et al.*, 2019 [40]	USA	14.5 years	STI	Simulation	n=4,562
Salikun *et al.*, 2021 [41]	Indonesia	4 years	Oral hygiene	Simulation	n=18
Sharma *et al.*, 2021 [42]	India	9.5 years	Oral hygiene	Board game/Card game	n=300
Shi *et al.*, 2023 [43]	China	4.5 years	Oral hygiene	Board game	n=160
Shruti *et al.*, 2021 [44]	India	4.5 years	Oral hygiene	Puppets	n=200
Sigaud *et al.*, 2017 [45]	Brasil	4 years	Hands hygiene	Card game/Music video/Simulation	n=44
Tidwell *et al.*, 2020 [46]	India	10 years	Hands hygiene	Music video/Puppets/Simulation	n=225
Winter *et al.*, 2021 [47]	Zambia	9.5 years	Hands hygiene	Board game	n=761
Younie *et al.*, 2020 [48]	England	4.5 years	Hands hygiene	Manual game/Music video/ Simulation	n=225

STI: sexually transmitted infections; HPV: human papilloma virus.

11,18, 22, 26, 34, 42], 5 with hand hygiene [15, 17, 45-47], 1 with vaccinations [31], and 1 with AMR [23]. The studies involving middle school students were much more heterogeneous: 3 concerned STI [24, 25, 35], 2 vaccinations [14, 20], one oral hygiene [28], and one hand hygiene [32]. One study dealt simultaneously with vaccinations, AMR and respiratory hygiene [19]. Out of 9 studies targeting high school adolescents, 7 articles were about STI [21, 27, 33, 36, 38-40], while only 1 was about oral hygiene [29], and 1 was about vaccinations [13].

The sample size ranges from a minimum of 18 [41], to a maximum of 4562 people [40]. Furthermore, we categorised the papers according to the type of game that had been implemented. First of all, it was evaluated whether it involved using a digital device (computer, tablet, smartphone) or not: 15 required it [10-14, 19, 23, 24, 26, 29, 35, 38-41], 24 did not [9, 15-18, 20-22, 25, 27, 28, 30-34, 36, 37, 42-47], while just one article implemented games involving both modes [48]. Then, we classified the studies according to the game type: 18 simulations [10, 12-17, 19, 20, 33, 35, 38-41, 45, 46, 48], 9 card games [16-18, 20, 22, 31, 37, 42, 45], 8 music videos [9, 17, 26, 29, 37, 45, 46, 48], 8 board games [15, 22, 30, 31, 36, 42, 43, 47], 5 games using puppets [16, 26, 37, 44, 46], 5 manual games [17, 21, 33, 37, 48], 5 role plays [19, 21, 23, 24, 27], 4 quizzes [11, 25, 28, 34], 2 theatre games [22, 27], and 2 motion games [31, 32]. Most studies have included more than one game mode. Among games that used electronic devices the most frequently were simulations [10, 12-14, 19, 35, 38-41, 48], role-playing [19, 23, 24], and music videos [26, 29, 48]. Among offline games, on the other hand, the most used were cards [16-18, 20, 22, 31, 37, 42, 45], simulations [15-17, 20, 33, 45, 46, 48], and board games [15, 22, 30, 31, 36, 42, 43, 47], while the least used were role-playing games [21, 27]. 25 studies compared the intervention group, provided with educational game-based instruction, with a control group, offered traditional instruction [9-14, 18, 20, 22, 24, 25, 27-30, 32, 34, 38-43, 46, 48]. The remaining 15 did not include a control group [15-17, 19, 21, 23, 26, 31, 33,

35-37, 44, 45, 47]. Almost all studies (37) showed an improvement in the knowledge of the health topic in the intervention group [9, 11, 12, 14-19, 21-48]. Only 3 showed no significant improvement [10, 13, 20].

DISCUSSION

This review provides a comprehensive overview about the use and evidence on the effectiveness of serious games in child and adolescent health education campaigns. Articles published between 2013 and 2023 were considered, and 10 types of games used in educational campaigns were identified. Although including four age groups, from 3 to 18 years, the most represented age group in the studies was the 6-10 years old. The findings confirm that games can be an effective tool for promoting healthy behaviors among children and adolescents. The review identified many studies that have shown the positive effects of serious games on health outcomes. Additionally, 37 out of 40 studies have found that serious games can improve knowledge and health literacy. Despite differences in study settings and other aspects, the results agree. However, each intervention had unique characteristics and structure, sometimes making direct comparisons difficult.

It should not be overlooked that there are factors that can contribute to the effectiveness of serious games, including game design, target audience and implementation [49]. The design of a game can have a significant impact on its effectiveness. Well-designed games are more likely to be engaging and motivating for children and adolescents [50]. They should also be relevant to the target audience's interests and needs [51]. Games should be designed for their target audience's specific needs and interests. Moreover, the target of a serious game, e.g., the segment of the population the game is designed for, severely influences its "technical" characteristics and educational elements [52]. Age and cultural background are key elements in building the game appropriately according to the target audience. Some other specific factors that can contribute to the game's effectiveness are narrative and graphics [53].

The implementation of a serious game is also important for its effectiveness. According to the literature, games should be implemented as part of a comprehensive health education program to have a lasting impact, and the game's effectiveness should be evaluated to ensure that it meets its intended goals [54]. Most public health interventions end with the message being conveyed to the audience. Instead, in interventions conveyed by interactive games for children and adolescents, topics must be presented in an accessible way, and the audience is challenged to examine their understanding [55]. In this way, the population is engaged in the important concepts, thereby increasing their engagement in understanding the same topic. It is known that complete immersion while performing an activity enhances learning [56]. Examples in this regard are "those occasions when we experience a sense of euphoria, a deep sense of enjoyment, which we retain for a long time and which becomes a landmark in our lives", called "optimal experiences" by [57] and before him "peak experiences" by Maslow (1964) [58] and "ecstatic experiences" by Laski (1961) [59]. Again, according to Csikszentmihalyi, these tend to occur when a person's body or mind is pushed to the limit in a voluntary effort to accomplish something difficult or useful [57].

Games are therefore very effective in increasing knowledge about the topics covered because they involve significantly more involvement than traditional teaching. Although few of the studies reviewed analyze the long-term change in knowledge, there is no question of the short-term increase in knowledge [9, 11, 12, 14-19, 21-48].

However, a common measurement tool would need to be developed to standardize the measurement of the effects of each intervention conveyed through play. The lack of a common outcome measurement tool makes it difficult to compare these interventions and determine what best educates children and adolescents and influences behavior change.

Limitations

Our study aimed to identify interventions and their benefits in educating children and adolescents with serious games about hand, oral and respiratory hygiene, immunisation, AMR and sexually transmitted infections. We had to adopt a narrative synthesis approach as each intervention had different outcome and evaluation methods, so a meta-analysis was impossible. Then, it was not possible to evaluate the interventions against each other directly using statistical analysis. In addition, only a few studies have measured long-term outcomes related to interventions, and it has not been possible to investigate the existence of effective long-term knowledge retention in all interventions.

CONCLUSIONS

New competencies may be learned through active experience with experiential learning or learning by doing or observation of others' experiences in learning by observation [60]. In fact, this review confirms findings in the literature that serious games can be a valuable tool for promoting healthy behaviors and improving health literacy among children and adolescents. We think it is important, quoting Plato: "Do not educate children in the various disciplines by resorting to force, but as by play, so that you may also better observe what the natural disposition of each one is". The key point, along with the significant increase in knowledge over the use of traditional teaching, lies in the involvement of children and young adults during learning. Indeed, there is no doubt about the improvement of knowledge through the use of games; however, we believe that the next step can be a more detailed investigation regarding the speed in changing behaviors and the assumption of virtuous behaviors following the acquisition of new knowledge through games. Indeed, the next step in educational campaigns using games is to quickly achieve a change in young people's behaviors in favor of virtuous behavior.

However, further research is needed to identify the most effective ways to design, implement, and evaluate serious games for health education. Further research is needed to identify the most effective game design

elements for promoting healthy behaviors among children and adolescents, particularly among hard-to-reach populations without Internet access. Further research is needed to evaluate the effectiveness of serious games in combination with other health education interventions. Developers of serious games should consider incorporating health behavior change theoretical frameworks into game design. Practitioners should consider the target audience, game design and implementation plan when using serious games for health education.

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Conflict of interest statement

Each Author declares that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Ethics approval

Ethical review and approval were not necessary given the nature of the paper.

Authors' contributions

Conceptualization, AA and AM; methodology, AA, CL and DG; emtree terms control, DG; validation, AA; investigation, AA and CL; data curation, AA; writing-original draft preparation, AA and CL; writing-review and editing, AA, and CL and FC; supervision, AM. All Authors have read and agreed to the published version of the manuscript.

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