Games that aim to promote antimicrobial stewardship: An overview of the entertainment potential
by Andreea Molnar

Abstract
Antimicrobial resistance is one of the most pressing healthcare issues. Healthcare awareness campaigns that promote antimicrobial stewardship have shown mixed results highlighting a need to look at complementary solutions to engage the public. In this context, games are increasingly used as an alternative to engaging users with healthcare issues; antibiotic stewardship makes no exception. The focus of research on games for health is on their effectiveness, the entertainment potential not receiving as much attention. In this paper, we address this gap. This study identifies a variety of methods used to assess entertainment value such as the number of users and user self-reported enjoyment. This provides a rich overview of the entertainment potential of games. However, as different games use different methods of assessment it makes it difficult to compare games and determine which aspects of games work best.

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1. Introduction
Antimicrobial resistance is one of the most critical global health challenges (Theuretzbacher, 2013). It leads to increased morbidity and mortality but also to an increase in healthcare costs (Jit, et al., 2020; Naylor, et al., 2018). It is estimated that by 2050, antimicrobial resistance could become the top cause of death (Review on Antimicrobial Resistance, 2016) and could cause an annual reduction of 3.8 percent in the global domestic product (World Bank, 2017).

Antibiotic resistance occurs when bacteria adapt in a way that antibiotics become ineffective in situations in which they were formally useful. The emergence of resistance is increased by misuse of antibiotics (Martin, 2006) or substandard or counterfeit antibiotic use (Kelesidis and Falagas, 2015). Discovery of new drugs helps; however in order for their impact to not be short-lived, changes in how antibiotics are used needs to
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be a priority. These changes have been challenged by various misconceptions regarding antibiotic use (Carter, et al., 2016; Oh, et al., 2018). For example, a survey of knowledge attitudes and perception towards antibiotics in South and East Asian countries have found that 50 percent of the sample mistakenly assumed that they could be used to treat colds (Oh, et al., 2018). Moreover, knowledge regarding antibiotic use and antibiotic resistance has been sometimes poorly communicated to the public; as a result, people think they know when they should use antibiotics (Wellcome Trust, 2015). Antibiotic resistance is often a concept difficult to understand, and people (including students in pharmacy, dentistry, and veterinary medicine) assume that it is the person who becomes resistant (Wellcome Trust, 2015). Some do not believe that antimicrobial resistance is an issue or assume that a solution will be found despite their behaviour (Wellcome Trust, 2015). In low and middle-income countries, up-to-date knowledge on optimal antibiotic use appears to be low (García, et al., 2011; Quet, et al., 2015; Thriemer, et al., 2013). A qualitative study done with GPs, pharmacists, and representative from pharmacies in England and Wales demonstrated that educational interventions were needed for staff (Jones, et al., 2018).

Therefore, educating people about the responsible use of antibiotics, and the risks involved, could potentially represent a solution, if not for eradicating antibiotic resistance completely, at least slowing its progress. However, existing healthcare campaigns often have shown mixed results in their effectiveness (Cox, et al., 2017). Some research has argued for a multifaceted approach in communicating targeted information (Cross, et al., 2017). Games have been suggested as an alternative to better involve people who might not otherwise be engaged (Molnar, 2019).

Traditional approaches to increase health awareness through campaigns (e.g., leaflets, TV or radio advertisements) or teaching students (lectures) have not not actively engaged their recipients. These are essentially passive methods, which have been shown in other contexts not to promote long-term retention (Lujan and DiCarlo, 2006) or understanding of critical concepts (McDermott, et al., 1994). It has been argued that games might be able to address these limitations due to their characteristics that actively involve players in the learning process (Molnar, 2019). Games have been used in educating clinicians (Castro-Sánchez, et al., 2016; Molnar, 2019) and the public (Molnar, 2019; Price, et al., 2018) about certain aspects of health, such as antimicrobial resistance.

Games were once neglected by science (Lujan and DiCarlo, 2006). Recently, they have been increasingly used in awareness campaigns, considered by some as more effective in education than traditional media (Molnar, 2019). Games can create a safe environment to test different decisions and strategies without multiple risks. They can simulate environments that are difficult to replicate due to time or resource constraints. Games increase enthusiasm in a topic (Gómez-Urquiza, et al., 2019) and can reinforce previously presented information (Molnar, et al., 2015). They have been shown to create a competitive atmosphere and increase interaction among students (Lujan and DiCarlo, 2006; Molnar, et al., 2019). Therefore, games could be seen as a viable solution to complement existing healthcare campaigns, addressing some of the limitations of the more “traditional approaches” (e.g., leaflets, advertisements).

Games under consideration in this paper combine two apparently contradictory aims: their entertainment potential and a healthcare message. Attention has been given to evaluating the effectiveness of games in delivering healthcare messages (i.e., knowledge, attitude, behaviour change) (Castro-Sánchez, et al., 2016; Farrell, et al., 2011a; van Dooren, et al., 2019). This research focuses on the entertainment potential of games, by presenting an overview of how entertainment has been measured in games aimed at improving antibiotic stewardship.

2. Methodology

To determine how the entertainment potential of games aims to improve antibiotic stewardship we performed a review. This review enabled the selection of an appropriate sample of papers and provided an
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The research follows Petticrew and Roberts’ (2006) recommendations: formulating research questions, deciding which databases to use as well as search terms, and determining how articles will be included, or excluded, from review.

2.1. Selection criteria

To identify articles included in the study we use the following query “(game OR games) AND (antimicrobial OR antibiotic ) AND (resistance)”. The search was restricted to title and abstract. We queried Scopus and PubMed for March 2021. All articles up to the query date were included. PubMed selects articles in the life sciences as well as biomedical topics while Scopus indexes articles on life sciences, social sciences, physical sciences, and health sciences. Scopus is one of the largest research databases. It is also an index service partner for main technical databases such as ACM (ACM, n.d.) and IEEE Explore (IEEE Explore, n.d.).

2.2. Inclusion and exclusion criteria

A total of 249 papers and documents were identified (111 from PubMed and 138 from Scopus). Among these, 84 were duplicate and removed. The remaining papers were screened in two rounds. Initially, the abstracts were reviewed to determine final selection criteria. If it was not possible to determine from an abstract alone whether the text needed to be included, a full review of the article was performed. The process is described in Figure 1 and the inclusion and exclusion criteria used are presented in Table 1. In addition, four more publications were identified through reading the publications and included at a later stage. Sixteen studies contained descriptions of games that promoted responsible antibiotic use (where multiple papers were published about the same game but did not include information about their entertainment potential only one was retained).

![Figure 1: Selection process.](image_url)

<table>
<thead>
<tr>
<th>Table 1: Selection criteria.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusion criteria</strong></td>
</tr>
<tr>
<td>Published in English</td>
</tr>
<tr>
<td>Indexed in Scopus or PubMed</td>
</tr>
<tr>
<td>Journal articles, conference proceedings, book chapters</td>
</tr>
<tr>
<td>Focused on games (including</td>
</tr>
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</tbody>
</table>
2.3. Research themes classification

Thematic synthesis was used to analyse data (Thomas, et al., 2017). This consisted of inductively identifying themes and categories (Thomas, et al., 2017). This was done through the analysis of data rather than using a predefined conceptual framework (Csikszentmihalyi, et al., 1997). The following stages were followed: familiarisation with the data; determining initial codes; searching for themes; reviewing and mapping the identified themes; and, defining and interpretation (Braun and Clarke, 2006).

3. Results — Entertainment potential

Table 2 describes briefly games that addressed different aspects of antimicrobial resistance. In the last two rows, “x” indicates those games with an entertainment potential. Interest and enjoyment were the main themes identified in the literature.

<table>
<thead>
<tr>
<th>Name of game</th>
<th>Brief description</th>
<th>Interest</th>
<th>Enjoyment</th>
</tr>
</thead>
<tbody>
<tr>
<td>e-Bug Junior Game (Farrell, et al., 2011b)</td>
<td>Based on the European curriculum, for 9 to 12 years old. It teaches about microbe transmission, hand and food hygiene, and antimicrobial resistance.</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Game</th>
<th>Description</th>
<th>Acknowledged</th>
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<tbody>
<tr>
<td><strong>e-Bug Senior Game</strong> (Farrell, et al., 2011a)</td>
<td>Three missions, explaining microbe transmission, hand and food hygiene, and antimicrobial resistance.</td>
<td>x</td>
</tr>
<tr>
<td><strong>Body Busters</strong> (Eley, et al., 2019)</td>
<td>Teaches how microbes interact with antibiotics.</td>
<td>x</td>
</tr>
<tr>
<td><strong>Doctor Doctor</strong> (Hale, et al., 2018)</td>
<td>Teaches when antibiotics need to be administered.</td>
<td>x</td>
</tr>
<tr>
<td><strong>Microbe Mania</strong> (Hale, et al., 2018)</td>
<td>Focuses on microbe transmission, explaining different kind of microbes and ways to identify them.</td>
<td>x</td>
</tr>
<tr>
<td><strong>On call: Antibiotics</strong> (Castro-Sánchez, et al., 2014)</td>
<td>Aimed at doctors, clinicians, and pharmacists to encourage prudent use of antibiotics.</td>
<td>x</td>
</tr>
<tr>
<td><strong>AntibioGame®</strong> (Tsopra, et al., 2020)</td>
<td>Designed to improve knowledge of responsible antibiotic use for primary medical care among medical students. Students meet patients and solve different case studies.</td>
<td>x</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Game</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GASDA (Birjovanu, et al., 2019)</td>
<td>Mobile app designed to refresh knowledge about antibiotic prescription guidelines and change prescription behaviour.</td>
</tr>
<tr>
<td><strong>Aevol Serious Game</strong> (Beslon, et al., 2013)</td>
<td>Simulates the Aevol model of bacterial evolution. Through the game, a player fights infections using different types of antibiotics.</td>
</tr>
<tr>
<td><strong>Edugames4all MicrobeQuest!</strong> (Molnar and Kostkova, 2018)</td>
<td>A mobile game developed based on the e-Bug junior game; explains microbe transmission, hygiene, and responsible antibiotic use.</td>
</tr>
<tr>
<td><strong>Superbugs</strong> (Servitje, 2019)</td>
<td>A mobile game creating awareness about proper antibiotic use through an understanding of concepts behind antimicrobial resistance.</td>
</tr>
</tbody>
</table>

**Interest**

Interest was defined in this context as people playing or accessing games or a willingness to recommend a
given game to others. Most of the studies highlighted the number of people accessing a Web site where a specific game was available or downloading a given game. Two studies reported on players willing to recommend games to others.

**Number of people playing or accessing games**

*e-Bug games*

*e-Bug Junior Game*, *e-Bug Senior Game*, *Body Busters*, *Doctor Doctor*, and *Microbe Mania* are all available on the e-Bug Web site ([https://www.e-bug.eu/](https://www.e-bug.eu/)). This site had visitors from more than 200 countries (McNulty, *et al.*, 2011). Between May and August 2009, a total of 1,700 players accessed the site (McNulty, *et al.*, 2011). Between January 2009 and March 2010, the site had over 60,000 visitors (Weerasinghe, *et al.*, 2020). Among these, 30 percent were unique users and 30 percent returning users, playing the *e-Bug Junior Game*; 15 percent unique users and 26 percent returning users, playing the *e-Bug Senior Game*. During the 2012–2013 academic year, the most visited e-Bug page in the student section of the site was the *Doctor Doctor* game, with 10,820 visits (Young, *et al.*, 2015). From 1 September 2016 to 31 August 2017 the home page for e-Bug games had 28,610 views and the page for the game for senior students had 10,154 visitors (Eley, *et al.*, 2019). During the same period, *Body Busters* had 12,719 views and *Stop the Spread* 9,830 views (Eley, *et al.*, 2019). Furthermore, students played *Body Busters* longer than *Stop the Spread* visitors (Eley, *et al.*, 2019).

Studies on *e-Bug Junior* and *Senior Games* reported players dropping out of a given game before completion (Farrell, *et al.*, 2011b; Molnar and Kostkova, 2014). During *Junior Game* evaluation roughly 50 percent of the players stopped before completing the first level, and 50 percent of the remaining players dropped before each of the subsequent levels (Farrell, *et al.*, 2011b). In the *e-Bug Senior Game* this issue was addressed by the introduction of a training mission which allowed players to become better acquainted with the game genre (Molnar and Kostkova, 2014).

*On call: Antibiotics*

From 1 October 2015 to September 2018 *On call: Antibiotics* was downloaded ~4,000 times and had ~2,100 unique users (Castro-Sánchez, *et al.*, 2019).

**Willingness to recommend the game**

An evaluation of the *e-Bug Senior Game* with 129 students demonstrated that 46 percent would play the game more than once and 43 percent would recommend the game to more than one person (Lazareck, *et al.*, 2010). All the users that played Antibiogame® mentioned that they would recommend the game to others (Tsopra, *et al.*, 2020).

**Enjoyment**

Under this category were games that provided different aspects of enjoyment. These studies included evaluations on whether students liked or enjoyed a given game or perceived it as being fun. Although the game *Stop the Spread* did not directly relate to antibiotic stewardship but to infection prevention, it was included as it was compared with one of the games that addressed antibiotic stewardship, *Body Busters* (Eley, *et al.*, 2019).

For *Body Busters*, *Doctor Doctor*, and *Microbe Mania* a study was performed to measure the thoughts and feelings of students as they were playing a specific game (Hale, *et al.*, 2017). Students reported how much they liked the game on a Likert scale from one to five. *Body Busters* was favored the most, followed by *Doctor Doctor* and *Microbe Mania*. Players also provided comments through a focus group in which they were prompted to describe their feelings. Qualitative comments supported Likert scale data.

*Body Busters* and *Stop the Spread* were also compared in terms of enjoyment on a Likert scale, as well as
open-ended survey questions and data from a focus group (Eley, et al., 2019). Body Busters was perceived as being more enjoyable both by junior and senior students taking part in the study (overall 7.6 average for Body Busters and 5.5 for Stop the Spread). The focus group collected feedback on the games as well.

AntibioGame® (Tsopra, et al., 2020) used the MEEGA+ method (Petri, et al., 2018) to measure player experiences. A total of 98 percent of the students perceived that the game made it easier for them to learn about antibiotic use and that the game was fun. Fifty-six percent of the students reported losing track of time while playing (Tsopra, et al., 2020).

4. Discussion

Games can complement existing healthcare campaigns, as well as reach different audiences. They could better engage people with educational content. Advances in game analytics and their usage to assess player learning (Hernández-Lara, et al., 2019; Molnar and Estrada, 2018) could allow measurements of some of the outcomes of a campaign without the need for separate interventions and also determine which aspects of the games were successful in achieving “serious” and “entertainment” aims. Although the “serious” potential is a necessary part of an educational game, the “entertainment” potential is also important for learning. In order for students to learn, learning “has to be engaging and rewarding” (Csikszentmihalyi, et al., 1997). Alongside learning, making sure that a player finds the experience of playing a game enjoyable needs to be considered. The enjoyment potential is the reason why a game is chosen over a less expensive non-gaming learning environment (Shoukry and Göbel, 2020). Engagement has been linked to many benefits in education, such as students obtaining higher grades and securing higher completion rates (Leach, 2016; McClenney, et al., 2012).

The articles identified in this review reported a variety of methods to measure the entertainment potential of games. This provides a rich overview of different aspects of what attracts players to these games and at the same time makes it difficult to compare games as different strategies were employed. Several of the games compared whether players enjoyed or liked the games and also provided a comparison of how this was related to the learning outcome (Eley, et al., 2019; Hale, et al., 2017). This makes it easier to determine which games were more effective.

Among the games identified in this article, most have been examined for some aspect of their entertainment potential. Many reported the number of users — either accessing a Web site where a given game was located, measuring downloads, or determining an estimated number playing a game. Data differed across games, making it difficult to compare because of differences in reporting. Different games indeed may have more people accessing or using them due to better awareness of the games through specific promotional activities. Accessing a web site, although a measure of interest (Imlig-Iten and Petko, 2018), does not necessarily mean that users actually played or enjoyed playing a given game.

Two of the identified games reported high dropout rates and proposed some strategies to address these issues. Dropout rates have been previously mentioned both in other studies (Frias-Martinez, et al., 2012; Lebres, et al., 2018) and in industry (GameCentral, 2017; Snow, 2011). Dropout rates in games for healthcare campaigns simply translates into incomplete learning objectives. Although only two games in this study reported dropout rates, other research may have yielded similar results, but failed to report negative data (Snow, 2011).

Although the entertainment potential is as important as serious aspects of games for health, it could also have negative consequences. Playing a game for a long period of time could lead to disruptions in daily routines which in turn could have negative overall consequences (Bilginer, et al., 2020; Bavelier, et al., 2011).
5. Conclusion

Entertainment is an important aspect of any game. With the increased use of games as an alternative in healthcare campaigns, in this research we explored how the entertainment potential of games, used to promote antibiotic stewardship, has been assessed. The results show that most games have reported the number of visitors, a willingness to play a game and recommend it to others, how much players enjoyed a given game, and becoming unaware of time while playing a specific game.

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