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A systematic mapping of game-based methods to tackle a public health problem*

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Abstract. Mosquito-borne diseases, such as dengue, endanger about half of the world's population. Their spread is affected by individual behavior in our mostly urban society. Public health policies generally include awareness campaigns on the control of the vectors. While game-based initiatives are developed and used to train students and professionals, support patients and educate citizens, public health education remains neglected. In this study, we identify game-based approaches to support education about diseases transmitted by *Aedes* mosquitoes. We carried out a systematic mapping to identify studies which address a proposal, use or contain an evaluation of game-based methods, aiming to raise awareness and promote behavior changes regarding dengue and its prevention. Only 12 papers met the criteria for inclusion and exclusion, and those were selected and categorized. As part of an ongoing project, next steps include adding other databases and other mosquito-borne diseases (e.g., malaria) and drafting guidelines to support the design of games for public health education about mosquito-borne diseases.

Keywords: Systematic mapping · Serious games · Gamification · Public health · Education · Awareness · *Aedes aegypti* · Dengue.

1 Introduction

A global public health concern, dengue is a mosquito-borne viral disease. Estimates suggest that about 3.9 billion people are at risk [1]. Its primary vector is the *Aedes aegypti* mosquito, which also transmits chikungunya, yellow fever and zika viruses. Vector population control is an important strategy to face this problem. Humans behavior may contribute to the growth of vector population [22, 23], for instance, through the improperly stock of water and inappropriate disposal of solid waste which can become vector breeding sites. Thereby, citizens have an important role and must be included in public health policies.

Generally, population awareness is based on traditional media advertisement and educational campaigns (e.g., classes, talks, theater) in schools and public

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places [4, 5, 9, 17, 19]. Game-based approaches are powerful tools to support education, awareness, engagement and behavior changes [2, 6, 7, 20, 26, 27]. In this context, serious games and gamification can be used to enhance the outcomes of education-based policies for public health. An example is a game which tackles on two related neglected and emerging tropical infectious diseases – Visceral Leishmaniasis and American Cutaneous Leishmaniasis [18].

In this study, we present an overview of game-based methods applied in education about dengue and other diseases transmitted by *Aedes* mosquito.

2 The systematic mapping process

There are some differences between Systematic Mapping (SM) and Systematic Literature Review (SLR) studies. The first may be used as a previous step toward the latter, as it can help to identify areas where is more appropriate to conduct an SLR or a primary study [10, 24]. In this study, a systematic mapping was performed. As described by [24], the process steps include: (i) definition of research questions, (ii) conduct search for primary studies (all papers), (iii) screening of papers for inclusion and exclusion (relevant papers), (iv) keywording of abstracts, and (v) data extraction and mapping of studies.

The goal of this study is to identify and analyze game-related methods aiming to understand their application in the context of public health education, in particular, those designed to support awareness and behavior changes for dengue prevention. For such, we established the following research questions:

- RQ1: Which game-based methods were used to raise awareness about *Aedes* mosquito-borne diseases and how to prevent them?
- RQ2: Which types of games have been proposed or used?
- RQ3: In which context and educational levels were they investigated?

The search query used was: *(game OR gamification) AND (dengue OR zika OR chikungunya OR "yellow fever" OR Aedes OR mosquito)*. The electronic databases searched were: ACM Digital Library, IEEE Xplore, PubMed, ScienceDirect, Scopus, Springer Link. The results covered articles, conference papers and book chapters published and indexed until May 10, 2018 (Table 1). Although some databases returned a large number of results, the vast majority of them had no relation to the research objectives. For instance, many papers had as subject the 2014 Olympic Games in Brazil and zika epidemic. Furthermore, there are a reasonable number of apps and games related to the subject available on the web and in app stores. However, the results covered only seven different games (see Table 2). Details about the research such as inclusion/exclusion criteria and protocol are available at www.github.com/ufopleds/publichealthgames.

3 Results and discussion

Few studies addressed games-based methods aimed at public health education about diseases transmitted by *Aedes*. In this section, we present some information about them, such as how they were conducted and which were their findings.

Table 1. Results summary

	ACM	IEEE	PubMed	ScienceDirect	Scopus	Springer
# papers	3	5	88	1464	143	3877
1st selection	3	3	4	7	19	4
2nd selection (relevant papers)	1	3	1	1	10	3
Total after removing duplicates	12					

Table 2. List of publications grouped by type

Type	References
journal	[3], [11], [12], [13], [14], [29]
conference	[8], [15], [25], [28]
book chapter	[16], [21]

Regarding the game-related methods used, RQ1, (Table 3), three of the studies addressed the game design by volunteer participants. Both the design of a game (made by authors) and the evaluation of a game were approached by four studies. Two of them used gamification. None of the studies presented a game from its conception, design and development phases to its systematic evaluation.

Table 3. Game related-methods

Game-related methods	References
Game design (by participants)	[11, 13, 16]
Game design and development (by authors)	[15, 21, 25, 28]
Gamification	[15, 21]
Game evaluation	[3, 12, 14, 29]

Answering RQ2, both digital and analog games were covered (see Table 4). However, the number of different games is even lower, and it is worse if we consider their availability to be used by educators and public health agents. There are two board games - here, the difficulty is having physical access to them. For computers, there are two options, but we found just one available online with the installer – *Pueblo Pitanga: enemigos silenciosos*[3]. Similarly, from the three games for mobile devices, we found only one publicly available – X-Dengue[4]. The context and educational level (RQ3) varies according to the study.

Two of the papers reported a study in which authors investigated the ability of a child to create educational games related to dengue using drawings [11, 13]. An active role in the creation process was also the subject of another study, in which was used a participatory design to engage a community and students to devise mobile apps.

[3] http://www.pueblopitanga.com
[4] https://play.google.com/store/apps/details?id=com.leds.xdengue

Table 4. Summary of games

Game	Platform	References	Easily acessible
Jugando en salud: dengue	board	[29]	no
Good-bye to dengue	board	[12, 14]	no
Pueblo Pitanga: enemigos silenciosos	computer	[8]	yes
Sherlock Dengue 8	computer	[3]	no
Hugo against dengue	mobile	[25]	no
X-Dengue	mobile	[15]	yes
AedesBusters	mobile	[21]	no

The board games were the subject of three studies. The game *Jugando en salud: dengue* was evaluated using a pre- and post-test experimental design with 621 students between eight to sixteen-years-old from nine different schools of a Venezuelan city [29]. According to authors, the game had a good acceptance and contributed to improving knowledge about dengue and its prevention. The game *Good-bye to dengue* was used in two studies. In one, the authors conducted a postgame debriefing with 81 Filipino students to explore aspects such as students' feelings, perceptions and information learned [12]. In the other, they evaluated the effectiveness of the game to increase knowledge, positive attitudes-beliefs, and self-efficacy for dengue prevention using an experimental design (pre- and post test) with primary and secondary students from Philippine schools [14].

Design, development and evaluation of digital games were the subjects of the other studies. [25] presented a prototype of a mobile game (*Hugo against dengue*). A simulation game that uses a view from the perspective of a mosquito was described by [28]. The game *Pueblo Pitanga: Enemigos Silenciosos* had its design patterns analyzed by [8]. The design of a mixed-reality game (2D, augmented reality and virtual reality), *X-Dengue*, was presented by [15]. The game *Sherlock Dengue 8* was used in a study-case addressing guidelines for designing and use collaborative-competitive serious games[3]. Moreover, a mobile app used gamification aiming to incentive volunteer contributions of *Aedes aegypti* breeding sites. Although such studies have in some way presented aspects about game design, development and evaluation, they lack a deeper and systematic evaluation to demonstrate their advantages and limitations to support awareness and behavior change so they can be used as tools for public health policies.

More than half of the worlds population live in areas where *Aedes* species are present. There is a consensus about habits to prevent vector breeding sites inside houses, and in many countries, this information is widely disseminated using traditional media and campaigns. However, the exclusive use of these methods demonstrated to be ineffective, since most of vector breeding sites are located inside or around houses. Innovative approaches such as those based on games are needed. Although, there is a lack of games and studies addressing public health education such as mosquito-borne diseases. Primary studies should be systematically undertaken to design and evaluate game-based methods and tools, which could be easily scalable if they prove to be effective and efficient to achieve awareness and behavioral changes.

4 Final remarks

Games for health is an emergent research area. There are many efforts aimed at training health students and professionals and rehabilitation of patients. However, there is a significant shortage of initiatives addressing global public health problems such as mosquito-borne diseases.

In this study, we performed a systematic mapping of game-based methods aiming to aware and promote behavior changes regarding dengue and its prevention. While some research areas (e.g., software engineering education) have a significant number of studies on games application, we found few studies related to public health education on diseases transmitted by *Aedes*, and fewer were those that did a systematic evaluation of the outcomes. The costs of mosquito-borne diseases are very high, and a significant amount of resources is used to promote awareness, but using advertisement in traditional media. Part of these should be used to conduct scientific research aiming to develop and evaluate the application of game-based methods to tackle public health complex problems, such as mosquito-borne diseases. The outcomes could be replicated and scalable.

As part of an ongoing project, future works include (i) adding other databases and games designed to target other mosquito-borne diseases (e.g., malaria), (ii) elaborate guidelines to support the design of games to promote public health education about mosquito-borne diseases.

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