



# Potential Adverse Effects Caused by Gamification Elements in mHealth Apps

Ivan Rocha   [ School of Technology - PUCRS | [ivan.rocha@edu.pucrs.br](mailto:ivan.rocha@edu.pucrs.br) ]

Milene Selbach Silveira  [ School of Technology - PUCRS | [milene.silveira@pucrs.br](mailto:milene.silveira@pucrs.br) ]

 School of Technology, Pontifical Catholic University of Rio Grande do Sul, Av. Ipiranga, 6681, Porto Alegre, RS, 90619-900, Brazil.

Received: 23 March 2024 • Accepted: 05 September 2024 • Published: 20 November 2024

**Abstract** Health practices using mobile devices (known as mobile health, or mHealth) have increased in recent years. To increase users' motivation to use it, mHealth researchers and developers have started to use gamification. However, no studies were found on the negative aspects of gamification in health. This work aims to determine the potential adverse effects of gamification in mHealth applications and analyze how different types of gamification elements can cause these effects. To this end, an analysis of 70 gamified mHealth applications extracted from the Google Play Store was performed to identify which gamification elements are commonly applied in mHealth. Then, to identify the negative aspects of gamification in mHealth and how the gamification elements can be related to them, a systematic review of the literature was carried out, where 37 studies were selected. Finally, a study was carried out with users of gamified mHealth applications to analyze in practice what was found in the previous steps. The results of these studies show which gamification elements are the most used in mHealth applications, the potential adverse effects found, and a list of which gamification elements can cause these effects. The results of this study provide insights into the risks associated with gamification in mHealth applications and can make developers, designers, and professionals aware of these harmful issues.

**Keywords:** mHealth, Gamification, Adverse effects

## 1 Introduction

Mobile Health (mHealth) is a medical and public health practice supported by mobile devices, such as cell phones, patient monitoring devices, or other wireless devices [WHO, 2011]. According to Sweileh *et al.* [2017], mHealth has had a positive impact on individual health services and national health services and has been applied to a wide range of health services, including promoting medication adherence, preventing behavioral associated with certain diseases, psychological support for patients with chronic illnesses, weight loss, smoking cessation, and many others.

In this scenario, technologies can be consciously designed to enhance or regulate people's emotions, where designers shift their focus from mere usability to making products enjoyable and engaging, often intending to increase use and engagement by users, to keep them always active [Peters *et al.*, 2018]. One of the alternatives used to do this is the use of gamification [Cheng *et al.*, 2018].

For mHealth apps, gamification has become an important topic, especially when bringing behavioral interventions into real-life contexts [Schmidt-Kraepelin *et al.*, 2020]. Previous research on gamification has focused on investigating the positive effects of gamification on psychological and behavioral outcomes, and little has been addressed about its risks and side effects [Andrade *et al.*, 2016; Hyrynsalmi *et al.*, 2017; Schmidt-Kraepelin *et al.*, 2019a].

Every technology can impact its users' psychological or physical well-being [Peters *et al.*, 2018]. Factors such as engagement and enjoyment do not necessarily contribute to

sustainable well-being. Too much engagement can exclude healthy activities to the detriment of overall well-being [Peters *et al.*, 2018]. Furthermore, as gamification is often used to motivate the user, it does not add anything extra if there is already enough motivation [Hyrynsalmi *et al.*, 2017].

Considering this, the main goal of the research presented here is to analyze the potential adverse effects caused by the use of gamification elements in mHealth applications. The following research question was defined to achieve this goal: "What are the potential adverse effects caused by using gamification elements in mHealth applications promoting health and well-being?". To address this question, the research encompasses three stages. The first involves an analysis of gamified mHealth applications, published in the Proceedings of the XXII Brazilian Symposium on Human Factors in Computing Systems (IHC2023) [Rocha and Silveira, 2023], where there were identified which health areas mHealth is typically found in and which gamification elements are most commonly found in them to promote health and well-being<sup>1</sup>. The second stage entails a systematic review utilizing the snowballing method to identify - in the literature - the potential adverse effects found when using gamification in mHealth applications. The third stage also focuses on identifying the adverse effects but from the point of view of mHealth application users. We hope this work's results can help developers and gamification researchers understand the potential adverse effects of gamification in mHealth ap-

<sup>1</sup>This work is an extension of Rocha and Silveira [2023], including a systematic literature review, a user study, and a deepen discussion considering the results obtained with the novel stages of research

plications.

This work is organized as follows. Section 2 presents the fundamental concepts associated with gamification that are used in this work. Section 3 summarizes the analysis of gamified mHealth applications presented at IHC2023 [Rocha and Silveira, 2023]. Section 4 presents the findings from the literature review, detailing the planning, execution, and analysis of results. Section 5 reports the results derived from the user study, including the planning, data collection methods, and results analysis. In Section 6, we discuss the research findings. Finally, in Section 7, we present the conclusions of this study, its limitations, and possibilities for future work.

## 2 Theoretical Background

According to Kapp [2012], in recent years, gamification has attracted a lot of attention from different areas, with promises to increase user engagement, as well as their motivation and behavioral changes. Gamification is defined as the use of game design elements in non-game contexts [Deterding *et al.*, 2011]. This may seem like a very broad definition, but Huotari and Hamari [2012] e Seaborn and Fels [2015] propose a more concrete definition: gamification is the use of game elements in non-game systems to provide a game-like experience and influence user motivation and engagement, aiming to promote benefits similar to those provided by games. Using game design elements in non-game contexts to motivate and increase user activity and retention quickly gained traction in the industry and digital marketing, where the term “gamification” originated [Deterding *et al.*, 2011].

The next sections discuss gamification elements, the effects of gamification, and gamification as motivation in health and well-being.

### 2.1 Gamification Elements

Gamification uses various game elements (gamification elements) to obtain a meaningful response from users regardless of the application context [Klock *et al.*, 2016, 2020]. Applying gamification elements to non-game contexts aims to promote users’ intrinsic motivation, making the applications or other systems more engaging and fun [Schmidt-Kraepelin *et al.*, 2019b].

The conceptual definition of gamification elements, as stated by Tondello *et al.* [2017], is as follows: “They are building blocks that are characteristic of gamified systems, meaning elements that are found in many (but not necessarily all) gamified systems and play a significant role in the user’s emergent experience with the system.”

Tondello *et al.* [2017] proposes a taxonomy classifying the 49 most used gamification elements, which can be grouped into eight main components according to user preferences. The eight main components, as described by Tondello *et al.* [2017], are outlined below.

**Socialization** elements correspond to various forms of social interaction, including collaborative, competitive, and purely social interactions.

**Assistance** elements pertain to the user receiving some form of aid for their progression, whether from the system

itself or other users.

**Immersion** elements relate to narratives or stories, including components associated with exploration and unpredictability.

**Risk/reward** elements are connected to tasks, gambling games, and rewards from victory, representing the expectation of winning prizes in challenges and lotteries.

**Customization** elements involve tailoring the user’s experience, whether through personalizing one’s representation with an avatar or customizing the overall experience within the system.

**Progression** elements are related to progression and meaning and represent the willingness to engage in meaningful goals and feel like you are progressing toward achieving them.

**Altruism** elements correspond to different ways of contributing to the system or other users, including sharing knowledge or goods, improving the system, and collaborating with other users.

Lastly, **incentive** elements correspond to incentives or rewards that the user can receive, such as medals, trophies, collectible items, and rewards.

### 2.2 Effects of Gamification

In recent years, researchers and developers have attempted to explore the motivational power of gamification across a wide range of domains such as work, health and wellness, education, commerce, marketing, crowdsourcing, and others [Rapp *et al.*, 2019]. In health and wellness, gamification is primarily applied to motivate individuals to continue using a mHealth application more regularly or to promote the completion of activities or tasks associated with positive health outcomes. [Schmidt-Kraepelin *et al.*, 2020].

Johnson *et al.* [2016] conducted a systematic literature review of empirical studies on gamification for health and wellness. Among the identified studies, the impact of gamified interventions was positive in 59% of them, with positive effects including empowerment, motivation, health monitoring, and adoption of healthier habits. However, 41% reported mixed or neutral effects.

Although gamification has been primarily used to enhance users’ engagement with virtuous issues and tasks, there are also clearly negative aspects [Hyrynsalmi *et al.*, 2017]. Previous research on gamification has focused on investigating the positive effects of gamification on psychological and behavioral outcomes or proposing theoretically grounded frameworks for designing specific gamified systems. Risks and negative aspects of gamification have only been addressed as side notes [Andrade *et al.*, 2016; Hyrynsalmi *et al.*, 2017; Schmidt-Kraepelin *et al.*, 2019a].

In the study conducted by Almeida *et al.* [2023], it was found that in gamified systems for education, the most cited negative effects were lack of effect, poorer performance, motivational issues, lack of understanding, and irrelevance. Ethical issues of gaming the system and cheating were also frequently reported. Indeed, gamification manipulates human psychology through game design elements, and it is natural to expect such manipulation to have adverse effects [Almeida *et al.*, 2023].

According to Schmidt-Kraepelin *et al.* [2019a], "mindless approaches" to gamification may not only be ineffective in increasing user motivation and engagement but also neutralize their positive effects or even harm their users.

### 2.3 Gamification as Motivation in Health and Well-being

Gamification has received considerable interest from the health and wellness research community for its potential to increase engagement with health interventions and motivate behavioral change. However, it should not be presumed that any gamification intervention will automatically enhance engagement. Even the commonly cited ability to provide enjoyable and engaging experiences cannot be taken for granted, as fun does not necessarily translate into greater motivation for engagement. [Cheng *et al.*, 2019].

Following the Self-Determination Theory (SDT), a well-established theory of motivation, not all forms of motivation are equal [Johnson *et al.*, 2016]. A crucial consideration is whether a behavior is intrinsically or extrinsically motivated. Intrinsic motivation describes activities done "for their own sake," which satisfy basic psychological needs of autonomy, competence, and relatedness. Extrinsic motivation leads you to do (or avoid) something because of an external reward or punishment [Johnson *et al.*, 2016].

According to Johnson *et al.* [2016], SDT has become a foundational framework for interventions and studies in health and well-being behavior in recent years. Much research has demonstrated the advantages of intrinsic motivation over extrinsic motivation regarding health and well-being behaviors. Humans are intrinsically motivated to satisfy their basic psychological needs for autonomy, competence, and relatedness. Since the subjective pleasure of video games has been empirically linked to the satisfaction of these constructs, gamification should, in theory, also be conducive to increasing intrinsic motivation. However, many instances of gamification for health and well-being often rely on positive reinforcement and extrinsic motivators, an approach that has been criticized [Cheng *et al.*, 2019].

In our modern way of life, health and well-being heavily depend on individual health behaviors; motivation is a key factor in health behavior change, and intrinsically motivated behavior change is desirable as it is sustained and directly contributes to well-being [Johnson *et al.*, 2016].

## 3 Gamification Elements in mHealth Apps

The first stage of the research involves an analysis of gamified mHealth applications Rocha and Silveira [2023] to identify the health areas that typically use gamification and the most used gamification elements.

To start, the taxonomy proposed by Tondello *et al.* [2017] was analyzed to understand the gamification elements and their meanings to later use these definitions during the analysis of gamified mHealth applications. <sup>2</sup>

Afterward, research was carried out to define the health areas where a mHealth application can act. Based on the work of Chung *et al.* [2018] and West *et al.* [2012], it was defined which health areas a mHealth application can be applied. These areas include physical health, mental health, nutrition, combating addictions, personal health, and women's health.

With this, mHealth applications were collected on the Google Play Store, with the following inclusion and exclusion criteria:

- Inclusion criteria:
  - Apps must be listed in the Health & Fitness and Medical categories;
  - Apps must be filtered by top apps (number of downloads);
  - Apps must be free to download.
- Exclusion criteria:
  - Duplicated apps across categories;
  - Apps that do not have English or Portuguese language versions;
  - Apps that are not considered mHealth;
  - Apps that, although free for download, are exempt from payments to create an account or use the features;
  - Apps that require a wearable from a specific brand for use;
  - Apps that are not gamified.

### 3.1 mHealth Applications Selection

To identify which gamification elements are commonly used to promote health and well-being in mHealth applications, it was decided to analyze applications from the Google Play Store, as this is the largest mobile application store in terms of app downloads (Google Play Store: 111.3 billion in 2021) and revenue (Google Play Store: US\$47.9 billion in 2021)[Iqbal, a,b]. As application availability varies from region to region, we emphasize that this analysis was conducted in Brazil.

mHealth applications (apps) are typically found in the Health and Fitness and Medical categories. These categories offer separate rankings, listing the top apps in terms of downloads for both paid and free apps. At this study stage, we decided only to consider free apps.

As the main app rankings on the Google Play Store tend to change a little from one day to the next, it is noteworthy that the initial set of selected apps was registered on May 8, 2022. We started with 578 apps extracted from the *Health and Fitness* and *Medical* categories. This large number of applications was collected to arrive at a set that could be representative, as not all applications in these categories are truly considered mHealth. After applying the inclusion and exclusion criteria from the previous section, we obtained 70 gamified mHealth apps to analyze. More details of the planning and processes were published in our previous work Rocha and Silveira [2023].

<sup>2</sup>The result of this review can be found in <https://bit.ly/4cukB91>

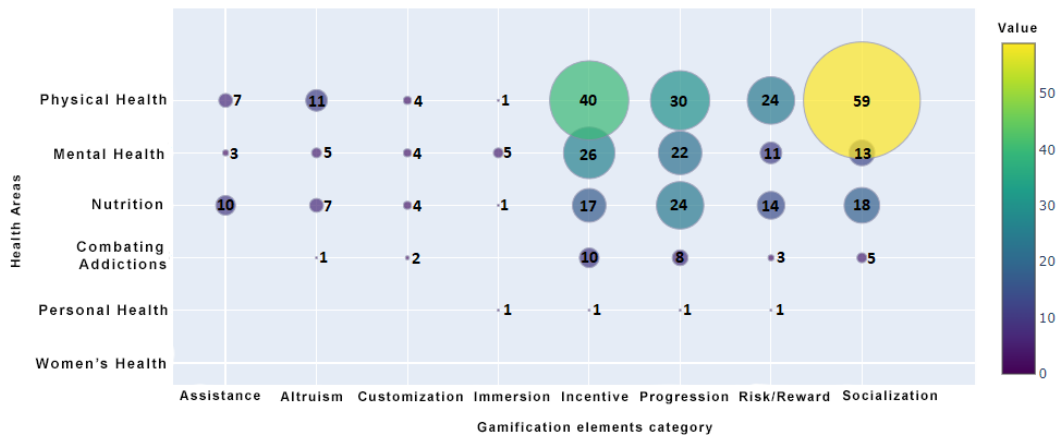


Figure 1. Occurrence of gamification elements by health area

### 3.2 Analysis of the Gamification Elements

The analysis of the selected applications lasted three months and 14 days. Each of the 70 applications was installed on an Android smartphone (Samsung Galaxy A54), and all available functions were used to collect the gamification elements used in it<sup>3</sup>.

The minimum number of elements in an app was two gamification elements (8/70, 11%), and the maximum was 14 (1/70, 1%) found in one mHealth app. More than half of the apps analyzed use 3 (10/70, 14%), 4 (18/70, 25%), or 5 (9/70, 12%) gamification elements.

The most commonly found health areas were physical health (27/70, 39%), mental health (19/70, 27%), nutrition (17/70, 24%), and combating addictions (8/70, 11%). The least commonly found category was personal health (1/70, 1%), and no gamified mHealth apps were found in the women’s health category set.

Considering the type of gamification elements found, the most commonly used were levels or progress feedback (67/70, 95%), quests or challenge (49/70, 70%), badges or achievements (35/70, 50%), points or scoring (22/70, 31%), social networking (22/70, 31%), personalization (20/70, 28%), exploratory world (20/70, 28%) and social status (19/70, 27%).

The least commonly used elements were development tools (2/70, 3%), lotteries (2/70, 3%), meaning or purpose (2/70, 3%), social cooperation (6/70, 8%), and narrative or theme (8/70, 11%). Those that had not been used once were the elements of artificial assistance, trading, and voting mechanisms.

The category of gamification elements most applied in the mHealth applications analyzed are incentive, progression, risk/reward, and socialization. The progression category, in which the element of gamification levels or progress feedback is present, is the most balanced category among the areas of activity, being widely used in all areas. The customization and immersion categories have few occurrences, thus being the least used categories.

In the field of **physical health**, the categories most used are socialization (59 elements), incentive (40 elements), progression (30 elements), risk/reward (24 elements), and al-

truism (11 elements). In the **mental health** area of activity, the most used categories are incentive (26 elements), progression (22 elements), socialization (13 elements), and risk/reward (11 elements).

In the **nutrition** area, the most used categories are progression (24 elements), socialization (18 elements), incentive (17 elements), risk/reward (14 elements), and assistance (10 elements). In the area of **combating addictions**, the most used are incentive (10 elements) and progression (8 elements). The areas of **personal health** and **women’s health** do not present significant results, as, in the set of mHealth applications analyzed, there are not enough applications in these areas.

We can still observe that, in Figure 1, the area of **physical health** mostly uses elements from the socialization category, which involve connection, cooperation, competition, and comparison between users, with ratings that determine how well users perform concerning other users. Other areas do not use many social elements such as these. Furthermore, the **physical health** area is the one that presents most elements in the incentive and risk/reward category, mainly in applications that offer challenges and rewards for meeting the challenges.

The **nutrition** area is where the assistance category is most used, related to the application’s ability to adapt to the user’s needs. The immersion category only appears more than once in **mental health** applications, where the application presents typically a story or narrative to be followed when using the application’s resources.

Figure 1 shows the occurrence of each category of gamification elements by health area.

## 4 Potential Adverse Effects: literature perspective

To investigate the potential adverse effects of gamification in mHealth applications, a literature review was carried out using the snowballing procedure [Wohlin, 2014]. The snowballing procedure was chosen due to its flexibility in inclusion. While systematic reviews often adhere to strict inclusion and exclusion criteria, the snowballing procedure can be more flexible in including studies that may be relevant but do

<sup>3</sup>The complete analysis of the gamified mHealth applications can be found in <https://bit.ly/3TNzpZk>

not meet all the specific criteria of a systematic review. Furthermore, according to Wohlin [2014], snowballing is particularly useful for extending a systematic literature review, as new studies are almost certain to cite at least one article from the previously relevant studies or systematic review already conducted in the field.

The next sections present the procedure for performing the snowballing, the execution of the process, and the results obtained.

## 4.1 Snowballing Procedure

The first step of the snowballing procedure is to define the initial set of studies to initiate the process. Following the guidelines established by Wohlin [2014], to avoid bias towards any specific publisher, we used Google Scholar to define this initial set.

Once the initial set is decided, it is time to start the first iteration, snowballing backward and forward. Including an article means that it must be examined against the inclusion and exclusion criteria before being used in subsequent iterations. For this purpose, the following inclusion and exclusion criteria were defined.

The inclusion criteria determined were:

- contains at least one of the following terms: “*Gamification*” or “*Gamification elements*”;
- contains at least one of the following terms: “*Negative impacts*” or “*Adverse effects*” or “*Disadvantage*” or “*Obstacles*”;
- the title, keywords, and abstract must be related to the research topic (mHealth);
- presents clear contributions to the research questions.

Publications that met any of the following criteria were excluded from the review:

- duplicate articles;
- studies that are not written in English;
- studies characterized as a tutorial, workshop, technical report, thesis, or dissertation;
- unavailability of access.

In the first iteration, each study from the initial set is analyzed. Then, the backward step is performed, where the reference list is examined to identify new studies, always seeking studies based on the inclusion and exclusion criteria. Studies that have already been analyzed in previous iterations are discarded. The title, publication venue, authors, and relevant parts are scrutinized for each potentially relevant study to decide whether it should be included in the next iteration.

In the forward step, studies that cite this study are analyzed. Each citation is found using Google Scholar. The study information is analyzed similarly as in the backward step. Each selected study is then added to a list for the next iteration.

Each new article is “stacked” for the next round of forward and backward steps. The process ends when no new articles are added to this stack. Then, each chosen study is read thoroughly to collect the research results.

## 4.2 Snowballing Execution

To initiate the snowballing process, studies on the adverse effects of gamification in mHealth were searched on Google Scholar using keywords such as “adverse effects” or “negative impacts.” According to Wohlin [2014], although there is no recipe for defining the initial set of studies, a helpful approach is to select highly cited articles in the field or those that contribute significantly to the research topic. After analyzing the results provided, based on these characteristics, the following studies were selected to compose the initial set:

- **P1:** Schmidt-Kraepelin, M., Thiebes, S., Stepanovic, S., Mettler, T., and Sunyaev, A. (2019) Gamification in health behavior change support systems - A synthesis of unintended side effects, in Proceedings of the 14th International Conference on Wirtschaftsinformatik, Germany. p. 1032-1046. = This study was selected considering its results are focused on the adverse effects of gamification in mHealth;
- **P2:** Johnson, D., Deterding, S., Kuhn, K.A., Staneva, A., Stoyanov, S., and Hides, L. (2016). Gamification for health and wellbeing: A systematic review of the literature. *Internet Interventions* 6. p. 89–106. = This study was selected for being highly cited and addressing gamification’s mixed and negative effects in mHealth.

The overall process lasted four iterations to complete the literature review until no new relevant studies were found. The procedure totaled 37 studies at the end of the iterations, as shown in Figure 2<sup>4</sup>.

## 4.3 Snowballing Results

During the analysis of the selected studies, 19 potential adverse effects of using gamification in mHealth applications were identified. Among these potential effects, motivation decreasing over time, lack of understanding, breakdown of intrinsic motivation, distraction from health purpose, privacy infringements, and irrelevance to health context were the most common adverse effects in the analyzed articles. Table 1 presents all the adverse effects found and the number of times they appear in the studies. These effects are described below.

**Motivation decreasing over time.** The novelty effects describe a situation where users are initially typically curious and excited about gamification, as it is visually appealing and something they have not experienced before [Sardi *et al.*, 2017]. However, interest and enthusiasm for gamification will likely diminish in the long term as these novelty effects wear off [Schmidt-Kraepelin *et al.*, 2019a]. Motivation may fade as the user becomes accustomed to and familiar with gamification [Sardi *et al.*, 2017]. It may also happen that gamification elements start to become repetitive; El-Hilly *et al.* [2016] describe this effect in their study of a gamified app for smoking cessation, where participants exhibited monotony and reduced levels of engagement. Studies suggest that gamification is a viable tool in the short term and that further investigation is needed to observe whether the effects are sustainable in the long term.

<sup>4</sup>The selected articles can be found in <https://bit.ly/4ap6MXw>





Figure 2. Snowballing iterations

**Lack of understanding.** The introduction of gamification into a mHealth app is invariably associated with adding new interaction possibilities for the user. Consequently, established paths of human-computer interaction may change, and users may initially become confused as the app no longer functions as it used to [Sardi *et al.*, 2017]. Gamifying an mHealth app adds a layer of interaction complexity and may thus lead to an initial decrease in usability [Schmidt-Kraepelin *et al.*, 2019a]. Furthermore, some gamification elements do not provide tangible meaning regarding the user’s health competence and progression and may sometimes be erroneously placed on the app screen [Sardi *et al.*, 2017].

Table 1. Potential adverse effects found in the articles

Potential Adverse Effects	Occurrences
Motivation decreasing over time	15
Lack of understanding	13
Breakdown of intrinsic motivation	9
Distraction from health purpose	9
Privacy infringements	9
Irrelevance to the health context	8
Unfulfilled expectations	7
Discouragement due to failure	7
Trivializing the health context	7
No consideration for target audience	6
Cheating	5
Lack of diversity of gamification elements	5
Pressure from competition or goals	5
Reward for incorrect execution	4
Overuse	3
Exaggerated or insignificant reward	2
Exaggerated punishment	2
Feeling of manipulation	2
Negative psychological states	2

**Breakdown of intrinsic motivation.** Gamified applications sometimes focus on extrinsic motivation and, consequently, may undermine and impair intrinsic motivation [Schmidt-Kraepelin *et al.*, 2019a]. As a result, users’ health behavior may become dependent on the presence of gamified elements, and their motivation may decrease immediately when extrinsic rewards are no longer available [Attig and Franke, 2019; El-Hilly *et al.*, 2016].

**Distraction from health purpose.** Due to a lack of un-

derstanding, gamification concepts sometimes fail to provide tangible health-oriented meaning regarding user health competence and progression [Sardi *et al.*, 2017]. As a result, it can be difficult for users to identify a connection between gamification concepts and their health behavior, leading to a lack of understanding regarding the purpose of certain gamification elements [Schmidt-Kraepelin *et al.*, 2019a]. Consequently, users may become distracted from the intended health goals, ultimately negatively impacting the effectiveness of mHealth applications [Boendermaker *et al.*, 2016].

**Privacy infringements.** According to Arora and Razavian [2021], privacy is one of the major concerns among many users of gamified mHealth applications. Several studies reported users’ concerns regarding the lack of privacy when using a gamified mHealth application. This concern stemmed from users feeling uncomfortable with tracking or sharing their data or unsure how the application might use them. In the study by Orji *et al.* [2017], the primary negative feedback identified was that socialization gamification elements could be invasive and interfere with an individual’s privacy by revealing the person’s health information to other users.

**Irrelevance to the health context.** Sometimes, gamification elements are perceived as meaningless and not helpful regarding the health purposes of the application [Sardi *et al.*, 2017]. In the work by Zuckerman and Gal-Oz [2014], it was found that certain gamification elements become irrelevant depending on the context in which they are implemented (physical health or mental health).

**Unfulfilled expectations.** Gamifying mHealth applications can raise high expectations, claiming to bring fun and engagement to health activities while maintaining the effectiveness of the application. If these expectations are unmet, users may become disappointed, decreasing satisfaction levels [Schmidt-Kraepelin *et al.*, 2019a].

**Discouragement due to failure.** Gamification typically relies on goal-oriented gaming elements [Schmidt-Kraepelin *et al.*, 2019a]. The work by van Dooren *et al.* [2019] found that if a user fails to complete a task despite significant effort, they may feel discouraged with the application. It is particularly important for more serious contexts, such as heart diseases, that developers avoid a sense of failure due to incomplete tasks [Dithmer *et al.*, 2016].

**Trivializing the health context.** Because gamification often resembles real games, its design is often colorful and appealing [Johnson *et al.*, 2016]. However, in some cases,

overly flashy visual design can lead to perceptions that important health topics, which deserve a serious and professional tone, may be trivialized. This can make users feel that gamification is more of a marketing gimmick than a serious tool supporting behavioral change in health [McDaniel, 2016; Schmidt-Kraepelin *et al.*, 2019a]. According to Sardi *et al.* [2017], healthcare professionals lack involvement in designing and developing gamified mHealth applications, which diminishes their credibility and respect among users.

**No consideration for the target audience.** Gamification employs game-like complex interfaces that are more challenging for individuals inexperienced with games [Warsinsky *et al.*, 2021]. Another significant issue is that most gamified solutions for mHealth are not user-centered, as they disregard the demographic characteristics of the target users to a significant extent, thus failing to provide an appropriate solution [Sardi *et al.*, 2017]. In this regard, gamification can become more challenging for children, the elderly, and individuals inexperienced with games [Johnson *et al.*, 2016; Sardi *et al.*, 2017].

**Cheating.** Gamification in mHealth can open the door to cheating and exploitation, similar to what happens in real games [Gal-Oz and Zuckerman, 2015]. Especially users who are more interested in obtaining rewards from the application than actual health behavior change sometimes attempt to achieve a goal in a way that should not be achieved according to the rules of the application [Gal-Oz and Zuckerman, 2015; Pereira *et al.*, 2014; Schmidt-Kraepelin *et al.*, 2019a].

**Lack of diversity of gamification elements.** According to Sardi *et al.* [2017], building an entire gamified solution based on a single gamification element can reduce the effectiveness of the solution and thus lead to direct failure. Meanwhile, Boendermaker *et al.* [2016] found that minimal gamification elements alone are insufficient to increase motivation; moreover, most users will likely compare any use of a gamified mHealth application with what they believe a gaming experience should look like.

**Pressure from competition or goals.** Gamification often includes competitive gamification elements that, for example, allow comparing scores among different users [Gal-Oz and Zuckerman, 2015]. However, competition and social comparison are not for everyone; introverted users are likely to be demotivated by gamification that contains social comparison [Orji *et al.*, 2017]. Users may feel uncomfortable using competition to motivate healthy behavior and may even become demotivated if they lose [Orji *et al.*, 2017]. Users may feel pressured to meet goals and challenges or progress in the application [Orji *et al.*, 2017].

**Reward for incorrect execution.** It is necessary to ensure that the rewards and progress within the gamified mHealth application adequately reflect people's health behavior [Schmidt-Kraepelin *et al.*, 2019a]. If the gamification concept is not sufficiently aligned with the desired health behavior change, users may be inadvertently incentivized by incorrect or harmful behaviors. [McDaniel, 2016].

**Overuse.** Gamification concepts that are not sufficiently balanced but reward excessive repetitions of certain tasks can encourage users to use a mHealth app excessively, thereby surpassing their limits and even becoming an obsession [Barratt, 2017; Schmidt-Kraepelin *et al.*, 2019a]. Users driven by

peer pressure and competition may end up overusing the app, negatively impacting their overall health [Barratt, 2017].

**Exaggerated or insignificant reward.** Sardi *et al.* [2017] found some gamified mHealth apps that offer a valuable reward for an activity that does not require significant effort and apps that offer insignificant rewards for activities that require considerable effort.

**Exaggerated punishment.** Users may be discouraged due to a disproportionate sense of punishment for failing a task, resulting in discouragement or even the user ceasing to use the application [Gal-Oz and Zuckerman, 2015; Schmidt-Kraepelin *et al.*, 2019a].

**Feeling of manipulation.** Users may perceive the feeling of being manipulated or coerced into performing certain activities or actions [Schmidt-Kraepelin *et al.*, 2019a]. Barratt [2017] reported that participants in a study of a cycling app complained of negative experiences due to a restricted level of autonomy. Similarly, Arora and Razavian [2021] reported that gamified mHealth apps exploit concepts from cognitive psychology to manipulate users into using the apps or sharing information about them.

**Negative psychological states.** Some users may experience extreme psychological states (such as stress, anger, and anxiety) due to the gamified mHealth app. Arora and Razavian [2021] found reports of users becoming overly stressed while chasing in-game rewards. Users may feel anxious or stressed because of competitive elements or because their data is being violated [Arora and Razavian, 2021; Yang and Li, 2021].

#### 4.4 Gamification elements and their potential adverse effects

From the analysis of the selected studies, it was possible to identify which gamification elements are related to potential adverse effects in mHealth applications. It was found that 30 out of the 37 selected studies addressed this relationship. Each study was examined to identify the connection between gamification elements and potential adverse effects. The graph presented in Figure 3 illustrates the results obtained from the conducted mapping. This visualization helps to understand how gamification elements may be associated with potential adverse effects and which are most likely to lead to a potential adverse effect.

Among the 19 potential adverse effects of gamification in mHealth found, only *no consideration for target audience*, *lack of diversity of gamification elements*, and *feeling of manipulation* did not have connections with gamification elements. The gamification elements most frequently cited as potential causes of adverse effects were *Badges* or *Achievements* (39), *Points* or *Scoring* (34), *Levels* or *Progress Feedback* (19), *Rewards* or *Prizes* (18), *Social Comparison* (16), and *Social Competition* (12).

For the gamification element of *Badges* or *Achievements*, El-Hilly *et al.* [2016] observed, in a mHealth application for smoking cessation, that this element can lead to diminishing motivation over time as they become repetitive. Additionally, some gamification elements (such *Points* or *Scoring*, *Badges* or *Achievements*, and *Levels* or *Progress Feedback*) did not provide a tangible health meaning in terms of

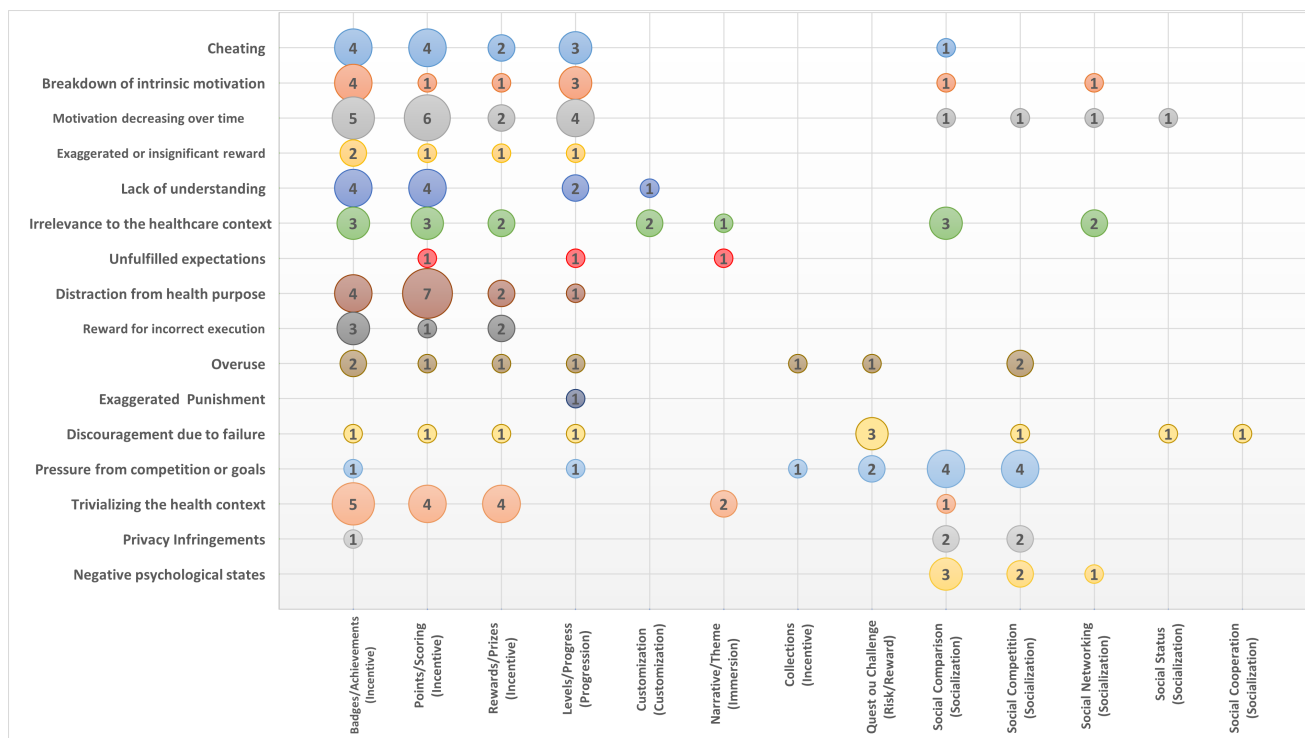


Figure 3. Gamification elements and their potential adverse effects

user competence and health progression and were sometimes mistakenly located on the app screen (lack of understanding and distraction) [Sardi *et al.*, 2017; Schmidt-Kraepelin *et al.*, 2019a].

For the gamification element of *Points* or *Scoring*, *Rewards* or *Prizes*, and *Badges* or *Achievements*, Johnson *et al.* [2016] reported that participants suggested that they did not fit well into the context of mental well-being and mindfulness. These elements were considered irrelevant to the health context and identified as potential distractions from the health purpose for users.

A user may become so obsessed with the *Points* or *Scoring*, and *Badges* or *Achievements* elements that they may lose sight of their original goal of being healthy, potentially leading to the trivialization of the health context as a potential adverse effect. [Arora and Razavian, 2021].

Negative psychological states can be induced by gamification elements such as *Social Competition* and *Social Comparison*, or when users suspect others of cheating to obtain rewards [Arora and Razavian, 2021]. Users more interested in gamification elements like rewards than in healthy activity may cheat by exploiting inherent limitations of the application [Gal-Oz and Zuckerman, 2015]. Cheating may escalate as users strive to reach higher levels solely for rewards [Sardi *et al.*, 2017]. Just as cheating occurs in online games, it is reasonable to assume it also occurs in gamified mHealth applications.

Even if a healthy exercise has not been performed correctly, distributing reward elements can lead to incorrect fixed execution of an activity [McDaniel, 2016]. Lumsden *et al.* [2016] reported that the gamification element *Narrative* or *Theme* can lead to the effect of unfulfilled expectations when used alone, as, according to the authors, the element

resembles a game but does not offer actual gameplay.

Motivation for physical activity in mHealth can become dependent on the presence of an element that tracks activity, such as *Levels* or *Progress Feedback*, and motivation decreases if these elements are no longer available [Attig and Franke, 2019]. Barratt [2017] reported, in their study with gamified mHealth for cyclists, that elements of *Social Competition*, *Levels* or *Progress Feedback*, *Rewards* or *Prizes*, and *Badges* or *Achievements* can create cyclists driven by obsession, resulting in issues related to overuse.

Social elements, such as *Social Competition*, *Social Comparison*, *Social Networking*, and *Social Cooperation*, can lead to privacy violations by sharing users' health data [El-Hilly *et al.*, 2016; Gal-Oz and Zuckerman, 2015; Orji *et al.*, 2017]. It has also been reported that *Social Competition* can lead to motivation breakdown when users lose, and *Social Cooperation* can become discouraging when a teammate fails in activities Orji *et al.* [2017]. The elements of *Social Comparison* and *Social Competition* can have adverse effects on users' health behavior, leading to a sense of pressure to win competitions and climb rankings [Barratt, 2017; Gal-Oz and Zuckerman, 2015; Zuckerman and Gal-Oz, 2014].

The findings of this study provide a comprehensive overview of the potential adverse effects of gamification in mHealth applications and the relationship between gamification elements and these potential adverse effects.

## 5 Potential Adverse Effects: users' perspective

A study was conducted through an online questionnaire to analyze the user's perspective about the theme. The study was



submitted and approved by the University Research Ethics Committee <sup>5</sup>.

The online questionnaire was conducted using the Google Forms tool and was available for one month and 14 days. The questionnaire comprised nine sections, collecting data about users' profiles, the use of mHealth applications, the health areas of mHealth applications, the use of gamification in these applications, the users' perspectives on the gamification elements used by the applications, as well as the potential adverse effects and their risks <sup>6</sup>. The definition of gamification and the definition of the gamification elements were included in the questionnaire to ensure that participants had the same understanding of them.

The questionnaire did not address all categories of gamification elements, focusing on the most commonly used categories identified during the analysis of mHealth applications. This approach was adopted to prevent the questionnaire from becoming lengthy and tiresome for the participants.

### 5.1 User Study Results

A total of 44 responses were obtained. Regarding the participants' profiles, 25 identified themselves as male, while 19 identified as female. Regarding age range, 30 indicated being between 18 and 30 years old, while 14 were between 31 and 52 years old.

Regarding mHealth applications, 41 participants responded that they use mHealth applications, while three responded that they do not. For these 3 participants, the questionnaire was ended before proceeding to the following sections. Considering the area of activity, the majority indicated was applications for physical health, as shown in Figure 4.

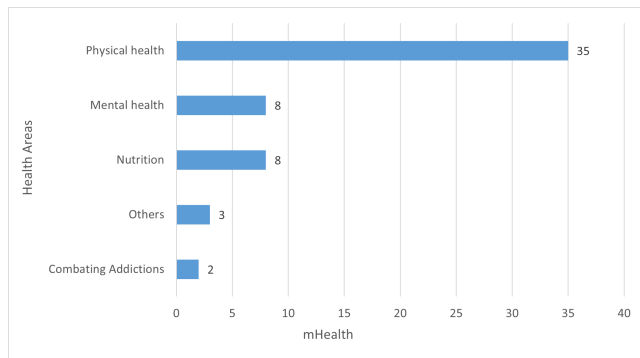


Figure 4. Health areas of participants' mHealth apps

Regarding gamified mHealth applications, 28 of the 41 participants who reported using mHealth applications stated that the application they use incorporates gamification. Only these 28 were eligible to answer the subsequent sections of the questionnaire.

In the following sections, which asked about the categories of gamification elements present in the mHealth applications used by the participants, 28 participants mentioned that gamified mHealth applications have Risk/Reward gamification elements, 27 mentioned Progression elements, 25

mentioned Incentive elements, 21 mentioned Socialization elements, and ten mentioned Customization elements.

Considering the potential adverse effects of **Progression** gamification elements, out of the 27 participants who reported that gamified mHealth applications have elements of this type, 12 considered themselves trapped or stuck in the progression of the mHealth app, 12 considered these elements irrelevant to the health context, stating that it would not affect their decision to use or not use the mHealth app, and 11 mentioned that these elements distract them from the app's health purpose.

Regarding the potential adverse effects of **Risk/Reward** gamification elements, out of the 28 participants who reported that gamified mHealth applications have elements of this type, 11 consider the Risk/Reward elements irrelevant to the health context, nine consider them to distract from the health app's purpose, and 17 responded that they have felt anxious or pressured to meet goals or challenges set by the application.

Concerning the potential adverse effects of **Incentive** gamification elements, out of the 25 participants who responded to the related questions, 14 considered Incentive elements irrelevant to the health context, eight mentioned that they distract from the health app's purpose, 19 reported that rewards associated with this element started to diminish or became too repetitive, and 15 mentioned that motivation and interest in the app decreased when this happened. Additionally, eight admitted attempting to circumvent the app to obtain a reward without performing the related activity.

Regarding the potential adverse effects of **Socialization** gamification elements, out of the 21 participants who responded to the related questions, 13 considered Socialization elements irrelevant to the health context, and 7 mentioned that they distract from the health app's purpose.

Concerning the potential adverse effects of **Customization** gamification elements, out of the 10 participants who responded to the related questions, five considered Customization elements irrelevant to the health context, and 2 mentioned that they distract from the health app's purpose.

Finally, regarding the potential adverse effects of gamification in mHealth apps, 4 out of 28 participants stated that they experienced some difficulty using the app due to gamification elements, six mentioned using the app excessively because of gamification elements, ten affirmed that excessive use of gamified mHealth apps can be detrimental to health, and eight stated that they felt losing motivation over time.

When asked about the possibility of these apps' gamification causing dependence or obsession, 23 participants expressed their opinions. Of the 23 participants, 13 responded affirmatively, believing that gamification in health and wellness apps can create dependence or obsession. This sentiment is exemplified by the following comments: "naturally, some people have a stronger sense of competition and, in these cases, this can reinforce dependence or obsession" and "I believe that (gamification) can generate an effect of anxiety, obsession to meet goals [...]. A kind of obligation" <sup>7</sup>

The comments also indicate that dependence and obses-

<sup>5</sup>CAEE protocol: 68524723.1.0000.5336

<sup>6</sup>The complete questionnaire in Portuguese can be found in <https://bit.ly/4ddPkqf>

<sup>7</sup>Translation of participant's responses was made by the authors (Portuguese to English)

sion may occur more frequently in mHealth apps for physical health, as evidenced by the following comments: *"...because not being able to meet the goal in some weeks leaves me a little shaken and I end up exerting myself more than ideal, which ends up causing injuries in the case of running"* and *"...I've seen reports like this mainly for physical activity apps"*.

This dependence and obsession can also occur when incentive elements are present, as indicated by the following comments: *"...it can happen due to the reward system, causing a certain addiction"* and *"I believe that receiving incentives and prizes can cause the same type of dependency as conventional electronic games with reward mechanics, with the release of happiness/pleasure neurotransmitters upon reaching goals"*. Additionally, they may occur when socialization elements are present: *"...it can happen with those who feel motivated to always show their progress on social networks, through the screens of the application [...]. Improve their ego"*.

When asked if they had experienced any other potential adverse effects while using a gamified mHealth app, 21 participants expressed their opinions, with eight reporting that they had experienced other potential adverse effects.

Of these, 5 participants reported experiencing extreme psychological states, such as anger and stress - *"...it just makes me angry that the app is demanding and requiring goals"* and *"...the rewards from Strava sometimes made me anxious for not progressing (advancing in the app) because I always ran in the same place"*.

Moreover, a user may experience a mix of negative feelings, such as anxiety, discouragement, and frustration (*"When the app notifies that the daily goal has not yet been achieved, it generates a certain anxiety and discouragement..."*). Another participant reported finding it challenging to understand and use a gamified mHealth app: *"...in the app, it's hard to decipher, causing anger, frustration, and eventually leading to inactivity in the app"*.

Three participants reported feeling pressured when using a gamified mHealth app, as mentioned by one of them: *"...the pressure to improve my performance"*. Another participant reported that he even stopped using the gamified app: *"I stopped using the apps that were supposed to help me with anxiety because they kept pressuring me, in a gamified way, to make the records and always record more, which made me more anxious. Terrible experience"*.

And finally, 3 participants reported that gamification is irrelevant to them: *"The negative effect of gamification is that for my profile it doesn't stimulate, and I find it boring..."* and *"...I don't want to post anything, earn any badge, medal, this or that"*. This can lead the user to have poor usage experiences: *"...for the app only that matters (achievements, badges), if there isn't one or the other badge it doesn't open new activities and the posted activities are already boring, and I'm not interested, I end up needing to cheat to be able to vary the stimuli [...]. And I end up abandoning the app"*.

With these results, in addition to the 19 potential adverse effects discovered through the literature review, three other potential adverse effects were identified based on the participant's responses, namely **dependency or obsession**, **decreasing rewards over time**, and **repetitive rewards**.

Furthermore, it is observed that some of the most commonly found potential adverse effects during the literature analysis were also encountered in the user study, such as **distraction from the health purpose**, **irrelevance to the health context**, **lack of understanding**, **motivation decreasing over time**, **cheating**, and **pressure from competition or goals**.

## 6 Discussion

Gamification should be used carefully, considering its possible adverse effects, even if unintentional. Developers of gamified mHealth applications must be aware of and understand the causes of these effects to incorporate appropriate strategies to address them during the design and development process.

To help understand these possible adverse effects, gamified mHealth apps were analyzed to discover which gamification elements are commonly used. It was found that more than half of the selected mHealth apps utilize 3, 4, or 5 gamification elements. The health areas of physical health, mental health, and nutrition were the most commonly encountered within the app set. Regarding gamification elements, *levels or progress feedback*, *quests or challenge*, *badges or achievements*, *points or scoring*, *social networking*, *personalization*, *exploratory world* and *social status*, were the most commonly employed for gamifying mHealth.

Another interesting result was the distribution of gamification elements by health area. For physical health apps, the most used elements are incentives, socialization, progression, and risk/reward. For mental health apps, the most used elements are incentives and progression. The most used elements for nutrition apps are progression, incentives, and socialization, and for addiction management apps, incentives, and progression. There was not enough data available for other focus areas within mHealth apps.

After the apps' analysis, a literature review was conducted to investigate potential adverse effects associated with the use of gamification in mHealth apps. After analyzing 37 studies selected through snowballing, 19 potential adverse effects were identified. Among them, the most commonly reported in the studies were motivation decreasing over time, lack of understanding, breakdown of intrinsic motivation, distraction from health purpose, privacy infringements, irrelevance to health context, unfulfilled expectations, discouragement due to failure, and trivialization of the health context.

Analyzing the selected studies, it was also possible to identify which gamification elements could cause the potential adverse effects identified. The results indicate that the gamification elements most commonly cited as causing potential adverse effects were: *badges or achievements* (incentive), *points or scoring* (incentive), *rewards or prizes* (incentive), *levels or progress feedback* (progression), *social comparison* (socialization) and *social competition* (socialization).

Considering the results obtained from the literature review, a user study was conducted through an online questionnaire for users of gamified mHealth applications. After analyzing the questionnaire results, it was found that most participants use mHealth applications for physical health. Additionally,

three other potential adverse effects were identified, namely dependence or obsession, decreasing rewards over time, and repetitive rewards.

Triangulating the results of the literature review and the user study, it was possible to relate gamification elements to the potential adverse effects they may cause. Progression elements may predominantly lead to a lack of understanding, irrelevance to the health context, distraction from health purposes, and inducing negative psychological states. Gamification elements of the risk/reward category may predominantly lead to irrelevance to the health context, distraction from health purposes, pressure from competition or goals, dependence or obsession, and inducing negative psychological states. Incentive elements may predominantly lead to irrelevance to the health context, distraction from health purposes, motivation decreasing over time, decreasing rewards over time, repetitive rewards, cheating, overuse, dependence, or obsession, and inducing negative psychological states. Socialization elements may predominantly lead to irrelevance from the health context, distraction from health purposes, dependence or obsession, overuse, and pressure from competition or goals. Lastly, customization elements may predominantly lead to irrelevance to the health context and distraction from health purposes.

After analyzing all the studies conducted in this research, 22 potential adverse effects of gamification in mHealth applications were found: 19 potential adverse effects extracted from the literature review results and three potential adverse effects extracted from the user study results.

## 7 Conclusion

While gamification has received significant attention from professionals and researchers interested in mHealth, little attention has been paid to its associated potential adverse [Schmidt-Kraepelin *et al.*, 2019a].

The results of this work contribute to the knowledge base on gamification by providing insights about these potential adverse effects. Based on the literature review and the user studies, 22 potential adverse effects were identified, along with an analysis of these effects, providing a connection between existing gamification elements and how they may potentially be related to adverse effects. Thus, we believe we have taken an important step toward understanding and contributing to this gap, as the risks associated with gamification in mHealth applications are essential aspects to be considered by developers, designers, and professionals in the field.

### 7.1 Limitations

One limitation of this work regarding application analysis is that it was carried out in only one of the existing app stores despite being the largest. Another limitation is that the app store lists the top apps by country, and different apps may appear in searches in different countries. This research was conducted in Brazil, so the findings may reflect app availability specific to that region.

Regarding the literature review, another limitation of this study is the presence of false negatives in the study filter-

ing process. All articles were selected based solely on titles, abstracts, and keywords, which may not contain sufficient information to make inclusion decisions.

Considering the user study, a limitation is related to the respondents' profiles, which have different usage experiences with a gamified mHealth application. It was also noted that most of the applications used by participants focused on physical health, leading to results that are more inclined toward this area. This same limitation was observed in the application analysis, with the majority focusing on physical health. Additionally, gender and age were not considered in the analysis, which may limit the understanding of how these factors influence the results.

Another limitation is the use of a small sample size of participants, which may affect the generalization of the findings. Furthermore, the focus was exclusively on free mHealth applications, which may not fully represent the range of available apps.

### 7.2 Future Works

In future work, new studies involving healthcare professionals to gather their perceptions on gamification elements and their adverse effects could bring light to this discussion. Also, analyzing potential adverse effects reported by mHealth users under the care of healthcare professionals is necessary research.

Another future work involves observing how designers and developers of gamified mHealth applications use the final set of adverse effects to track how the research's outcomes may influence their design.

Lastly, longitudinal studies are recognized as necessary to monitor the usage of these applications and gather more precise results.

## Declarations

### Acknowledgements

The authors would like to thank the research participants.

### Funding

This work was achieved in cooperation with HP Brasil Indústria e Comércio de Equipamentos Eletrônicos LTDA. and with resources from the Information Technology Law (Law No. 8,248, of 1991).

### Authors' Contributions

**Ivan Rocha:** Conceptualization, Methodology, Investigation, Validation, Writing – original draft. **Milene Selbach Silveira:** Supervision, Methodology, Validation, Writing – review and editing.

### Competing interests

The authors declare that they have no competing interests.

## Availability of data and materials

The materials are available on the links provided in the article. If the links become broken, the materials can be made available upon request.

## References

- Almeida, C., Kalinowski, M., Uchôa, A., and Feijó, B. (2023). Negative effects of gamification in education software: Systematic mapping and practitioner perceptions. *Information and Software Technology*, 156:107142. DOI: 10.1016/j.infsof.2022.107142.
- Andrade, F. R., Mizoguchi, R., and Isotani, S. (2016). The bright and dark sides of gamification. In *13th International Conference on Intelligent Tutoring Systems*, pages 176–186. Springer-Verlag. DOI: 10.1007/978-3-319-39583-8\_17.
- Arora, C. and Razavian, M. (2021). Ethics of gamification in health and fitness-tracking. *International Journal of Environmental Research and Public Health*, 18(21):11052. DOI: 10.3390/ijerph182111052.
- Attig, C. and Franke, T. (2019). I track, therefore i walk—exploring the motivational costs of wearing activity trackers in actual users. *International Journal of Human-Computer Studies*, 127:211–224. DOI: 10.1016/j.ijhcs.2018.04.007.
- Barratt, P. (2017). Healthy competition: A qualitative study investigating persuasive technologies and the gamification of cycling. *Health & Place*, 46:328–336. DOI: 10.1016/j.healthplace.2016.09.009.
- Boendermaker, W. J., Maceiras, S. S., Boffo, M., and Wiers, R. W. (2016). Attentional bias modification with serious game elements: Evaluating the shots game. *Journal of Medical Internet Research: Serious Games*, 4(2):e6464. DOI: 10.2196/games.6464.
- Cheng, V. W. S., Davenport, T., Johnson, D., Vella, K., and Hickie, I. B. (2019). Gamification in apps and technologies for improving mental health and well-being: Systematic review. *Journal of Medical Internet Research: Mental Health*, 6(6):e13717. DOI: 10.2196/13717.
- Cheng, V. W. S., Davenport, T. A., Johnson, D., Vella, K., Mitchell, J., and Hickie, I. B. (2018). An app that incorporates gamification, mini-games, and social connection to improve men’s mental health and well-being (mind-max): Participatory design process. *Journal of Medical Internet Research: Mental Health*, 5(4):e11068. DOI: 10.2196/11068.
- Chung, A. E., Griffin, A. C., Selezneva, D., and Gotz, D. (2018). Health and fitness apps for hands-free voice-activated assistants: Content analysis. *Journal of Medical Internet Research: mHealth and uHealth*, 6(9):e9705. DOI: 10.2196/mhealth.9705.
- Deterding, S., Dixon, D., Khaled, R., and Nacke, L. (2011). From game design elements to gamefulness: defining “gamification”. In *International academic MindTrek conference: Envisioning future media environments*, pages 9–15. Association for Computing Machinery. DOI: 10.1145/2181037.2181040.
- Dithmer, M., Rasmussen, J. O., Grönvall, E., Spindler, H., Hansen, J., Nielsen, G., Sørensen, S. B., and Dinesen, B. (2016). The heart game: Using gamification as part of a telerehabilitation program for heart patients. *Games for Health Journal*, 5(1):27–33. DOI: 10.1089/g4h.2015.0001.
- El-Hilly, A. A., Iqbal, S. S., Ahmed, M., Sherwani, Y., Muntasir, M., Siddiqui, S., Al-Fagih, Z., Usmani, O., and Eisingerich, A. B. (2016). Game on? smoking cessation through the gamification of mhealth: A longitudinal qualitative study. *Journal of Medical Internet Research: Serious Games*, 4(2):e5678. DOI: 10.2196/games.5678.
- Gal-Oz, A. and Zuckerman, O. (2015). Embracing cheating in gamified fitness applications. In *2015 Annual Symposium on Computer-Human Interaction in Play*, pages 535–540. Association for Computing Machinery. DOI: 10.1145/2793107.2810298.
- Huotari, K. and Hamari, J. (2012). Defining gamification: a service marketing perspective. In *16th International Academic MindTrek Conference*, pages 17–22. Association for Computing Machinery. DOI: 10.1145/2393132.2393137.
- Hyrnsalmi, S., Smed, J., and Kimppa, K. (2017). The dark side of gamification: How we should stop worrying and study also the negative impacts of bringing game design elements to everywhere. In *GamiFIN*, pages 96–104. Available at: [https://www.researchgate.net/publication/316755065\\_The\\_Dark\\_Side\\_of\\_Gamification\\_How\\_We\\_Should\\_Stop\\_Worrying\\_and\\_Study\\_also\\_the\\_Negative\\_Impacts\\_of\\_Bringing\\_Game\\_Design\\_Elements\\_to\\_Everywhere](https://www.researchgate.net/publication/316755065_The_Dark_Side_of_Gamification_How_We_Should_Stop_Worrying_and_Study_also_the_Negative_Impacts_of_Bringing_Game_Design_Elements_to_Everywhere).
- Iqbal. App download and usage statistics 2022. Available at: <https://www.businessofapps.com/data/app-statistics>, Acesso: 2022-05-23.
- Iqbal. App revenue statistics 2022. Disponível em: <https://www.businessofapps.com/data/app-revenues>, Acesso: 2022-05-23.
- Johnson, D., Deterding, S., Kuhn, K.-A., Staneva, A., Stoyanov, S., and Hides, L. (2016). Gamification for health and wellbeing: A systematic review of the literature. *Internet Interventions*, 6:89–106. DOI: 10.1016/j.invent.2016.10.002.
- Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. John Wiley & Sons. Book.
- Klock, A. C. T., Gasparini, I., and Pimenta, M. S. (2016). 5w2h framework: a guide to design, develop and evaluate the user-centered gamification. In *15th Brazilian Symposium on Human Factors in Computing Systems*, pages 1–10. Association for Computing Machinery. DOI: 10.1145/3033701.3033715.
- Klock, A. C. T., Gasparini, I., Pimenta, M. S., and Hamari, J. (2020). Tailored gamification: A review of literature. *International Journal of Human-Computer Studies*, 144:102495. DOI: 10.1016/j.ijhcs.2020.102495.
- Lumsden, J., Edwards, E. A., Lawrence, N. S., Coyle, D., Munafò, M. R., et al. (2016). Gamification of cognitive assessment and cognitive training: A systematic review of applications and efficacy. *Journal of Medi-*

- cal Internet Research: Serious Games*, 4(2):e5888. DOI: 10.2196/games.5888.
- McDaniel, R. (2016). A taxonomy for digital badge design in medical technologies. In *IEEE International Conference on Serious Games and Applications for Health*, pages 1–8. IEEE. DOI: 10.1109/SeGAH.2016.7586254.
- Orji, R., Nacke, L. E., and Di Marco, C. (2017). Towards personality-driven persuasive health games and gamified systems. In *Conference on Human Factors in Computing Systems*, pages 1015–1027. DOI: 10.1145/3025453.3025577.
- Pereira, P., Duarte, E., Rebelo, F., and Noriega, P. (2014). A review of gamification for health-related contexts. In *International Conference of Design, User Experience, and Usability*, pages 742–753. DOI: 10.1007/978-3-319-07626-3\_70.
- Peters, D., Calvo, R. A., and Ryan, R. M. (2018). Designing for motivation, engagement and wellbeing in digital experience. *Frontiers in Psychology*, 9:797. DOI: 10.3389/fpsyg.2018.00797.
- Rapp, A., Hopfgartner, F., Hamari, J., Linehan, C., and Cena, F. (2019). Strengthening gamification studies: Current trends and future opportunities of gamification research. *International Journal of Human-Computer Studies*, 127:1–6. DOI: 10.1016/j.ijhcs.2018.11.007.
- Rocha, I. and Silveira, M. S. (2023). An analysis of gamification elements in mhealth applications. In *Proceedings of the XXII Brazilian Symposium on Human Factors in Computing Systems*, pages 1–10. Association for Computing Machinery. DOI: 10.1145/3638067.3638126.
- Sardi, L., Idri, A., and Fernández-Alemán, J. L. (2017). A systematic review of gamification in e-health. *Journal of Biomedical Informatics*, 71:31–48. DOI: 10.1016/j.jbi.2017.05.011.
- Schmidt-Kraepelin, M., Thiebes, S., Stepanovic, S., Mettler, T., and Sunyaev, A. (2019a). Gamification in health behavior change support systems—a synthesis of unintended side effects. In *14th International Conference on Wirtschaftsinformatik*, pages 1032–1046. Available at: [https://serval.unil.ch/resource/serval:BIB\\_4B8751E9C432.P001/REF.pdf](https://serval.unil.ch/resource/serval:BIB_4B8751E9C432.P001/REF.pdf).
- Schmidt-Kraepelin, M., Thiebes, S., and Sunyaev, A. (2019b). Investigating the relationship between user ratings and gamification—a review of mhealth apps in the apple app store and google play store. In *52nd Hawaii International Conference on System Sciences*, pages 1496–1505. DOI: 10.24251/HICSS.2019.181.
- Schmidt-Kraepelin, M., Toussaint, P. A., Thiebes, S., Hamari, J., Sunyaev, A., et al. (2020). Archetypes of gamification: Analysis of mhealth apps. *Journal of Medical Internet Research: mHealth and uHealth*, 8(10):e19280. DOI: 10.2196/19280.
- Seaborn, K. and Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of Human-Computer Studies*, 74:14–31. DOI: 10.1016/j.ijhcs.2014.09.006.
- Sweileh, W. M., Al-Jabi, S. W., AbuTaha, A. S., Zyoud, S. H., Anayah, F., and Sawalha, A. F. (2017). Bibliometric analysis of worldwide scientific literature in mobile-health: 2006–2016. *Bio Med Central: Medical Informatics and Decision Making*, 17(1):1–12. DOI: 10.1186/s12911-017-0476-7.
- Tondello, G. F., Mora, A., and Nacke, L. E. (2017). Elements of gameful design emerging from user preferences. In *Annual Symposium on Computer-Human Interaction in Play*, pages 129–142. Association for Computing Machinery. DOI: 10.1145/3116595.3116627.
- van Dooren, M. M., Siriaraya, P., Visch, V., Spijkerman, R., and Bijkerk, L. (2019). Reflections on the design, implementation, and adoption of a gamified ehealth application in youth mental healthcare. *Entertainment Computing*, 31:100305. DOI: 10.1016/j.entcom.2019.100305.
- Warsinsky, S., Schmidt-Kraepelin, M., Thiebes, S., and Sunyaev, A. (2021). Are gamification projects different? an exploratory study on software project risks for gamified health behavior change support systems. In *54th Hawaii International Conference on System Sciences*, pages 1305–1315. DOI: 10.24251/HICSS.2021.159.
- West, J. H., Hall, P. C., Hanson, C. L., Barnes, M. D., Giraud-Carrier, C., and Barrett, J. (2012). There’s an app for that: Content analysis of paid health and fitness apps. *Journal of Medical Internet Research*, 14(3):e1977. DOI: 10.2196/jmir.1977.
- WHO (2011). New horizons for health through mobile technologies. *World Health Organization*, pages 1–102. Available at: <https://www.afro.who.int/publications/mhealth-new-horizons-health-through-mobile-technologie>.
- Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. In *18th International Conference on Evaluation and Assessment in Software Engineering*, pages 1–10. Association for Computing Machinery. DOI: 10.1145/2601248.2601268.
- Yang, H. and Li, D. (2021). Understanding the dark side of gamification health management: A stress perspective. *Information Processing & Management*, 58(5):102649. DOI: 10.1016/j.ipm.2021.102649.
- Zuckerman, O. and Gal-Oz, A. (2014). Deconstructing gamification: Evaluating the effectiveness of continuous measurement, virtual rewards, and social comparison for promoting physical activity. *Personal and Ubiquitous Computing*, 18:1705–1719. DOI: 10.1007/s00779-014-0783-2.