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Full title: Gamifying health literacy: How can digital technology optimise patient outcomes in surgery?

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Abstract
The digital age is entrenched in our society, with constant innovation driving change in the way clinicians and patients manage their health concerns. Health literacy is emerging as an important modifiable factor that can affect clinical and patient outcomes, yet traditional forms of patient education have shown mixed results. Digital media and technologies, the concept of gamification as a means to improve patient health literacy, and its potential for misuse will be explored in this review, in the context of a digital, gamified tool that could support patients along their surgical journey.
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Introduction

Health literacy is defined as the extent to which an individual has the capacity to obtain, process and understand basic health information and services to make appropriate health decisions[1]. Sixty percent of patients have low health literacy in Australia[2]. Low health literacy is an important driver of patients' dissatisfaction with their care, associated with poor patient understanding of their medical conditions and unrealistic expectations of surgical outcomes[3]. To mitigate low health literacy, the medium in which health information is conveyed has been shown to be an important modifiable factor[4]. Traditionally, this has been in verbal or paper format. Concerted efforts in these areas have shown mixed results, suggesting the need to find additional strategies of engaging and educating patients[5].

Digital media and technologies have advanced insofar that they are now widespread and accessible. Digital technologies now show great potential in serving as a means to convey health information[6]. Known as eHealth, it is the use of nascent information and communication technology to improve or enable health and healthcare[7]. eHealth and its related resources, such as the Internet, have fundamentally altered the way clinicians and patients alike provide and assimilate information.

A changing landscape has seen healthcare consumers want to be more active in their own health, which has spurred initiatives to prioritise accessibility and comprehension of health information[8, 9]. Such patient participation is known to improve patient-clinician trust, satisfaction, understanding of personal requirements, and reduce anxiety[10]. Thus, if deployed smartly and sustainably, digitized health information could enable patients to improve their health literacy, be better prepared for surgery, and ultimately obtain better outcomes.

Opportunities to facilitate patient engagement with digitized health information are presented by the emerging field of gamification. Gamification involves the use of game elements and techniques in a non-gaming context as a way to improve user engagement[11]. Examples include reward systems such as points, badges and leaderboards. Gamification has previously been shown to have a positive impact on health and wellbeing, for example, encouraging patients to record their own glucose levels more frequently, or undertake more physical activity[12]. This increase in patient engagement supports the notion that a gamified digital tool designed to improve patient health literacy could be a useful adjunct to patient care enhancing surgical outcomes.

This review will explore components of health literacy and eHealth literacy. It will examine aspects of gamification, drawing on examples from medical and surgical fields,

education and business, and consider how it could be used to optimise health literacy during preparation for surgery, potentially enhancing surgical outcomes and patient satisfaction. Finally, we will reflect on barriers for the usage, including misuse, of gamification in this context and consider opportunities for research in this nascent field.

Methodology

In this narrative review, databases, including Pubmed, Scopus and Web of Science were used. Meshterms used for identifying relevant research included “health literacy”, “eHealth literacy”, “expectations”, “satisfaction”, “gamification”, “digital health”, “digital technology”, “surgery”, “patient engagement”, and "motivation".
We searched for and retrieved articles that included one or more of the following concepts: i) health literacy, ii) gamification and digital technology, iii) surgery/medicine. Specifically, we wanted to learn if and how digital technology was used to improve health literacy in patients undergoing surgery.

Health literacy

Health literacy is itself a multifaceted and complex network of knowledge and skills[13, 14]. According to the Health Literacy Management Scale, it incorporates a variety of abilities, ranging from literacy skills and verbal comprehension, to extrinsic factors such as community resources and intrinsic factors such as educational background[15]. Despite a limited number of surgical patient groups researched, low health literacy is common in surgical patients[16]. In bariatric surgery, low health literacy may prevent patients from undergoing surgery[17], while in major abdominal surgery, lower health literacy prolongs length of stay[18]. Importantly, recent research has shown that poor health literacy of patients or caregivers can detract from having realistic expectations of joint replacement surgery[19].

By contrast, studies suggest that health literacy is a modifiable factor that can rationalise expectations, reduce anxiety, length of stay and dissatisfaction and enhance outcomes in orthopaedic surgery[20, 21]. In line with this, research also suggests that enhancing surgeon-patient communication and alignment of expectations can improve satisfaction[22, 23]. Studies also suggest that improving health literacy by providing health education, both preoperatively[24, 25] and postoperatively[26], can achieve better outcomes and satisfaction.

Overall, this suggests that enhancing health literacy may benefit patients preparing for and recovering from surgery. The utility and ubiquity of digital technology could be a convenient, accessible and steady source of educational materials for patients to improve their health literacy. However, it is necessary to understand how the eHealth literacy of patients impacts this option.

eHealth literacy

eHealth literacy is a component of health literacy. According to the Lily model[27], eHealth literacy is the ability to seek, find, understand and appraise health information from eHealth sources and apply the knowledge gained to addressing or solving a health problem. This model has since been extended into the eHealth Literacy Framework, which outlines the required knowledge and skills to obtain optimal understanding from eHealth sources[28]. According to this model, if digital technology is to be used widely, it is important that patients understand how to interact with devices such as the Internet and smartphones.

In line with a growing acceptance of digital technologies, it has previously been shown that the older adult population with chronic health conditions is increasingly using the Internet[29]. Indeed, orthopaedic patients frequently utilise the Internet for health information[30]. There is some evidence that when provided with Internet-based educational material for their surgery, these patients have better knowledge, are less anxious, and more satisfied with the consent process[31].

The standard of eHealth literacy of Internet users is unclear. One study showed that while approximately 50% of older adults from urban and rural clinics in North Carolina, America, use the Internet, half of those users have low eHealth literacy[32] according to the eHealth Literacy Scale[33]. Development of a digital intervention would need to consider baseline patient eHealth literacy. Design thinking may assist this process to develop a universally accessible interface for patients regardless of their health or eHealth literacy.

Research shows that as literacy skills improve, the perceived utility of computers, and intensity of Internet usage increases, even while factoring in age, income and education levels[27]. Use of digital technology could benefit patients in multiple ways, for example enhancing both their health literacy (the aim of the intervention) and their eHealth literacy (mastery of the technology). This would also suggest that patients with a higher baseline health and eHealth literacy could be better positioned to obtain optimal outcomes of their surgical procedure.

Knowledge gaps for health and eHealth literacy in surgical patients

There is a paucity of studies to exploring the health literacy needs of surgical patients. Fewer still aim to modify aspects of health literacy. With this in mind, given the utility of digital technology discussed earlier, future research and design of health and eHealth literacy interventions could be more useful if developed on digital platforms for greater community reach; for example, patients with reduced access to healthcare. Development of such interventions targeting the core components of health literacy could also improve their overall relevancy and efficacy. However, how can digital interventions be designed in such a way that encourages sustained patient engagement? Gamification could address this issue.

Digital interventions and gamification

The goal of health and eHealth literacy is to empower patients to engage with healthcare and information and make informed decisions about their own health. In an increasingly digital world, with an ageing population, a tool that addresses both health and eHealth literacy deficiencies may be key to improving understanding, expectations and satisfaction of surgery. Hence, it is necessary to explore what makes a digital intervention successful in engaging users and patients in healthcare. Three key parts of a digital intervention – platform, gamification and motivation – will be discussed here. Please see Doc S1 for glossary of terms.

Platform

With widespread adoption of smartphones globally, topping five billion[34], digital health technology may become one of the most important adjuncts to patient care in the near future. A large body of research champions the value of smartphones and other

handheld tablets as applied to various health disciplines, with a positive impact across developed and, to a lesser extent, developing countries[35]. Thus, in addition to the Internet, patients may also improve their health literacy by using smartphone apps if information is provided in an accessible, data-driven way[36]. A digital platform may enable new gamified interventions in surgery if conveyed with an interface accessible to health consumers of varying health literacy.

Gamification

Gamification has been used extensively in the spheres of education and business, with significant success[37]. This review suggests that gamification of an educational curriculum or business platform for employees or consumers can encourage a desired behaviour by rewarding engagement in that activity and also monitor ongoing usage. Positive behaviour change and ongoing monitoring are two aspects that would benefit both patients and clinicians. Importantly, gamified tools have been developed in a healthcare context in the form of virtual reality simulators. They have been applied to surgery for training and surgical planning purposes[38]. Various surgical specialities[39, 40], endoscopic procedures[41] and response in rehabilitation[42] have been tested, with promising results, suggesting that skills and knowledge improve with this technology[43, 44]. This technology, combined with game elements such as points or badges, could also benefit patients. Though this technology may not be currently scalable, simple and effective gamified websites or apps may be more pragmatic, accessible and beneficial to patients.

Motivation

Gamification appears to be more psychological than technological[45]. It utilises the principles of motivational psychology and behavioural economics in game design and dynamics [46]. Gamification leverages engagement, reward and incentive to effect a positive behavioural change[47]. Extrinsic motivation is governed by the promise of reward or punishment, such as money, material objects, or points. This may be a useful strategy in the short term. Conversely, intrinsically motivated activities are completed for their own sake, satisfying the basic psychological needs for autonomy, competence and relatedness[48]. Several studies have shown the benefits of intrinsic motivation in a health behaviour context[49-51], highlighting its increased sustainability compared to extrinsically motivated change[52]. Gamification has been shown to be an effective intrinsic motivator for health behaviour change[12]. An intrinsically motivating interface may facilitate patient engagement and maximise the utility of a digital platform conveying health information. That surgery is successful could be enough intrinsic motivation for patients to use the digital intervention.

Evidence of utility

At present, there is only one published study exploring the possible benefit of a gamified tool for patients understanding pain management after surgery[53]. This study highlights how patients can improve their understanding of aspects of surgical care through immersive gaming media. Despite the resource-intensive nature of constructing and validating a computer game, there is a clear benefit to patients of knowing how to manage their postoperative pain better.

A body of work by Almarshedi et al [45] examined the effect of gamification on patients dealing with diabetes. With the purpose of promoting better self-management of diabetes,

Almarshedi et al have created a framework – The Wheel of Sukr – to highlight eight elements of human behaviour that can be optimised through gamification. These elements, such as Socialising and Self-esteem, have further been validated[54, 55], suggesting that gamifying aspects of this framework may have lasting positive effects on patients. Following these principles, the surgical journey could also be gamified to have a positive impact on patients.

Examples of gamified digital tools

Innovative solutions to different health issues have impacted the way clinicians and consumers view 21st century healthcare. Examples of gamified digital tools include: SuperBetter, a mobile and web-based gamified app that challenges users to overcome their anxiety and depression by building resilience[56]. Ayogo, a leading mobile eHealth company, whose mobile app helps patients nourish positive behavioural changes specific to their chronic illnesses[57]. Mango Health awards points and larger rewards such as vouchers for users adhering to their medication regime[58].

Commercially, wearables such as the Apple Watch motivate users to engage with their products by matching activity with an explanation of how the device benefits the user and what its goals are. For example, game elements like 'closing the rings' daily, attaining exercise-related trophies on the Apple Watch, as well as recording times and energy expenditure from sessions, all encourage ongoing participation and improvement. Furthermore, the latest version of the Apple Watch has been created to detect atrial fibrillation with increasing accuracy and alert the user to see a doctor[59, 60]. This research suggests how important and symbiotic gamified tools could become for patients and clinicians for educational and monitoring purposes.

Gamifying health literacy

Currently, no gamified tool exists targeting health literacy, the preoperative surgical phase, or the surgical patient journey. One could imagine, for example, a smartphone app gamifying the educational process when a patient embarks upon their surgical journey. Through daily challenges, similar to the Apple Watch, patients may be more engaged and motivated to 'close the ring' for their health literacy, and use the 'health literacy leaderboard' to track their progress. As patients choose to participate in these challenges, they choose to learn as much information as they wish, without being overwhelmed. See figure 1 in supporting documents.

By gamifying deliberate practice[61] – where practice and feedback are essential for improved learning – patients may aspire to a proficient understanding of their own condition and management, as well as mastery of the digital technology they use. With this in mind, a digital, gamified platform could be constructed with the deliberate aim to improve users' health literacy and understanding of their surgical journey. Overall, this gamified tool could help to rationalise patients' expectations and lead to better outcomes of surgery.

A gamified health literacy tool would require input from a multidisciplinary team. An opportunity therefore exists where healthcare, Government, and/or commercial organisations collaborate to achieve a paradigm shift in high volume conditions and care such as arthritis and total joint replacement management. This core team would see the

convergence of medical expertise, game design, software engineering and motivational psychology. A co-design framework with consumer involvement may benefit this process[62].

Barriers to uptake of new health technologies

While gamification shows great promise, digital technologies do not guarantee success. If user experience is required, poor usability of the technology may result in cessation of usage[63]. Hence, it will be important for gamified tools to be continuously tested and redesigned in innovative ways to maintain user engagement and outcomes. Iteration of prototypes and versions will be crucial to ongoing success.

Importantly, healthcare groups use online platforms to market their practice and educate patients, sometimes with external commercial forces[64]. Clinicians might pay a premium to augment the appearance of their own website to a more prime position of a Google search. As with any nascent technology, the over-promise of better results might negatively impact patients. For example, patients may set their expectations too high, or the technology itself may simply not be good enough. Clinicians would need to be wary of the misrepresentation of gamified digital technologies that might incite unknowing patients.

Furthermore, it may be difficult for patients to assess new gamified digital technology objectively. Clinicians again play an important role to educate patients impartially about such matters. For example, they can help direct patients to reliable websites and encourage the use of Health on the Net (HON)[65]. This toolbar function assesses website information quality through an algorithm and provides a visible prompt if a website has reliable information. Regardless, the provision of health information on a digital platform – website, app or otherwise – made and endorsed by clinicians would need to be balanced with their own marketing. The benefit of such a platform, if designed correctly, could empower patients to seek out accurate information.

Further research must address a number of barriers for patients accessing a digital platform. To optimise relevance and efficacy, it is first crucial to identify what aspects of health literacy are lacking for patients undergoing surgery. This establishes a framework around which a gamified tool can be built that empowers and upskills patients prior to their procedure.

Next, outlining what the most important needs of surgical patients are, will enable construction of a gamified tool that targets relevant areas of the surgical journey. Finally, understanding patient attitudes, habits and usage of digital technology will guide development of a tool that can sustainably engage patients.

Conclusion and Future Clinical Applicability

To continue improving postoperative outcomes and satisfaction, potential lies in boosting health literacy. Enhancing the provision of high-quality information from surgeons through novel digital platforms could assist in readying patients appropriately for surgery.

It will be important that these platforms are data- and patient-driven to remain accurate and relevant. While digital technology is promising, it must be emphasised that it is not a panacea in itself. Rather, it is an adjunct to clinical care; a means to empower patients

to improve themselves. It remains to be seen what effect this type of digital technology will have on patients.

The rise of digital health and gamification may improve health literacy. In turn, it may assist patients in preparing for and recovering from surgery. It may also help their general understanding to manage recurring or new health issues. A new paradigm of gamified healthcare may modernise the surgical journey and become a critical adjunct to patient-centred care.

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Author Contribution:
MTD – conceptualization, writing (original draft), writing (review and editing)
SB – conceptualization, writing (review and editing)
MMD – conceptualization, writing (review and editing)
PFC – conceptualization, writing (review and editing)

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Legends:
Figure 1. This pictograph illustrates important aspects of development of a digital health tool.

List of Supporting information:

- Doc S1 (Glossary of terms)
- Figure S1 (This pictograph illustrates important aspects of development of a digital health tool.)