Development and Preliminary Outcomes of a Behaviour-change Intervention Aimed at Preventing Mosquito-borne Arboviruses

Silvana Santos (✉ silvanaape@gmail.com)

Universidade Estadual da Paraíba

Roberta Smania-Marques

Universidade Estadual da Paraíba

Victor Alves Albino

Universidade Estadual da Paraíba

Izabelly Dutra Fernandes

Universidade Estadual da Paraíba

Francisco Fernandes Abel Manguiera

Universidade Estadual da Paraíba

Ricardo Olinda

Universidade Estadual da Paraíba

Carol S Bond

University of Wolverhampton

David Matheson

University of Wolverhampton

John Traxler

University of Wolverhampton

Research Article

Keywords: Mosquito-borne arboviruses, Health Education, Behaviour Change

Posted Date: January 18th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-784559/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background: This article describes the development of the theoretical background, methodology and preliminary outcomes of a behaviour-change intervention aimed at preventing the spread of mosquito-borne arboviruses.

Objective: To compare perceptions and behaviours, before and after the intervention, between a group of health workers (experts) with a group of college students (learners). Health workers have already learned the target behaviours that every citizen must develop to reduce the mosquito population; college students may or may not grasp these behaviours. Our working hypothesis considers that the intervention should approximate the pattern of students' perceptions, and behaviours to those of health workers.

Methods: Using a distance-learning platform adapted for mobile devices, the intervention consisted of tasks that were presented through short videos with people performing the desired target behaviour. To demonstrate the accomplishment of the tasks, participants produced videos and shared these on social networks. A questionnaire was completed before and after the intervention by 58 participants, 31 college students and 27 health workers.

Results: Most of the participants were female (83.9% and 72.2% of college students and health workers, respectively); 27.8% of health workers attended higher education and 70.4% were married contrasting with 9.8% of the students. Among college students, a significant difference in the chi-square test was found for all ten target behaviours after the intervention. ANOVA analysis showed that health workers have a higher perception of susceptibility and more fear of acquiring mosquito-borne arboviruses than students do, and there was a correlation between facilitating behaviours with behaviour change.

Conclusion: Intervention based on behaviour change theories thus contributed to bring students' behaviour patterns closer to those of health workers. Here we have presented a model for effectuating behaviour change perhaps applicable in other settings.

Background

This paper describes the development of the theoretical background, methodology and preliminary outcomes of an educational intervention, based on behavioural change theories, aimed at preventing the spread of mosquito-borne arboviruses. A distance-learning platform adapted for mobile devices was used to engage and mobilize the population in arboviral prevention actions. During the educational intervention, participants learned to inspect their homes, keep water reservoirs capped, separate recyclables to donate to pickers, put screens on windows, and implement procedures to identify where mosquitoes might breed, and hence make clean-up efforts. The content was taught through short videos with examples of people performing the desired target behaviour. This pilot study corresponds to the second phase of the "Impact of mobile learning on the prevention and management of complications caused by arbovirus (Zika, Dengue, Chikungunya) - ZAMOB" project, founded by British Council.

Theoretical background

The World Health Organization (WHO) published in 2012 a document entitled "Health Education: Theoretical Concepts, Effective Strategies and Core Competencies" which outlines the main theories of behavioural change and those that can be used in educational interventions [1]. The WHO highlighted nine behavioural change theories that have been widely used in health interventions; three were selected whose constructs were studied in this investigation. The Theory of Rational Action (TRA) considers that knowledge contributes to changing attitudes and beliefs, which are essential for behavioural change [1]. The Health Belief Model (HBM) advocates that decision-making depends on the perception of susceptibility, disease severity, benefits and barriers associated with behaviour [1]. Later, the model added the concept of self-efficacy. Social Cognitive Theory (SCT) describes three main factors that affect a person's likelihood of changing health behaviour: self-efficacy, goals, and outcome expectations. Learning target behaviours can be facilitated by observing people performing the same [1].

Changing the frequency with which a person performs a particular behaviour requires a change in at least one of the following observables: ability, motivation, or opportunity to engage in the activity [2, 3]. Ability refers to the physical and psychological condition to perform a behaviour. Motivation involves all processes that energize and direct behaviour, including not only goals, plans, and beliefs, but also "automatic" processes that involve emotions, habits, and impulses. Opportunity involves all factors external to an individual that can influence engagement in an activity, ranging from the physical environments in which people spend time to the social and cultural environment that determines how we perceive and think about actions. It includes reducing the distance between intention and action. Therefore, to maximize the potential benefit of behaviour change interventions, it is important to understand that capacity, motivation, and opportunity vary depending on specific behaviours, target populations, and social and environmental contexts [2, 3].

Experience in performing a behaviour can make it habitual, so that intention and motivation over time become less important in determining individual performance. In order to foster change, it is necessary to show people performing the target behaviour that one wants to establish in the population, and transmitting personalized, interactive and accessible information. However, it is not necessary to link the preliminary or previous change in attitudes to the subsequent change in behaviour, as both may occur concomitantly [4–6]. Familiarity, observation of others performing the desired behaviour, and social norms are predictors of behaviour change.

Hypothesis and objectives

Here, the intervention aimed to teach the students to perform some actions, which are carried out by the health workers who are experts in mosquito control surveillance. These workers are responsible for inspecting public and private properties to control vector mosquito populations, since in these places there is a higher incidence of mosquito-borne arboviruses outbreaks [7–9]. During visits, health workers survey water deposits to identify outbreaks and explain to the population the importance of keeping these containers clean, avoiding the accumulation of water and solid waste that can serve as breeding sites. Having identified the presence of larvae or mosquitoes in a neighbourhood, health workers then use insecticides, including cold spatial fogging in the area around where the larvae of mosquitoes have been found, thereby reducing the vector population [10, 11].

In this paper, we compared perceptions and behaviours before and after an educational intervention based on behavioural change theories of a group of health workers (experts) with a group of first-year college students (learners). Health workers have already learnt the target behaviours that every citizen must achieve in order to reduce the population of vector mosquitoes; college students may or may not have these behaviours. Our working hypothesis considers that educational intervention should approximate the pattern of students' perceptions and behaviours to those of the health workers.

In short, we set out to answer the following guiding questions:

- 1 - What differences exist in the perceptions and behaviours of health workers (experts) and under-graduate students (learners) before and after the intervention?
- 2 - What factors are associated with behavioural change? (sociodemographic characteristics, external factors such as risks and benefits, intrinsic factors such as motivation, self-efficacy, perceptions of susceptibility and severity, intention, among others).
- 3 - Which constructs of behavioural change theories explain the findings?
- 4 - How do the pilot study outcomes contribute to the planning of future educational actions and public policies aimed at preventing mosquito-borne arboviruses?

Methods

This is a quasi-experimental two-group intervention study, one composed of health workers (experts in mosquito-control surveillance) and one of college students (learners). The study was conducted in the city of Campina Grande, being the second largest urban centre of Paraíba in north-eastern Brazil and currently has 355,000 inhabitants. In the city, there are about 350 health workers linked to the Entomological Surveillance of the municipality.

The study population included 100 students and 50 health workers who signed up for a voluntary distance-learning course which would use mobile devices. The course was disseminated through the university's website and in partnership with the Department of Health of the Municipality of Campina Grande, which allowed 50 workers to participate in the course. The health workers had developed the preventive attitudes and behaviours that every citizen should learn and perform in their homes. For this reason, the health workers are the group with the preventive behaviours and the first-year college students represent the target population of the further school-based intervention.

All participants were invited to evaluate the educational activities and the questionnaire, point out mistakes, misconceptions or suggest changes. Participation was in the form of a scavenger hunt where a cash prize was offered to those who completed all activities, including the course evaluation. The project was initiated after approval by the Research Ethics Committee of the State University of Paraíba (Protocol CASE 67429517.5.0000.5187) and the participants having signed the informed consent form.

For the purpose of statistical analysis, only participants who completed the totality of the elements of the programme, answering both questionnaires, before and after the intervention, and performing all activities of the intervention. Participants who did not complete these steps or who skipped the course were excluded. The final sample consisted of 58 participants, 31 students and 27 health workers.

Intervention – description and assessment tools

Table 1 summarizes the constructs of behaviour change theories selected for study in this investigation; it contains a brief description of the theory and concepts, and some questions for reflection. Using a distance-learning platform adapted for mobile devices, the intervention consisted of tasks that were presented through short videos with people performing the desired target behaviour. To demonstrate the accomplishment of the tasks, participants produced audio-visual content (videos) which they shared on social networks (Facebook). The posts had specific hashtags such that it was possible to track the post and interactions on social networks. In addition, the participant also included the link to their publication on the virtual platform. There were ten tasks to be performed in the 40-hour course, held between October and December 2018, with two face-to-face meetings, one to explain the objectives and operation of the platform and the other to reward participants. This strategy was previously described and tested by Manguiera et al. (2019) [12].

Table 1

Constructs of behavioural change theories chosen to support this research on prevention of mosquito-borne arboviral diseases.

<i>Theory - Premise</i>	<i>Constructs</i>	<i>Research questions</i>
Theory of Rational Action (TRA) Knowledge is necessary, but usually not sufficient for individual or collective behaviour change.	Knowledge and skills	What knowledge and skills are required to perform the target behaviours?
Health Belief Model (HBM) Decision making regarding behaviour change is influenced by fear or fear of acquiring a disease (susceptibility and severity), associated with the perception that it is worth changing (benefit) and overcoming barriers.	Self-perception of susceptibility	What is the chance of the person getting the disease?
	Self-perception of gravity	How serious is the disease?
	Self-perception of benefits	What are the benefits of changing behaviour?
	Obstruction self-perception	What prevents the person from changing behaviour?
Theory of Planned Behaviour Attitudes and the subjective norm determine an individual's intention to change a behaviour or not. The individual must have the perception that the power of decision is his own.	Intention	Does the person want to change their behaviour or not? (willingness to change)
	Attitudes (expected result by STC)	How does the person see behaviour change (positive, negative or neutral)
	Perceived norm (beliefs and behaviours of others)	Who would approve or support this change? (What is the opinion of others?)
	Perceived control	Does the person understand that he has the power to change?
Social Cognitive Theory (SCT) If individuals have a sense of self-efficacy, they can change behaviour even when faced with obstacles. If they feel unable to exercise control over their health behaviour, they remain unmotivated and unable to persist with the challenges. When an individual adopts new behaviour, it causes changes in both the environment and the individual because people learn by watching others.	Reciprocal determinism	What environmental factors can be modifiable by the target audience, enhancing the influence on other people?
	Result Expectations	What expectations does one have for the results of your action?
	Self-efficacy	Belief in individual ability to change.
		What is the level of self-confidence to perform the targeted behaviour?
	Collective Effectiveness	Belief in the group's ability to change. What is the group's level of self-confidence to perform the target behaviour?
	Observational Learning	Learning behaviour by observing model pairs. Who are the people who, through their own actions, can influence the development of behaviour in others?

<i>Theory - Premise</i>	<i>Constructs</i>	<i>Research questions</i>
	Reinforcement (induced motivation)	Create self-reward mechanisms and incentives to reinforce behaviour. What are the benefits and incentives for achieving target behaviour?
	Facilitation	Tools, guidelines, resources, and environmental changes that facilitate behaviour change. What are the conditions that favor the development of target behaviour?
Other theories (Daniel Kannemann in Fast and Slow) Clear, crisp, short messages from positive leaders increase a person's familiarity with behaviour and enhance their imitation. The induction of a behaviour occurs the more one observes others performing the same behaviour.	Halo Effect (Leadership)	Well-liked and sympathetic leaders have more influence over others. Who are the people who, through their own actions, can influence the development of behaviour in others?
	Cognitive comfort	Short, clear, crisp, humorous messages make learning easier. What are the characteristics of supportive and incentive actions for behaviour change that can positively influence the acquisition of target behaviour?
	Familiarity	Enlarge and reiterate images of behaviour to increase familiarity and reduce cognitive strain. What are the characteristics of supportive and incentive actions for behaviour change that can positively influence the acquisition of target behaviour? What are the barriers that can be removed to achieve target behaviour?
	Priming	Always show people doing the behaviour you want to change by increasing the view for imitation. Who are the people who, through their own actions, can influence the development of behaviour in others?

During the course, the content of the tasks was evaluated by the health workers and students to identify possible errors in inspection procedures or elimination of mosquito breeding sites. Thus, the participants also answered some questions to evaluate the quality and relevance of each task so that the content could be reproduced with students and teachers of Basic Education in the next stage of the project.

The assessment of perceptions and behaviours before and after the intervention was performed by applying a self-reported questionnaire containing questions with binary yes/no answers. Positive responses indicated that the participant could demonstrate perception and preventive behaviour, or less risk of acquiring mosquito-borne arboviruses, and they were worth 1 to 3 points; negative answers, or those that were not applicable to the participant's situation, were worth zero points.

Each of the behaviours target prevention and breeding elimination was considered a dependent categorical variable. The sum of the score for the ten questions related to prevention actions led to the "Prevention Score", which could range from 0 to 10 points; which could be added to the score of the five answers regarding breeder elimination ("Breeding Elimination Score") thus giving rise to the "Target Behaviour Score" (0 to 15 points).

Independent variables were grouped into the following subgroups:

1. Sociodemographic variables such as gender, age, marital status, income, occupation and whether the participant had children.
- 2) Variables related to environmental risk that encompassed conditions outside the participant's home such as the existence of vacant land or abandoned houses, offer of garbage collection services, running water and entomological surveillance. The sum of the score of the answers gives rise to the "Environmental Risk Score", ranging from 0 to 5 points;
- 3) Home risk corresponds to conditions that may or may not facilitate the proliferation of mosquitoes in the participant's home. For example, if the person lives in rented accommodation, they are likely to be less interested in window screens or home improvements. Roofless houses with water tanks, water storage containers, gardens and plants are more likely to have breeding grounds. Positive statements were scored and the higher the value of this score, the greater the risk of having breeding grounds at the participant's residence. Thus, the "Home Risk Score" ranges from zero to ten points. The sum of the two previous scores gave rise to the "Environmental and Household Risk Score", ranging from 0 to 15 points.
- 4) Constructs of Behaviour Change Theories: 25 statements were proposed with which the participant could agree or not, being assigned one to three points for positive responses that revealed knowledge, perceptions, attitudes and beliefs that favour behaviour change. The sum of the scores gave rise to different scores: "Knowledge Score" (TRA) consisting of five assertions; "Self-efficacy and observation score" (SCT) that evaluated the constructs of self-efficacy, collective efficacy and observation; the "Facilitator Score" (SCT) which assessed familiarity, the existence of target behaviours prior to intervention, and behaviours that facilitate behaviour change. Finally, constructs of the Health Belief Model ("Health Belief Score") (HBT), such as perception of susceptibility, severity, barriers and benefits associated with behaviour change, were analysed. All positive answers meant having a positive understanding or perception of the concept examined. The "Behaviour Change Theories Score" resulted from the sum of all scores and ranged from 0 to 25 points. This score allowed us to measure whether the participant changed his perceptions after the educational activities.

Statistical analysis

Descriptive statistics were used to describe the population profile and the frequency of each questionnaire response before and after the intervention. To assess whether there were differences in the median (categorical variables) or mean (normal distribution scores) values between the groups analysed, the Chi-square test, Fisher's exact test and ANOVA Kruskal Wallis and Friedman tests for independent and paired samples were used [13], considering the significance level of 5% (p -value < 0.05). The reliability analysis of the instrument was performed using Cronbach's alpha. The analyses were performed with the aid of the R statistical software [14].

Secondly, multivariate analysis techniques were used, adjusting the Principal Component Analysis (PCA), whose eigenvalues were greater than one ($\lambda > 1$), as suggested by Kaiser (1960) [15], in order to identify a smaller number of variables. uncorrelated alternatives that somehow summarize the main information of the original variables. Subsequently, these main components were presented in Biplot graphs for individuals and variables with their respective confidence ellipses (with 95% reliability). Biplot is a method that represents two-dimensional multivariate data, where each observation is represented by the pair of scores of the first two main components, representing each group (students and experts) in their respective confidence ellipses.

Results

Socio Economic Profile, environmental and household risk

Table 2 shows the results for the category of students and health workers before and after the intervention regarding socio economic profile, environmental and household risk. Regarding gender, 83.9% and 72.2% of students and health workers, respectively, were female, with no significant difference between them ($p = 0.128$). All college students were starting higher education and only 9.8% of them were married or

were in a stable relationship. In the health workers group, 27.8% of them attended higher education and 70.4% were married. As expected, these differences between the groups were significant ($p < 0.001$). Regarding family income, about 75% of both students and health workers live on two to six times the minimum wage (about R\$ 1,000 or US\$ 200 per month).

Table 2

Frequency of socioeconomic variables, environmental and household risks, comparing the data before (pre-test) and after the intervention (post-test) within the same group (college students or health workers), and between different groups with values of the Chi Square test (X^2 test) (* $p < 0,05$).

Independent variables		Students				χ ² test	Health workers				χ ² test	Students		Health Workers		X ² test
		Pre-test		Post-test			Pre-test		Post-test			Pre-test		Post-test		
		n	%	n	%	p	n	%	n	%	p	n	%	n	%	p
SX - Gender	1 - Feminine	26	41.9	26	41.9	1.00	20	37.0	19	35.2	0.76	52	83.9	39	72.2	0.13
	2 - Male	5	8.1	5	8.1		7	13.0	8	14.8		10	16.1	15	27.8	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
ESC - Schooling	1 – Elementary School	0	0.0	0	0.0	0.75	1	1.9	1	1.9	1.00	0	0.0	2	3.7	0.00*
	2 – High school	5	8.1	7	11.3		18	33.3	19	35.2		12	19.4	37	68.5	
	3 – College education	26	41.9	24	38.7		8	14.8	7	13.0		50	80.6	15	27.8	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
ECV - Marital status	1 – Single, separated or divorced.	27	43.5	29	46.8	0.67	8	14.8	8	14.8	1.00	56	90.3	16	29.6	0.00*
	2 - Married or stable union	4	6.5	2	3.2		19	35.2	19	35.2		6	9.7	38	70.4	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RT -Total income of the family residing in the same household	1 – Up to one minimum wage	7	11.3	7	11.3	1.00	7	13.0	7	13.0	1.00	14	22.6	14	25.9	0.60
	2 –From two to five minimum wages	23	37.1	24	38.7		20	37.0	20	37.0		47	75.8	40	74.1	
	3 – More than six minimum wages	1	1.6	0	0.0		0	0.0	0	0.0		1	1.6	0	0.0	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCA1 -Is there any vacant land and / or property closed or abandoned on the block of your home?	0 - no	13	21.0	13	21.0	1.00	10	18.5	11	20.4	1.00	26	41.9	21	38.9	0.74
	1 - yes	18	29.0	18	29.0		17	31.5	16	29.6		36	58.1	33	61.1	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCA2 - Do you have garbage collection service by the city at	0 - no	3	4.8	1	1.6	0.63	0	0.0	0	0.0	N/C	4	6.5	0	0.0	0.06
	1 - yes	28	45.2	30	48.4		27	50.0	27	50.0		58	93.5	54	100.0	

Independent variables		Students				χ ² test	Health workers				χ ² test	Students		Health Workers		χ ² test
		Pre-test		Post-test			Pre-test		Post-test			Pre-test		Post-test		
least twice a week?	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCA3 -Do you have running water service?	0 - no	1	1.6	2	3.2	1.00	0	0.0	0	0.0	N/C	3	4.8	0	0.0	0.10
	1 - yes	30	48.4	29	46.8		27	50.0	27	50.0		59	95.2	54	100.0	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCA4 – Is there open streams and sewers near your home?	0 - no	21	33.9	22	35.5	1.00	20	37.0	17	31.5	0.56	43	69.4	37	68.5	0.92
	1 - yes	10	16.1	9	14.5		7	13.0	10	18.5		19	30.6	17	31.5	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCA5 - Did you get a visit from the Endemic Fighting Agent last month?	0 - no	24	38.7	22	35.5	0.77	0	0.0	2	3.7	0.49	46	74.2	2	3.7	0.00*
	1 - yes	7	11.3	9	14.5		27	50.0	25	46.3		16	25.8	52	96.3	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD1 - Do you reside in a single storey house or place?	0 - no	15	24.2	16	25.8	1.00	5	9.3	2	3.7	0.42	31	50.0	7	13.0	0.00*
	1 - yes	16	25.8	15	24.2		22	40.7	25	46.3		31	50.0	47	87.0	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD2 - Lives in rented property?	0 - no	19	30.6	20	32.3	1.00	24	44.4	23	42.6	1.00	39	62.9	47	87.0	0.003*
	1 - yes	12	19.4	11	17.7		3	5.6	4	7.4		23	37.1	7	13.0	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD3 - The roof of your house is open. ie without ceiling? (Yes – no ceiling)	0 - No.	22	35.5	23	37.1	1.00	24	44.4	24	44.4	1.00	45	72.6	48	88.9	0.028*
	1 - Yes.	9	14.5	8	12.9		3	5.6	3	5.6		17	27.4	6	11.1	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD4 - Does the roof of your house have gutters?	0 - Gutters.	12	19.4	17	27.4	0.31	17	31.5	15	27.8	0.78	29	46.8	32	59.3	0.18
	1 - NO gutters.	19	30.6	14	22.6		10	18.5	12	22.2		33	53.2	22	40.7	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD5 - Does your house have a water box?	0 - No	8	12.9	8	12.9	1.00	3	5.6	5	9.3	0.70	16	25.8	8	14.8	0.15
	1 - yes	23	37.1	23	37.1		24	44.4	22	40.7		46	74.2	46	85.2	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD6 - Is there a cistern in your house?	0 - No	26	41.9	26	41.9	1.00	25	46.3	25	46.3	1.00	52	83.9	50	92.6	0.15
	1 - yes	5	8.1	5	8.1		2	3.7	2	3.7		10	16.1	4	7.4	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD7 - Do you use buckets as a water reservoir?	0 - No	16	25.8	13	21.0	0.61	11	20.4	12	22.2	1.00	29	46.8	23	42.6	0.65
	1 - Yes	15	24.2	18	29.0		16	29.6	15	27.8		33	53.2	31	57.4	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD7 - Do you use	0 - No	26	41.9	21	33.9	0.24	14	25.9	16	29.6	0.79	47	75.8	30	55.6	0.021*

Independent variables	Students					χ^2 test	Health workers				χ^2 test	Students		Health Workers		χ^2 test
	Pre-test		Post-test				Pre-test		Post-test			Pre-test		Post-test		
buckets as a water reservoir in your home because you lack water?																
	1 - Yes	5	8.1	10	16.1		13	24.1	11	20.4		15	24.2	24	44.4	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD8 - Are the buckets of water in your house without covers?	0 – With caps.	26	41.9	30	48.4	0.20	25	46.3	27	50.0	0.49	56	90.3	52	96.3	0.205
	1 - Uncapped.	5	8.1	1	1.6		2	3.7	0	0.0		6	9.7	2	3.7	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD9 - Are the trashcans without covers?	0 – With caps.	26	41.9	29	46.8	0.43	25	46.3	25	46.3	1.00	55	88.7	50	92.6	0.46
	1 - Uncapped.	5	8.1	2	3.2		2	3.7	2	3.7		7	11.3	4	7.4	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
RCD10 - Do you have yard with potted plants in your home?	0 - No	14	22.6	17	27.4	0.61	15	27.8	15	27.8	1.00	31	50.0	30	55.6	0.55
	1 - Yes	17	27.4	14	22.6		12	22.2	12	22.2		31	50.0	24	44.4	
	Total	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	

About 60% of students and health workers have some vacant land near their homes; 93.5 to 100% said they had running water and garbage collection at least twice a week; about 30% of participants have open sewers or streams near their homes. When asked if they were visited by health workers who are responsible for mosquito control surveillance, only 25% of the students replied positively. The health workers themselves were responsible for performing this service (Table 1).

To verify the reliability of the students' and health workers' answers, the same questions regarding socio-demographic and environmental and household risk variables were used before and after the test; no significant differences were observed between them for both groups. Therefore, the answers were reproduced as expected (Table 2). The analysis of Cronbach's alpha results considering 102 categorical variables used before and after the test showed a value of 0.842, indicating that the instrument has good reliability.

Knowledge, Perceptions, and Constructs of Behaviour Change Theories

Health workers are responsible for teaching arboviral prevention practices to the community, and they deal with the prospect of getting sick every day or the phenomenon of diseases such as Zika, dengue and chikungunya. They therefore have more knowledge, attitudes and positive behaviours towards prevention than any other segments of society. In the Theory of Reasoned Action (TRA) section of the questionnaire, of the five statements that portrayed specific knowledge, in two there was a significant difference between the group of health workers and college students. In fact, 96.3% health workers and 82.3% of students knew that *Aedes aegypti* mosquito larvae are photophobic ($p = 0.017$) and 98.1% of health workers and 87.1% of students knew that it was necessary to perform the identification of mosquito larvae species for infestation counting ($p = 0.026$). More than 95% of both groups knew about mosquito habits and, in relation to reporting Health Surveillance, 100% answered affirmatively (Table 3).

Table 3

Descriptive analysis of knowledge, perceptions and beliefs associated with theories of behaviour change in the same group and between different groups (college students and health workers). Abbreviations: Chi-square test (χ^2 test); level of significance of 5% (* $p < 0.05$).

Independent variables	Student						Health Workers					Group comparison					
	Pre-test		Post-test		χ ² test		Pre-test		Post-test		χ ² test	Student		Health Workers		χ ² test	
	n	%	n	%	p	n	%	n	%	p	n	%	n	%	p		
TRA – Theory of Rational Action (knowledge)																	
BCT1 - Dengue-bearing mosquitoes prefer damp, dark places and rough surfaces to lay their eggs on; so we have to inspect bathroom drains and potted plants.	False	1	1.6	0	0.0		0	0.0	0	0.0	1.00	1	1.6	0	0.0	1.000	
	True	30	48.4	31	50.0		27	50.0	27	50.0		61	98.4	54	100.0		
BCT2 - The mosquito female lays her eggs in various containers for up to hundreds of meters. Therefore, it is important to inspect several neighbouring houses when identifying a breeding site.	False	1	1.6	2	3.2	1.000	1	1.9	1	1.9	1.00	3	4.8	2	3.7	0.764	
	True	30	48.4	29	46.8		26	48.1	26	48.1		59	95.2	52	96.3		
BCT3 - Mosquito larvae like the dark and have a phobia of light, so when we open a container such as a bucket or water tank with larvae, they run to the bottom.	False	9	14.5	2	3.2	0.043*	2	3.7	0	0.0	0.49	11	17.7	2	3.7	0.017*	
	True	22	35.5	29	46.8		25	46.3	27	50.0		51	82.3	52	96.3		
BCT4 - By identifying a mosquito outbreak, the endemic control agent collects larvae and places them in a container with alcohol to identify them and confirm that it is <i>Aedes aegypti</i> .	False	5	8.1	3	4.8	0.707	0	0.0	1	1.9	1.00	8	12.9	1	1.9	0.026*	
	True	26	41.9	28	45.2		27	50.0	26	48.1		54	87.1	53	98.1		

BCT5 - After independent variables site or developing symptoms of dengue, zika or chikungunya, it is necessary to inform the Epidemiologic and Environmental Surveillance services to notify them.	False	0	0.0	0	0.0	N/C	0	0.0	0	0.0	N/C	0	0.0	0	0.0	N/C
	Student						Health Workers					Group comparison				
		Pre-test		Post-test		X ² test	Pre-test		Post-test		X ² test	Student		Health Workers		X ² test
		n	%	n	%	p	n	%	n	%	p	n	%	n	%	p
	True	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
SCT - Self-efficiency. collective efficiency and observation																
BCT6 - I can change my daily habits to prevent the spread of mosquitoes.	No	0	0.0	0	0.0	N/C	0	0.0	0	0.0	N/C	0	0.0	0	0.0	N/C
	Yes	31	50.0	31	50.0		27	50.0	27	50.0		62	100.0	54	100.0	
BCT7 - I can influence other people to change their habits to prevent the proliferation of mosquitoes.	No	0	0.0	1	1.6	1.000	0	0.0	0	0.0	1.00	1	1.6	0	0.0	0.349
	Yes	31	50.0	30	48.4		27	50.0	27	50.0		61	98.4	54	100.0	
BCT8 - I believe my family members, colleagues and neighbours are able to change their habits in order to prevent these diseases.	No	1	1.6	1	1.6	1.000	0	0.0	0	0.0	1.00	2	3.2	0	0.0	0.183
	Yes	30	48.4	30	48.4		27	50.0	27	50.0		60	96.8	54	100.0	
BCT9 - I often use mobile apps to study, read news, communicate with other people and / or post on social networks (Whatsapp, Facebook, Instagram or other).	No	6	9.7	4	6.5	0.731	0	0.0	0	0.0	0.74	10	16.1	0	0.0	0.002*
	Yes	25	40.3	27	43.5		27	50.0	27	50.0		52	83.9	54	100.0	
BCT10 - I really enjoy posting photos and videos, and I	No	7	11.3	8	12.9	1.000	0	0.0	1	1.9	1.00	15	24.2	1	1.9	0.000*

Independent variables from colleagues and family.	Student						Health Workers					Group comparison				
	Yes	24	38.7	23	37.1	X ² test	27	50.0	26	48.1	X ² test	47	75.8	53	98.1	X ² test
		Pre-test		Post-test			Pre-test		Post-test			Student		Health Workers		
SCT - Pre-existing facilitator behaviours (familiarity)		n	%	n	%	p	n	%	n	%	p	n	%	n	%	p
BCT11 - I'm home when mosquitoes are most active at dusk or dawn and I always close doors and windows, so they don't get in.	No	17	27.4	7	11.3	0.018*	2	3.7	0	0.0	0.49	24	38.7	2	3.7	0.000*
	Yes	14	22.6	24	38.7		25	46.3	27	50.0		38	61.3	52	96.3	
BCT12 - I often help with housework, such as littering, cleaning, or caring for potted plants.	No	5	8.1	3	4.8	0.700	0	0.0	0	0.0	0.71	8	12.9	0	0.0	0.006*
	Yes	26	41.9	28	45.2		27	50.0	27	50.0		54	87.1	54	100.0	
BCT13 - I have a habit of inspecting home environments once a week for mosquito breeding sites.	No	24	38.7	6	9.7	0.00*	0	0.0	0	0.0	N/C	30	48.4	0	0.0	0.000*
	Yes	7	11.3	25	40.3		27	50.0	27	50.0		32	51.6	54	100.0	
BCT14 - I sort out recyclables to donate to pickers or to sell.	No	20	32.3	7	11.3	0.002*	2	3.7	0	0.0	0.49	27	43.5	2	3.7	0.000*
	Yes	11	17.7	24	38.7		25	46.3	27	50.0		35	56.5	52	96.3	
BCT15 - I have participated in community campaigns and actions to eliminate mosquito-breeding sites.	No	22	35.5	12	19.4	0.021	0	0.0	0	0.0	0.07	34	54.8	0	0.0	0.000*
	Yes	9	14.5	19	30.6		27	50.0	27	50.0		28	45.2	54	100.0	
HBM - Perception of susceptibility, severity, benefits, or barriers																
BCT16 - I have had symptoms of dengue, zika or chikungunya.	No	17	27.4	15	24.2	0.800	9	16.7	9	16.7	1.00	32	51.6	18	33.3	0.047*
	Yes	14	22.6	16	25.8		18	33.3	18	33.3		30	48.4	36	66.7	
BCT17 - The risk of me catching one of these	No	20	32.3	18	29.0	0.791	14	25.9	13	24.1	1.00	38	61.3	27	50.0	0.222

Independent variables	Student						Health Workers					Group comparison				
	Yes	Pre-test		Post-test		X ² test	Pre-test		Post-test		X ² test	Student		Health Workers		X ² test
		n	%	n	%		n	%	n	%		n	%	n	%	
of these diseases (dengue, zika or chikungunya) is low because there are few mosquitoes where I live.	No	15	24.2	18	29.0	0.611	13	24.1	12	22.2	1.00	33	53.2	25	46.3	0.457
	Yes	16	25.8	13	21.0		14	25.9	15	27.8		29	46.8	29	53.7	
BCT18 -The risk of me catching one of these diseases (dengue, zika or chikungunya) is high because there are so many mosquitoes where I live.	No	28	45.2	27	43.5	1.000	22	40.7	23	42.6	1.00	55	88.7	45	83.3	0.402
	Yes	3	4.8	4	6.5		5	9.3	4	7.4		7	11.3	9	16.7	
BCT20 - I am very afraid of getting one of these diseases and I take preventative measures (e.g. I use repellents; I have window screens or others).	No	7	11.3	2	3.2	0.147	0	0.0	1	1.9	1.00	9	14.5	1	1.9	0.015*
	Yes	24	38.7	29	46.8		27	50.0	26	48.1		53	85.5	53	98.1	
BCT21 - I think diseases like dengue are very serious.	No	0	0.0	1	1.6	0.231	0	0.0	0	0.0	1.00	1	1.6	0	0.0	0.349
	Yes	31	50.0	30	48.4		27	50.0	27	50.0		61	98.4	54	100.0	
BCT22 - Although I consider these serious illnesses, I find it very difficult to change my daily habits and behaviours.	No	27	43.5	29	46.8	0.671	25	46.3	25	46.3	1.00	56	90.3	50	92.6	0.664
	Yes	4	6.5	2	3.2		2	3.7	2	3.7		6	9.7	4	7.4	
BCT23 - These diseases are serious and I consider it fundamental	No	0	0.0	0	0.0	1.00	0	0.0	1	1.9	1.00	0	0.0	1	1.9	0.282
	Yes	31	50.0	31	50.0		27	50.0	26	48.1		62	100.0	53	98.1	
to change my habits to avoid getting sick.	Yes	31	50.0	31	50.0		27	50.0	26	48.1		62	100.0	53	98.1	

Independent variables		Student					Health Workers					Group comparison				
		Pre-test		Post-test		X ² test	Pre-test		Post-test		X ² test	Student		Health Workers		X ² test
		Yes														
		n	%	n	%	p	n	%	n	%	p	n	%	n	%	p
BCT24 - I think that if I do the weekly home survey, this can benefit me but it has no impact on the lives of my neighbours.	No	27	43.5	26	41.9	1.00	20	37.0	22	40.7	0.75	53	85.5	42	77.8	0.282
	Yes	4	6.5	5	8.1		7	13.0	5	9.3		9	14.5	12	22.2	
BCT25 - I think that if I do the weekly home survey, this can benefit my neighbours and me as well.	No	1	1.6	1	1.6	1.00	1	1.9	0	0.0	1.00	2	3.2	1	1.9	0.642
	Yes	30	48.4	30	48.4		26	48.1	27	50.0		60	96.8	53	98.1	

In the section of the questionnaire on Social Cognitive Theory, the three statements dealt with the belief that the individual, their family and community are able to perform preventive activities. The totality of both groups answered affirmatively. Regarding the use of mobile phones and the behaviour of posting and viewing contents in social media, there was a significant difference between the two groups: 83.9% of health workers and 75.8% of students ($p < 0.01$) (Table 3).

Regarding the Health Belief Model, only two statements had significant differences between health workers and college students: 66.7% of health workers and 48.4% of students reported having symptoms of some mosquito-borne arbovirus ($p = 0.047$); and 98.1% of the health workers and 85.5% of the students reported being afraid of acquiring these diseases. The health workers, who work directly with this theme, are more afraid than students of acquiring mosquito-borne arboviruses and the prevalence of these diseases is higher in the group of health workers (Table 3). There was no difference regarding the perception of risk, severity, benefits and barriers between the two categories.

Comparison of data before and after the intervention for each category separately showed that there was behaviour change only in the student group (Table 3). Regarding the acquisition of knowledge, only one of the statements had significant difference with the intervention, which concerns the photophobia of the larvae ($p = 0.043$). In the section of the questionnaire related to the constructs of the Health Belief Model, there was no difference due to the intervention. However, considering the facilitating behaviours that coincided with the behaviours to be modified with the intervention, there was a significant difference in four of the five variables analysed (Table 3).

Target Behavioural Changes

The educational activities aimed to modify ten target behaviours and, if the participants had found a breeding site, they should perform five actions to ensure the resolution of the problem according to the guidelines of the Environmental Surveillance. In the case of health workers, it was expected that they already had these behaviours in their daily lives, and, in fact, there was a difference only in relation to the screening of windows and drains ($p = 0.001$) (Table 4). For the group of college students, a significant difference in the chi-square test was found for all ten target behaviours after the intervention. In the comparison between the two categories (students and health workers), it was found that there was a significant difference between them for all target behaviours except for having a repellent plant pot or using repellents and tiling windows and drains (Table 4).

Table 4

Descriptive analysis of dependent variables and comparison of behavioural change before and after intervention for the two groups studied separately and between groups (students and health workers), using the Chi-square test (χ^2 test) with level of significance of 5 (* $p < 0.05$).

Dependent Variables		Students					Health Workers					Group comparison				
		Pre-test		Post-test		χ^2 test	Pre-test		Post-test		χ^2 test	Students		Health Workers		χ^2 test
		n	%	n	%	p	n	%	n	%	p	n	%	n	%	p
DP01 - Have you closed doors and windows at dawn and / or dusk over the past week?	No	8	12.9	2	3.2	0.038*	2	3.7	0	0.0	0.15	10	16.1	2	3.7	0.028*
	Yes	23	37.1	29	46.8		25	46.3	27	50.0		52	83.9	52	96.3	
DP02 - Have you surveyed your home's drains, potted plants, and water reservoirs this past week?	No	18	29.0	2	3.2	0.000*	1	1.9	0	0.0	0.31	20	32.3	1	1.9	0.000*
	Yes	13	21.0	29	46.8		26	48.1	27	50.0		42	67.7	53	98.1	
DP03 - Did you stop the buckets that serve as water or garbage dumps for your home last week?	No	7	11.3	1	1.6	0.023*	1	1.9	1	1.9	1.00	8	12.9	2	3.7	0.038*
	Yes	24	38.7	30	48.4		26	48.1	26	48.1		54	87.1	52	96.3	
DP04 - Did you separate the recyclables last week?	No	18	29.0	3	4.8	0.000*	2	3.7	1	1.9	0.55	21	33.9	3	5.6	0.000*
	Yes	13	21.0	28	45.2		25	46.3	26	48.1		41	66.1	51	94.4	
DP05 - Did you donate recyclables to waste pickers last week?	No	23	37.1	13	21.0	0.01*	5	9.3	3	5.6	0.44	36	58.1	8	14.8	0.000*
	Yes	8	12.9	18	29.0		22	40.7	24	44.4		26	41.9	46	85.2	
DP06 - Do you have at least one pot with a repellent plant (e.g. citronella) in your home or did you use body repellent last week?	No	20	32.3	10	16.1	0.011*	12	22.2	16	29.6	0.28	30	48.4	28	51.9	0.710
	Yes	11	17.7	21	33.9		15	27.8	11	20.4		32	51.6	26	48.1	
DP07 - Have you screened the windows and / or doors of your home to prevent mosquitoes from entering?	No	23	37.1	8	12.9	0.000*	19	35.2	7	13.0	0.001*	31	50.0	26	48.1	0.84
	Yes	8	12.9	23	37.1		8	14.8	20	37.0		31	50.0	28	51.9	
DP08 - Have you inspected your home gutters (if you have one) and your water tank (if you have one) this month?	No	23	37.1	11	17.7	0.002*	7	13.0	4	7.4	0.31	34	54.8	11	20.4	0.000*
	Yes	8	12.9	20	32.3		20	37.0	23	42.6		28	45.2	43	79.6	
DP09 - Have you washed your water box in the last six months?	No	20	32.3	11	17.7	0.022*	7	13.0	5	9.3	0.51	31	50.0	12	22.2	0.002*
	Yes	11	17.7	20	32.3		20	37.0	22	40.7		31	50.0	42	77.8	
DP10 - In the past month, have you organized or	No	26	41.9	5	8.1	0.000*	9	16.7	4	7.4	0.11	31	50.0	13	24.1	0.004*

participated in a task force to clean up a mosquito-breeding site?	Yes	5	8.1	26	41.9		18	33.3	23	42.6		31	50.0	41	75.9	
DP11 - When diagnosed with dengue, zika or chikungunya arboviruses, did you or your family members request (or would you) notify the case to the Health Surveillance services?	No	20	32.3	13	21.0	0.075*	2	3.7	2	3.7	1.00	33	53.2	4	7.4	0.000*
	Yes	11	17.7	18	29.0		25	46.3	25	46.3		29	46.8	50	92.6	
DP11b - Have you found mosquito breeding?	No	10	16.1	13	21.0	0.43	3	5.6	4	7.4	0.69	23	37.1	7	13.0	0.003*
	Yes	21	33.9	18	29.0		24	44.4	23	42.6		39	62.9	47	87.0	
DP12 - Did you notify the Environmental Surveillance service by phone or app?	No	29	46.8	29	46.8	1.00	6	11.1	6	11.1	1.00	58	93.5	12	22.2	0.000*
	Yes	2	3.2	2	3.2		21	38.9	21	38.9		4	6.5	42	77.8	
DP13 - Have you discarded larval water on the ground and in a sunny place?	No	11	17.7	10	16.1	1.00	1	1.9	2	3.7	1.00	21	33.9	3	5.6	0.000*
	Yes	20	32.3	21	33.9		26	48.1	25	46.3		41	66.1	51	94.4	
DP14 - Did you wash the container where the larvae were in bleach and used a dowel?	No	13	21.0	9	14.5	0.43	1	1.9	2	3.7	1.00	22	35.5	3	5.6	0.000*
	Yes	18	29.0	22	35.5		26	48.1	25	46.3		40	64.5	51	94.4	
DP15 - Have you surveyed other places in your home to check for other mosquito spots?	No	15	24.2	8	12.9	0.07	2	3.7	1	1.9	0.55	23	37.1	3	5.6	0.000*
	Yes	16	25.8	23	37.1		25	46.3	26	48.1		39	62.9	51	94.4	
DP16 - Have you warned your neighbours about the possibility of mosquito outbreaks in their home as well?	No	26	41.9	19	30.6	0.046*	3	5.6	3	5.6	1.00	45	72.6	6	11.1	0.000*
	Yes	5	8.1	12	19.4		24	44.4	24	44.4		17	27.4	48	88.9	

Comparison and correlation of scores

Table 5 shows ANOVA analysis results comparing the scores before and after the intervention for the different groups and between them. No significant differences in environmental and household risk variables were observed, because they have not changed over time. In relation to the other scores, we found that there is a clear difference in relation to the constructs of the Health Belief Model when comparing the health workers and the students. In fact, health workers have a higher perception of susceptibility and more fear of acquiring mosquito-borne arboviruses than do the students. After the intervention, students feel safer because they are more knowledgeable and have taken more measures that are preventive. This change in the perception of susceptibility and severity did not occur in the health workers group.

Table 5

Comparison of the scores before (pre-test) and after (post-test) of intervention for each of the groups (college students and health workers) and between these groups, using ANOVA Friedman and Kruskal Wallis tests, respectively (*p < 0.05).

SCORES	Test	Comparison of pre and post intervention scores for each group				Comparison of scores between different groups		
		Students		Health Workers		Students	Health Workers	
		<i>Median (Quartiles)</i>	<i>p-value</i>	<i>Median (Quartiles)</i>	<i>p-value</i>	<i>Median (Quartiles)</i>	<i>Median (Quartiles)</i>	<i>p-value</i>
Prevention Score	Pre	4.00[3.00: 5.50]	< 0.001	8.00[6.50: 8.00]	0.0135	4.00[3.00: 5.50]	8.00[6.50: 8.00]	< 0.001
	Post	8.00[7.00: 9.00]		9.00[8.00: 10.00]		8.00[7.00: 9.00]	9.00[8.00: 10.00]	
Breeding Elimination Score	Pre	2.00[0.00: 3.00]	0.0133	5.00[4.00: 5.00]	0.8241	2.00[0.00: 3.00]	5.00[4.00: 5.00]	<0.001
	Post	3.00[1.50: 4.00]		5.00[5.00: 5.00]		3.00[1.50: 4.00]	5.00[5.00: 5.00]	
Total Target Behaviour Score	Pre	7.00[4.50: 6.42]	0.0013	14.00[11.50: 14.00]	0.8713	7.00[4.50: 8.50]	14.00[11.50: 14.00]	<0.001
	Post	11.00[8.00: 12.00]		14.00[12.50: 14.00]		11.00[8.00: 12.00]	14.00[12.50: 14.00]	
Environmental Risk Score	Pre	3.00[2.00: 4.00]	0.6552	4.00[3.00: 4.50]	0.9999	3.00[2.00: 4.00]	4.00[3.00: 4.50]	0.0017
	Post	3.00[2.50: 4.00]		4.00[3.00: 5.00]		3.00[2.50: 4.00]	4.00[3.00: 5.00]	
Home Risk Score	Pre	4.00[3.00: 5.00]	0.0904	4.00[3.00: 5.00]	0.9999	4.00[3.00: 5.00]	4.00[3.00: 5.00]	0.5752
	Post	4.00[3.00: 5.00]		4.00[3.00: 5.00]		4.00[3.00: 5.00]	4.00[3.00: 5.00]	
Knowledge Score	Pre	5.00[4.00: 5.00]	0.0594	5.00[5.00: 5.00]	0.7728	5.00[4.00: 5.00]	5.00[5.00: 5.00]	0.0868
	Post	5.00[5.00: 5.00]		5.00[5.00: 5.00]		5.00[5.00: 5.00]	5.00[5.00: 5.00]	
Self-efficacy score and observation	Pre	5.00[4.00: 5.00]	0.9999	N/C		5.00[4.00: 5.00]	5.00[5.00: 5.00]	0.0913
	Post	5.00[4.00: 5.00]		N/C		5.00[4.00: 5.00]	5.00[5.00: 5.00]	
Facilitators score	Pre	N/C		N/C		2.00[1.00: 3.00]	5.00[5.00: 5.00]	< 0.001
	Post	N/C		N/C		4.00[3.00: 5.00]	5.00[5.00: 5.00]	
Health Belief Score	Pre	13.00[11.00: 14.00]	0.6631	13.00[11.00: 14.00]	0.6631	13.00[11.00: 14.00]	14.00[13.50: 16.00]	0.02568
	Post	12.00[11.00: 15.00]		12.00[11.00: 15.00]		13.00[11.00: 15.00]	14.00[14.00: 16.00]	
Total Score - BCT	Pre	23.00[21.00: 25.00]	0.0538	23.00[21.00: 25.00]	0.0538	23.00[21.00: 25.00]	28.00[27.00: 30.00]	< 0.001
	Post	25.00[23.00: 26.50]		25.00[23.00: 26.50]		25.00[23.00: 26.50]	29.00[28.00: 31.00]	

Regarding the results of Spearman's correlation analysis, we found that there is indeed a correlation between facilitating behaviours and the fact that a participant already has some of the behaviours before the intervention with the behaviour change, which highlights the importance of the concept of familiarity and of performing the behaviour (Supplementary Table 1). There was also a correlation between the

Health Belief Model score and the dependent variables in the case of health workers before and after the intervention, evidencing that the health workers have not lost their fear of acquiring mosquito-borne arboviruses. On the other hand, it was found that, in the case of students, there was correlation just before the intervention. This shows that students, in fact, changed their perception of susceptibility and severity with the intervention (Supplementary Table 1).

Multivariate analysis

Figure 1 shows the Biplot plot from Principal Component Analysis (PCA) showing different patterns for the two groups analysed before and after the intervention. When analysing the dispersion ellipses, the health workers group has less variability in relation to sociodemographic characteristics, perceptions and behaviours than college students. The two groups have quite different standards regarding mosquito-borne arbovirus prevention, as expected. With the intervention, it was found that students' appropriate knowledge, perceptions and behaviours in such a way as to overlap with the health workers. Intervention based on behaviour change theories thus contributed to bring students' behaviour patterns closer to those of health workers.

Discussion

In this pilot-study, we have described the framework of behaviour-change intervention using mobile devices aimed to prevent mosquito-borne arboviruses. In the literature, most studies describe perceptions and knowledge about mosquito-borne arbovirus prevention [16–23] with few reports of interventions using ICTs and behaviour-change theories. Here, as the bivariate and multivariate statistics analysis showed, the pattern of students' attitudes (learners) and behaviours prior to the intervention was quite different from that of the health workers (experts); however, students were able to learn and to perform the target behaviours to control vector mosquito populations. The preliminary outcomes showed significant difference in the prevalence of target behaviour among college students after the behaviour-change intervention.

The review and choice of the theories of behaviour on which the research was based was carried out after an extensive literature review. In fact, some models and theories of behaviour change have been revised in the last decade; however, the WHO guideline continues to be used as reference worldwide [1].

The stage of defining the target behaviours of the intervention involved the participation of managers and workers in the Health Surveillance area, as described in the first pilot study conducted by the group [18]. In this work, we defined 10 target behaviours for educational actions; however, most participants suggested reducing this number focusing on what was most relevant. In addition, the health workers also emphasized, in their evaluation comments, the importance of highlighting window screening and the valorisation of recycling and donation of recyclable materials to collectors, activities that are not the target of the more traditional actions of Health Surveillance. Besides this, the health workers pointed out that most of the mosquito breeding is found in water containers; especially water tanks that stay in the backyards and are used during the dry season, when the water service is offered only two of the seven days of the week.

The use of the distance-learning platform has not been well evaluated by the participants for use with high school students, since it is quite complex and with multiple functionalities; for this reason, and to facilitate the monitoring of the competition activities, the group decided to develop a software (ZikaMob), that can also account for interactions on social networks. The health workers have produced videos explaining the target behaviours for the prevention of mosquito-borne arboviruses and have published them on social networks. This strategy had never been used before by these professionals. In fact, the experiences of using social networks to perform health education actions by Health Surveillance services in Brazil are still very much incipient.

Regarding the preliminary results, as already pointed out in the literature, the main predictor of behaviour change is already having previously targeted behaviour or related behaviours [1, 2, 4, 5]. Manguiera et al. (2019) [12], for example, found that military police officers, who are trained to keep everything clean and organized, inspect their homes to identify mosquito breeding sites more often than do college students. The present work, however, shows that stimulating domestic activities among young people can contribute to them developing arboviral prevention behaviours as adults.

The educational intervention did not contribute to increasing the students' fear; on the contrary, they felt safer and the perception of susceptibility decreased over time. The fact that students perform preventive actions may have contributed to reduce their fear of acquiring the disease. In fact, data on the mortality rates of mosquito-borne arboviruses or information that made students reflect on the severity of these diseases were not included in educational activities. Other published studies have shown that some risk groups, such as pregnant women, have a different perception of susceptibility to mosquito-borne arboviruses [24].

Whether or not living at home and in a region most at risk for mosquito breeding sites did not imply more behaviours that are preventive. In fact, in the health workers group, participants with higher household risk showed more target behaviours in relation to the elimination of mosquito breeding sites. In the literature, some studies have shown that the perception of those residing in risk areas is different from those

in areas with lower risk [25], and there are differences between those who live in urban and rural areas [22]. Further studies should explore the factors that influence the feeling of being at risk of acquiring mosquito-borne arboviruses to support the planning of behaviour-change interventions.

Finally, the main limitation of this pilot study was the sample. The Health Department of Campina Grande did not allow the participation of more than 50 health workers, because they needed to spend some time of the week to perform the educational activities of the course, so they could not work. At the university, first-year college students had to perform preventive activities during the weekends because of their university agenda. Further studies involving high-school students should consider the time needed to perform the activities at home, to produce the videos and to publish on social media as a limitation for engagement.

Conclusion

The course we provided encompassed not only theories of behavioural change in its design and implementation; it was also presented in a format easily accessible to our participants. Effectively, we reduced the distance between intention and action. It stimulated motivation by means of interim tasks to be accomplished and displayed on social media, thereby stimulating a sense of group identity and perhaps even some sense of competition whereby participants would not wish to be seen not to have performed the set tasks. And then there was also the cash prize for those who completed all the tasks. These factors came together to bring the students' behaviour pattern in combating vector mosquitoes closer to that of the health workers and also giving the students a greater sense of agency in respect of prevention of mosquito-borne arbovirus.

In sum, we have presented a model for effectuating behavioural change perhaps applicable in other settings.

Declarations

Author's contributions

SS: study conception, study design, acquisition of data, analysis and interpretation of data, and drafting the manuscript. RSM, FFAM, VAA and IDF: acquisition of data, analysis and interpretation of data. RO: statistical analysis. CSB, DM and JT: drafting the manuscript and final revision. All authors read and approved the final manuscript.

Consent for publication

Not applicable.

Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

The current study was funded by Fundação de Apoio à Pesquisa do Estado da Paraíba (FAPESQ – Edital Zika Virus 02/2017), CAPES and British Council 274560199. The role of the funding body: the design of the study; collection, analysis, and interpretation of data; and in writing the manuscript.

Ethics approval and consent to participate

This research was approved by the Research Ethics Committee of Paraíba 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.

References

1. World Health Organization. Health Education: Theoretical Concepts, Effective Strategies and Core Competencies. 2012. https://books.google.com/books/about/Health_Education.html?hl=&id=fP8uLgEACAAJ.
2. Michie S, Atkins L, West R. The Behaviour Change Wheel: A Guide to Designing Interventions. 2014. https://books.google.com/books/about/The_Behaviour_Change_Wheel.html?hl=&id=1TGlrEACAAJ.
3. West R, Evans A, Michie S. Behavior change techniques used in group-based behavioral support by the English stop-smoking services and preliminary assessment of association with short-term quit outcomes. *Nicotine Tob Res.* 2011;13:1316–20. doi:10.1093/ntr/ntr120.
4. Glanz K, Bishop DB. The role of behavioral science theory in development and implementation of public health interventions. *Annu Rev Public Health.* 2010;31:399–418. doi:10.1146/annurev.publhealth.012809.103604.
5. Michie S, Abraham C. Interventions to change health behaviours: evidence-based or evidence-inspired? *Psychology & Health.* 2004;19:29–49. doi:10.1080/0887044031000141199.
6. Noar SM, Zimmerman RS. Health Behavior Theory and cumulative knowledge regarding health behaviors: are we moving in the right direction? *Health Educ Res.* 2005;20:275–90. doi:10.1093/her/cyg113.
7. Guida HFS, de Souza KR, dos Santos MBM, da Silva SMCL, Silva VP. As relações entre saúde e trabalho dos agentes de combate às endemias da Funasa: a perspectiva dos trabalhadores. *Saúde e Sociedade.* 2012;21:858–70. doi:10.1590/s0104-12902012000400006.
8. Fraga L dos S, dos Santos Fraga L, Monteiro S. A gente é um passador de informação: práticas educativas de agentes de combate a endemias no serviço de controle de zoonoses em Belo Horizonte, MG. *Saúde e Sociedade.* 2014;23:993–1006. doi:10.1590/s0104-12902014000300021.
9. Libanio KR, Favoreto CAO, Pinheiro R. Análise da integração da Vigilância Ambiental no controle da dengue com a Estratégia Saúde da Família: impacto nos saberes e práticas dos agentes comunitários de saúde. *Physis: Revista de Saúde Coletiva.* 2014;24:147–63. doi:10.1590/s0103-73312014000100009.
10. Silva IB da, da Silva IB, Mallmann DG, de Vasconcelos EMR. ESTRATÉGIAS DE COMBATE À DENGUE ATRAVÉS DA EDUCAÇÃO EM SAÚDE: UMA REVISÃO INTEGRATIVA. *Saúde (Santa Maria).* 2015;41. doi:10.5902/2236583410955.
11. Pessoa JP de M, de Moraes Pessoa JP, de Oliveira ESF, Teixeira RAG, Lemos CLS, de Barros NF. Controle da dengue: os consensos produzidos por Agentes de Combate às Endemias e Agentes Comunitários de Saúde sobre as ações integradas. *Ciência & Saúde Coletiva.* 2016;21:2329–38. doi:10.1590/1413-81232015218.05462016.
12. Abel Manguera FF, Smania-Marques R, Dutra Fernandes I, Alves Albino V, Olinda R, Acácia Santos-Silva T, et al. The prevention of arboviral diseases using mobile devices: a preliminary study of the attitudes and behaviour change produced by educational interventions. *Trop Med Int Health.* 2019;24:1411–26. doi:10.1111/tmi.13316.
13. Siegel A. Practical Business Statistics. Academic Press; 2011. <https://play.google.com/store/books/details?id=1lCwX1uWWWhoC>.
14. R: The R Project for Statistical Computing. <https://www.r-project.org/>. Accessed 25 Feb 2020.
15. Kaiser HF. The Application of Electronic Computers to Factor Analysis. *Educational and Psychological Measurement.* 1960;20:141–51. doi:10.1177/001316446002000116.
16. Darrow W, Bhatt C, Rene C, Thomas L. Zika Virus Awareness and Prevention Practices Among University Students in Miami: Fall 2016. *Health Educ Behav.* 2018;45:967–76. doi:10.1177/1090198118760687.
17. 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. *Am J Trop Med Hyg.* 2018;98:845–8. doi:10.4269/ajtmh.17-0799.
18. 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. *Malar J.* 2015;14:522. doi:10.1186/s12936-015-1047-y.
19. Plaster AN, Painter JE, Tjersland DH, Jacobsen KH. University Students' Knowledge, Attitudes, and Sources of Information About Zika Virus. *Journal of Community Health.* 2018;43:647–55. doi:10.1007/s10900-017-0463-z.
20. Samuel G, 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;18:98. doi:10.1186/s12889-017-4991-3.
21. 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;18:484. doi:10.1186/s12889-018-5372-2.
22. 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;5:1402. doi:10.18203/2394-6040.ijcmph20181207.

23. Wong LP, AbuBakar S. Health beliefs and practices related to dengue fever: a focus group study. *PLoS Negl Trop Dis*. 2013;7:e2310. doi:10.1371/journal.pntd.0002310.
24. Khun S, Manderson L. Community and school-based health education for dengue control in rural Cambodia: a process evaluation. *PLoS Negl Trop Dis*. 2007;1:e143. doi:10.1371/journal.pntd.0000143.
25. Flamand C, Camille Fritzell, Pauline Obale, 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. *Am J Trop Med Hyg*. 2017;97:344–55. doi:10.4269/ajtmh.16-1028.

Figures

Figure 1

Multivariate analysis showing Biplot plots for individuals and groups, college students in RED and health workers in BLUE, with their respective confidence ellipses (with 95% reliability). Graph A refers to the pre-intervention data analysis and B refers to the post-intervention for prevention of mosquito-borne arboviral diseases.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [S1.docx](#)