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ARTICLE

Emerging arboviruses (dengue, chikungunya, and Zika) in Southeastern Mexico: influence of socio-environmental determinants on knowledge and practices

Arbovirosis emergentes (dengue, chikunguña y Zika) en el sudeste de México: la influencia de los determinantes socioambientales sobre el conocimiento y las prácticas

Arboviroses emergentes (dengue, chikungunya e Zika) no Sudeste do México: a influência dos determinantes socioambientais sobre o conhecimento e as práticas

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Abstract

The proliferation of arboviruses and their vectors is influenced by a complex interplay between vector, environment and human behaviors. The aim of this work is to analyze the influence of socio-environmental determinants on knowledge and practices regarding arboviruses transmission, among the residents of three communities on the southern border of Mexico. Between June 2017 and August 2018, a set of 149 households from three communities of Tapachula (Chiapas) and Villahermosa (Tabasco) were covered. This study consists of the application of a community prevention project. Different surveys and methodological approaches were used. Associations between socio-environmental determinants and knowledge and practices for arboviruses transmission control were estimated by odds ratio. Logistic regression and qualitative techniques were used. Although around 75% of households had an adequate knowledge about arboviruses' origin and transmission, only 30% of them adopted adequate practices. Domestic risk practices were associated with serious deficiencies in water and sanitation services. Furthermore, a perception of greater risk and difficulty in complying with preventive measures were detected. An adequate knowledge does not necessarily lead to adequate prevention practices. Intermediate social determinants influence on the persistence of risk behaviors for arboviruses proliferation. Addressing such related aspects requires the achievement of an effective and sustainable vector management.

Arboviruses; Mosquito Control; Environment and Public Health; Sanitation

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Introduction

Dengue (DENV), Chikungunya (CHIKV) and Zika (ZIKV) are arthropod-borne viruses (arboviruses). In America, the *Aedes aegypti* mosquito is the primary vector of their transmission, a mosquito of tropical urban areas, widely adapted to domestic environments, and globally distributed [1,2]. *Aedes albopictus* is also present in America as a secondary vector of these diseases, transmitting the virus to different species of host through its blood-feeding behavior in rural or wild environments [3].

In the Region of the Americas context, already endemic for DENV and with high *Aedes* infestation levels, the recent spread of CHIKV and ZIKV threatens and challenges the public health systems [4].

In Mexico, autochthonous cases of CHIKV and ZIKV by *Ae. aegypti* transmission were detected for the first time in the southern border with Guatemala, near the city of Tapachula (Chiapas), in October 2014 and November 2015, respectively [5,6]. In the state of Tabasco, first cases appeared between June 2015 and February 2016 [7].

Since then, these diseases have been spreading northwards through the country. However, Mexico's southern border, currently a highly endemic area for the three arboviruses [7,8], has been the most affected region due to repeated outbreaks and epidemics that heavily impacted the local health and economy.

The global burden of arboviral diseases and their rapid geographical spread require the formulation of effective and sustainable strategies to reduce the proliferation of viruses and their vectors. Therefore, it is extremely important to understand the nature and interaction of the risk factors behind arboviruses' emergence, reemergence and persistence [1,2,9].

Human practices play a fundamental role in the diseases spread, closely related to domestic and peri-domestic indices of *Aedes* larval infestation. The wide availability of breeding sites (trashes, residues, disused bottles, disused tires, or any containers that can be filled with rainwater) within domestic environments can be considered an indicator of vector proliferation and disease transmission risk, as they enable the proliferation of the mosquitoes, and therefore the diseases transmission [10].

Vector control, especially at domestic level, is an essential component for arboviral diseases prevention, and the identification of arbovirus-related knowledge and practices contributes for the development of more effective and context-adapted strategies [9]. Yet, more factors must be considered and assessed to prevent arboviral epidemics and endemicity [11]. Since the epidemiological patterns of arboviral diseases are associated with a set of social, ecological, and environmental determinants [9,10,11,12,13,14], the World Health Organization (WHO) strongly recommends the implementation of an integrated vector management for controlling and preventing arboviral diseases [15]. According to the WHO Commission on Social Determinants of Health (CSDH), intermediate determinants are assets or circumstances with great impact on human health by their interrelations with biological, psychosocial and behavioral factors [16,17].

Arboviral diseases are deeply associated to water, sanitation, and hygiene (WASH) indicators, infrastructure conditions, education level and socioeconomic status [11,12,13,14,18,19,20,21,22,23]. Thus, the aim of this work is to assess the influence of these socio-environmental factors on the knowledge about arboviral diseases and related preventive practices among inhabitants of three rural communities of Southern Mexico. Social and intermediate health determinants such as education, water supply and public hygiene services were investigated to identify possible associations with community knowledge, interpretations and behaviors affecting the vector ecology.

Methods

Study setting

The study was conducted at three coastal rural villages near the southern border of Mexico: *Ejido* Hidalgo and *Ejido* Río Florido, of the municipality of Tapachula (state of Chiapas) and Ranchería Guineo Segunda Sección, of the municipality of Villahermosa (state of Tabasco).

These three locations were chosen for sharing socioeconomic, geographical and ecological conditions, presenting *Ae. aegypti* and *Ae. albopictus* vectors, as well as being located along chikungunya and Zika south-north expansion since 2015 [8].

Ejido Hidalgo (14º53'02"N and 92º21'37"W) and *Ejido* Río Florido (14º51'18"N and 92º20'29"W) are located at approximately 15km southwest of Tapachula city, in the coastal plain of Chiapas at a 56m mean altitude. Both *Ejidos* are separated by a distance of 3.5km. The predominant climate is tropical monsoon ("Am"), with an average annual temperature of 26.5ºC and 2,700mm of annual precipitations. *Ejido* Río Florido comprises an area of 20 hectares, 789 inhabitants, 172 inhabited households and 4.59 inhabitants per household. *Ejido* Hidalgo comprises an area of 24 hectares, 697 inhabitants, 184 inhabited households and 3.79 inhabitants per household. In both villages, people are mainly dedicated to agricultural activities and the cultivation of several commercial crops [24,25].

In Tabasco, the Ranchería Guineos Segunda Sección (17º54'33.63"N and 93º2'6.40"W) is located at approximately 13km southeast of Villahermosa city, in the alluvial plain of Tabasco, at an 11m mean altitude. The predominant climate is "Am", with average annual temperature of 27.3ºC and about 1,972mm of annual precipitations. The village comprises approximately 20 hectares, approximately 1,032 inhabitants, 263 inhabited households and 3.92 inhabitants per household. Most households have electricity and piped water. People are mainly dedicated to agricultural and aquaculture activities [24,26].

Ejido Hidalgo and *Ejido* Río Florido on one hand, and Ranchería Guineo Segunda Sección on the other represent two extremes of a DENV, CHIKV and ZIKV prevalence gradient. In 2017, there were over 17,404 confirmed cases of the three diseases in the whole country: 1,240 in Chiapas (7% of the total) and only 98 confirmed cases in Tabasco (0.6% of the total) [7].

The three localities were setting for a multidisciplinary pilot project focused on arboviruses control and prevention, coordinated by the El Colegio de la Frontera Sur (ECOSUR) [27]. The first step was the development of a community engagement plan with local stakeholders of the two Tapachula's villages, to improve community involvement and participation in arboviral diseases control [28] (Supplementary Material 1: http://cadernos.ensp.fiocruz.br/site/public_site/arquivo/suppl-1-e00110519_9667.pdf).

Study design and participants

The present cross-sectional mixed-method study consisted of two stages:
(1) Pre-intervention: in June 2017, prior to Tapachula's community engagement interventions, one Household Survey (about knowledge and reported practices on arboviruses) and one Risk Observational Assessment (about risk practices for vector proliferation at domestic level) were applied per household.
(2) Post-intervention: between July and August 2018, the Risk Observational Assessment was reapplied in the same households. Furthermore, information regarding predisposing circumstances for vector proliferation at community level (water supply and environmental public health services) was gathered by the application of a Community Background Survey, complemented by a qualitative questionnaire.

The surveys were applied to a set of 149 households, chosen through a simple random sampling process: 82 households in Tapachula municipality (34 from *Ejido* Río Florido and 48 from *Ejido* Hidalgo) and 67 households in Villahermosa municipality, totaling 643 residents. Sample size was calculated at 95% confidence interval (95%CI), with 5% margin of error and 10% non-response rate.

For the qualitative questionnaire, a purposive sampling process was used to recruit two key informants per community, members of local organizations playing a relevant role in the management of community health problems: the local community health center (*Casa de Salud*) and the main local government body (*Asamblea Ejidal*).

All participants of the study were informed of its purpose and gave their consent. In agreement with article 23 of the Regulation of the General Health Law in the Field of Research of Mexican Ministry of Health, considering the nature of the investigation, only verbal informed consent was applied. The research project proposal was approved by the Ethics Research Committee of ECOSUR, with reference n. CEI-006-2018.

Surveys (Supplementary Material 2; http://cadernos.ensp.fiocruz.br/site/public_site/arquivo/suppl-2-e00110519_2525.pdf)

- **Household Survey**

A structured, standardized and pre-coded questionnaire was designed to obtain information on the sociodemographic characteristics of the household residents regarding age, schooling level, number of residents per household and average women per household. In addition, residents were asked about their knowledge on arboviruses' origin and transmission, as well as the use of preventive measures. Interviews were conducted using the "breadwinner" as the main respondent.

- **Risk Observational Assessment**

In 2017 and 2018, through the application of a structured, standardized and pre-coded household observational checklist, the following information were collected regarding the presence or absence of risk factors for vector proliferation in the households: presence or absence of unprotected water deposits, solid waste accumulation and others risk elements. Observations were made in the households surroundings, or patio (courtyard), a fundamental extension of the house where the kitchen, dining room and rustic bathroom are generally located [29].

- **Community Background Survey**

The presence of risk factors for *Aedes* breeding within the whole community was first assessed through pre-coded questions to household residents. The questions focused on sanitation, hygiene services and infrastructures available in the villages.

Then, a semi-structured questionnaire for the key informants of each community was designed to provide a better insight of information recorded during home visits. In addition, further qualitative data were collected to explore risk perceptions and community's expectations regarding arboviral diseases and their prevention.

Data collection and management

Fieldwork data collection was performed by trained staff and graduate students from ECOSUR, Andalusian School of Public Health (EASP; Granada, Spain) and Touro University (Vallejo, USA). A representant from the *Comisariado Ejidal* (representation of the *Asamblea Ejidal*) of each community accompanied the team during fieldwork to gain a better understanding and acceptance from the rest of the community.

Information were collected using paper questionnaires and quantitative data were entered (twice) into a database, using spreadsheets files. All data files were checked and cleaned separately by field supervisors. Data files of all study stages were first analyzed separately and then merged and analyzed altogether.

Qualitative data from the Community Background Survey were written as field notes, initially by hand, during or directly after interview process. Afterwards, data were transcribed and organized into a data analysis template.

Knowledge, referred and observed practice score system development (Supplementary Material 2; http://cadernos.ensp.fiocruz.br/site/public_site/arquivo/suppl-2-e00110519_2525.pdf)

To evaluate each section of the proposed surveys, indices were designed to score the adequate or inadequate knowledge and practices at stake, as previously done in several studies [30,31,32,33].

Questions regarding knowledge allowed a single correct answer. Each correct answer was rated one point. Questions regarding practices allowed several correct answers so that each interviewee had up to five possible options. Each correct answer was rated 0.5 points. In any case, wrong answers or the lack of answer were rated 0 points. Direct observations, made in interior and exterior spaces of household units, focused on two aspects: presence of unprotected water deposits and detection of organic or inorganic solid waste. One point was assigned when these elements were absent (observed adequate practices) and 0 points if not. A knowledge or practice was considered adequate when the "overall score" was equal or greater than 60% of the maximum expected score.

Variables of study

Adequate or inadequate (according to the previous scale) knowledge, referred and observed practices were the dichotomous categorical dependent variables. Independent variables for socio-environmental determinants were: age, schooling level, number of residents per household, average women per household, perceived prevalence of arboviral diseases, presence of sewage system and frequency of water supply and waste collection services.

Statistical analysis

Univariate and bivariate categorical statistical analysis were performed. As categorical dependent variables had only two possible outcomes, a binary logistic regression model was used to explore associations among independent and dependent variables. Odds ratios (OR) and their respective 95%CI were derived, and goodness of fit was assessed using the Hosmer-Lemeshow test. Statistical analysis was performed with R 3.2.1 (http://www.r-project.org) and the R Commander package 2.4-4.

Qualitative analysis

A content analysis approach, following a hybrid process of deductive and inductive analysis, was used to identify common or recurrent patterns among explored themes. Transcriptions were systematically reviewed, organized and coded according to the main themes explored: water, sanitation and hygiene services in the community, arboviral diseases risk and their prevention within the community [34]. Information obtained by qualitative data enabled a triangulation with community background data, collected using the quantitative survey [35].

Results

Sociodemographic characteristics

Table 1 shows the sociodemographic characteristics of the study sample by residence locality. The majority of households had an average of three or more inhabitants (82,5%). Overall, the most common type of family was "young", represented by a mean age for household members of less than 35 years (55%). There were no significant differences in schooling level, gender and age distribution among the localities of the two municipalities.

Table 1

Sociodemographic characteristics (Household Survey and Community Background Survey).

Characteristics	Tapachula (n = 82)		Villahermosa (n = 67)		Global (n = 149)		
	n	%	n	%	n	%	p-value
Residents per household							
1-2	17	20.7	9	13.4	26	17.4	0.503
3-4	33	40.2	29	43.3	62	41.6	
> 4	32	39.0	29	43.3	61	40.9	
Women per household							
0-1	28	34.1	20	29.9	48	32.2	0.843
2-3	41	50.0	35	52.2	76	51.0	
> 3	13	15.9	12	17.9	25	16.8	
Average women per household (%)							
< 50	58	70.7	48	71.6	106	71.1	0.902
≥ 50	24	29.3	19	28.4	43	28.9	
Family's age structure							
Young (< 35 years old)	40	48.8	42	62.7	82	55.0	0.089
Adult and old (≥ 35 years old)	42	51.2	25	37.3	67	45.0	
Average schooling level (≥ 15 years old)							
Uneducated	11	13.4	4	6.0	15	10.1	0.186
Incomplete elementary	17	20.7	12	17.9	29	19.5	
Elementary	32	39.0	37	55.2	69	46.3	
Advanced (secondary and higher education)	22	26.8	14	20.9	36	24.2	
Female average education (≥ 15 years old)							
Uneducated	12	15.2	8	11.9	20	13.7	0.919
Incomplete elementary	16	20.3	16	23.9	32	21.9	
Elementary	32	40.5	27	40.3	59	40.4	
Advanced (secondary and higher education)	19	24.1	16	23.9	35	24.0	
Solid waste collection services							
Daily	0	0.0	0	0.0	0	0.0	0.000
Weekly	0	0.0	65	97.0	65	43.3	
Monthly	82	100.0	2	3.0	84	56.7	
Water supply services							
Regular	0	0.0	0	0.0	0	0.0	0.000
Irregular	0	0.0	54	80.6	54	36.0	
Absent	82	100.0	13	19.4	95	64.0	
Drainage system							
Present	0	0.0	0	0.0	0	0.0	NA
Partial	0	0.0	0	0.0	0	0.0	
Absent	82	100.0	67	100.0	149	100.0	

NA: not available.

Community background contextualization

As shown in Table 1, significant difficulties in community sanitation were detected, as the frequency of solid waste collection by municipal services was monthly in the two Tapachula's communities and mostly weekly (97%) in Villahermosa. There was no public sewage system in both communities. A significantly high percentage of irregular water supply was reported in Villahermosa (80,6%), whereas completely absent in Tapachula.

These findings were supported by the key informants during interviews. Furthermore, a high level of annoyance and concern was detected, especially regarding waste management. As reported by a member of the Río Florido *Comisariado Ejidal*:

P1: *"Before, there were no such problems: each family consumed what they had. Now, everything comes in plastic, packaging, and then we do not know what to do with so many things. There is a landfill tax, but it is only for families who can afford it"*.

Most of the six informants defined the situation as "[institutional] *abandonment*" and perceived an increased risk of infection for the community. They also mentioned perceiving a greater difficulty in complying with preventive measures.

P1: *"More and more people get sick"*.

P2: *"There are more and more mosquitoes"*; *"They are everywhere"*; *"We need to stop it"*.

P3: *"This has already become a problem"*.

Cleaning domestic spaces was stressed as the main preventive measure to be followed. Community participation in this task was described as a fundamental element for prevention effectiveness, although difficult to achieve. As a health staff member expressed:

P2: *"The most important thing is to keep the patios* [backyards] *clean. It is a task of the whole community; we all must do it to make it work. This is why it is very difficult"*.

Regarding water management, wells (private or communal) were pointed out by all informants as the main solution to precarious supply. In *Ejido* Hidalgo, it was reported that the lack of a functioning communal well forced families without other resources to store rainwater in domestic containers.

Knowledge and reported vector control practices

Table 2 describes the scores regarding knowledge and reported preventive practices, as determined by the Household Survey. Nearly all respondents had already heard of the diseases (99.3%), and knowledge about arboviruses and their transmission was generally good (75.2%), especially regarding DENV (81.2%). However, there were only a few cases (30.7%) of adequate personal (how to protect themselves from mosquito bites) or domestic (how to avoid mosquitoes breeding in and around households) prevention measures.

Observed vector control practices

As shown in Table 3, both in 2017 and in 2018, a high proportion of households presented some unprotected water containers in outdoors areas (Tapachula: 73.7% and 42.1%; Villahermosa: 58.2% and 54.5% respectively), as well as waste accumulation (Tapachula: 60.5% and 65.8%; Villahermosa: 36.4% and 30.3% respectively). In 2017, Villahermosa's village showed a higher percentage of adequate practices than Tapachula's villages (56.1% and 18.4%, $p < 0.001$). However, in 2018, Tapachula's villages presented an increase in observed adequate practices, from 18.4% to 27.6%. Such change is closely associated with a decrease of unprotected water deposits, as the amount of organic and inorganic waste recorded in 2018 was even higher than 2017. In Villahermosa's village, observed adequate practices slightly decreased from 56.1% to 42.4%, due to the growth of unprotected water deposits and waste in 2018. It is interesting to observe that the percentages of adequate practices in both sites were not statistically different in 2018 ($p = 0.064$).

Logistic regression model

Tables 4 and 5 show the results of logistic models for the association between independent variables for the investigated socio-environmental determinants and reported knowledge and practices. Higher schooling levels were associated with better scores on knowledge and prevention. Household members with incomplete education had 4 times (OR = 4.13; 95%CI: 1.2-13.9) more probability of presenting inadequate knowledge on arboviruses when compared to members with primary or higher education. Likewise, they showed a higher probability of presenting observed inadequate practices, both in 2017 (OR = 38.33; 95%CI: 7.87-186.53) and 2018 (OR = 15.04; 95%CI: 3.89-58.05).

Table 2

Knowledge and reported practices to prevent arboviral diseases (Household Survey).

	Tapachula (n = 82)		Villahermosa (n = 67)		Global (n = 149)		
	n	%	n	%	n	%	p-value
Had heard about DENV, ZIKV, CHIKV							
Yes	81	98.8	67	100.0	148	99.3	0.364
No	1	1.2	0	0.0	1	0.7	
Where?							
Television	20	24.7	30	44.8	50	33.8	0.000
Neighbors	18	22.2	14	20.9	32	21.6	
Health center	17	21.0	15	22.4	32	21.6	
Disease exposure	22	27.2	0	0.0	22	14.9	
Other	0	0.0	2	3.0	2	1.4	
Perceived prevalence							
Yes	62	75.6	22	32.8	84	56.4	0.000
No	20	24.4	45	67.2	65	43.6	
Knowledge							
Adequate (global)	64	78.0	48	71.6	112	75.2	0.368
Inadequate (global)	18	22.0	19	28.4	37	24.8	
Dengue							
Adequate	67	81.7	54	80.6	121	81.2	0.255
Inadequate	15	18.3	13	19.4	28	18.8	
Chikungunya							
Adequate	63	76.8	49	73.1	112	75.2	0.210
Inadequate	19	23.2	18	26.9	37	24.8	
Zika							
Adequate	58	70.7	43	64.2	101	67.8	0.311
Inadequate	24	29.3	24	35.8	48	32.2	
Reported practices							
Adequate (global)	31	38.6	14	20.9	45	30.7	0.019
Inadequate (global)	51	61.4	53	79.1	104	69.3	
Personal protection							
Adequate	13	16.2	9	13.4	22	15.2	0.701
Inadequate	69	84.3	58	86.6	128	84.8	
Home protection							
Adequate	44	53.0	22	32.8	66	44.4	0.013
Inadequate	38	47.0	45	67.2	84	55.6	

Moreover, a higher percentage of domestic risk practices was associated with significant deficiencies in sanitation and water supply services. When frequency of solid waste collection was monthly, it was noticed a higher risk of observed inadequate practices than weekly collection (2017: OR = 6.17; 95%CI: 2.75-14.52) (2018: OR = 2.09; 95%CI: 0.99-4.53). Similar results were found regarding the comparison between the lack of a water supply network and its presence, even though irregular (2017: OR = 6.02; 95%CI: 2.69-13.93) (2018: OR = 3.60; 95%CI: 1.64-8.01).

Table 3

Observed practices (Risk Observational Assessment).

	2017					2018				
	Tapachula (n = 76)		Villahermosa (n = 66)		p-value	Tapachula (n = 76)		Villahermosa (n = 66)		p-value
	n	%	n	%		n	%	n	%	
Adequate *	14	18.4	37	56.1	0.000	21	27.6	28	42.4	0.064
Inadequate **	62	81.6	29	43.9		55	72.4	38	57.6	
Unprotected water deposits										
Absent	20	26.3	28	41.8	0.050	44	57.9	30	45.5	0.138
Present	56	73.7	39	58.2		32	42.1	36	54.5	
Solid waste accumulation										
Absent	30	39.5	42	63.6	0.375	26	34.2	46	69.7	0.000
Present	46	60.5	24	36.4		50	65.8	20	30.3	

* Absence of unprotected water deposits and/or solid waste;

** Presence of water deposits and/or solid waste accumulation.

Table 4

Respondents' sociodemographic characteristics and reported knowledge and practices in 2017.

Characteristics	Knowledge (2017)							Reported practices (2017)						
	Adequate		Inadequate		p-value	OR	95%CI	Adequate		Inadequate		p-value	OR	95%CI
	n	%	n	%				n	%	n	%			
Residents per household														
1-2	16	61.5	10	38.5	0.067	1.00	Reference	4	15.4	22	84.6	0.911	1.00	Reference
3-4	52	83.9	10	16.1		0.30	0.10-0.87	11	17.7	51	82.3		0.84	0.24-2.93
> 4	44	72.1	17	27.9		0.62	0.23-1.62	9	15.0	51	85.0		1.03	0.28-3.70
Women per household														
0-1	31	64.6	17	35.4	0.003	1.00	Reference	9	18.8	39	81.2	0.463	1.00	Reference
2-3	66	86.8	10	13.2		0.27	0.11-0.67	13	17.3	62	82.7		1.10	0.43-2.81
> 3	15	60.0	10	40.0		1.21	0.44-3.29	2	8.0	23	92.0		2.65	0.52-13.36
Average women per household (%)														
< 50	32	74.4	11	25.6	0.892	1.00	Reference	9	20.9	34	79.1	0.319	1.00	Reference
≥ 50	80	75.5	26	24.5		0.94	0.42-2.13	15	14.3	90	85.7		1.58	0.63-3.96
Family's age structure (average age)														
Young (< 35 years old)	63	76.8	19	23.2	0.603	1.00	Reference	14	17.3	67	82.7	0.698	1.00	Reference
Adult (≥ 35 years old)	49	73.1	18	26.9		1.22	0.57-2.56	10	14.9	57	85.1		1.19	0.49-2.88
Average education (≥ 15 years old)														
Uneducated *	29	65.9	15	34.1	0.057	4.13	1.23-13.9	13	36.1	23	63.9	0.072	0.81	0.90-3.49
Elementary	51	73.9	18	26.1		2.82	0.87-9.09	15	21.7	54	78.3		2.03	0.83-4.95
Advanced **	32	88.9	4	11.1		1.00	Reference	18	40.9	26	59.1		1.00	Reference
Female average education (≥ 15 years old)														
Uneducated *	28	69.2	16	30.8	0.492	1.77	0.64-4.91	20	38.5	32	61.5	0.400	1.07	0.42-2.72
Elementary	45	76.3	14	23.7		1.24	0.44-3.46	16	27.1	43	72.9		0.64	0.25-1.60
Advanced **	28	80.0	7	20.0		1.00	Reference	10	28.6	25	71.4		1.00	Reference

(continues)

Table 4 (continued)

Characteristics	Knowledge (2017)							Reported practices (2017)						
	Adequate		Inadequate		p-value	OR	95%CI	Adequate		Inadequate		p-value	OR	95%CI
	n	%	n	%				n	%	n	%			
Solid waste collection services														
Monthly	64	78.0	18	22.0	0.367	1.40	0.66-2.96	33	38.8	52	61.2	0.013	0.04	0.17-0.87
Weekly	48	71.6	19	28.4		1.00	Reference	13	20.0	52	80.0		1.00	Reference
Water supply services														
Absent	72	75.8	23	24.2	0.815	0.91	0.40-2.14	34	35.4	62	64.6	0.092	0.52	0.22-1.18
Irregular	40	74.1	14	25.9		1.00	Reference	12	22.2	42	77.8		1.00	Reference
Perceived prevalence														
Yes	66	78.6	18	21.4	0.274	1.00	Reference	13	15.7	70	84.3	0.836	1.00	Reference
No	46	70.8	19	29.2		1.51	0.71-3.20	11	16.9	54	83.1		0.91	0.37-2.19

95%CI: 95% confidence interval; OR: odds ratio.

* Without schooling or incomplete;

** Secondary and higher.

Table 5

Respondents' sociodemographic characteristics and observed practices in 2017 and 2018.

Characteristics	Observed practices (2017)							Observed practices (2018)						
	Adequate		Inadequate		p-value	OR	95%CI	Adequate		Inadequate		p-value	OR	95%CI
	n	%	n	%				n	%	n	%			
Residents per household														
1-2	3	11.5	23	88.5	0.009	1.00	Reference	6	24.0	19	76.0	0.418	1.00	Reference
3-4	22	36.7	38	63.3		0.22	0.06-0.83	20	35.1	37	64.9		0.58	0.20-1.69
> 4	26	46.4	30	53.6		0.15	0.04-0.55	23	39.0	36	61.0		0.49	0.17-1.42
Women per household														
0-1	1	23.9	35	76.1	0.073	1.00	Reference	12	26.1	34	73.9	0.320	1.00	Reference
2-3	28	38.9	44	61.1		0.49	0.21-1.12	27	38.6	43	61.4		0.56	0.25-1.27
> 3	12	50.0	12	50.0		0.31	0.11-0.89	10	40.0	15	60.0		0.53	0.18-1.49
Average women per household (%)														
< 50	11	26.8	30	73.2	0.561	1.00	Reference	10	25.0	30	75.0	0.125	1.00	Reference
≥ 50	40	39.6	61	60.4		0.55	0.25-1.24	39	38.6	62	61.4		0.53	0.20-1.27
Family's age structure (average age)														
Young (< 35 years old)	36	46.8	41	53.2	0.003	1.00	Reference	34	44.2	43	55.8	0.010	1.00	Reference
Adult (≥ 35 years old)	15	23.1	50	76.9		2.90	1.33-6.55	15	23.4	49	76.6		2.56	1.17- 5.80
Average education (≥ 15 years old)														
Uneducated *	3	4.8	39	95.2	0.000	38.3	7.87-186.53	3	7.3	38	92.7	0.000	15.00	3.89-58.05
Elementary	26	40.0	39	60.0		2.87	1.22-6.76	27	41.5	38	58.5		1.67	0.73-3.82
Advanced **	23	65.7	12	34.3		1.00	Reference	19	54.3	16	45.7		1.00	Reference
Female average education (≥ 15 years old)														
Uneducated *	5	10.2	44	89.8	0.000	51.00	13.56-192.06	0	0.0	49	100.0			
Elementary	17	30.4	39	69.6		13.30	4.40-40.24	22	40.0	33	60.0			
Advanced **	29	85.3	5	14.7		1.00	Reference	26	76.5	8	23.5		1.00	Reference

(continues)

Table 5 (continued)

Characteristics	Observed practices (2017)							Observed practices (2018)						
	Adequate		Inadequate		p-value	OR	95%CI	Adequate		Inadequate		p-value	OR	95%CI
	n	%	n	%				n	%	n	%			
Solid waste collection services														
Monthly	14	17.9	64	82.1	0.000	6.17	2.75-14.52	21	26.9	57	73.1	0.035	2.09	0.99-4.53
Weekly	37	57.8	27	42.2		1.00	Reference	28	43.8	36	56.2		1.00	Reference
Water supply services														
Absent	18	20.5	70	79.5	0.000	6.02	2.69-13.93	21	23.6	68	76.4	0.000	3.60	1.64-8.01
Irregular	33	61.1	21	38.9		1.00	Reference	28	52.8	25	47.2		1.00	Reference
Perceived prevalence														
Yes	24	30.0	56	70.0	0.095	1.00	Reference	30	38.5	48	61.5	0.303	1.00	Reference
No	27	43.5	35	56.5		0.55	0.26-1.17	19	30.2	44	69.8		1.44	0.67-3.13

95%CI: 95% confidence interval; OR: odds ratio.

* Without schooling or incomplete;

** Secondary and higher.

Discussion

Key findings and other studies comparison

Although the study population presented high scores for knowledge on DENV, CHIKV and ZIKV transmission, the overall score for self-reported and observed practices was generally low. Similar findings have been previously reported in other localities with recent history of arboviral diseases [20,33,36,37,38,39]. These outcomes suggest that knowledge does not necessarily lead to adequate prevention practices, especially in contexts where the complex interactions among environmental and social determinants increase human vulnerability to vector borne diseases [12,13,14,40].

Our findings show a high percentage of domestic risk practices associated with great deficiencies in water supply and sanitation services. Among households where these intermediate social determinants were more deteriorated, there was a higher risk of predisposing behaviors for arboviruses proliferation.

Water and sanitation infrastructure are significant determinants for vector breeding risk, and should be considered for the development of strategies for intervention and evaluation of vector control [11,17]. High rates of household water storage and increased density of *Aedes* mosquitoes have been described as related to low socioeconomic conditions, unplanned urbanization and poor water supply [19,20,21,22,23,41,42]. In Mexico's context, flaws in water and waste services coverage have been identified as key factors for arboviruses endemicity and the persistence of recurrent outbreaks [43].

According to the presented results, the community engagement plan performed in Tapachula partially modified the percentage of domestic risk practices. Observations made in 2018, after the community engagement plan, revealed a decrease in the accumulation of unprotected household water deposits. Nevertheless, waste accumulation within domestic environments persisted and even increased. Seemingly, the potential community engagement plan impact could have been affected by Tapachula's villages contextual circumstances, such as: monthly solid waste collection, absence of water supply services and non-functioning communal well. In Villahermosa's village, where no community engagement plan was operated, sanitation and water supply services are more frequently provided than in Tapachula, possibly the reason why Villahermosa's residents showed better practices than Tapachula's.

The responsibility of the whole community in arboviral diseases prevention, as well as the needed action on a problem perceived as very urgent, were recurrent themes on key informants' interviews. Although community involvement was highlighted as a key element for vector control, it was also perceived as something difficult to achieve. The process of community participation in vector control

activities is described as difficult because it requires time and resources [11], possibly being more fragile in under-privileged contexts with inadequate infrastructures [21].

Maintaining good hygiene conditions in households and their surroundings was identified as the main practice to prevent the diseases spread, a concept previously described in other studies conducted in Mexico regarding community's perspectives on dengue and its prevention [44,45,46].

Furthermore, a major difficulty in translating preventive measures into everyday actions and behaviors was reported, in accordance with similar findings [21,47,48].

When asked about irregularities in water supply and sanitation services, participants' reported feeling highly exposed to the diseases, as previously mentioned in the context of Tapachula city [45]. Such dimensions are perceived as barriers to encourage community participation in vector control strategies.

Community engagement strategies are complex processes that require a broad understanding of the context, both before and after its implementation. Although evaluating arbovirus-related knowledge, behaviors and perceptions enable the identification of community's needs and expectations, more indicators should be considered and addressed to improve vector control strategies [11].

Decreasing *Aedes* vector population from domestic environments is an essential step to reduce the risk of arboviral diseases occurrence [8,9,13] and empowered processes of community-based interventions are potential strategies to effectively and sustainably achieving this goal [9,10,49,50]. Nonetheless, characteristics of environments and public infrastructures, as health determinants fundamental parts, could significantly persuade people's ability to perform preventive behaviors and measures [16]. If the impact of these contextual circumstances on people's behaviors and perceptions is not properly considered and addressed, achieving a real change in prevention practices could be a difficult process [11,12,13,14,22,40].

Limitations of the study

The reduced sample size and data sparsity regarding surveys quantitative information may possibly have reduced the statistical power for some associations inferential analysis. Surveys regarding knowledge and practices, due to their extension and quantitative approach, do not encourage a deeper understanding of these dimensions and their interaction. Likewise, the categorization of survey data using a scoring system may not be the most appropriate method to approach such a complex issue, difficult to measure and quantify. Information obtained from the "breadwinner" may not always be completely representative of the whole household unit. Inter-observer variability may have affected the information obtained by the Risk Observational Assessment.

Conclusions and implications

The endemicity of arboviral infection in Southern Mexico results of complex interactions among vector, socio-environmental determinants and human behaviors. To achieve strategies of an effective, sustainable and ethical vector control, a more integrated and contextualized approach is required. Community empowerment is more than just providing information: it is about facilitating and encouraging stakeholders to take control of their actions, through strategies adapted to local conditions, culture and needs. Furthermore, intermediate social determinants of water supply and sanitation services need to be addressed to reduce community vulnerability to arboviral diseases.

Contributors

All authors contributed to the drafting and correction of the manuscript. R. Solís-Hernández contributed to the statistical analysis.

Additional informations

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Resumen

La proliferación de los arbovirus y sus vectores está influenciada por la interacción compleja entre vectores, medio ambiente y comportamientos humanos. El objetivo de este estudio es analizar la influencia de los determinantes socioambientales sobre el conocimiento y las prácticas relacionadas con la transmisión de los arbovirus entre los residentes de tres comunidades en la frontera sur de México. Entre junio de 2017 y agosto de 2018, se estudiaron 149 domicilios en las comunidades de Tapachula (Chiapas) y Villahermosa (Tabasco). El estudio tuvo como base la aplicación de un proyecto de prevención comunitaria, utilizando diferentes encuestas y abordajes metodológicos. Se usaron odds ratios para estimar las asociaciones entre determinantes socioambientales y el conocimiento y prácticas para el control de la transmisión de los arbovirus, con el uso de regresión logística y técnicas cualitativas. Cerca de un 75% de los domicilios mostraban conocimiento adecuado sobre el origen y transmisión de los arbovirus, pero solamente un 30% habían adoptado prácticas apropiadas. Las prácticas de riesgo en los domicilios estaban asociadas a deficiencias significativas en los servicios de saneamiento y abastecimiento de agua. Además, se detectó la percepción de un mayor riesgo y de dificultad en adoptar medidas preventivas. El conocimiento adecuado no necesariamente conduce a prácticas preventivas adecuadas. Los determinantes sociales intermedios influencian la persistencia de comportamientos que actúan como factores de riesgo para la proliferación de los arbovirus. La gestión de vectores eficaz y sostenible es necesaria para lidiar con esos aspectos interrelacionados.

Arbovirus; Control de Mosquitos; Medio Ambiente y Salud Pública; Saneamiento

Resumo

A proliferação dos arbovírus e seus vetores é influenciada pela interação complexa entre vetores, meio ambiente e comportamentos humanos. O objetivo do estudo é de analisar a influência dos determinantes socioambientais sobre o conhecimento e as práticas relacionados à transmissão dos arbovírus entre os residentes de três comunidades na fronteira sul do México. Entre junho de 2017 e agosto de 2018, foram estudados 149 domicílios nas comunidades de Tapachula (Chiapas) e Villahermosa (Tabasco). O estudo teve como base a aplicação de um projeto de prevenção comunitária, utilizando diferentes inquéritos e abordagens metodológicas. Foram usadas odds ratios para estimar as associações entre determinantes socioambientais e conhecimento e práticas para controle da transmissão dos arbovírus, com o uso de regressão logística e técnicas qualitativas. Cerca de 75% dos domicílios mostravam conhecimento adequado sobre a origem e transmissão dos arbovírus, mas apenas 30% haviam adotado práticas apropriadas. As práticas de risco nos domicílios estavam associadas a deficiências significativas nos serviços de saneamento e abastecimento de água. Além disso, foi detectada a percepção de maior risco e de dificuldade em adotar medidas preventivas. O conhecimento adequado não necessariamente leva a práticas preventivas adequadas. Os determinantes sociais intermediários influenciam a persistência de comportamentos que agem como fatores de risco para a proliferação dos arbovírus. A gestão de vetores eficaz e sustentável é necessária para lidar com esses aspectos interrelacionados.

Arbovirus; Controle de Mosquitos; Meio Ambiente e Saúde Pública; Saneamento

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