Exploration of Digital Health Technologies

Open Exploration

Open Access Perspective

Serious games: a game changer in cancer education

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Academic Editor: Hari Prasad Devkota, Kumamoto University, Japan
Received: February 28, 2025 **Accepted:** April 28, 2025 **Published:** June 3, 2025

Cite this article: Salami AA, Aladelusi TO, Ramprasad VP, Jayasinghe RD, Kanmodi KK. Serious games: a game changer in cancer education. Explor Digit Health Technol. 2025;3:101150. https://doi.org/10.37349/edht.2025.101150

Abstract

The enormous global burden of cancer has created the need to develop cutting-edge strategies for enhancing public education on cancer. Over the years, conventional educational strategies, such as the use of posters and leaflets, have been preferentially employed as public education strategies on oral cancer; however, the use of digital education-based strategies has been largely underutilized. Notably, the use of digital education-based strategies, particularly serious games, has proven to be a superior cancer education strategy, when compared to conventional strategies, due to their rigorous design and features. This commentary discusses serious games as a game changer in cancer education, itemizing their diverse roles in cancer prevention, advocacy, and management. Also, this commentary also detailed those factors that might limit the use and availability of serious games in resource-limited settings.

Keywords

Cancer, education, games, gamification, intervention, public health

Introduction

Cancer remains a leading cause of morbidity and mortality globally, making it a major problem of public health concern [1]. According to the Global Cancer Observatory (GLOBOCAN), about 20 million new cases of cancer and about 10 million cancer-related deaths were recorded globally in the year 2020 alone [1]. Despite numerous public health efforts to improve awareness and limit the rising global epidemiological burden of cancer, late cancer diagnosis remains common in many countries of the world especially in low-

and middle-income countries (LMICs) due to low levels of cancer literacy, low socio-economic status, and poor access to healthcare [2].

The socio-economic burden of cancer on the global economy, especially in the LMICs, is very heavy; hence, there is a need to promote preventative strategies against cancer. Public education on cancer remains an indispensable strategy that can be adopted to promote healthy behaviors and enhance early and prompt cancer diagnosis and treatment [2]. Notably, empirical evidence has proven that conventional/non-digital education-based strategies, such as the use of print-based information, education, and communication (IEC) materials (e.g., posters, leaflets, pamphlets) have been effective in improving knowledge on cancers [3]; however, these strategies were found to have inferior successes, when it comes to the effectiveness of learning and information retention when compared with digital education-based strategies [4].

In the field of cancer education, the use of serious games is one of the emerging digital-based strategies used for delivering public education on cancer [4]. Through engagement with serious games on cancer, users could acquire basic knowledge of the case definition, risk factors, symptoms, and preventive and treatment options for cancer. Their immersive and interactive features promote the understanding of the crucial elements of the educational material [4]. From a public health perspective, the adoption of serious games in educating the lay public about cancer is very promising, especially among young people due to their excellent adaptability to newer technologies and their access to these serious games [5]. Therefore, serious games have been continuously studied within the context of cancer prevention, cancer care, and cancer education for the purpose of limiting the global epidemiological burden of cancer. According to previous reports, there are over 3 billion digital game users worldwide, the majority of whom are young people [6, 7] underscoring the potential of serious games in delivering cancer education among this population.

A serious game is defined as an entertaining game designed for specific educational purposes [5]. Serious games create an entertaining learning platform as well as simulate real-life situations for their players to achieve a change in behaviors [8, 9]. Historically, the term "serious game" was popularized in the digital context in the early 2000s when it was conceived to train individuals on specific tasks in the military, business, and education despite appearing as a medium of public education as early as the 1970s [10]. However, in the last decade, there has been progressive growth in the development of serious games in the field of health, especially in the training of health professionals, patients' education, and patients' care [11]. This intervention strategy may be a potential game changer in cancer education due to its uniqueness, particularly in users' motivation. In fact, compared with conventional methods of cancer education, serious games enhance better information retention. Thus, promoting early detection of symptoms, enhancing self-examination, and instilling adherence to therapies and rehabilitation among people receiving cancer care [8, 9, 12].

This commentary discusses serious games as a game changer in the different cancer education domains including cancer prevention, cancer health-seeking intentions, cancer advocacy, cancer risk awareness, and cancer-related complications as well as the factors that might limit their use and availability in resource-limited settings.

Serious games as a game changer in cancer education

Over the years, serious games have continued to revolutionize the learning experience in various fields including the military [13], healthcare [14], and business fields [15]. Serious games have the capacity to simulate real-life combative situations in the training of soldiers to improve their decision-making, particularly in unfamiliar and complex operational environments. Hence, their adoption in the military. The users of such serious games are made to detect rule changes in the game world and make decisions accordingly for simulation in real-life scenarios [12]. Also, the use of serious games in healthcare and particularly in cancer education is growing and has been employed in various domains including cancer prevention, cancer control, and cancer care to achieve behavioral change [12, 14, 16, 17]. The following

discusses the principal areas of cancer education that can be positively impacted through the adoption of serious games.

A game changer in cancer prevention

Based on current evidence, up to 50% of all cancer types are potentially preventable [18] and reports have shown that the development of cutting-edge preventive strategies will further increase the rate of prevented cancer cases [18, 19]. Over the years, preventative strategies, including the use of brochures, campaigns, practical workshops, and lectures have been adopted to improve preventative behaviors against cancer [3, 20]. However, the need for educational methods with better knowledge retention and the need for educational content that is compatible with individuals' cultural environments to improve cancer risk behaviors have been topical in the field of cancer education. Hence, the adoption of serious games for the delivery of cancer education remains crucial and of public health importance [16, 21].

Serious game design involves input from game-based researchers, game designers, content experts, clinicians, and the target users in its conceptualization, to reduce their risk of failure [17]. The ease of use (usability), the fun and educational content (playability) as well as the user retention and familiarity (learnability) underscore their balanced design and users' retention which makes the serious game a potential game changer in delivering cancer education.

Notably, the Augmented Reality Serious Game (called Spot), a notable example of a serious game, was designed to promote skin self-examination efficacy for the prevention of skin melanomas among users. This serious game engages users through the identification of suspected skin lesions to inform users of decisions for melanoma prevention. Following the use of the game, a large majority of the participants agreed that the game has a real impact on melanoma prevention by increasing their awareness about skin self-examination and prompt identification of skin changes which is crucial to melanoma prevention [22].

A game changer in improving health-seeking intentions

The survival rates and overall quality of life of patients with cancer may be hinged at the time of diagnosis. The time of diagnosis of cancer usually predicts the prognosis. Serious games prioritize efficient and effective learning by providing a platform that specifically encourages change in health-seeking intentions [23]. The improvement of health-seeking intentions of people has been shown to encourage early cancer detection [24]. According to a previous study, a greater level of symptom awareness and health-seeking intention was reported within a short period after playing a pancreatic cancer awareness game designed to improve symptom awareness and health-seeking intentions of pancreatic cancer among individuals [25]. Additionally, the "Time After Time" serious game is designed to promote the quality of life of men with prostate cancer by improving their health-seeking intention [26]. This serious game platform contains highly immersive features that make learning quicker and highly engaging for effective education. Men who played this game reported better health-seeking intentions when compared to those who did not play the game. Hence, it can be argued that serious games offer superiority in improving health-seeking intentions toward cancer prevention, therefore, such games have the capacity to revolutionize the field of cancer education in the future.

A game changer in self-advocacy

Self-advocacy refers to the ability of an individual to seek, evaluate, and use available information to promote their own health [27]. Therefore, individuals can become advocates for their own health even amidst uncertainties through the acquisition of adequate knowledge. Cancer survivors are usually faced with the need to make serious informed decisions about their own health, and this underscores the growing need for self-advocacy among individuals with cancer [27]. As an adaptive gaming platform, serious game ensures that its educative contents are useful regardless of the player's age, gender, socioeconomic status, and purpose, and this promotes effective learning. Cancer survivors achieve self-advocacy by improving decision-making for a better quality of life [27]. Furthermore, the adaptive capacity, appropriateness, and effectiveness of serious games have been emphasized in previous studies which makes serious games superior to other conventional health education strategies [28, 29].

A randomized controlled trial conducted among adolescents and young adults who were undergoing cancer therapy in the United States, Canada, and Australia on the effectiveness of serious games on behavioral outcomes reported a significant improvement in treatment adherence and cancer-related self-efficacy and knowledge when compared with the control group. This, however, underscores the effectiveness of serious games in cancer education and patient care [30].

A game changer in improving cancer risk awareness

An individual will modify their health behavior based on awareness of known risk factors of diseases [2]. Such modification of health behavior may be influenced by accessibility to knowledge and cultural beliefs [31, 32]. Therefore, the need for an educational platform that provides real-time, consistent, and accessible educational content within a cultural context will be highly suitable for effective cancer education. Serious games direct knowledge in a fun, user-friendly, and engaging fashion which improves the retention of knowledge among players [11, 12]. This fact has also been confirmed by a previous study among the Malaysian population where an increase in the level of awareness of breast cancer was demonstrated due to consistent and real-time engagement with serious games [10].

A game changer in the management of cancer care-related complications

Treatment-related complications are one of the most important reasons for hospital attendance and admission among patients with cancer [33]. Patients with cancer are faced with cancer care-related complications ranging from immediate (e.g., chemotherapy-induced nausea and vomiting, sepsis) to late complications (e.g., depression, anxiety), and this may limit patient adherence to therapy [33]. Notably, persistent interaction with serious games has been reported to produce widespread activation changes in the brain cortex including the sensory region (e.g., the visual cortex) as well as the insula and thalamus regions of the brain which are neural circuits in mood processing [34]. Additionally, the use of conventional cancer education strategies to provide information about side-effects of cancer treatment (such as the use of take-home written materials) has been reported to be challenging for many patients with cancer, especially the elderly; most of the users claimed that the information within these materials is complex which serves as a barrier to effective home care of cancer-related complications. Serious games have been designed to enable cancer patients to practice self-care decision-making and visualize the consequences of these decisions to improve their self-care efforts [35]. For example, the electronic symptom self-management training-cancer induced nausea and vomiting (eSSET-CINV) serious game was developed to provide older adults with cancer the opportunity to practice self-care decisions and positively impact their preventative activities. Cancer survivors who interacted with this game showed better self-care and preventive behaviors than those who did not interact with the game. This shows that the use of serious games in improving home care (especially those related to chemotherapy-induced nausea and vomiting) among the elderly is more effective when compared with the use of conventional cancer education strategies [33].

Limitations of use of serious games in cancer education

Despite the acclaimed superiority of serious games in cancer education, notable limitations have been reported in their use. Firstly, the development of serious games requires huge financial and technological resources which may not be readily available in the LMICs [36]; therefore, the adoption of this technology in resource-limited regions of the world would be limited, largely due to poor access to stable internet facilities, suitable devices and required technical support. Secondly, most serious games are designed for specific learning purposes and may not be adjustable to suit other learning situations; therefore, the versatility of serious games in advancing cancer education may be limited [37]. In addition, the conceptualization, designing, and standardization of a feasible and cost-effective serious game requires a multidisciplinary and rigorous process that involves collective input from computing and gaming experts, clinicians, and health education experts, as well as specialized software [17]. Unfortunately, the required skilled personnel needed for serious game co-production is scarce in many regions, especially in underserved communities, this therefore renders the use of serious games for cancer education in these regions relatively inaccessible when compared to conventional educational strategies on cancer [38].

Furthermore, there is still limited research evidence on the ethical implications of the use of serious games for health including their risks and benefits [39]. Hence, its adoption may be questionable in societies where the legal implications of interventions are considered with stringent rules.

Finally, there is limited research evidence on the scalability (the ability of the games to reach large audiences), especially in diverse and large populations [40]. Therefore, their adoption by healthcare providers and the public may be limited.

Future directions

The future of serious games in patients' education and empowerment, especially in cancer prevention and cancer care, is very promising [5]. Therefore, an extensive study including a longitudinal study with a large sample size and diverse study population as well as evidence from randomized controlled trials and systematic reviews will be required to comprehensively determine the effectiveness of serious games interventions among the oncology population. Hence, more empirical studies are needed for the understanding of serious game interventions in cancer education.

Also, the economic implication of developing a serious game is very heavy [36], and this cost could be burdensome on regions within the LMICs, therefore, funding through non-governmental organization (NGO) partnerships, government interventions and policies, and public-private partnerships for training of healthcare professionals on the evaluation of serious games for healthcare purposes as well as the development of digital health interventions like the serious games will be highly desirable. This will promote their availability to end users regardless of socio-economic status and location.

Furthermore, the utilization of a standardized and recognized framework in the design of serious games is currently not clear in the literature [41, 42]. Hence, there is no generally acceptable guideline for the development or evaluation of serious games. It is believed that this framework will guide game-based researchers, game designers, content experts, clinicians, and educators through a collaborative process during the design of the games to ensure the incorporation of relevant learning content for the intended end-users to ensure effective education and limit their risk of failure. The guidelines will also make replication of studies easier to obtain more consistent results.

Finally, the approach to ensuring game diversity has not been thoroughly investigated in the literature [43]. Hence, future game designs may target ensuring diversity and meeting user preferences. This may necessitate the creation of a wider range of interventions to manage user expectations. Therefore, more work is required in developing games that are specific to individual patients' needs which can be easily integrated into the existing healthcare system.

Conclusions

Despite their limitations, the use of serious games remains a superior intervention strategy and a game changer in the field of cancer education. However, more research work is required to better harness their potential in improving cancer prevention and control among the global population.

Abbreviations

LMICs: low- and middle-income countries

Declarations

Author contributions

AAS: Conceptualization, Data curation, Methodology, Resources, Investigation, Visualization, Supervision, Validation, Writing—original draft, Writing—review & editing. TOA, VPR, and RDJ: Methodology, Resources, Supervision, Writing—review & editing. KKK: Data curation, Methodology, Resources, Investigation, Visualization, Supervision, Validation, Writing—original draft, Writing—review & editing.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent to publication

Not applicable.

Availability of data and materials

Not applicable.

Funding

Not applicable.

Publisher's note

References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin. 2021;71:209–49. [DOI] [PubMed]
2. Lombe DC, Mwamba M, Msadabwe S, Bond V, Simwinga M, Ssemata AS, et al. Delays in seeking, reaching and access to quality cancer care in sub-Saharan Africa: a systematic review. BMJ Open. 2023;13:e067715. [DOI] [PubMed] [PMC]
3. Shao Y, Hu H, Liang Y, Hong Y, Yu Y, Liu C, et al. Health literacy interventions among patients with chronic diseases: A meta-analysis of randomized controlled trials. Patient Educ Couns. 2023;114: 107829. [DOI] [PubMed]
4. Wouters P, van Nimwegen C, van Oostendorp H, van der Spek ED. A meta-analysis of the cognitive and motivational effects of serious games. J Educ Psychol. 2013;105:249–65. [DOI]
5. Kim S, Wilson P, Abraham O. Investigating the Use of Serious Games for Cancer Control Among Children and Adolescents: Scoping Review. JMIR Serious Games. 2024;12:e58724. [DOI] [PubMed] [PMC]
6. 45+ Out of this world video games industry statistics in 2024 [Internet]. TechJury.net; [cited 2025 Apr 5]. Available from: https://techjury.net/blog/video-games-industry-statistics
7. Distribution of serious games in the United States in 2021, by age group [Internet]. Statista; [cited 2025 Apr 5]. Available from: https://www.statista.com/statistics/189582/age-of-us-video-game-players
8. Tong JWA, Hee MQ. The impact of an online educational game on breast cancer awareness among university female students, Malaysia: a pilot study. BMC Cancer. 2023;23:947. [DOI] [PubMed] [PMC]

9. Krath J, Schürmann L, von Korflesch HFO. Revealing the Theoretical Basis of Gamification: A Systematic Review and Analysis of Theory in Research on Gamification, Serious Games and Game-Based Learning. Comput Hum Behav. 2021;125:106963. [DOI]
10. De Gloria A, Bellotti F, Berta R. Lavagnino E. Serious Games for education and training. Int J Serious Games. 2014:1. [DOI]
11. Wattanasoontorn V, Boada I, Hernandez R, Sbert M. Serious games for health. Entertain Comput. 2013;4:231–47. [DOI]
12. Craig S, Stark P, Wilson CB, Carter G, Clarke S, Mitchell G. Evaluation of a dementia awareness game for undergraduate nursing students in Northern Ireland: a Pre-/Post-Test study. BMC Nurs. 2023;22:177. [DOI] [PubMed] [PMC]
13. Mun Y, Oprins E, van den Bosch K, van der Hulst A, Schraagen JM. Serious Gaming for Adaptive Decision Making of Military Personnel. Proc Hum Factors Ergon Soc Annu Meet. 2017;61:1168–72. [DOI]
14. Damaševičius R, Maskeliūnas R, Blažauskas T. Serious Games and Gamification in Healthcare: A Meta-Review. Information (Basel). 2023;14:105. [DOI]
15. Beranič T, Heričko M. The Impact of Serious Games in Economic and Business Education: A Case of ERP Business Simulation. Sustainability (Basel). 2022;14:683. [DOI]
16. Khalil GE, Beale IL, Chen M, Prokhorov AV. A Video Game Promoting Cancer Risk Perception and Information Seeking Behavior Among Young-Adult College Students: A Randomized Controlled Trial. JMIR Serious Games. 2016;4:e13. [DOI] [PubMed] [PMC]
17. Carcioppolo N, Kim S, Sanchez M, Mao B, Malova E, Ryan A, et al. Evaluating a game-based randomized experiment to increase melanoma identification among adults living in the U.S. Soc Sci Med. 2022;310:115281. [DOI] [PubMed]
18. Cancer prevention and control in the context of an integrated approach [Internet]. World Health Organization; [cited 2024 Dec 10]. Available from: https://apps.who.int/gb/ebwha/pdf_files/EB140/B140_31-en.pdf
19. Lopez AM, Hudson L, Vanderford NL, Vanderpool R, Griggs J, Schonberg M. Epidemiology and Implementation of Cancer Prevention in Disparate Populations and Settings. Am Soc Clin Oncol Educ Book. 2019;39:50–60. [DOI] [PubMed] [PMC]
20. Smith SA, Blumenthal DS. Efficacy to effectiveness transition of an Educational Program to Increase Colorectal Cancer Screening (EPICS): study protocol of a cluster randomized controlled trial. Implement Sci. 2013;8:86. [DOI] [PubMed] [PMC]
21. Lana A, Faya-Ornia G, López ML. Impact of a web-based intervention supplemented with text messages to improve cancer prevention behaviors among adolescents: results from a randomized controlled trial. Prev Med. 2014;59:54–9. [DOI] [PubMed]
22. Ribeiro N, Tavares P, Ferreira C, Coelho A. Melanoma prevention using an augmented reality-based serious game. Patient Educ Couns. 2024;123:108226. [DOI] [PubMed]
23. Ferwerda B, Lee MJ. Tamagotchi++: A serious, personalized game to encourage healthy behavior. In Joint Proceedings of the ACM IUI 2019 Workshops; 2019 Mar 20; Los Angeles, USA.
24. Kim HJ, Kim SM, Shin H, Jang J, Kim YI, Han DH. A Mobile Game for Patients With Breast Cancer for Chemotherapy Self-Management and Quality-of-Life Improvement: Randomized Controlled Trial. J Med Internet Res. 2018;20:e273. [DOI] [PubMed] [PMC]
25. Anderson T, Prue G, McDowell G, Stark P, Wilson CB, Wisener LG, et al. Co-design and evaluation of a digital serious game to promote public awareness about pancreatic cancer. BMC Public Health. 2024;24:570. [DOI] [PubMed] [PMC]
26. Reichlin L, Mani N, McArthur K, Harris AM, Rajan N, Dacso CC. Assessing the acceptability and usability of an interactive serious game in aiding treatment decisions for patients with localized prostate cancer. J Med Internet Res. 2011;13:e4. [DOI] [PubMed] [PMC]

27. Poliani A, Gnecchi S, Villa G, Rosa D, Manara DF. Gamification as an Educational Approach for Oncological Patients: A Systematic Scoping Review. Healthcare (Basel). 2023;11:3116. [DOI] [PubMed] [PMC]
28. Thomas TH, McLaughlin M, Hayden M, Shumaker E, Trybus J, Myers E, et al. Teaching Patients with Advanced Cancer to Self-Advocate: Development and Acceptability of the Strong Together™ Serious Game. Games Health J. 2019;8:55–63. [DOI] [PubMed]
29. Kondylakis H, Bucur A, Crico C, Dong F, Graf N, Hoffman S, et al. Patient empowerment for cancer patients through a novel ICT infrastructure. J Biomed Inform. 2020;101:103342. [DOI] [PubMed]
30. Kato PM, Cole SW, Bradlyn AS, Pollock BH. A video game improves behavioral outcomes in adolescents and young adults with cancer: a randomized trial. Pediatrics. 2008;122:e305–17. [DOI] [PubMed]
31. Quintana Y, McWhirter J. Culturally appropriate behavioral change in maternal health: role of mobile and online technologies over time. In: Patel V, Arocha J, Ancker J, editors. Cognitive Informatics in Health and Biomedicine. Health Informatics. Cham: Springer; 2017. pp. 217–33.
32. Rodgers WM, Christina CL. The role of motivation in behavior change: how do we encourage our clients to be active? ACSM Health Fit J. 2009;13:7–12. [DOI]
33. Loerzel VW, Clochesy JM, Geddie PI. Using Serious Games to Increase Prevention and Self-Management of Chemotherapy-Induced Nausea and Vomiting in Older Adults With Cancer. Oncol Nurs Forum. 2020;47:567–76. [DOI] [PubMed] [PMC]
34. Kim SM, Kim H, Hwang HC, Hong JS, Bae S, Min KJ, et al. The Effects of a Serious Game on Depressive Symptoms and Anxiety in Breast Cancer Patients with Depression: A Pilot Study Using Functional Magnetic Resonance Imaging. Games Health J. 2018;7:409–17. [DOI] [PubMed]
35. Loerzel VW. Symptom Self-Management: Strategies Used by Older Adults Receiving Treatment for Cancer. Clin J Oncol Nurs. 2018;22:83–90. [DOI] [PubMed]
36. Hafeez M. Effects of game-based learning in comparison to traditional learning to provide an effective learning environment—A comparative Review. Contemp Educ Res J. 2021;8:89–105. [DOI]
37. Purnama WG, Maulidevi NU, Suwardi IS. Challenges and Opportunities in Serious Game for Learning Authority Tool. Int J Innov Technol Explor Eng. 2019;8:227–32.
38. Klemke R, van Rosmalen P, Ternier S, Westera W. Keep It Simple: Lowering the Barrier for Authoring Serious Games. Simul Gaming. 2015;46:40–67. [DOI]
39. Arora C, Razavian M. Ethics of Gamification in Health and Fitness-Tracking. Int J Environ Res Public Health. 2021;18:11052. [DOI] [PubMed] [PMC]
40. Warsinsky S, Schmidt-Kraepelin M, Rank S, Thiebes S, Sunyaev A. Conceptual Ambiguity Surrounding Gamification and Serious Games in Health Care: Literature Review and Development of Game-Based Intervention Reporting Guidelines (GAMING). J Med Internet Res. 2021;23:e30390. [DOI] [PubMed] [PMC]
41. Ayed I, Ghazel A, Jaume-I-Capó A, Moyà-Alcover G, Varona J, Martínez-Bueso P. Vision-based serious games and virtual reality systems for motor rehabilitation: A review geared toward a research methodology. Int J Med Inform. 2019;131:103909. [DOI] [PubMed]
42. Mubin O, Alnajjar F, Mahmud AA, Jishtu N, Alsinglawi B. Exploring serious games for stroke rehabilitation: a scoping review. Disabil Rehabil Assist Technol. 2022;17:159–65. [DOI] [PubMed]
43. Doumas I, Everard G, Dehem S, Lejeune T. Serious games for upper limb rehabilitation after stroke: a meta-analysis. J Neuroeng Rehabil. 2021;18:100. [DOI] [PubMed] [PMC]