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ORIGINAL RESEARCH

Knowledge, attitudes, and practices of medical students towards synanthropic *Aedes* (Diptera: Culicidae) mosquitoes and *Aedes*-borne diseases in the Dominican Republic

Conocimientos, aptitudes y prácticas de estudiantes de medicina hacia los mosquitos sinantrópicos Aedes (Diptera: Culicidae) y las enfermedades transmitidas por Aedes en la República Dominicana

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Abstract

Introduction: The unprecedented dengue epidemic experienced in the Americas in 2024 made evident that *Aedes*-borne diseases can significantly impact endemic countries such as the Dominican Republic. Within this context, general practitioners are considered key players in the management of arbovirus epidemiological cycles.
Objectives: To characterize the knowledge, attitudes, and practices (KAP) of medical students at the Universidad Iberoamericana (UNIBE) in Santo Domingo (Dominican Republic) towards synanthropic *Aedes* mosquitoes and *Aedes*-borne diseases, and to determine the effect of these KAPs on the students' self-report of arbovirus infection history.
Materials and methods: A cross-sectional study was conducted in March 2021. An electronic questionnaire consisting of 21 questions (4 on socio-demographic characteristics, 9 on knowledge, 4 on attitudes, and 4 on practices) was administered to 224 students enrolled from the 1st to the 16th semesters of the medical program offered at UNIBE. Comparisons between students who had taken Tropical Medicine and Global Health subject (TMGH+) and those who had not (TMGH-) were made for each KAP question using the Fisher's Exact test, together with Odds ratios (OR) calculation. The Wilcoxon signed-rank test was used to evaluate the effect of biological sex, nationality, and having taken the TMGH subject on knowledge score. Finally, the effect of these KAPs on the self-report of arbovirus infection history was determined using a logistic regression model (knowledge), as well as ORs calculation and the Fisher's exact test (attitudes and practices).
Results: Medical students' knowledge about *Aedes* mosquitoes and *Aedes*-borne diseases was poor (mean score=3.84/10). Knowledge was significantly higher among men, non-Dominicans, and students who had taken the TMGH subject compared to women (4.20 vs. 3.69; $p<0.05$), Dominicans (4.65 vs. 3.64; $p<0.01$), and students who had not taken the subject (4.18 vs. 3.22; $p<0.001$). In total, 113 students reported experiencing at least 1 arbovirus infection, and although knowledge did not have any effect on the self-report rate of arbovirus infection history, the following practices and attitudes did: reporting the presence of one breeding site around the household (OR=1.78; $p<0.05$), being unable to recall the las time the breeding site in the household was cleaned (OR=2.89; $p<0.05$), and using insecticide as a prophylactic measure (OR=2.55; $p<0.005$).
Conclusions: In general, medical students at UNIBE had a poor knowledge of *Aedes* mosquitoes and *Aedes*-borne diseases, being significantly higher among students who had taken the Tropical Medicine & Global Health subject. However, our data suggest that this knowledge did not have any effect on the students' self-report of arbovirus infection history, whereas certain practices and attitudes did.

Resumen

Introducción. La epidemia de dengue sin precedentes ocurrida en las Américas en 2024 evidenció que las enfermedades transmitidas por mosquitos *Aedes* pueden tener un impacto significativo en países endémicos como la República Dominicana. En este contexto, los profesionales de la salud son considerados actores clave en la gestión de los ciclos epidemiológicos de los arbovirus.
Objetivos. Caracterizar los conocimientos, aptitudes y prácticas (CAP) hacia mosquitos sinantrópicos *Aedes* y las enfermedades que transmiten en estudiantes de medicina de la Universidad Iberoamericana (UNIBE) en Santo Domingo (República Dominicana) y determinar el efecto de estos CAP en el autorreporte de antecedente de infección por arbovirus.
Materiales y métodos. Estudio transversal realizado en marzo de 2021. Se aplicó un cuestionario electrónico compuesto por 21 preguntas (4 sobre características sociodemográficas, 9 sobre conocimientos, 4 sobre actitudes y 4 sobre prácticas) a 224 estudiantes matriculados entre el primer y el decimosexto semestre del programa de medicina de la UNIBE. Se realizaron comparaciones entre los estudiantes que habían cursado la asignatura de Medicina Tropical y Salud Global (TMGH+) y los que no (TMGH-) para cada pregunta sobre los CAP utilizando la prueba exacta de Fisher, junto con el cálculo de *odds ratios* (OR). Además, se usó la prueba de rangos con signo de Wilcoxon para evaluar el efecto del sexo biológico, la nacionalidad y haber cursado la asignatura TMGH en los conocimientos. Por último, el efecto de estos CAP en el autorreporte de antecedentes de infección por arbovirus se determinó mediante un modelo de regresión logística (conocimientos), así como el cálculo de OR y la prueba exacta de Fisher (actitudes y prácticas).
Resultados. Los estudiantes de medicina mostraron escasos conocimientos sobre los mosquitos *Aedes* y las enfermedades que transmiten (puntuación media= 3.84/10). El nivel de conocimientos fue significativamente más alto en los hombres, los no dominicanos y los estudiantes que habían cursado la asignatura TMGH en comparación con las mujeres (4.20 vs. 3.69; $p<0.05$), los dominicanos (4.65 vs. 3.64; $p<0.01$) y los estudiantes que no habían cursado la asignatura (4.18 vs. 3.22; $p<0.001$). En total, 113 estudiantes informaron haber sufrido al menos una infección por arbovirus y, aunque los conocimientos no tuvieron ningún efecto sobre la tasa de autorreporte de antecedente de infección por arbovirus, las siguientes prácticas y actitudes sí lo tuvieron: informar de la presencia de un criadero de mosquitas en o cerca al hogar (OR=1.78; $p<0.05$), no recordar la última vez que se limpió el criadero presente en el hogar (OR=2.89; $p<0.05$) y usar insecticidas como medida profiláctica (OR=2.55; $p<0.005$).
Conclusiones. Los estudiantes de medicina de la UNIBE tuvieron un conocimiento escaso sobre los mosquitos *Aedes* y las enfermedades que transmiten, siendo significativamente mayor en aquellos que habían cursado la asignatura TMGH. Sin embargo, nuestros datos sugieren que este conocimiento no tuvo ningún efecto en el autorreporte de antecedente de infección por arbovirus, mientras que ciertas prácticas y actitudes sí lo tuvieron.

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Palabras clave: *Aedes albopictus; Aedes aegypti*; Arbovirus; Educación; Enfermedades Infecciosas (DeCS).

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Introduction

Aedes-borne diseases, such as dengue, pose a major public health and economic burden worldwide.[1] In 2023, the Americas accounted for almost 80% of global dengue cases,[2] and throughout 2024, it witnessed an unprecedented dengue epidemic with more than 8 million reported cases during the first 20 epidemiological weeks.[3] In the case of the Dominican Republic, a total of 9 239 potential dengue cases were reported as of August 31, 2024.[4]

Traditionally, *Aedes aegypti* (Linnaeus, 1762) has been considered as the primary vector of the dengue virus after being introduced to the Americas from West Africa through slave trading ships during the 16th and 17th centuries.[5] However, since *Aedes albopictus* (Skuse, 1894) was first reported in the Caribbean region, specifically in Santo Domingo (Dominican Republic), in 1993, the epidemiological context of dengue has changed due to the rapid expansion of this novel vector species throughout the continent.[6,7] Furthermore, the recent identification of *Aedes vittatus* (Bigot, 1861) in the Americas in 2019, also in the Dominican Republic, represents a new threat that could worsen the risk of dengue transmission in the continent.[8]

The proper implementation of vector control programs in endemic areas is necessary to reduce the impact of *Aedes*-borne diseases.[9] Although control programs targeting synanthropic *Aedes* mosquitoes in urban settings, such as *Ae. albopictus*, typically rely on adulticides and larvicide insecticides, with a greater emphasis on the latter due to their prolonged effect and reduced environmental impact,[10] other strategies, such as community-based educational interventions aiming to prevent and eliminate breeding sites in households are also essential for effective *Aedes* control in residential environments.[11] Therefore, understanding citizens' knowledge, attitudes, and practices toward *Aedes* spp. is important for the effective implementation of any community-based control intervention.[12] Nevertheless, previous entomological surveys conducted among citizens in the Dominican Republic have revealed a lack of general knowledge among the population regarding invasive *Aedes* mosquitoes.[13]

As such, education at the community level is considered key to effectively control *Aedes* mosquitoes,[14] making evident the need for channels to correctly educate the general population on the control of these mosquitoes and the prevention of *Aedes*-borne diseases. Whitin this context, general practitioners play a crucial role, as they are routinely in direct contact with patients during consultations. Taking this into account, the objectives of the present study were to characterize the knowledge, attitudes, and practices (KAP) of medical students at the Universidad Iberoamericana (UNIBE) in Santo Domingo (Dominican Republic) towards synanthropic *Aedes* mosquitoes and *Aedes*-borne diseases, and to determine the effect of these KAPs on the students' self-report of arbovirus infection history.

Materials and methods

Study type and setting

A cross-sectional study was conducted in March 2021. The study population comprised active medical students at the Universidad Iberoamericana (UNIBE), a private nonprofit coeducational university in Santo Domingo (Dominican Republic). Participants were recruited by sending an invitation via social media groups (WhatsApp) created by the university for each semester of the M.D. program, ensuring that all active medical students at UNIBE (i.e., 1st-16th semester) received the invitation. Subsequently, students

who expressed their interest in participating in the study were provided with a link to an online survey, created in Google Forms, which included an informed consent outlining the objectives of the study and the participant's rights, as well as a questionnaire that, besides demographic questions, included questions designed to obtain information on the student's KAPs towards *Aedes* mosquitoes and *Aedes*-borne diseases. The survey was available for three consecutive weeks during March 2021.

Instrument

The questionnaire was developed based on previous research[13] and consisted of 21 items divided into four sections: 'Knowledge' questions (n=9), related to the biology, taxonomy, and the risks posed by *Aedes* mosquitoes to public health; 'Attitudes' questions (n=4), aimed to profile the respondents' epidemiological situation and background; 'Practices' questions (n=4), addressing the general arbovirus prophylactic measures implemented by students; and 4 demographic questions inquiring about students' age, sex, nationality, and whether they had already taken the 'Tropical Medicine and Global Health' (TMGH) subject or not, as it included contents regarding *Aedes* mosquitoes and other arthropods of medical importance.

It is worth noting that, immediately after filling the survey, students were provided with a World Health Organization link (https://www.who.int/es/emergencies/disease-outbreak-news/item/2023-DON498) containing detailed information to clarify any doubts or questions regarding the bio-ecology of mosquitoes, the diseases they transmit, and control and prevention strategies.

Data processing and analysis

Data curation and analysis were conducted in RStudio (version 4.1.2 (2021-11-01)), employing the statistical packages 'dplyr' and 'ggplot2'. An initial exploratory data analysis (EDA) was carried out to define the respondents' main socio-demographic characteristics and to obtain a general overview of the data. Data are expressed as absolute frequencies and percentages for categorical variables, and means, medians, standard deviations (SD), and ranges (minimum and maximum) for continuous variables depending on their distribution (Shapiro-Wilks test). In addition, data are also presented separately for students who had taken the TMGH subject (TMGH+) and those who had not (TMGH-).

Regarding inferential analyses, comparisons between groups (TMGH+ vs. TMGH-) were performed for each of the KAP questions using odds ratio (OR) calculations and the Fisher's Exact test with the 'fisher.test()' function of the Base-R software. A statistical significance level of $p \leq 0.05$ was considered, while values of $p \leq 0.10$ were defined as slight statistical differences. It is worth noting that KAP questions were classified as binary (n=5), multiple-choice multiple-select questions (n=5), and multiple-choice single-select questions (n=6).[11] In the former category, a special type of question was defined as 'picture', in which participants had to select a single image among several possible options.

Concerning knowledge, a general score for each participant was derived from the 9 knowledge responses, awarding one point (+1) for each correct answer, while incorrect responses received no points (+0). The score was then weighted over 10 to obtain a final score. The effect of sex (male and female), nationality (Dominican or other), and having taken the TMGH subject (TMGH+ or TMGH-) on the knowledge score was evaluated utilizing the Wilcoxon signed-rank test, since data showed a non-parametric distribution;

a significance level of $p \leq 0.05$ was considered. The effects of sex and nationality were represented using a boxplot, while the effect of TMGH was graphed as a density diagram. Both graphs were created using the R package 'ggplot2'.

Lastly, to determine the effect of the KAPs towards *Aedes*-mosquitoes and *Aedes*-borne diseases on the self-report of arbovirus infection history, students were divided into two groups: those who reported experiencing at least one arbovirus infection (Arbov+) in the past and those who did not (Arbov-). The effect of the knowledge score was determined through a logistic regression model using the 'glm' function of the Base-R software. In the case of attitudes and practices, the effect was evaluated for each question using ORs and the Fisher's exact test.

Ethical considerations

The study followed the ethical principles for conducting biomedical research involving human subjects established in the Declaration of Helsinki[15] and was approved by the Research Ethics Committee of UNIBE on March 3, 2021 (Minutes CEI2021-39). All students signed an informed consent form authorizing their participation in the study. Data confidentiality and the participants' anonymity were ensured at all times.

Results

Demographic characteristics

A total of 224 medical students completed the survey. Participants' mean age was 23 years (SD=2.93, range 17-34), 71.43% (n=160) were women, 80.80% were from the Dominican Republic, and 64.73% (n=145) had taken the TMGH subject (TMHG+). Table 1 presents the demographic characteristics of students who took the TMGH subject vs. those who did not.

Table 1. Demographic characteristics of the students (TMGH+ vs. TMGH-).

Variable	Category	TMGH+ (n=145)		TMGH- (n=79)	
		n	%	n	%
Sex	Male	41	28.28%	56	70.89%
	Female	104	71.72%	23	29.11%
Age	≤18	0	0.00%	11	13.92%
	19-21	36	24.83%	47	59.49%
	22-24	84	57.93%	12	15.19%
	25-27	10	6.90%	8	10.13%
	28-30	11	7.59%	1	1.27%
	≥31	4	2.76%	0	0.00%
Nationality	Dominican	114	78.62%	67	84.81%
	Other	31	21.38%	12	15.19%

TMGH+: students that had taken the Tropical Medicine and Global Health subject. TMGH-: students that had not taken the Tropical Medicine and Global Health course.

Students' knowledge, attitudes, and practices toward *Aedes* mosquitoes and *Aedes*-borne diseases

Knowledge

Most students did not know the correct order of the life cycle of *Aedes* mosquitoes (proportion of students who correctly answered the question: total sample: 41.07%; TMGH+: 44.83%; TMGH-: 34.18%), although most of them were able to correctly identify the larval stage when shown a picture (total: 70.98%; TMGH+: 74.48%; TMGH-: 64.56%) and were aware that *Aedes* mosquitoes are disease vectors (total: 92.41%; TMGH+: 98.62%; TMGH-: 81.01%). However, the majority of them were unable to correctly identify adult *Aedes* mosquitoes (*Ae. albopictus, Ae. aegypti, Ae. japonicus, Ae. koreicus*) in pictures (total: 7.14%-16.52%; TMGH+: 8.28%-19.31%; TMGH-: 3.80%-11.39%).

TMGH+ students were much more likely to correctly answer that a new species of *Aedes* mosquito (*Ae. vittatus*) had been recently discovered in the Americas (OR=2.73) and that *Aedes* mosquitoes can transmit diseases (OR=16.76), being these differences statistically significant ($p<0.001$ and $p<0.0001$, respectively). Also, TMGH+ students were more likely to correctly identify *Ae. albopictus* than TMGH- students (OR=3.14), being this difference slightly significant ($p=0.08$) (Table 2).

Table 2. Results of the knowledge, attitudes, and practices questionnaire (KAP) towards *Aedes* mosquitoes and *Aedes*-borne diseases among medical students from the UNIBE.

KAP	Question		Total (n=224)		TMGH+ (n=145)		TMGH- (n=79)		OR	p
			n	%	n	%	n	%		
Knowledge	Can you identify the correct order of the mosquitoes' life cycle?[a]		92	41.07%	65	44.83%	27	34.18%	1.56	0.16
	In what stage of its life cycle is this larva? (picture)		159	70.98%	108	74.48%	51	64.56%	1.60	0.13
	Identify *Aedes albopictus* (picture)		19	8.48%	16	11.03%	3	3.80%	3.14	**0.08**
	Identify *Aedes aegypti* (picture)		37	16.52%	28	19.31%	9	11.39%	1.86	0.14
	Identify *Aedes japonicus* (picture)		17	7.59%	12	8.28%	5	6.33%	1.34	0.79
	Identify *Aedes koreicus* (picture)		16	7.14%	12	8.28%	4	5.06%	1.69	0.43
	Did you know that mosquitoes can transmit diseases?[b]		207	92.41%	143	98.62%	64	81.01%	16.76	**<0.0001***
	Did you know of the recent discovery of a novel *Aedes* species in the Americas?[b]		106	47.32%	81	55.86%	25	31.65%	2.73	**<0.001***
	In what type of water do mosquitoes breed?[a]		121	54.02%	80	55.17%	41	51.90%	1.14	0.68
Attitude	Are there mosquitoes in your house?[b]		121	54.02%	83	57.24%	38	48.10%	1.44	0.21
	Have you ever suffered from an arbovirus infection?[b]		113	50.45%	70	48.28%	43	54.43%	0.781	0.40
	Have you ever suffered from any of the following diseases?[c]	Dengue	55	24.55%	39	26.90%	16	20.25%	1.45	0.33
		Zika	7	3.13%	4	2.76%	3	3.80%	0.72	0.70
		Chikungunya	28	12.50%	14	9.66%	14	17.72%	0.50	**0.09**
		Dengue and Zika	4	1.79%	1	0.69%	3	3.80%	0.18	0.13
		Dengue and chikungunya	13	5.80%	9	6.21%	4	5.06%	1.24	0.55
		Zika and chikungunya	1	0.45%	0	0.00%	1	1.27%	0.00	0.35
		Dengue, Zika, and chikungunya	6	2.68%	4	2.76%	2	2.53%	1.09	1.00
		Total cases	144	NA	89	NA	55	NA	0.85	NA

KAP	Question		Total (n=224)		TMGH+ (n=145)		TMGH- (n=79)		OR	p
			n	%	n	%	n	%		
Attitude	Are there any mosquito breeding sites in or around your household?[c]	Water tank	111	49.55%	69	47.59%	42	53.16%	0.80	0.48
		Plant pots	114	50.89%	71	48.97%	43	54.43%	0.80	0.49
		Animal drinkers	37	16.52%	22	15.17%	15	18.99%	0.76	0.46
		Tires	19	8.48%	14	9.66%	5	6.33%	1.58	0.46
		Fallen trees	30	13.39%	13	8.97%	17	21.52%	0.36	**0.01***
		Empty bottles	45	20.09%	28	19.31%	17	21.52%	0.87	0.73
		Other	3	1.34%	2	1.38%	1	1.27%	1.09	1.00
		None	4	1.79%	4	2.76%	0	0.00%	NA	0.30
		NA	40	17.86%	28	19.31%	12	15.19%	1.34	0.47
Practices	Do you or someone in your family clean the breeding sites in your household?[b]		123	54.91%	73	50.34%	50	63.29%	0.588	**0.07**
	How do you clean the breeding sites? [Those who clean them][c]	Only water	15	12.20%	9	12.33%	6	12.00%	1.031	1.00
		Water and soap	38	30.89	20	27.40%	18	36.00%	0.671	0.33
		Water and chlorine	68	55.28%	37	50.68%	31	62.00%	0.63	0.27
		Do not know	21	17.07%	16	21.92%	5	10.00%	2.526	**0.09**
	How often do you clean the breeding sites? [Those who clean them][c]	Every three days	23	18.70%	10	13.70%	13	26.00%	0.452	**0.10**
		Weekly	48	39.02%	28	38.36%	20	40.00%	0.933	0.85
		Monthly	16	13.01%	7	9.59%	9	18.00%	0.483	0.19
		I do not recall the last time I cleaned them	18	14.63%	16	21.92%	2	4.00%	6.737	**<0.001***
		Do not know	18	14.63%	12	16.44%	6	12.00%	1.443	0.61
	Which prophylactic measures do you use?[c]	Insecticide	58	25.89%	43	58.90%	15	30.00%	1.799	0.11
		Aerosol repellents	84	37.50%	53	72.60%	31	62.00%	0.892	0.77
		Citronella candles	28	12.50%	16	21.92%	12	24.00%	0.693	0.40
		Bed nets	9	4.02%	6	8.22%	3	6.00%	1.094	1.00
		Covering legs and arms	37	16.52%	25	34.25%	12	24.00%	1.163	0.85
		Others	7	3.13%	5	6.85%	2	4.00%	1.375	1.00
		I do not use any protection measure	90	40.18%	57	78.08%	33	66.00%	0.903	0.78
		Do not know	4	1.79%	1	1.37%	3	6.00%	0.176	0.13

TMGH+: students that had taken the Tropical Medicine and Global Health subject: TMGH-: students that had not taken the Tropical Medicine and Global Health subject; n: total number of students who correctly answered the question; %: percentage of students who correctly answered the question; OR: odds ratio; *p: p*-value, Fisher's exact test; (picture): image selected from multiple options.

[a] Multiple-choice single-select questions (multiple options, one possible answer)

[b] Binary questions (two options, one possible answer)

[c] Multiple-choice multiple-select questions (multiple options, multiple possible answers)

(picture): image selected from multiple options.

In bold: slight statistical differences were observed ($p<0.1$, Fisher's exact t-test).

*: statistical differences were observed ($p<0.05$, Fisher's exact t-test).

Knowledge score

The mean knowledge score was 3.84 (SD=1.93; median=3.33, min=0, max=10). Regarding the effect of sex, nationality, and having taken the TMGH subject (Wilcoxon signed-rank test), scores were higher in men (mean=4.20, SD=1.92; median=4.44, min=1.11, max=8.89), non-Dominicans (mean=4.65, SD=2.19; median=4.44, min=1.11, max=10), and

students who had taken the TMGH subject (mean=4.18, SD=1.83; median=4.44, min=1.11, max=10) compared to women (mean=3.69, SD=1.92; median=3.33, min=0, max=10), Dominicans (mean=3.64, SD=1.82; median=3.33, min=0, max=10), and students who had not taken the subject (mean=3.22, SD= 1.98; median=3.33, min=0, max=10), being these differences statistically significant in all three cases ($p<0.05$, $p<0.01$ and $p<0.001$, respectively) (Figure 1).

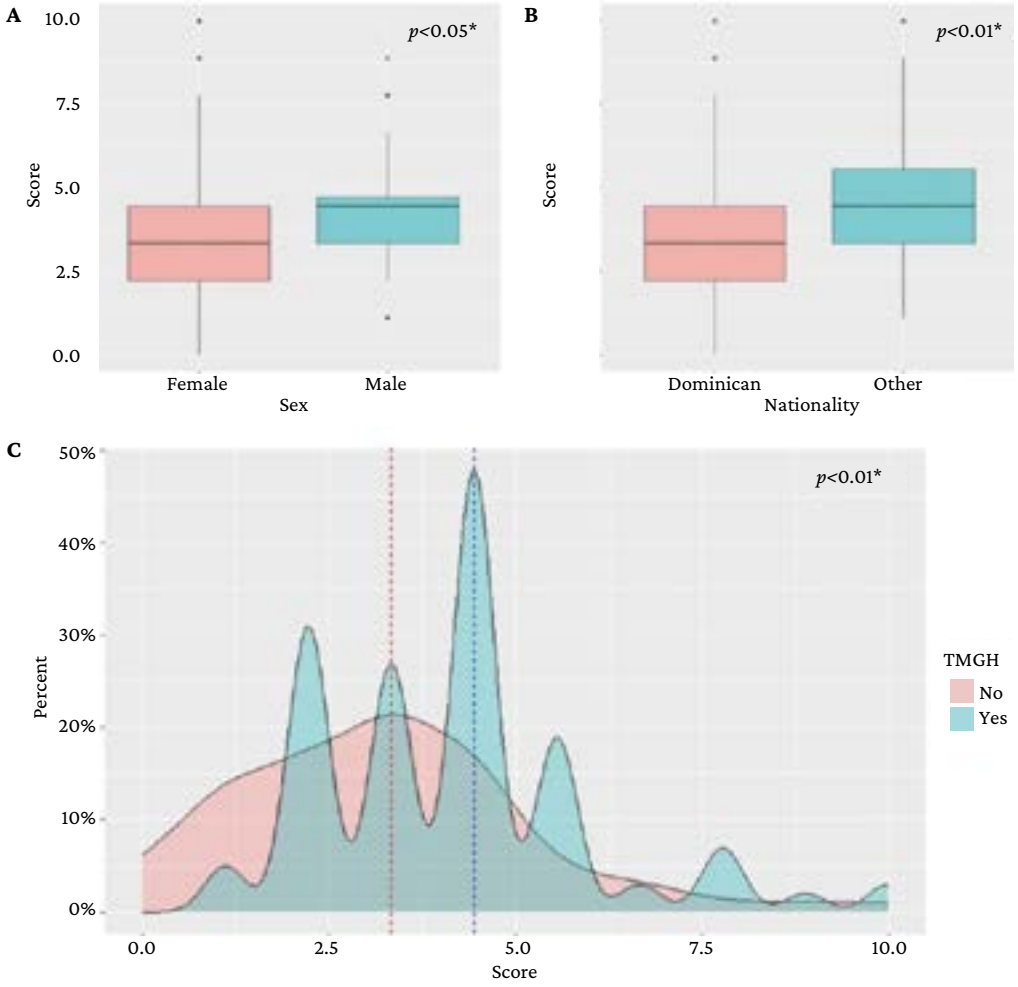

Figure 1. Evaluation of the effect of biological sex, nationality, and having taken the TMGH subject on the general knowledge score about *Aedes* mosquitoes and *Aedes*-borne diseases among the participants (n=224). A) red, females; blue, males; B) red, Dominicans; blue, others); C) red, students who had taken the TMGH subject; blue, students who had not taken the TMGH subject).

Attitudes

A total of 121 students (54.02%) reported the presence of mosquitoes in their houses, and 113 (50.45%) reported having a history of arbovirus infection, for a total of 144 self-reported arbovirus infection cases, being dengue the most frequent (n=72; 50%), followed by chikungunya (n=38; 26.38%), and Zika (n=18; 12.5%). In addition, 18 students (8.03%) reported having been infected by two of these viruses, while 6 (2.68%) were affected by all three pathogens. Also, when asked about the presence of breeding sites near their homes, the most frequently identified mosquito foci were plant pots (50.89%), water tanks (49.55%), and empty bottles (20.09%).

Finally, the proportion of students reporting a history of chikungunya virus infection was higher in the TMGH- group, being this difference slightly significant (OR=0.50; $p=0.09$). Moreover, the proportion of students reporting the presence of fallen trees as breeding sites around their households was higher in the TMGH- group, making this difference statistically significant (OR=0.36; $p=0.01$). There were no statistically significant differences between groups in the remaining questions (Table 2).

Practices

A total of 123 students (54.91%) reported that they or a member of their family cleaned *Aedes* mosquitoes breeding sites in their households, with a higher proportion stating this in the TMGH- group (63.29% vs. 50.34%; OR=0.59, $p=0.07$). Furthermore, when this subgroup was asked about the frequency of breeding site cleaning, a slight statistically significant difference was observed between the TMGH+ and TMGH- groups in terms of the proportion of students who reported cleaning every three days, being higher in the TGMH- group (13.70% vs. 26.00%; OR=0.45, $p=0.10$).

On the contrary, the proportion of students who stated that they did not recall the last time the breeding sites had been cleaned was statistically higher in the TMGH+ group (21.92% vs. 4.00%; OR=6.74, $p<0.001$). It is also worth noting that, when asked how the breeding sites were cleaned, the proportion of students who stated they did not know was higher in the TMGH+ group, being this difference slightly significant (21.92% vs. 10.00%; OR=2.526, $p=0.09$). The frequency of cleaning and cleansing elements that were most frequently reported were every week (39.02%) and water and chlorine (55.28%), respectively, with no statistically significant differences between groups.

Finally, aerosol repellents (37.50%) and insecticide spraying use (25.69%) were the most frequently employed prophylactic measures. It is important to note that 40.18% of the participants reported that they did not implement any protective measures. There were no statistically significant differences between groups.

Effect of the KAPs towards Aedes mosquitoes and Aedes-borne diseases on the self-report of arbovirus infection history by the students

While knowledge did not show any effect on the self-report rate of arbovirus infection history among participants (logistic regression model: Arbov+ score; intercept: estimate=0.15, $p=0.61$; Arbov- score: estimate=-0.03, $p=0.62$), some attitudes and practices did. In this regard, students who reported having suffered from at least one arbovirus infection were more likely to also report the presence of at least one breeding site in or around their household (OR=1.78; $p<0.05$), being unable to recall the last time they or a family member had cleaned the breeding sites in their households (OR=2.89; $p<0.05$), and to use insecticide as a prophylactic measure (OR=2.55; $p<0.005$) than those who had never been infected. In contrast, students who reported never suffering from an arbovirus infection were more likely to cover both their arms and legs as a prophylactic measure than those in the Abov+ group (OR=0.47; $p<0.05$) (Table 3).

Table 3. Evaluation of the effect of attitudes and practices on the infection risk among surveyed medical students from UNIBE.

Variable		Arbov+ (n=113)		Arbov- (n=111)		OR	*p*
		n	%	n	%		
TMGH+		70	61.95%	75	67.57%	0.78	0.40
Are there any mosquitoes in or around your house?	At least one reported breeding site	69	61.06%	59	53.15%	1.78	**<0.05***
	Water tank	64	56.64%	47	42.34%	1.78	**<0.05***
	Plant pots	58	51.33%	56	50.45%	1.04	0.90
	Animal drinkers	23	20.35%	14	12.61%	1.77	0.12
	Tires	7	6.19%	12	10.81%	0.54	0.22
	Fallen trees	17	15.04%	13	11.71%	1.33	0.47
	Empty bottles	22	19.47%	23	20.72%	0.92	0.82
How often do you clean the breeding sites? [Those who reported at least one breeding site]	Every three days	10	14.49%	13	25.00%	0.99	**0.6**
	Weekly	25	36.23%	24	46.15%	1.31	0.72
	Monthly	10	14.49%	7	13.46%	1.62	0.80
	I do not recall the last time I cleaned them	16	23.19%	6	11.54%	2.67	*0.06*
	Never/Do not know	8	34.78%	2	3.85%	4.28	0.11
How do you clean the breeding sites? [Those who reported at least one breeding site]	Only water	7	10.14%	9	17.31%	0.96	0.43
	Water and soap	21	30.43%	18	34.62%	1.37	1.00
	Water and chlorine	39	56.52%	32	61.54%	1.35	0.86
	Do not know	2	2.90%	0	0%	NA	NA
Which prophylactic measures do you use?	Insecticide	39	34.51%	19	17.12%	2.55	**<0.005***
	Aerosol repellents	41	36.28%	43	38.74%	0.900517	0.78
	Citronella candles	12	10.62%	16	14.41%	0.705446	0.42
	Bed nets	4	3.54%	5	4.50%	0.777982	0.7472
	Covering legs and arms	13	11.50%	24	21.62%	0.47	**<0.05***
	Others	4	3.54%	3	2.70%	1.32	1.00
	I do not use any protection measures	41	36.28%	49	44.14%	0.72	0.72
	Do not know	1	0.88%	3	2.70%	0.32	0.32

TMGH+: students who had taken the Tropical Medicine and Global Health subject. Arbov+: students who reported having suffering from an arbovirus infection; Arbov-: students who reported never suffering from an arbovirus infection.
In bold: slight statistical differences were observed (p<0.1, Fisher's exact t-test).
*: statistical differences were observed (p<0.05, Fisher's exact t-test).

Discussion

General practitioners are considered key in educating citizens about vector-borne diseases, such as dengue.[11] Consequently, medical schools should prepare these professionals to properly diagnose and treat *Aedes*-borne diseases and implement preventive measures based on scientific evidence.[16]

The 2024 dengue epidemic outbreak in the Americas demonstrated that *Aedes*-borne diseases can significantly affect public health in the region.[3] In this sense, understanding

the KAPs towards *Aedes* mosquitoes and the diseases they transmit of future general practitioners is an epidemiological priority in countries such as the Dominican Republic.[17]

To the best of our knowledge, this is the first study conducted in the Dominican Republic aimed at assessing medical students' KAPs towards synanthropic *Aedes* mosquitoes and *Aedes*-borne diseases. However, over the past decade, several authors have assessed the KAPs towards mosquito-borne diseases in endemic countries in the Americas, including Jamaica,[18] El Salvador,[19] Colombia,[20] and Mexico,[21] but they have primarily focused on the general population. The findings of those studies underscore the critical need for developing communication and community engagement strategies in low- and middle-income countries tailored to the specific characteristics of each region to control these vectors.

Furthermore, entomological studies, such as the one conducted by Diéguez-Fernández *et al.*[22] in two municipalities of Guatemala and the Dominican Republic or López-de-Felipe *et al.*[23] in Spain, indicate that it is also necessary to focus efforts towards control measures in residential areas, as they greatly contribute to the effectiveness and sustainability of integrated mosquito management programs.

Our data suggests that medical students who had taken the TMGH subject, which included comprehensive content on medical entomology, had a better understanding of *Aedes* mosquitoes (Figure 1). Nevertheless, a general lack of knowledge was observed among all surveyed medical students (mean knowledge score=3.84). These results are in line with prior assessments of KAPs towards vector-borne diseases among medical students made in Latin America. For example, Ríos-González *et al.*,[24] in a study conducted in medical students of Argentina, Bolivia, Chile, Colombia, Ecuador, Mexico, Panama, Paraguay, Peru, and Venezuela, reported that 88% of respondents had a low level of knowledge about the Oropouche virus disease.

In the case of basic taxonomy, medical students showed insufficient capacities to identify the *Aedes* species (correct identification rates through pictures: 7.14% and 16.52%). *Aedes aegypti* was the most accurately identified species by students (16.52%), likely due to its widespread presence in breeding sites nationwide.[25] In the same line, *Ae. japonicus* was the least commonly identified species, which is an expected finding considering that it is an invasive mosquito in North America[26,27] and has yet to be officially reported in the Dominican Republic.

It should be noted that 7.59% (17/224) of the respondents were not aware of the role of *Aedes* mosquitoes in arbovirus transmission, with students who had not taken the TMGH subject being much more likely to make this mistake (1.38% [2/145] vs. 18.99% [15/79]; OR=16.76; $p<0.0001$). Given the significant role that general practitioners play, not only in the diagnosis, but also in the prevention and surveillance of arboviral diseases, and considering the general lack of knowledge about these infections among medical students in Latin America —as evidenced both in the present study and the work by Ríos-González *et al.*[24]—, it is clear that the implementation of medical entomology subjects in medical curricula needs to be strengthened in the Dominican Republic and across the region. Therefore, initiatives undertaken in other regions, such as offering postgraduate diplomas in medical entomology and vector control,[28] could be considered to close this knowledge gap.

In our study, 40.18% of the respondents stated that they did not use any protective measures against mosquitoes. Although this proportion may be deemed as high, it is considerably lower than the one reported by Diéguez-Fernández *et al.*[22] in a study conducted in 200 households of 2 municipalities from Guatemala and the Dominican Republic

(52.96%). This difference could be explained by sample-related differences between studies, since the research by Dieguez Fernández *et al.*[22] was carried out with general population, whereas approximately 64% of our respondents, besides being medical students, had taken the TMGH subject. Protective measures against *Aedes*-borne diseases include the use of insect repellents and personal protective clothing to mitigate exposure to mosquitoes, as well as the emptying of nearby containers with stagnant water.[27]

Our findings indicate that knowledge about *Aedes* mosquitoes and *Aedes*-borne diseases did not have any effect on the self-report rate of arbovirus infection history among participants, but certain attitudes and practices did. In this regard, students who reported the presence of at least one breeding site in or around their households, could not recall the last time the breeding sites in their household were cleaned, and used insecticides as a prophylactic measure were more likely to report a history of arbovirus infection. Conversely, students who stated they covered both their arms and legs as a prophylactic measure were less likely to report having experienced any *Aedes*-borne disease. Similarly, Desjardins *et al.*,[20] in a study that evaluated the KAPs towards dengue, chikungunya, and Zika in Cali (Colombia), found that individuals who reported having had one or more of these vector-borne diseases were significantly more likely to report higher attitude scores.

The present study effectively deals with a critical public health issue in Latin America and the Caribbean, particularly in the Dominican Republic, by assessing the KAPs of medical students towards *Aedes* mosquitoes and *Aedes*-borne diseases through a comprehensive online questionnaire and in a significant sample size, thus enhancing the reliability of its findings. The study also highlights the positive impact of medical entomology training on medical students' knowledge about these vectors and the diseases they can transmit.

However, the use of self-reported data may introduce bias, and the cross-sectional nature of the study limits causal inferences. Additionally, it does not explore the long-term knowledge retention or its application in real-world scenarios. Also, as this is a single center study, the generalizability of the results may be limited. Despite these limitations, the data curation and analyses employed here may be of interest for replication in similar studies. In this sense, the study provides valuable insights into the educational needs of medical students regarding vector-borne diseases in the Dominican Republic, while identifying areas for improvement for further research.

Conclusions

General practitioners are considered key actors in the surveillance and control of arboviral diseases, since their direct interaction with the general population makes them a valuable source of information on the prevention of these diseases at the community level in endemic countries such as the Dominican Republic. Therefore, characterizing their KAPs towards *Aedes*-borne diseases is crucial.

Our findings imply that, in general, medical students had a poor understanding of *Aedes* mosquitoes and *Aedes*-borne diseases. However, the implementation of medical entomology training, such as the 'TMGH' subject, demonstrated an improvement in students' knowledge level.

Even though understanding the basic biological and ecological concepts of vector mosquito species is considered essential, our data suggests that knowledge about *Aedes* mosquitoes and *Aedes*-borne diseases did not have any effect on the students' self-report rate of arbovirus infection history, whereas certain practices and attitudes did have some effect.

As such, the inclusion and/or expansion of medical entomology courses in medical programs in countries where *Aedes*-borne diseases are endemic is imperative. Also, prophylactic measures and risk factors should be considered as key aspects to be addressed in such subjects.

Conflicts of interest

None stated by the authors.

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