The prevention of arboviral diseases using mobile devices: a preliminary study of the attitudes and behaviour change produced by educational interventions

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ABSTRACT

Background: In Brazil, the National Policy for Dengue Control seeks to incorporate the lessons of national and international experience in Dengue control, emphasizing the need for health education activities.

Objectives: The objective of this study was to evaluate and compare knowledge, attitudes and behaviours related to the prevention of arboviruses before and after a two-month educational intervention using a learning platform on mobile devices.

Methods: This quasi-experimental study corresponds to the first phase of the project "Impact of mobile learning in the prevention and management of complications caused by arboviruses (Zika, Dengue, Chikungunya) – ZIKAMOB", sponsored as part of the British Council Newton Fund.

Results: Thirty of the 93 participants were first-year undergraduate university students (36.7% male) and 63 were police officers (84.1% male). The pattern of attitudes and behaviour was very similar in both groups before the intervention. The students changed their attitudes and behaviour ($p=0.032$) in relation to their engagements in actions for the prevention of arboviral diseases and several other activities related to house inspections and precautions with water tanks ($p<0.01$). However, recycling and surveillance activities were not as effective in changing behaviour. Female participants showed more motivation to participate in preventive activities, but living alone and working were barriers to participation. Individuals, who already perform selective waste collection and are cultivating gardens, demonstrated both a positive attitude and positive behaviour towards actions for the prevention of arboviral diseases.

Conclusion: Mobile learning and behaviour change theories might be successful as the basis for school-based and community-based interventions to avoid arboviruses. These outcomes need to be confirmed in broader future studies.

Keywords: Arboviruses; Health Education; Behaviour Change; Mobile Health

Introduction

In recent years, the prevalence of diseases transmitted by arboviruses, such as Zika, Dengue and Chikungunya, has been increasing at an alarming rate in tropical countries. This is due to urbanization, climate change and other socio-environmental conditions that favour the breeding of vector mosquitoes, especially the *Aedes aegypti* mosquito(1-4). The World Health Organization (WHO), for example, reported the risk of Zika virus transmission in more than 80 countries in Asia, the Pacific Islands, America and Africa (5). Between 2015 and 2016, an annual average of 1,586,155 probable cases of Dengue were registered in Brazil; a reduction of 252,054 cases being observed in 2017, two to four years after the probable introduction of Zika virus(6). Despite the widespread distribution of the vector mosquito in Brazil, 94% of cases of congenital Zika syndrome, for instance, were reported in the Northeast affecting the poorest and most vulnerable populations who have insufficient access to basic sanitation and waste collection(7).

In the 1990s, the model for vector-control was based on several epidemiological and entomological surveillance activities that aimed to eradicate mosquitos, as recommended by the Program for the Eradication of the *Aedes aegypti* (PEAa)(8, 9). Later, this model was revised and started to prioritize biological control and health promotion practices with the objective of promoting social mobilization and community participation in identifying problems, seeking solutions and changing behaviours(10). However, vector-control interventions have prioritized the use of insecticides and larvicides, including their use in water tanks such as cisterns. The indiscriminate use of these products has resulted in gradual increase of resistant populations of mosquitoes, which has aggravated the situation(11-14).

The WHO highlights selective and integrated mosquito management with community and intersectional participation as a strategy for the prevention and control of Dengue(15) , the effective and permanent participation of the community being essential for the prevention and control of diseases transmitted by the vectors. The WHO also recommends that health promotion practices be based on behaviour change models(16). In Brazil, the National Policy for Dengue Control, established in 2002, seeks to incorporate the lessons of national and international experience in Dengue control, emphasizing the need for health education activities and for the mobilization of the population(9).

The engagement of the population in educational activities for the prevention of arboviral diseases can be boosted with the use of Information and Communication Technology (ICT) which includes mobile learning (m-learning), which has been defined as any educational provision in which the only, or dominant, technologies are portable devices, such as mobile phones and tablets (17, 18). The use of these devices has also grown in the field of health (m-health), proving to be effective in providing health information services(19). The use of mobile devices is gradually increasing and diversifying in all sectors of education and health, both in developed and developing countries(20, 21).

The objective of this study was to evaluate and compare knowledge, attitudes and behaviours related to the prevention of arboviruses before and after a two-month educational intervention using a learning platform on mobile devices (m-learning and m-health). This is a quasi-experimental study that corresponds to the first phase of the project "Impact of mobile learning in the prevention and management of complications caused by arboviruses (Zika, Dengue, Chikungunya) – ZIKAMOB" sponsored as part of the British Council Newton Fund Institutional Links programme.

Methods

Type of Study and Population

This is a quasi-experimental study conducted in Campina Grande and João Pessoa (North-Eastern Brazil), being the first phase of a school-based intervention; in other words, proof of principle and validation of the intervention. To test the instruments and the virtual activities, 69 first-year university students on an undergraduate Biological Sciences program and 63 police officers were invited to participate in a course on the use of mobile devices to promote the prevention of arboviral diseases. The first-year undergraduate students were chosen because they are of a similar age and have similar interests to high school students, while the police officers were representing the students' families (outside group). Before the intervention, all of the participants attended a seminar that explained aims of the project. Following the seminar, if they agreed to participate, the free and informed consent form was signed (Protocol CAAE 67429517.5.0000.5187 by the Research Ethics Committee of Paraiba State University). The 63 police officers answered the pre-intervention questionnaire in order to establish a representation of families' knowledge and/or attitudes and behaviours with regard to the prevention of arboviruses while 30/69 students answered both the pre- and post-intervention questionnaires and undertook the educational intervention on the virtual platform.

Description of the intervention

Before the intervention, the target behaviours of the educational activities were defined taking into consideration the technical information and suggestions gathered from several

meetings and interviews with representatives of health departments working in epidemiological and environmental surveillance, and from a review of the literature. The targets were defined as follows:

1. identify and inspect breeding site, such as drains, water tanks and plant pots;
2. cover water tanks, thought to account for 80% of the breeding sites in Campina Grande;
3. implement preventive measures; for example, install insect screens, use natural repellents etc.;
4. reduce solid waste and the consumption of manufactured goods, as well as sorting waste for recycling;
5. encourage the development of community leadership skills, asking the students to organize community activities to reduce breeding sites in vacant lots or public areas.

In the development of the educational activities (“missions”), we considered some ideas and constructs of cognitive psychology as well as ideas from Daniel Kahneman´s "Thinking Fast and Slow", associating new information with existing patterns, or thoughts and using this to stimulate new patterns of behaviour(22). The educational messages were personified (using association as a "priming" effect) to show people undertaking the target behaviour that it was something a person like them might want to do (i.e. Kahneman’s System 1-type thinking and behaviour) (22). The messages were created to be crisp, clear and simple to enlarge cognitive comfort, as well as to increase familiarity with the situation or target behaviour. During the period of intervention, some researchers worked as coaches or supervisors to stimulate the participants, giving them positive reinforcement on performing the activities. Finally, the

missions were described as goals to be achieved by participants and these messages were reminded using clear messages which builds into Kahneman's System 2-type thinking and behaviour(22).

The intervention took place over a forty-day period, comprising the initial explanations, registration of the students in the distance-learning platform and carrying out the intervention missions as well as the students responding to the pre- and post-test. All participants had to perform the "missions" (preventive activities) and post photographs using specific hashtags (#Zikamob) on social networks, such as Instagram or Facebook, as a means of proof of compliance. The "missions" were practical and preventive actions to be developed at home; and they were explained using videos available in the internet.

The participants learned how to make traps for mosquitoes; to make screens for windows; to inspect mosquito-breeding sites; to clean water tanks and reservoirs, to install the screens in drains and cover water tanks and garbage bins. They were also invited to make a card of the Citizen Account (*Conta Cidadã*) of the Paraiba Energy Company, learn how to use the recycling app "CATAKI" and organize a clean-up of a vacant lot. The course had eight hours of face-to-face activities and 32 hours of distance-learning activities using mobile devises. The participants who completed 80% of activities received a 40 hours-course certificate.

Assessment procedures

A self-report questionnaire containing 40 statements was developed to assess knowledge, attitudes and behaviours. The questionnaire was divided into four main sections, each one with ten statements; five of which regarded knowledge (*I know that*), belief (*I believe that*) or attitude (*I like*, *I feel like doing*, or *I think that is good or not good*) and the last five

describing behaviours (*I do, I usually do, I make, I perform*). Answering the questionnaire, participants could also reflect on their attitudes and practices. This tool was tested with a few students to evaluate their internal validation and it was evaluated by expert judges (health and educational researchers). There was also a section aimed at gathering socio-demographic information and facilitating the behaviour change process. The variables used were: age, education (basic, high school and higher education); type of education institutional (public school, private or both); sex; family structure (living alone, with colleagues, parents and siblings or spouse with/without children); number of individuals living in the same household and how many of them are under 18; type of housing (house, apartment building or gated community); if the participant did housework and waste collection at home (if he or she performed these activities himself or herself or if it was his or her parents, other family members or someone else who did them); if the participant sorted waste for recycling; who was responsible for purchasing food in the participant's home (the participant himself or herself, parents or relatives, a maid or somebody else); if the participant had, and took care of, potted plants at home.

Of the four main sections in the questionnaire, the section **A** (Engagement) aimed at evaluating engagement, motivation and self-efficacy of the participants; the **B** section (Monitoring) focused on life-cycle of mosquitos and preventive practices regarding their proliferation; the **C** section (Recycling) examined families' knowledge of the programs and applications related to recycling; and section **D** (Surveillance) evaluated the interaction of the family of the participants with endemic disease control agents (*agentes de combate a endemias* - ACEs) and other surveillance themes.

The pre- and post-questionnaires contained identical items in the main sections. For each item, the participant had to state the extent to which they agreed or disagreed with the statement

in the item by selecting a value on a Likert scale. If the participant agreed strongly, they were to choose 5 on the scale; agreed = 4; not sure / don't know = 3; disagreed = 2; strongly disagreed = 1. Participants could score from 10 to 50 points for each section of the questionnaire, and the higher the score, the more favourable their knowledge, attitudes or behaviours were to preventing arboviral diseases.

Statistical analysis

Descriptive statistics were used to describe the profile of the population and the frequency of each of the questionnaire answers before and after intervention. Each of the statements used in the questionnaire, as well as the partial and total scores, were considered dependent variables. Normality tests were used to verify whether the partial or total scores had normal distribution. To assess whether there were differences in the median (categorical variables) or mean (scores with normal distribution) values between the groups, chi-square tests, Fisher's exact tests and Student t-tests were conducted for independent and paired samples considering a level of significance of 5% ($p < 0.05$) and confidence interval of 95%. The analysis was performed with the support of the statistical software R and specific packages for analysis (23).

Ethics approval and consent to participate

This research was approved by the Research Ethics Committee of Paraiba State University (UEPB) under protocol CAAE: 67429517.5.0000.5187 and was in accordance with the principles of Resolution 466/12 of the Brazilian National Health Council.

Results

Table 1 shows the profile of the participants and their socio demographic characteristics. Among the university students, 36.7% were male, while 84.1% of the police officers were men. Regarding the family structure, most of the students lived with parents or relatives (80.0%), while most of the police officers were married with or without children (54.8%). Most of the students (66.7%) and officers (50.8) did not perform household chores, such as managing and disposing of home-generated waste. As for the sorting of waste for selective collection, only 26.7% of students and 27.0% of the officers responded positively. As for grocery shopping, 10.0% of the students and slightly more than half (50.8%) of the officers replied that they perform this activity themselves. As to having plants or cultivating vegetable gardens at home, 53.3% of the students and only 33.3% of the officers responded affirmatively.

Comparison of attitudes and behaviours

As explained in the methods section, the pre-intervention questionnaire was answered by police officers (P) and undergraduate students before the intervention (E1), and the post-intervention questionnaire was answered by students (E2) only. Table 2 shows the frequency of each of the responses to the questions in Section A for engagement as well as the median values and the Fisher's exact test results, comparing the group of police officers and the group of students before the intervention (P x E1) and students' answers before and after the intervention (E1 x E2).

The majority of the interviewees stated that it is possible to reduce mosquito breeding, liked the idea of the project to promote a student mobilization movement for the prevention of

arboviral diseases and believed that both the interviewees themselves and their families would be willing to engage in educational activities. Self-efficacy, in other words, the belief in the engagement of the population for the prevention of diseases, was not significantly different among students and police officers. Moreover, the educational intervention did not contribute to changing these view of the participants before and after the intervention. In fact, the frequency of the answers to the first four statements, for example, showed little variability among groups.

Before the intervention, more students agreed with the idea that larvicides can be harmful to health than did police officers. On the other hand, more police officers inspected their homes to identify mosquito-breeding sites than did university students. As to the other statements, there was no significant difference between these two groups and they showed great similarity in thinking and in reported behaviour (Table 3).

Following the intervention, the frequency of students who observed that mosquitoes often feed at dawn and dusk increased from 46.7% before to 80% after. One of the most striking differences was in relation to the assembly of mosquito traps. Before the intervention, fewer than 2% of the students had ever performed this activity; after it, the frequency increased to 93%, that is, almost all of the students participated in activity of assembling traps (Table 3).

As to inspecting breeding sites, a significant difference was observed with the intervention (Table 3). In the pre- intervention questionnaire , students reported that only 13% of them performed daily inspection of breeding sites while 23% reported that someone in their family did so. After the intervention, these numbers increased to 53% and 67%, respectively. Only 33.3% of the students strongly agreed with the statement on covering buckets and water tanks before the intervention and this increased to 70% after it. Regarding the use of screens on windows, although there was significant difference between the groups due to the intervention, it

was observed that only 33% of the students carried out this activity (Table 3).

The results of Section C, which dealt with solid waste recycling, are shown in Table 4. No significant differences were observed between the groups of police officers and students in the pre-intervention phase for any of the statements, showing that there is a relative homogeneity of knowledge and behaviour standards between them. On the other hand, there was also no significant difference in any of the items when comparing the responses of the students before and after the intervention. Nevertheless, there was a small increase in frequency for some attitudes and behaviours related to solid waste recycling. For example, 43.3% of the students said that they knew how to sort the materials for recycling before the intervention, reaching 67% after the educational activities.

As to the statement concerning the visit of the ACEs to their homes, 23.8% of the police officers answered affirmatively while, among the students, the frequency increased from 36.7% to 47% with the intervention. Half of the participants had vacant lots close to their homes, which highlights the importance of carrying out preventive actions in these locations, as these account for 20% of mosquito breeding sites in the cities of the state of Paraíba. On the other hand, only 20% of respondents said that there were streams and open sewers near their homes. Almost 70% of the officers and 60% of the students supported the access of ACEs to vacant lots or abandoned properties to reduce mosquito breeding sites. About 15% of the officers and students showed willingness to participate in community actions for the prevention of arboviral diseases, and this number almost doubled among the university students after the intervention (37%) (Table 5).

Comparison of attitudes and behaviours between police officers and university students

The Figure 1A shows the results of the scores for the four sections of the questionnaire,

subdivided in two groups (attitudes and behaviours). Surprisingly, we find that the pattern of attitudes and behaviour was very similar in the groups of police officer and university students before the intervention. The sum of the score of the statements of each section resulted in a total score of the section, which could range from 10 to 50 points. Figure 1B shows the comparative results for the total score and similar pattern were observed again between the two groups, the recycling section being the only one to show differences between them.

To verify if there were significant differences in the attitude, behaviour or total scores of each section, comparing the group of students and the group of police officers, we used the Mann-Whitney-U test for independent samples. Only three of the twelve evaluated scores presented significant differences between groups, showing how similar were the thinking and practices of participants. There were significant differences between two groups in the score of the B section, which dealt with the habits and life cycle of the mosquito ($p=0.001$), in the score in relation to knowledge and attitudes about recycling ($p = 0.026$), and in the total score related to recycling ($p = 0.014$). These data pointed to the fact that students and officers show differences in terms of their understanding (knowledge) the question about the life cycle of mosquitoes and recycling, but this does not necessarily imply different behaviours.

Comparison of attitudes and behaviours of students before and after the intervention

The analysis found that the students changed their attitudes ($p = 0.032$) and behaviour ($p=0.032$) in relation to their engagements in actions for the prevention of arboviral diseases. That is, the students came to believe more that it is possible to control the populations of disease vectors by mobilizing people, and they were more receptive to community actions after they performed this type of activity in the intervention (Figure 1C).

The assembly of mosquito traps and several other activities related to house inspections, such as how the precautions with water tanks and other breeding site were carried out, showed significant differences in the attitudes ($p<0.01$) and behaviour ($p<0.01$). However, no significant difference was found in the remaining four parameters, which referred to recycling and the work of endemic disease control agents in section C (Figure 1C).

The Figure1D shows the median values and their dispersion in relation to the total scores of each section of the survey, comparing the group of students before and after the educational intervention. There was an increase in the values of all of the total scores, and these differences are statistically significant, as shown by the results of the Student t test for paired samples (Table 6).

Factors associated with attitudes and behaviours

The mean of the total scores of each section of the survey for different variables, considering data from the police officers and from the students before the intervention, was compared in order to see whether any of these variables could influence or predict the change in attitude and behaviour. In terms of engagement, a significant difference between male and female participants was observed, as shown in Table 7. Women showed more motivation to participate in the intervention activities.

The group with no paid occupation had a higher mean score in the section about recycling than did the participants who work. The participants who lived alone or with friends had significantly different mean scores compared to those of the participants who lived with family members in relation to the scores of sections B, C and D, no significant difference being

observed in terms of engagement. Living alone is a predictor factor for performing fewer preventive activities. The participants who already participated in selective collection of solid waste before the intervention had higher means in the sections about engagement and recycling. No differences were observed in the attitudes and behaviours of the participants who lived in houses and those who lived in apartment buildings, although the former have increased risk of arbovirus infection (Table 7).

The activity that proved to be a predictor factor and that presented significant differences in the mean scores of all of the sections analysed was cultivating a garden. The participants that cultivate a garden have a higher mean score in terms of engagement, performing preventive activities and recycling. They also showed more knowledge about the missions and activities of endemic disease control agents and about the issue of vacant lots and abandoned properties (Table 7).

Discussion

This was the first study to use a learning platform that employed mobile devices and behaviour change models to carry out an educational intervention aimed at promoting the prevention of arboviral diseases in Brazil. In the literature, most of the studies describes knowledge, attitudes and practices related to other arboviral diseases (24-30), few of them being educational intervention studies. They have, for example, investigated perceptions of risk and susceptibility (31), evaluated differences between groups such as pregnant and non-pregnant women (32), looked at individuals living inside or outside a risk area or not (33), and looked at differences between those who live in rural and non-rural areas (34). In Kenya, instructional videos released via a video platform accessible with mobile devices were used (35, 36) and, in Sri Lanka, there

was an evaluation of knowledge and attitudes around the use of an application to identify and notify mosquito outbreaks were evaluated (35-37), an educational intervention *per se* not being performed.

The results of the current pre-intervention questionnaire were used to compare two different groups: university students in a Biological Science undergraduate course who have more motivation and interest in matters regarding arboviruses and police officers who have no specific training in this area. Surprisingly, these two categories show significant homogeneity in their attitudes and behaviours. This can be explained by the fact that they were not asked about specific knowledge, but about their everyday practices. In the literature, individuals with higher levels of education have a more positive attitude towards participating in preventive activities against arboviral diseases (32).

University students showed more willingness to participate in preventive activities than the police officers. These findings corroborate other studies, in which university students in the health area showed more interest and participated more actively in preventive activities than do students in other fields of knowledge (25, 38). However, unlike the police officers, their willingness and motivation to carry out educational activities did not translate to the behaviour of participating in campaigns promoted by schools and churches either before nor after the intervention. About 10% of participants performed community actions. So, the will to participate (motivation) does not necessarily imply participating (action) in educational and preventive activities, an example of divergence between the participants' espoused theory of action and their theory in use (39).

On the other hand, the police officers performed inspections of potential mosquito breeding sites and cleaned their homes more than the university students. This can be explained

by the fact that the officers have already started their families and are responsible for participating in domestic activities, since more than half of them said they helped their families in these activities. Another factor that may also contribute to these attitudes is the fact that the officers are often responsible for cleaning their headquarters. This is a practice adopted in the institution and is part of its established discipline policy. Such practices must be better understood, as they may be factors that facilitate behaviour change.

The results of this study pointed to greater willingness and engagement to participate in preventive activities on the part of women when compared to men. Other studies conducted with college students in the United States showed similar differences between the sexes. Whereas the women participate in preventive activities more often, the men experience more risk situations, such as doing outdoor activities (24, 25, 27). In a study on the Zika virus conducted in Florida, about 62% of the participants were women, 90.5% of whom believed that the disease was preventable (26). Pregnant women show a greater perception of risk and more engagement in preventive activities than those who are not in the same condition (27).

A factors which was a predictor in all of the sections evaluated in this study was that of having and cultivating plants or gardens. Participants who adopted these practices were more engaged and motivated to carry out prevention activities. They also performed better in terms of carrying out inspections, recycling and interacting with Environmental Surveillance agents (ACE). This can be explained two ways: on the one hand, these individuals already adopted practices related or associated with vector control and this fact would be a facilitator for behaviour change; on the other hand, they may also have had a different perception of risk and susceptibility compared to other people. This aspect needs to be further investigated in future studies. In the literature, we found no study that has made this association.

In this study, the two main factors that were shown to act as barriers to the prevention of arboviral diseases were living alone and working. In fact, compared to the participants who lived with family members, those who lived alone showed significant differences in three of the four sections of the questionnaire, no difference being observed only in engagements and motivation. The participants who worked reported difficulty in performing activities related to recycling solid waste.

The results of this study showed that 60 to 70% of the participants often used mobile applications to study or to stay up-to-date with the news. These results corroborate the global trend with the number of people accessing the internet via mobile devices rapidly growing, which demonstrates the potential of the concept of mobile learning (17, 40-42).

The difference in relation to the statistical significance of the tests performed with the total scores and for each of the individual variables was due to methodological limitations. Each statement had five possible answers using the Likert scale, and the sample was small – only 30 students – for the study

References

1. Sukhralia S, Verma M, Gopirajan S, Dhanaraj P, Lal R, Mehla N, et al. From dengue to Zika: The wide spread of mosquito-borne arboviruses. European Journal of Clinical Microbiology & Infectious Diseases. 2019;38(1):3-14.
2. Suwanmanee S, Luplertlop N. Dengue and Zika viruses: lessons learned from the similarities between these Aedes mosquito-vectored arboviruses. Journal of Microbiology. 2017;55(2):81-9.
3. Kindhauser MK, Allen T, Frank V, Santhana RS, Dye C. Zika: the origin and spread of a mosquito-borne virus. Bulletin of the World Health Organization. 2016;94(9):675.
4. Simmons CP, Farrar JJ, van Vinh Chau N, Wills B. Dengue. New England Journal of Medicine. 2012;366(15):1423-32.
5. Martinez JD, Garza JAC, Cuellar-Barboza A. Going Viral 2019: Zika, Chikungunya, and Dengue. Dermatol Clin. 2019;37(1):95-105.
6. Lopes TRR, Silva CS, Pastor AF, Silva Júnior JVJ. Dengue in Brazil in 2017: what happened? Revista do Instituto de Medicina Tropical de São Paulo. 2018;60.
7. Possas C. Zika: what we do and do not know based on the experiences of Brazil.

Epidemiology and health. 2016;38.
8. Gonçalves R, Lima E, Lima J, Silva M, Caprara A. Contribuições recentes sobre conhecimentos, atitudes e práticas da população brasileira acerca da dengue. Saúde e Sociedade. 2015;24:578-93.
9. Minísterio da Saúde, Fundaçao Nacional de Saúde. Programa nacional de controle da dengue. Brasilia: Brazilian Ministry of Health and National Health Foundation; 2002.
10. Barreto ML, Teixeira MG, Bastos FI, Ximenes RA, Barata RB, Rodrigues LC. Successes and failures in the control of infectious diseases in Brazil: social and environmental context, policies, interventions, and research needs. The lancet. 2011;377(9780):1877-89.
11. Carvalho MS, Honorio NA, Garcia LMT, de Sa Carvalho LC. Aedes ægypti control in urban areas: A systemic approach to a complex dynamic. PLoS neglected tropical diseases. 2017;11(7):e0005632.
12. Lima EP, Oliveira Filho AMd, Lima JWdO, Ramos Júnior AN, Cavalcanti LPdG, Pontes RJS. Aedes aegypti resistance to temefos in counties of Ceará State. Revista da Sociedade Brasileira de Medicina Tropical. 2006;39(3):259-63.
13. Macoris M, Andrighetti M. takaku L, Glasser CM, Garbeloto VC & Cirino VCB. Alteração de resposta de suscetibilidade de Aedes aegypti a inseticidas organofosforados em municípios do Estado de São Paulo, Brasil Rev Saúde Pública. 1999;33(5):521-22.
14. Tauil PL. Critical aspects of dengue control in Brazil. Cadernos de Saúde Pública. 2002;18(3):867-71.
15. World Health Organization, Special Programme for Research, Training in Tropical Diseases, World Health Organization. Department of Control of Neglected Tropical Diseases, World Health Organization. Epidemic, Pandemic Alert. Dengue: guidelines for diagnosis, treatment, prevention and control: World Health Organization; 2009.
16. World Health Organization. Health education: theoretical concepts, effective strategies and core competencies: a foundation document to guide capacity development of health educators. Cairo: World Health Organization. Regional Office for the Eastern Mediterranean; 2012.
17. Traxler J, editor Mobile learning-The future already behind us. Proceedings of 2012 International Conference on Interactive Mobile and Computer Aided Learning (IMCL); 2012: IEEE.
18. Traxler J, Compton H. Mobile learning. In: Yan Z, editor. Encyclopedia of Mobile Phone Behavior. Hershey PA: IGI Global; 2015. p. 506-18.
19. Free C, Phillips G, Watson L, Galli L, Felix L, Edwards P, et al. The effectiveness of mobile-health technologies to improve health care service delivery processes: a systematic review and meta-analysis. PLoS medicine. 2013;10(1):e1001363.
20. Karageorgos G, Andreadis I, Psychas K, Mourkousis G, Kiourti A, Lazzi G, et al. The Promise of Mobile Technologies for the Health Care System in the Developing World: A Systematic Review. IEEE reviews in biomedical engineering. 2018;12:100-22.
21. Traxler J. Mobile Learning Across Developing and Developed Worlds: Tackling Distance, Digital Divides, Disadvantage, Disenfranchisement In: Berge ZL, Muilenburg L, editors. Handbook of Mobile Learning. London and New York: Routledge; 2013.
22. Kahneman D. Thinking, fast and slow: Macmillan; 2011.
23. Venables W, Smith D, R Core Team. An Introduction to R. Vienna: The R Foundation for Statistical Computing; 2019.
24. Feldstein LR, Rowhani-Rahbar A, Staples JE, Halloran ME, Ellis EM. An assessment of

household and individual-level mosquito prevention methods during the chikungunya virus outbreak in the United States Virgin Islands, 2014–2015. The American journal of tropical medicine and hygiene. 2018;98(3):845-8.
25. Plaster AN, Painter JE, Tjersland DH, Jacobsen KH. University students' knowledge, attitudes, and sources of information about Zika virus. Journal of community health. 2018;43(4):647-55.
26. Darrow W, Bhatt C, Rene C, Thomas L. Zika Virus Awareness and Prevention Practices Among University Students in Miami: Fall 2016. Health Education & Behavior. 2018;45(6):967-76.
27. Gregory S, DiBartolo-Cordovano R, Taj I, Merriam A, Lopez JM, Torres C, et al. A survey of the knowledge, attitudes and practices on Zika virus in New York City. BMC Public Health. 2018;18.
28. Nyunt MH, Aye KM, Kyaw MP, Wai KT, Oo T, Than A, et al. Evaluation of the behaviour change communication and community mobilization activities in Myanmar artemisinin resistance containment zones. Malaria journal. 2015;14(1):522.
29. Storey JD, Babalola SO, Ricotta EE, Fox KA, Toso M, Lewicky N, et al. Associations between ideational variables and bed net use in Madagascar, Mali, and Nigeria. BMC public health. 2018;18(1):484.
30. Wong LP, AbuBakar S. Health beliefs and practices related to dengue fever: a focus group study. PLoS neglected tropical diseases. 2013;7(7):e2310.
31. Khun S, Manderson L. Community and school-based health education for dengue control in rural Cambodia: a process evaluation. PLoS neglected tropical diseases. 2007;1(3):e143.
32. Brusich M, Grieco J, Penney N, Tisgratog R, Ritthison W, Chareonviriyaphap T, et al. Targeting educational campaigns for prevention of malaria and dengue fever: an assessment in Thailand. Parasites & vectors. 2015;8(1):43.
33. Flamand C, Fritzell C, Obale P, Quenel P, Raude J. The role of risk proximity in the beliefs and behaviors related to mosquito-borne diseases: the case of chikungunya in French Guiana. The American journal of tropical medicine and hygiene. 2017;97(2):344-55.
34. Ramaiah R, Jayarama S. Awareness and practices related to dengue fever among rural high school students: a cross sectional study. International Journal Of Community Medicine And Public Health. 2018;5(4):1402-6.
35. Bello-Bravo J, Pittendrigh BR. Scientific animations without borders (SAWBO): Animating IPM information and education everywhere. Outlooks on Pest Management. 2018;29(2):58-61.
36. Lwin MO, Vijaykumar S, Rathnayake VS, Lim G, Panchapakesan C, Foo S, et al. A social media mHealth solution to address the needs of dengue prevention and management in Sri Lanka. Journal of medical Internet research. 2016;18(7):e149.
37. Lwin MO, Jayasundar K, Sheldenkar A, Wijayamuni R, Wimalaratne P, Ernst KC, et al. Lessons from the implementation of Mo-Buzz, a mobile pandemic surveillance system for dengue. JMIR public health and surveillance. 2017;3(4):e65.
38. Koralek T, Runnerstrom MG, Brown BJ, Uchegbu C, Basta TB. Lessons from Ebola: sources of outbreak information and the associated impact on UC Irvine and Ohio University college students. PLoS currents. 2016;8.
39. Argyris C, Schon DA. Theory in practice: Increasing professional effectiveness: Jossey-Bass; 1974.
40. Ally M. Mobile learning: Transforming the delivery of education and training: Athabasca

University Press; 2009.
41. Traxler J. Students and mobile devices. Alt-j. 2010;18(2):149-60.
42. Zhao J, Freeman B, Li M. Can mobile phone apps influence people's health behavior change? An evidence review. Journal of medical Internet research. 2016;18(11):e287.