

Science & Society

Antimicrobial Resistance Awareness and Games

Andreea Molnar^{1,*}

Antibiotic resistance is an increasingly global problem that requires different approaches to be undertaken. This article argues that games could be used to complement existing antibiotic-resistance awareness campaigns as they have several characteristics that could help people engage with information.

Current Antibiotic Use

The inappropriate use of antibiotics is being recognised as one of the most pressing challenges in most medical systems as it can lead to antibiotic resistance [1]. Antibiotic resistance represents an increased burden on the population's health through an increase in morbidity and mortality: there are 700 000 deaths each year due to bacterial resistance, and if the trend continues, by 2050 antimicrobial resistance is predicted to become the top cause of death. Moreover, there is a corresponding increase in healthcare costs: it is estimated that the losses due to antimicrobial resistance could reach 100 trillion USD of economic output by 2050.

Although new drugs may help, the impact is short lived unless changes in antibiotic use are also achieved [2]. Such change is impeded by various public misconceptions regarding antibiotic use [3,4]. This could be because knowledge regarding antibiotic use and antibiotic resistance is sometimes poorly communicated to the public and, as a result, people think they know when they should use antibiotics. Moreover, a notable proportion of the population does not

perceive antibiotic resistance as being a problem (for example, 70% of participants of a US-based survey responded neutrally or they disagreed that antibiotic resistance is a problem [3]). Some people also believe that a solution will be found irrespective of their antibiotic usage. Furthermore, most assume that it is a person that becomes resistant to the drug and not the bacteria influencing the way they see the effect of their behaviour on society.

Considering that inappropriate use of antibiotics increases antimicrobial resistance, responsible antibiotic use and the risk involved if not correctly administered could present a solution for slowing down antibiotic resistance. This is especially important in countries where the option to purchase antibiotics over the counter is still available, or the market for antibiotics is not well regulated and people have the possibility of purchasing counterfeit antibiotics. These might have a suboptimal antibiotic concentration that could lead to further increases in resistance. Even in countries where the use of antibiotics is not possible without a prescription, sometimes doctors find it difficult to turn down a patient's request for an antibiotic. Moreover, even if the patient does not ask for antibiotics but the doctor believes that s/he is expecting to be prescribed antibiotics, the doctor is more likely to prescribe them even if they are not required [5].

Awareness campaigns aimed at educating the general public often use posters and leaflets, TV and radio advertisement, and other web-based resources. Moreover, sometimes presentations are targeted at students or clinicians. They have shown mixed results on knowledge, behaviour, or prescription rates among adults [6]. However, most of the approaches used do not actively engage people (i.e., people are the passive recipients of the information – for example, in

radio advertisements people listen to the information provided but they are not necessarily actively engaged). Passive methods of delivering information have been shown in other contexts not to promote long-term retention [7] or deep understanding of critical concepts [8]. This article argues that games might be able to address some of the limitations that current healthcare awareness campaigns have and that more research needs to be done in order to understand how to design them to be effective and in which contexts they should be used.

Games for Changing Behaviour

Games actively involve players and hence could have the potential to actively involve players in the learning process. They show several key principles that educators, psychologists, and neuroscientists believe to enhance learning [9]. They allow players to test different strategies and see the consequences of their actions without suffering consequences in real life and also experiment with situations which would be difficult or expensive to reproduce in real life.

Games could help in explaining and understanding antibiotic resistance. Moreover, although the consequences of antibiotic resistance are experienced by some of the patients and immediate family or close circle friends, most of the public at large has difficulty understanding how these affect them and the population. However, the games have the potential to bring this phenomenon closer. Knowledge and understanding of antibiotic resistance is a prerequisite to behaviour change. Furthermore, games have been successfully employed for changing other, different health behaviours such as eating and physical activity [10]. Not surprisingly, they have started to be employed as a means of creating awareness: initially addressing children and young adults, and then clinicians and the general public.

Games for Children and Younger Adults

Although children do not have the power to make decisions regarding their antibiotic purchase yet, they are the future prescribers and antibiotic consumers. They also have the potential to further deliver the information that they learn in their families and indirectly in the community. Moreover, it is easier to teach and install behaviour at an earlier stage than to change it later on. Websites such as e-bugiii and edugames4alliv contain games aimed at children covering a comprehensive range of topics from hygiene and infection prevention to responsible antibiotic use. They are also based on the European curriculum [8]. Different games are divided based on the age group (primary and secondary school children) and employ different strategies for engaging children [11].

These games have been evaluated, and most of the evaluations have focused on the players' change in knowledge between the beginning and the end of the game [11,12]. The effect of games on children's learning has been mixed, with some of the games being more successful at teaching certain learning objectives. All of these studies were short-term interventions, and none of them has attempted to look at attitude or behaviour changes among children or the long-term effect on communities.

Games for Clinicians and Pharmacists

Games aimed at clinicians, such as On call: antibioticsv or Flu.0, focused on changing clinicians' antibiotic-prescribing behaviour or refreshing clinicians' knowledge of hygiene issues such as how to properly wash your hands. Among these games, Flu.0 was evaluated. They found that 95% learned as a result of using the game and some of them believe that certain aspects of practice would improve as a result [13].

Although clinicians and pharmacists are experts on the prescription of antibiotics,

antibiotics are often prescribed when not needed – or are used when they are not needed [14]. In the UK alone, up to half of antibiotic prescriptions are considered suboptimal [14]. Moreover, in countries – such as Albania – where people self-purchase antibiotics, despite regulations, improving pharmacist knowledge and addressing misconceptions is important for the optimal use of antibiotics [15]. Therefore, refreshing their knowledge could be beneficial. As the results of the Flu.0 evaluation show [13], playing the game improves the players' knowledge, and some of the players reported that they would perform better and take additional precautions as a result of playing the game.

Games for the Public

The education of the public, in general, is especially important in those countries where the population could self-purchase antibiotics. Several commercial games were aimed at creating awareness about antimicrobial resistance among the population in general – such as the Superbugs Game developed by Preload and released in 2016. All of these games address the public in general, and further research is needed to understand whether they are effective.

Current Challenges in Using Games

Adopting games as part of the campaigns does not come without challenges. The field is nascent, and therefore further research is needed to understand how to best incorporate them. The games have shown mixed results about knowledge change, and none of the examples mentioned above has actually measured behaviour change (except for participant intention to change behaviour). The interventions presented above were small scale and were done in experimental settings that limit the knowledge about their effectiveness to a particular setting. Furthermore, not all of the games are the

same, and what works in one setting might not work in another. There are also some known negative effects of video games (e.g., a long time spent playing a video game could distract from other activities), and these effects need to be mitigated when they are introduced.

Concluding Remarks

Although games alone are not likely to fully solve the antimicrobial-resistance problem, games could be considered as a way to complement existing campaigns that want to raise awareness about antibiotic resistance. They already have been used across different population sections: public, children and young adults, clinicians, and pharmacists and have focused on infection prevention and understanding antibiotic resistance in people's treatment. Other areas of concern, such as the usage of antibiotics in agriculture, aquaculture, or for animals, have not received as much attention for game development around antibiotic resistance.

In order to address antimicrobial resistance, we need to tackle the problem in all settings, and to educate people in all the ways in which they could help to reduce the issue. Games could be a more effective way of engaging with the public; however, future research is needed to better understand how effective computer games are at disseminating knowledge, influencing attitude, and effecting behavioural changes, and to better understand the contexts in which the games work best.

Resources

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ⁱⁱⁱE-bug (n.d.) www.e-bug.eu/ Accessed July 24, 2018

^{iv}Edugames4all (n.d.) www.edugames4all.org/ Accessed September 3, 2018

^vAntibiotic prescribing game (n.d.) www.imperial.ac.uk/medicine/hpru-amr/applications-and-tools/antibiotic-prescribing-game/ Accessed July 24, 2018

¹Swinburne University of Technology, Melbourne, Australia

*Correspondence: amolnar@swin.edu.au (A. Molnar).
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Spotlight Structure Regulates Phage Lysis–Lysogeny Decisions

Jimmy T. Trinh^{1,2} and
Lanying Zeng^{1,2,*}

There are many strategies by which cell fates are decided. In one intriguing case, viruses communicate via the quorum-sensing-like 'arbitrium' system to bias infection outcomes. Through elucidating the detailed molecular mechanisms of such strategies, we can better understand viral propagation and offer insights into the treatment of viral diseases.

Cellular decision-making is a ubiquitous and vital process for all living systems, and guides development and disease in organisms. Therefore, it is of paramount importance to characterize the detailed mechanisms of how cell fate selection occurs. The lysis–lysogeny decision that bacteriophages ('phages') make upon infecting their bacterial host represents one of the simplest decisions occurring in nature. Temperate phages choose between lysis, a lifestyle featuring the production and release of viral progeny via host destruction, and lysogeny, a dormant lifestyle where the virus propagates along with its host. Complex decision-making behaviors have recently been discovered in different phage systems, including intracellular individuality and interactions [1,2], non-binary fate outcomes [3,4], and small-molecule communication between generations of phages [5]. Regarding the communication

behavior, mechanistic details are relatively scant.

Bacillus phages phi3T and SPbeta produce different 'arbitrium' peptides during infection, which are processed by their hosts and released in their mature form into the environment, as reported by Erez *et al.* [5]. These mature six amino acid peptides are then imported into neighboring cells. If these cells become infected, the peptides bind to AimR, which controls the expression of *aimX*, to bias the cells toward lysogeny. This overall process can be interpreted as viruses of one generation informing later generations of host scarcity, particularly at high levels of the peptide. The features of this system have also been identified in many other *Bacillus* phages. This motivates investigation of the detailed mechanisms of strategies for communication and consequent decision-making.

In a newly published paper in *Nature Microbiology*, Dou *et al.* focused on characterizing and comparing the action of different communication peptides from a structural perspective [6]. One key observation was that the different phages (phi3T and SPbeta) with different peptides (SAIRGA and GMPRGA, respectively) appeared to influence the lysis–lysogeny decision to different degrees. This suggests that there are differences in the molecular mechanisms of their action. Notably, phi3T and SPbeta both infect *Bacillus subtilis*, but were used to infect different strains by Erez *et al.* and Dou *et al.* because some *B. subtilis* strains carry the SPbeta prophage, making them immune to SPbeta infection. AimR was reported to activate *aimX* to promote lysis, likely by binding to phage DNA as a transcriptional activator, because the lysogeny-inducing, AimR-binding peptides decreased *aimX* transcription [5]. Dou *et al.* explored the effects of the peptide binding to AimR by crystallizing AimR from different phages, finding a