School-based health education in Yucatan, Mexico about the Chikungunya virus and mosquito illness prevention

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Abstract

The Chikungunya virus (CHIKV) has been rapidly spreading throughout Latin America, utilizing pre-existing vectors to infiltrate the immunologically naïve populations. With the current rise of the Zika Virus, there is an urgent need for more rigorous vector control efforts to prevent further Zika breakout. We designed a school-based education module on CHIKV and mosquito prevention and presented it to the local students of ages of 6-18 in a rural town called Sudzal in Yucatan, Mexico. We distributed questionnaires before and after education to test the students' knowledge of CHIKV and mosquito prevention. Chi-squared test was performed to determine the efficacy of the presentation in increasing their knowledge. The education presentation has proven to effectively educate the local residents in several critical methods of mosquito prevention, increasing the average test scores by 67% post-education. These include applying repellent, staying hydrated during recuperation, and cleaning indoor water containers to eliminate breeding sites ($P<0.001$). Furthermore, the questionnaire captured the residents' behavioral patterns regarding CHIKV and mosquito prevention and identified cultural, ecological, and socioeconomic factors hindering effective implementation of vector control.

Introduction

Epidemiology

The Chikungunya virus (CHIKV) is an arbovirus spread by mosquito vectors. About 3-25% of the patients are asymptomatic.[1] The hallmark symptoms of CHIKV include sudden onset of fever (typically 39-40°C) and severe arthralgia.[2] Other typical symptoms include headache, skin rash, retro-orbital pain, myalgia, neurological syndromes, insomnia, and myelopathy.[3] The first wave of CHIKV epidemic started autochthonous to Kenya in 2005, affecting African and Asian countries bordering the Indian Ocean and eventually continental Europe and Oceania by 2011.[4-7] A large-scale epidemic did not appear in the Americas until 2013, which started from Saint Berthélmy in the Caribbean.[8,9] By 2014, CHIKV had spread to other Caribbean islands, numbering over 17,000 cases.[10] Because the population was immunologically naïve, CHIKV case reports have spiked dramatically; with the first two cases reported in Florida in July 2014, by October 2014 the case number had risen to 777,069 cases in the Americas.[11]

Yucatan and Sudzal

Sudzal is a municipality in the state of Yucatan. With the total municipal population being approximately 1700, the ethnic profile of Sudzal is fairly homogeneous. As Yucatan is inhabited primarily by descendants of indigenous Mayan population, almost all of Sudzal population is of Mayan descent. They speak mainly Spanish, while the older generation (>60 years old) often speaks Mayan, which is the indigenous language in Yucatan. In 2010, SEDESOL (Mexico's Secretary of Social Development) reported that as a marginalized rural town in one of the poorest states in Mexico, 42.3% of the Sudzal population is under moderate poverty, while another 27.9% is under extreme poverty.[12] 14.7% of the population is without access to health care services, while 88.4% have scarce access to social security. The same report states that 71.5% is currently under living conditions without *basic services available*, qualifications of inadequate living conditions including lack of drainage, insufficient living spaces, access to public water system, or lack of electricity.

Role of community education in mosquito illness prevention

Successful eradication of mosquito vectors is almost unheard of. Fernández-Salas *et al*. suggests that the challenge of complete, successful vector control must utilize a multi-faceted approach, which includes insecticide rotation to subside resistance at a reasonable level, an efficient vector control system that is sustainable and manageable by the geographic and demographic profile, and finally empowerment of the community to promote personal preventative measures.[13-16] Social mobilization and changes of social norm require significant efforts and funding, and this is an area in dire need of skilled expertise that unfortunately remains largely unaddressed. Studies have shown that different socioeconomic groups have different pathological patterns, most likely because people regulate their health behaviors according to their understanding of the diseases.[17,18] Consequently, proper health education of populations in regions at risk of mosquito illnesses is imperative in integrating community cooperation in vector control strategies. Horstick *et al*. states that despite the acknowledgment of community health promotion and education as a key factor in vector control, few studies address this process in detail.[15] Even throughout the dengue virus outbreaks, education methodologies and effective model for community behavior change

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Key words: School-based; community education; mosquito; Chikungunya; prevention.

Acknowledgements: Samy Azael Acosta Lopez.

Contributions: MSC, principal investigator and author, RAB, project supervisor.

Conflict of interest: the authors declare no potential conflict of interest.

Funding: we have received personal donations from members of New Hope Baptist Church to fund the project expenses. We thank Phi Kappa Phi University of Michigan Chapter and the Edward Ginsberg Center of the University of Michigan, Ann Arbor for their generous donations toward the mosquito installation in Sudzal, Mexico.

Conference presentation: this study was be presented at the University of Michigan, 27th Annual Pediatric Research Symposium in Ann Arbor, MI on October 10th, 2016 and at the Henry Ford Global Health Initiative Symposium in Detroit, MI on October 21st, 2016.

Received for publication: 20 September 2016.
Revision received: 16 January 2017.
Accepted for publication: 27 January 2017.

Infectious Disease Reports 2017; 9:6894
doi:10.4081/idr.2017.6894

have never been seriously evaluated.[19]

According to Lloyd's study of mosquito vector control program in Merida, Yucatan in 1994, much of the previous vector control revolved around government personnel entering the household to apply insecticide.[20] She observed that health communication and education among the community remained *narrow and didactic* within the vertical programs of mosquito vector control. Such approaches do not allow the residents to gain substantial knowledge about the disease but instead render them as passive recipients of vector control treatments. Rather than using education materials originally mass-produced by a central office to be distributed everywhere, Lloyd instead suggests a community-based horizontal programs by decentralizing the educational materials to take into account the ecological, social, and cultural aspects of the specific community. Her community-based education study in 1992 has proven effective in changing residents' behaviors in household larval production site elimination practices.[21] To effectively educate the community in CHIKV and mosquito prevention and illicit higher *locus* of health control that will ultimately induce behavioral change, this project has three goals:

i) Educate the community in the CHIKV and mosquito borne illness prevention through community-based education module to increase their personal *locus* of control.
ii) Document the Sudzal population's perception and behavioral patterns of mosquito prevention by surveying the Sudzal students from ages of 6-18.
iii) Evaluate the efficacy of the school-based education module in increasing their knowledge via a quantitative analysis of the questionnaire completed by Sudzal students before and after education.

Materials and Methods

Development of community-based educational module

The population-specific community education module development of this project closely followed Lloyd's Five-stage process used to develop and implement education intervention.[20] The education module in this project focused largely on effectively conveying the importance of engaging in mosquito prevention behaviors. According to Lloyd, formative research encompasses all collection of data regarding the community's social, cultural, behavioral, and economic data that cannot be extracted from previous literature. This step is imperative in identifying which preventative methods can be feasibly complied by the residents. Furthermore, it distinguishes lack of knowledge or unique cultural perceptions of Sudzal residents that affect mosquito prevention behaviors.

The formative research in this project was carried out qualitatively with open, semi- structured interviews with convenience sampling and door-to-door visits. Through interviewing 12 residents, mostly women since they were present during the day, we investigated their knowledge of the transmission mechanism, symptoms, treatments, and prevention of CHIKV. Furthermore, we investigated their behavioral patterns and knowledge of vector prevention. Several areas of potential improvement were identified from formative research, and specific recommendations were formulated in a manner that residents could find relatable and compliable.

Questionnaire and data analysis

In order to test the efficacy of the education module and document their behavioral patterns, we distributed a knowledge, beliefs, and practices (KBP) questionnaire based on formative research before and after the education (n=106). While the education module was delivered to the general Sudzal population, due to low literacy factors among the general population, the KBP questionnaire was distributed only to students of ages 6-18. There were *Behavior Questions*, which gauged the residents' patterns and perceptions of mosquito preventative behaviors, along with *Efficacy Questions*, which directly tested the knowledge the audience gained from the education. After each questionnaire collection, education contents were revised to specifically target areas where the residents lacked knowledge about mosquito prevention according to the questionnaire results. For the *Efficacy Questions*, each answer choice for individual question was quantitatively analyzed via Chi-squared test to screen for significant changes in the frequency of correct responses before and after the education using Microsoft Excel. For the *Behavior Questions*, histograms were produced to determine the major, predictable patterns of the residents' behaviors and their perceptions.

Results

Behavior questions documenting the residents' prevention behaviors

The questionnaire results generally reflected the patterns we observed during the formative research. 41% answered that they have already received some form of health education about CHIKV. 82% responded that they do not use repellents, the main reason being *I am not accustomed to it*, which 55% of respondents selected (Figure 1). The next two most prevalent reasons for not employing repellent was *It's too expensive* and *It's not necessary* at 7%. For those who do not wear long sleeve clothes for vector prevention, the two main reasons

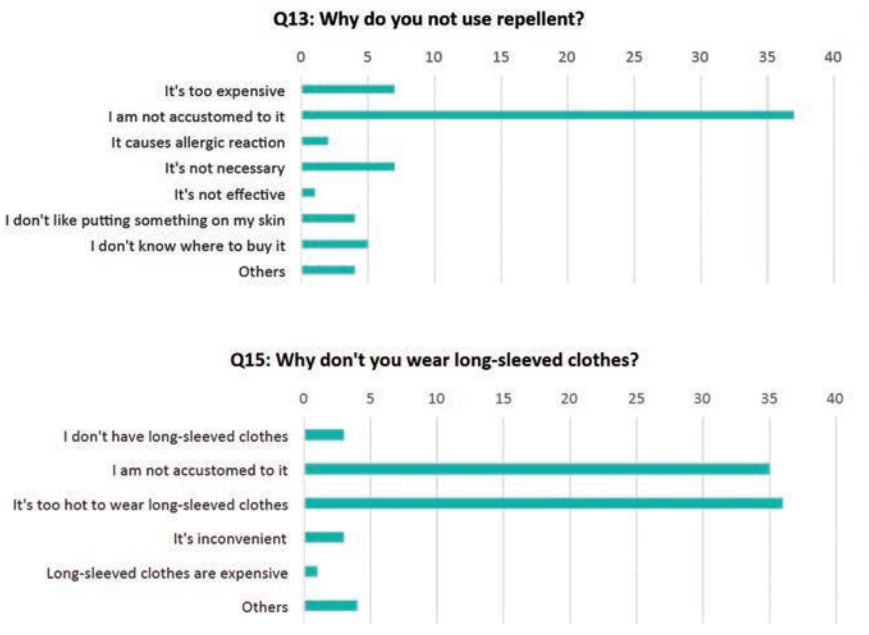

Figure 1. Selected histograms of *Behavior Questions* responses (n=106).

were *I am not accustomed to it* and *It's too hot to wear long-sleeved clothes* with 43% and 44%, respectively (Figure 1). Close to equal amount of residents answered either *Yes* or *No* to the question *Do you avoid woody areas to prevent mosquito bites*?. 75% responded that they already have mosquito screens installed in their houses. Among without mosquito screens, the predominant reason for lack of mosquito screens was its cost, which 32% of responders selected. 91% of the respondents answered that they eliminate breeding sites of mosquitoes to a certain extent.

Quantitative analysis of efficacy questions

Table 1 shows the Chi-squared test analysis result of the *Efficacy* questions that were constructed to test the audience's knowledge of CHIKV and mosquito prevention measures. The result shows that the community-based education module successfully improved the residents' knowledge of CHIKV and mosquito prevention in several critical areas. Residents became more knowledgeable in the various symptoms of CHIKV (Table 1). Post-education, there was a 62.5% decrease in the number of residents who responded that they do not believe CHIKV is preventable. Also, there was a 55% decrease in the number of audience who responded *Bacteria or germs in the air* as a possible spreading mechanism of CHIKV (data not shown).

Two biggest sections of improvement were knowledge of mosquito prevention methods and mosquito breeding site identification. There was a 75% increase in the number of responses that identified putting repellent as a preventative method (Table 1). Close to 200% increase was observed in the response frequency of *Wear long-sleeved clothes* to the same question, and 360% change for the frequency of *Avoid woody areas*. There was a 120% increase in the number of audience that correctly identified *Water containers inside the house* as a possible breeding site of mosquitoes ($P<0.001$), along with 76% increase in *Old Tires* as another larval production site. Lastly, we observed a 485% increase in the response frequencies that correctly identified *Drinking much water* as part of recuperation regime of CHIIKV.

Discussion

There already exist many efforts to promote mosquito prevention in Sudzal, including posters around the town hall and visits by government officials to talk about mosquito prevention among the residents. However, the efficacies of such education methods have never been properly evaluated in Sudzal. During formative research, we discovered that the Autonomic University of Yucatan (UADY) has previously donated mosquito screens for all households in Sudzal. To our shock, the residents had uninstalled the mosquito screens and sold them for profit, claiming that the mosquito screens do not allow proper ventilation. This reflects the lack of residents' understanding in the mechanism of mosquito screens and mosquito illnesses in general, and more seriously the community's general perception of mosquito illnesses as insignificant illnesses. Such phenomenon suggests a discrepancy between the health message delivered by the central government and the population's comprehension of the disease and prevention methods.

Table 1. Chi-squared test analysis of the *Efficacy Questions* to test the audience's knowledge of CHIKV and mosquito prevention measures gained from community-based education module (selective data shown).

Questions	% change of correct responses	P-value
Q7. What are the symptoms of CHIKV?		
Fever	128.21	0.133716215
Joint pain (Arthralgia)	80	0.000199742
Muscle pain (Myalgia)	159.09	0.407309709
Rash	104.35	0.000782413
Pain behind the eyes	360	4.97228E-08
Q9. Do you think you can prevent CHIKV?		
Yes	117.65	0.084234195
No	62.5	0.042677426
I don't know	66.67	0.279582614
Q11. If you believe you can prevent CHIKV by avoiding mosquito bites, what can you do to prevent mosquito bites?		
Put repellent	75	2.54669E-08
Wear long-sleeved clothes	194.74	0.000214439
Avoid woody areas	360	0.000563731
Install mosquito screens on doors and windows	42.86	0.105545089
Eliminate mosquito breeding sites	19.44	0.394061407
Spray the house with "Baygon" (a well-known pesticide)	8	0.873174933
Q21. If you believe you can prevent mosquito bites by eliminating mosquito breeding sites, which places do you think are breeding sites of mosquitoes?		
Water containers (Buckets, water tanks) outside the house	44.11	0.77251453
Water containers (Buckets, vases) inside the house	120	0.000579734
Coconut shells	100	1.55227E-10
Old tires	76.9	0.005861291
Tall grasses	209	0.000219801
Natural water holes (sink holes, caves, lagoons)	92.86	0.036915619
Trash	16.13	0.554594237
Q26. How can you treat the symptoms of CHIKV?		
Medications	0	0.890259443
Resting	18.87	0.214316511
Drinking much water	485.71	6.111443-08
Praying and other religious endeavors	-20	1
There is no treatment	66.67	0.613709994

This study addresses this problem by providing a more decentralized, community- oriented health education program that takes into account the specific community's socioeconomic, cultural, and literacy factors. Chi-squared analysis of the KBP questionnaire shows that the education has improved the residents' knowledge in CHIKV and mosquito prevention, including the disease mechanism, treatment, and possible mosquito breeding sites. Furthermore, the questionnaire captured the residents' behavioral patterns and perception towards CHIKV and mosquito prevention practices.

Limiting factors affecting implementation of vector control

It must be noted that there although this education module effectively enhanced the residents' knowledge in the mechanism of CHIKV and prevention methods, the actual implementation of vector control practices prove challenging because there exist several environmental, cultural, and economical factors that disable residents from being compliant. For example, mosquito repellent is a method widely advertised in the United States as the forefront, immediate prevention strategy against mosquito diseases. However, some residents expressed that the price range of repellents in Yucatan, which ranges from about $1.2-7.2 USD, is unaffordable by many residents. Moreover, our questionnaire result showed that in the case of Sudzal, many residents have never even considered the option of using repellent, nor did they any inclination to the idea of testing it out.

The majority of the attendees of the education were already familiar with mosquito screens, and most interviewees from the formative research responded they already installed mosquito screens in their households. For those without mosquito screens, the most prominent contributing factor was its high cost. Especially in the case of CHIKV, where vaccines are still under investigation and chemoprophylaxis has proven largely ineffective due to insecticide resistance and inconsistent insecticide/larvicide treatment, vector control efforts must prioritize source reduction at the individual household level. Due to the lack of constant access to flowing water, virtually all households in Sudzal own several water buckets for water storage, at time exceeding ten in number for large families. Formative research shows that no buckets are sold with lids in nearby markets, and they are maintained exposed to the environment within households. The backyards of the Sudzal houses are often open fields with holey rocks, trees, and forests available for water accumulation. Trash bags, old furniture, old tires, and broken coconut shells are frequently found strewn around the backyards and the streets due to poor refuse collection system. Furthermore, many residents − about 46.8% according to a previous study − raise livestock in their backyard with cages open to the atmosphere and provides an ideal living environment for the vectors.[22]

Limitations of the study

The limitations of this study must be noted. The questionnaire was not taken under private setting, allowing the possibility that questionnaire answers were affected by social conformation desirability and not representative of the residents' true mosquito prevention behavioral patterns. Due to high illiteracy among the adult population and their long working hours, our questionnaire samples consisted only of students with some level of literacy from the age of 6-18, which composes about 23% of the total population. Thus, the prevention behaviors that we have compiled may not be representative of the adult populations, who have more influence on mosquito vector control efforts within the community. Focus groups with oral discussions or door-to-door interviews could allow a better representation of the adult population in the study. Furthermore, interview subjects during formative research was not collected via random sampling, and its demographics may not accurately represent the population. Since the post-education KBP questionnaire was distributed immediately after the education, our study may not have captured the long-term information retention as effectively as it would have after a period of latency. Lastly, this study does not investigate how effectively increase in knowledge translated into actual behavioral changes regarding mosquito prevention.

Further implications of the study

Mobilizing the community towards collective mosquito prevention efforts mandates more human and financial resources than what is currently available; knowledge gained from education may be futile if the community does not have any substantial means to implement the learned prevention methods. Moreover, general apathy and lack of communal commitment with vector control strategies is a serious barrier when it comes to implementing mosquito prevention initiatives in low socioeconomic status.[23] We emphasize perceived lack of health locus of control induced by inability to comply to preventative efforts and lack of robust community programs as demotivating factors in active participation in vector control.

With this in mind, we initiated a project that would allow the Sudzal population to reach a tangible goal together as a community.[23] Based on field observation and previous literature, we identified school grounds as high-risk infection site for mosquito illnesses.[24] We asked the community and school faculties to collaborate with raising funds to install mosquito screens in the classrooms to protect students during school hours. If they raised a certain portion of the mosquito screen installation fee, we proposed to provide financial support for the remaining amount. Town representatives − including the mayor − and school faculty and parents have collaborated to successfully reach the fundraiser goal. We are currently installing the mosquito screens on school properties. While our study did not directly measure the adult residents' understanding of our education module, the town adults' participations in community-wide fundraiser project likely reflects a heightened understanding and awareness of the mosquito illnesses. A possible extension of this study would be to investigate the efficacy of this fundraiser in raising awareness of mosquito illnesses and altering the residents' preventative behaviors.

To avoid repeating the history where residents uninstalled the mosquito screens provided for free in individual households, we will provide proper care techniques and advise the school faculty members to provide surveillance over mosquito screen maintenance. Since all school faculties financially contributed towards this effort, this project has raised awareness among the students about the importance of mosquito prevention. Moreover, we hypothesize that the achievement of a tangible goal − physically seeing the mosquito screens installed − will stimulate the community members to further engage in vector control efforts.

Conclusions

Much research has been done in chemical vector control and vaccine development of mosquito illnesses since the twentieth century. However, little efforts have been invested in creating a model to effectively stimulate community participation in mosquito-illness endemic countries. With the idea that robust understanding of the disease is a key factor in stimulating community participation, this study's main aim was to educate the local residents of Sudzal, Mexico in the Chikungunya Virus and mosquito prevention. We did so by formulating a health education module specifically targeting the Sudzal population. While our education module audience included resi-

dents of all age groups, we surveyed the student population from ages 6-18 to document their prevention behaviors and evaluate the efficacy of the education module. While this study directly addresses mosquito vector control, community mobilization and empowerment in countries of underserved population are crucial contributing factors in alleviating any health issues, including both infectious and non-communicable disease, and furthermore chronic illnesses. We must move away from complete reliance on passive compliance to centralized health policy enforcement, and promote active, independent health mobilization from within the community in order to create a better health standing in any population.

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