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Cross-sectional study of dengue-related knowledge, attitudes and practices in Villa El Salvador, Lima, Peru

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ABSTRACT

Objectives   To describe and quantify the dengue-related knowledge, attitudes and practices of residents in an urban shantytown in Lima, Peru.

Design/setting   A cross-sectional survey of adults between 18 and 80 years living in approximately 120 blocks in Oasis, an urban shantytown situated in the low-to-middle income district of Villa El Salvador in Southern Lima. The survey was adapted from an existing survey previously used in Iquitos, Peru, and included questions relating to knowledge of dengue symptoms, transmission, prevention and current mosquito control practices.

Participants   A total of 240 surveys were completed with 80% of respondents being female and approximately 50% of all respondents describing themselves as housewives.

Results   Although 97.9% of respondents had heard of dengue, only 6.2% of people knew someone who had experienced the disease. Approximately half (54.2%) of the respondents knew dengue was transmitted by mosquitoes and 51.7% were able to identify fever and one other correct symptom of dengue. Female sex was significantly associated with greater symptom knowledge (OR 2.22, 95% CI 1.08 to 4.72) and prevention knowledge (OR 2.12, 95% CI 1.06 to 4.21). Past or current higher education attendance was significantly associated with symptom knowledge (OR 2.56, 95% CI 1.25 to 5.44) and transmission knowledge (OR 3.46, 95% CI 1.69 to 7.57). Knowledge of dengue was not significantly associated with carrying out practices to control mosquitoes (OR 1.76, 95% CI 0.87 to 3.54).

Conclusions   This population demonstrated baseline dengue knowledge. However, this was incomplete and substantially less when compared with endemic areas. Given the sporadic nature of dengue transmission in Lima, it is not surprising that knowledge of the disease was not associated with carrying out practices to reduce mosquitoes. However, as dengue transmission in Lima is likely to increase, understanding how best to improve public knowledge of the disease and how to translate this into appropriate community action will be a key public health consideration.

Strengths and limitations of this study

► This study uses a dengue-related knowledge, attitudes and practices survey that has been used successfully in a number of studies in Iquitos, Peru.

► We target an urban population of Lima, Peru, where dengue is not endemic but where there is a potential for increased future transmission. This is an understudied group.

► Our study was limited to one site in Lima and could have benefited from further data collection in a range of different locations in Lima thus enabling comparison between districts, including those that have experienced previous dengue outbreaks.

► The community in which this study took place, however, is representative of many socioeconomically similar sites in Lima to which these results could be cautiously extrapolated.

INTRODUCTION

Dengue is a mosquito-borne viral infection caused by one of four distinct serotypes of dengue virus (DENV). It is common in tropical and subtropical regions of the world where its principal mosquito vector, *Aedes aegypti*, is abundant. There are believed to be around 100 million clinically apparent infections per year.[1] Approximately 50% of the global population is estimated to live in areas suitable for dengue transmission, and this burden is expected to grow substantially in the coming 50 years in part due to the impact of climate change and urbanisation.[2]

The Americas contribute substantially to the global burden of dengue with an annual average of approximately 1.5 million cases reported to the Pan American Health Organization (PAHO) between 2014 and 2019 inclusive.[3] In 2019, over 3 million cases of dengue were reported to PAHO, the highest annual number since records began.[4] The transmission of DENV in Peru has been well documented since its re-emergence in the early 1990s with cases reported every year since 1990.[3 5 6] The areas of Peru with the highest incidence of dengue are the eastern departments (states) located within the Amazon basin (Loreto, Ucayali and Madre de Dios)

and coastal departments in the north of the country (Piura, Tumbes, La Libertad and Lambayeque).[7]

In recent years, sizeable outbreaks of dengue have occurred in regions of Peru previously only reporting sporadic autochthonous cases. Between 2000 and 2015, the department of Ica, located 300 km south of Lima, had reported less than four cases per year. Entomological surveillance detected the presence of *A. aegypti* in Ica in 2015, and an outbreak of dengue occurred the following year with 156 confirmed cases reported to the Peruvian Ministry of Health (MINSA). Transmission has persisted with over 1500 cases reported in 2017.[8 9] Since 2000, MINSA has recorded the presence of *A. aegypti* in 41 out of 43 districts in the metropolitan area (province) of Lima where Peru's capital is located,[10] and a number of dengue outbreaks have occurred.[11 12] However, with a population of 8.8 million and its prominence as a travel hub, the province remains at risk of more substantial dengue transmission in the future.[13]

As part of their global dengue prevention strategy, the WHO recommends an integrated vector management (IVM) approach relying on dengue-specific vector control measures implemented in partnership with local government and communities.[14] A baseline understanding of the public's knowledge, attitude and practices (KAP) with respect to dengue can help governments define and address local barriers to vector control implementation. KAP surveys relating to dengue have been carried out in many countries, including a number in Latin America.[15–23] MINSA carried out a survey in 2004 reporting how KAP can influence the successful implementation of public health campaigns.[24] Since then, they have carried out numerous campaigns to promote and educate the public in relation to dengue and other *A. aegypti* transmitted diseases.[25] As the impact of dengue varies widely across the country, it is reasonable to expect varying knowledge and practices dependent on the specific location. A previous KAP survey carried out in 2009 in the Peruvian Amazonian city of Iquitos where dengue is endemic revealed that 85.6% of participants knew that dengue was transmitted by mosquitoes compared with 40%–58.4% in a smaller study in Ica in 2010 prior to the 2015 outbreak.[9 26] The Iquitos study highlighted the association of a higher education level and a better understanding of dengue, as well as higher income level being associated with vector control practices that required purchasing power, such as the use of mosquito coils and insecticide sprays. Further evidence also links adequate knowledge of dengue and community empowerment to a reduction of entomological *A. aegypti* indices and rates of dengue.[27–29]

KAP surveys related to dengue have tended to be carried out in communities where dengue is endemic or where ongoing or recent outbreaks have occurred. As the risk of dengue expands to new areas, having an understanding of the population's baseline knowledge could help to better design and implement community-based interventions specific to this population and could provide insights for many similar communities around

Figure 1 Pictures of Oasis showing nature of housing and local roads.

the globe where dengue may spread. These lessons could have the largest impact in large urban areas such as Lima, where millions of people are at risk. With this in mind, the objective of this manuscript is to examine the dengue-related KAP of participants recruited from an urban shantytown in Lima's southern district of Villa El Salvador.

METHODS
Study setting
This cross-sectional study took place in Oasis (figure 1), an urban shantytown located in the low-to-middle income district of Villa El Salvador on the outskirts of southern Lima (estimated population of 450 000 in 2015).[13] Villa El Salvador was initially established as a 'recent settlement' or '*pueblo joven*' in the 1970s; Oasis was established slightly later, in the late 1980s and early 1990s. As occurs with settlements that are allowed to remain on the land, individuals eventually replace their straw mat homes for longer term materials, such as wood and bricks and eventually install electricity and water. Some Oasis homes closer to the asphalted main highway are made of bricks, but within blocks, roads are not asphalted, houses are made of chipboard, house roofs are made of sheets of corrugated iron and flooring is often dirt. The majority of homes have piped water, but most have only one faucet, and water is sometimes rationed at certain times of day. Hence, people keep water in buckets and water tanks for use in different areas of the house, as well as

in preparation for routine water rationing or shortages. MINSA has reported the presence of *A. aegypti* in Villa El Salvador since 2005 and, notably, the neighbouring district of Villa Maria del Triunfo was the site of a substantial outbreak of dengue in 2013.[10 30]

Study design
Four local, experienced field workers applied a cross-sectional survey to households from Oasis in 2013, which comprises of approximately 120 blocks. To ensure spatial distribution of the houses surveyed, we aimed to recruit three houses per block. Using field maps, field workers selected the first house at random and performed door-to-door sequential surveying. If a house was closed, they moved to the house next door, until three households had been recruited. If less than three households were recruited and all remaining houses declined to participate or were closed, field workers moved to the next block. If more than one adult was present, the field worker requested to speak with the adult most likely to be a caregiver in the household. Unfortunately, we did not document the number of houses that refused to participate, nor the number of closed homes at time of recruitment.

Inclusion criteria
Survey participation was completed by one adult member of the household between the age of 18 and 80 years, with verbal consent, as approved by institutional review boards.

Study instrument
The survey was adapted from an existing KAP survey previously used in Iquitos, Peru.[26] The survey was piloted on 19 people and modified slightly to suit the local study population. The questions on the paper-based survey were mostly closed-ended, with pre-established response categories. After questions regarding respondents' sociodemographic characteristics, we focused on knowledge of dengue: its symptoms, transmission, treatment and current mosquito control practices. Each survey took approximately 40 min and was conducted in Spanish.

Patient and public involvement
To help design and implement this study, we used data available from a dengue-related KAP study carried out in Iquitos, by members of our team. The engagement with the community during this process informed many of the methodological approaches taken here. The local participants were not directly involved in the design, recruitment or implementation of this study; however, they were given time at the end of each survey to address any dengue specific questions that could help improve their understanding of the disease. We do not plan to directly disseminate the results of this study to the community but hope that its contribution to the scientific literature can help inform public health bodies in their community-based work.

Data analysis
Data collected from the household surveys were entered into a Microsoft Excel 2010 V.14.0 (Microsoft, Redmond, Washington, USA) spreadsheet, using double data entry. Surveys were coded using a numerical sequence, and no patient identifiable data were recorded. R V.3.6.1 was used to clean and analyse all data.[31] Responses to questions with an open-ended 'other' option were reviewed, and new response categories were created if common and relevant themes were identified. We reported frequencies for categorical variables and medians for continuous variables. χ^2 tests examined associations between question responses and gender. Missing data were not imputed, and denominators were adjusted accordingly.

Six logistic regression models were conducted, each using different binary dependent variables. Models 1–4 examine factors associated with knowledge of dengue and models 5 and 6 examine factors associated with current mosquito control practices. The models' dependent and independent variables are described below.

Dependent variables
► Model 1: knowledge of dengue symptoms, defined as: knowledge of fever/chills plus one other correct symptom (body/joint pain, headache/eye pain, rash or malaise).
► Model 2: knowledge of dengue transmission, defined as knowing that dengue is transmitted by a mosquito.
► Model 3: knowledge of the importance of covering water containers to help prevent dengue.
► Model 4: in order to measure an overall 'good' knowledge of dengue, the fourth model used a composite of knowing at least two outcome variables from models 1–3.
► Model 5: carrying out any action with the intention of controlling mosquitoes in the home for whatever reason.
► Model 6: being in the top 25% of annual spenders on mosquito control products. Our hypothesis was that people with higher income or higher education may be more willing to spend more on mosquito control products such as coils or insecticide sprays than their counterparts.

Independent variables
► Age, as a binary variable cut at the median age of 40 years.
► Sex.
► Attendance or previous attendance of post high school education, such as university or technical training, as a binary variable.
► High income, as a binary variable, defined as a household income of >$5000 annually.
► The presence of a child 5 years or younger in the house, as a binary variable. Children less than 5 years do not generally attend school, and we hypothesised having a child in the home during the day might have a greater influence on preventive practices.
► For models 5 and 6, to examine whether knowledge of dengue itself was associated with practices, we

Table 1	Population characteristics
Characteristic	**Value**
Age median (IQR)	40.0 (30–46)
Sex % (n/d)*	
Female	80.0 (192/240)
Male	20.0 (48/240)
Education level reached % (n/d)	
Primary	32.1 (77/240)
Secondary	46.2 (111/240)
Technical or university	21.6 (52/240)
Occupation % (n/d)	
Housewife	51.7 (124/240)
Sales	14.2 (34/240)
Unskilled	7.1 (17/240)
Student	6.3 (15/240)
Unemployed	1.2 (4/240)
Other	19.2 (46/240)
Annual household income US$ % (n/d)	
0–499	17.5 (40/229)
500–999	38.4 (88/229)
1000–4999	15.7 (36/229)
5000+	28.4 (65/229)
Household information	
People per household median (IQR)	5 (4–6)
Households with child <5 years % (n/d)	46.7 (112)

*n=number of people answering affirmatively; d=number of people who answered the question. Where the denominator is less than expected, this represents missing values due to participants choosing not to answer certain questions.
IQR, interquartile range.

also included the dependent variable from model 4 (composite score of 'good knowledge').

We performed logistic regression models using the 'glm' function from the 'stats' package in R and used base R functions to calculate adjusted ORs and 95% CIs. We looked for the presence of multicollinearity between independent variables in the models by calculating the variance inflation factor (VIF) using the 'vif' function from the 'car' package in R. For each model, we present the maximum VIF of the model's independent variables. With a maximum VIF <5 not highly suggestive of the presence of multicollinearity. Furthermore, we calculated McFadden's R^2 as a measure of model fit.

RESULTS
Population
A total of 240 surveys were completed, 80% of respondents were female and the median age was 40 years

(table 1). Approximately half of respondents (51.7%) were housewives (table 1). The next most common professions were sales (14.2%), unskilled work (7.1%) and 6.3% were full-time students (table 1). Almost half of respondents (46.2%) had some level of secondary education, and almost a fifth (21.6%) had at least some technical programme or university education (table 1). Due to the informal nature of employment, respondents were asked to estimate from various income brackets. Most respondents (38.4%) reported annual household incomes of $500–$999 (table 1). The majority of respondents owned their homes (69.6%) and had electricity (97.9%) and piped water (93.3%) in the home.

Knowledge: general
Most respondents (97.9%) had heard of dengue, and 95.1% correctly believed there had been dengue cases in Lima (table 2). Despite this, only 6.2% knew someone who had previously had dengue (table 2).

Knowledge: symptoms
Although 80.0% knew that fever and/or chills were symptoms of dengue, only 51.7% of respondents were able to identify an additional correct symptom (body/joint pain, headache/eye pain, rash or malaise) (table 2). Model 1 (table 3) showed that variables significantly associated with correctly identifying classic dengue symptoms were: female sex (OR 2.22, 95% CI 1.08 to 4.72), attendance of higher education (OR 2.56, 95% CI 1.25 to 5.44) and presence of a child ≤5 years old in the house (OR 3.16, 95% CI 1.74 to 5.86).

Knowledge: transmission
Approximately half of the respondents (54.2%) knew dengue is transmitted by a mosquito (table 2), with only 1.7% of respondents naming the mosquito species, *A. aegypti*. Additionally, 18.3% of respondents reported believing dengue is transmitted through water and 12.5% implicated the mosquito egg as the infectious agent. Another 1.7% believed DENV is transmitted through person–person contact. Model 2 (table 3) showed that having attended higher education was significantly associated with knowing that dengue was transmitted by a mosquito (OR 3.46, 95% CI 1.69 to 7.57).

Knowledge: treatment
Only 25.0% of individuals listed an appropriate treatment for dengue (ie, taking paracetamol, oral rehydration or going to a health clinic), whereas 17.1% reported an inappropriate treatment of symptoms, such as antibiotics or vaccination, and the remaining 57.9% did not know or did not give an answer.

Knowledge: prevention
Approximately two-thirds of individuals (66.7%) knew that covering water containers is an effective measure to prevent dengue. Other actions that were believed to reduce dengue were cleaning inside the home (60.4%), use of purchased products (sprays, coils and bleach)

Table 2 Key survey responses by gender

Question	Total % (n/d)†	Male % (n/d)	Female % (n/d)	χ^2 P value
General				
Heard of dengue	97.9 (234/239)	93.8 (45/48)	99.0 (189/191)	0.09
Believe dengue has occurred in Lima	95.1 (215/226)	93.2 (41/44)	95.6 (174/182)	0.78
Believe their risk of dengue is high	26.2 (60/229)	21.7 (10/46)	27.3 (50/183)	0.56
Knows someone who has had dengue	6.2 (13/208)	5.1 (2/39)	6.5 (11/169)	>0.99
Transmission				
Dengue transmitted by mosquito	54.2 (130/240)	45.8 (22/48)	56.2 (108/192)	0.26
Knowledge of following symptoms				
Fever or chills	80.0 (192/240)	72.9 (35/48)	81.8 (157/192)	0.24
Headache or eye pain	40.0 (96/240)	27.1 (13/48)	43.2 (83/192)	0.06
Malaise or fatigue or appetite loss	20.4 (49/240)	16.7 (8/48)	21.4 (41/192)	0.6
Joint or body pain	14.6 (35/240)	4.2 (2/48)	17.2 (33/192)	0.04*
Dengue symptoms‡	51.7 (124/240)	35.4 (17/48)	55.7 (107/192)	0.02*
Knowledge of the following preventative measures§				
Covering water containers	66.7 (160/240)	50.0 (24/48)	70.8 (136/192)	0.01*
Cleaning inside the home	60.4 (145/240)	50.0 (24/48)	63.0 (121/192)	0.14
Using purchased products (sprays, coils and so on)	8.3 (20/240)	8.3 (4/48)	8.3 (16/192)	>0.99
Fumigation	3.8 (9/240)	4.2 (2/48)	3.6 (7/192)	>0.99
Using bed nets	3.3 (8/240)	2.1 (1/48)	3.6 (7/192)	0.93
Discarding potential outdoor water recepticles	2.9 (7/240)	0.0 (0/48)	3.6 (7/192)	0.39
Experience of mosquitoes in the home				
Seen mosquitoes in the home in last year	72.5 (174/240)	64.6 (31/48)	74.5 (143/192)	0.23
Mosquitoes seen mainly at night	88.3 (151/171)	83.3 (25/30)	89.4 (126/141)	0.54
Season(s) that mosquitoes most abundant				
Summer	64.2 (154/240)	66.7 (32/48)	63.5 (122/192)	0.81
Winter	30.4 (73/240)	25.0 (12/48)	31.8 (61/192)	0.46
Spring	3.8 (9/240)	4.2 (2/48)	3.6 (7/192)	>0.99
Autumn	2.1 (5/240)	4.2 (2/48)	1.6 (3/192)	0.57
Practices performed to control mosquitoes¶				
Any practice attempting to control mosquitoes	78.3 (188/240)	66.7 (32/48)	81.2 (156/192)	0.05*
Insecticide spray	35.0 (84/240)	41.7 (20/48)	33.3 (64/192)	0.36
Clean the house	17.5 (42/240)	25.0 (12/48)	15.6 (30/192)	0.19
Coil repellents	10.8% (26/240)	6.2 (3/48)	12.0 (23/192)	0.38
Fumigation	9.6 (23/240)	4.2 (2/48)	10.9 (21/192)	0.25
Use of fly swatter	6.2 (15/240)	2.1 (1/48)	7.3 (14/192)	0.32
Cleaning floors with bleach	4.6 (11/240)	4.2 (2/48)	4.7 (9/192)	>0.99
Cover water containers	2.1 (5/240)	4.2 (2/48)	1.6 (3/192)	0.57
Vaporising repellents	0.8 (2/240)	0.0 (0/48)	1.0 (2/192)	>0.99
Reason to control mosquitoes				
Nuisance factor (biting or buzzing sound)	69.7 (161/231)	59.6 (28/47)	72.3 (133/184)	0.13
Fear of disease	15.2 (35/231)	21.3 (10/47)	13.6 (25/184)	0.28

†n=number of people answering affirmatively; d=number of people who answered the question. Where the denominator is less than expected, this represents missing values due to participants choosing not to answer certain questions.
‡Respondents correctly identified fever/chills and at least one of the following: malaise/fatigue/anorexia, joint/body pain, head/eye pain and rash.
§This is knowledge of the action and does not imply the action is actually carried out.
¶These are actions actually completed by the participant. People may perform multiple actions.

Table 3 Predictors of dengue knowledge

Predictors	Model 1	Model 2	Model 3	Model 4
	Symptoms OR (95% CI)	Transmission OR (95% CI)	Prevention OR (95% CI)	Overall OR (95% CI)
Age (>40 years)	1.04 (0.57 to 1.92)	1.27 (0.71 to 2.29)	0.65 (0.35 to 1.19)	1.30 (0.71 to 2.41)
Sex (f)	2.22 (1.08 to 4.72)	1.82 (0.91 to 3.69)	2.12 (1.06 to 4.21)	3.29 (1.63 to 6.87)
Higher education	2.56 (1.25 to 5.44)	3.46 (1.69 to 7.57)	0.55 (0.27 to 1.09)	2.43 (1.16 to 5.39)
Child ≤5 years in house	3.16 (1.74 to 5.86)	1.01 (0.57 to 1.82)	1.03 (0.56 to 1.88)	1.75 (0.96 to 3.25)
High income	1.72 (0.92 to 3.25)	0.97 (0.53 to 1.78)	1.65 (0.87 to 3.23)	1.75 (0.93 to 3.41)
McFadden's R^2	0.14	0.09	0.08	0.12
Maximum VIF†	1.19	1.18	1.15	1.18

*Multiple logistic regression models demonstrating factors associated with knowledge of dengue, p<0.05. See methods for description of dependent variables.

†VIF=these are the maximum variance inflation factor of all the independent variables in the model. High VIF values (>5) indicate the presence of multicollinearity between independent variables. As the maximum detected VIF was <5, multicollinearity is not likely to be present in these models.

(8.3%), fumigation (3.8%) and use of bed-nets (3.3%) (table 2). Model 3 (table 3) showed that female sex was significantly associated with knowing the importance of covering water containers for prevention (OR 2.12, 95% CI 1.06 to 4.21).

Knowledge: overall

Model 4 (table 3) assessing overall knowledge of dengue (symptoms and/or transmission and/or prevention) showed that female sex (OR 3.29, 95% CI 1.63 to 6.87) and attendance of higher education (OR 2.43, 95% CI 1.16 to 5.39) were significantly associated with overall knowledge of dengue.

Experience of mosquitoes in the home (not specific to *A. aegypti*)

The majority of respondents (72.5%) reported having seen mosquitoes in the home in the last year. Of these, 88.3% said they mainly notice being bitten by mosquitoes throughout the night (between 20:00 and 05:00). People most commonly reported seeing mosquitoes during the summer months (64.2%) (table 2).

Attitudes

Most respondents believed they are at low or no risk for contracting DENV (73.8%). The most common reason for controlling mosquitoes in homes was the nuisance of mosquito bites or the annoyance of the buzzing sound of the mosquito (69.7%). Only 15.2% said they attempted to control mosquitoes due to fear of disease (table 2). Respondents decide which mosquito products to buy based on perceived effectiveness or quality (38.8%) or what they feel best protects against disease (11.2%).

Current practices

Purchased products used in an attempt to control mosquitoes included: insecticide sprays (35.0%), coil repellents (10.8%) and bleach applied to internal floors (4.6%). An additional 21.7% of respondents reported doing nothing

to reduce mosquitoes. Despite 66.7% of people knowing that covering external water containers may prevent dengue, only five respondents (2.1%) said they actually cover water containers as practice against mosquitoes. The median estimated annual spend on mosquito control products was ~13 PEN (IQR 0–65) or ~3.8 US$ (IQR 0–19.6). Age (OR 2.19, 95% CI 1.05 to 4.70) and the presence of a child ≤5 years (OR 2.38, 95% CI 1.13 to 5.20) were significantly associated with doing anything to control mosquitoes (table 4, model 5). Model 6 (table 4) showed no significant predictors of being in the top 25% of spenders on mosquito control products.

Table 4 Predictors of mosquito control practices

Predictors	Model 5	Model 6
	Mosquito control OR (95% CI)	Top 25% spenders OR (95% CI)
Age (>40 years)	2.19 (1.05 to 4.70)	1.08 (0.56 to 2.08)
Sex (f)	1.71 (0.74 to 3.83)	0.93 (0.42 to 2.15)
Higher education	2.47 (0.98 to 7.23)	1.15 (0.53 to 2.41)
Child ≤5 years in house	2.38 (1.13 to 5.20)	1.60 (0.83 to 3.10)
High income	1.35 (0.62 to 3.15)	1.47 (0.75 to 2.81)
Good knowledge	1.76 (0.87 to 3.54)	1.67 (0.85 to 3.35)
McFadden's R^2	0.15	0.06
Maximum VIF†	1.21	1.17

*Multiple logistic regression models demonstrating factors associated with practices to control mosquitoes, p<0.05

†VIF=these are the maximum variance inflation factor of all the independent variables in the model. High VIF values (>5) indicate the presence of multicollinearity between independent variables. As the maximum detected VIF was <5 multicollinearity is not likely to be present in these models.

DISCUSSION

Despite dengue being uncommon in Lima, this population demonstrated some baseline knowledge with 97.9% of people having heard of dengue and 80% associating the disease with fever. Of our participants, 54.2% were aware that the disease is transmitted by mosquitoes. This is slightly less than reported in the KAP carried out by MINSA in 2004 on residents of Lima and similar to data from a KAP survey carried out in the Ica province south of Lima in 2010 (40%–58%) but substantially less than in Iquitos (86%) where dengue is endemic.[9 26 32] While individuals living in endemic regions have more exposure to public health campaigns, most also have a more personal connection with the disease having either had the disease themselves or knowing someone who has, strongly reinforcing knowledge of the disease. The Iquitos KAP revealed that knowledge of dengue was significantly associated with knowing someone who had previously had dengue in the past.[26] In our study, only 6.2% of individuals knew somebody who had previously experienced dengue, compared with 65% in Iquitos.

Despite this baseline knowledge, many individuals had an incomplete understanding of disease transmission. For example, approximately a third of people were aware of the connection with water or insect eggs, but many suggested the presence of contaminated water or the contamination of water with insect eggs as being responsible for transmission. One individual stated *'pone el huevo en el agua y si tomas nos contaminamos con el dengue'* implying the following understanding: drinking water with eggs (presumably placed by a mosquito or other insect) can transmit dengue, and this was a common theme (online supplementary file S1).

Consistent with the Iquitos KAP survey and those in other endemic countries, we found that higher education levels and female sex were significantly associated with a better knowledge of dengue (symptoms, prevention and overall knowledge).[26 33] Eighty per cent of respondents in our sample were women, probably due to lower rates of employment among women compared with men in Peru with women more likely to be home at the time of the interviews.[34] Also, the Peruvian MINSA deploys community health workers (CHWs) to disseminate dengue knowledge through door to door visits.[25 35] Knowledge in women could be higher as they are more likely to encounter CHWs during the day and because they are likely to be implementing any practical steps associated with dengue prevention. While directing dengue prevention campaigns to those that manage households seems a sensible approach, using other methods of communication such as social media, television and radio could disseminate information to those not at home during the day, broadening coverage. MINSA are currently running a campaign called 'Mi casa sin zancudos' (My house without mosquitoes) using social media and advertisements (figure 2).[25] Measuring the effectiveness of these approaches would require a different methodology to

Figure 2 Photographs of current government lead campaign 'Mi Casa Sin Zancudos' on bus in Chorillos district of Lima.

that taken in this study and is an important consideration for future studies.

Given the sporadic nature of DENV transmission in Lima, we would not expect people's practices to be driven by fear of this disease. Indeed, most people (73.8%) believed they were at no or low risk of dengue. This attitude is consistent with the findings that most people (67.1%) reported carrying out mosquito control practices due to the nuisance of mosquitoes rather than disease prevention and that despite approximately two-thirds of people being aware of the importance of covering water containers, only a very small minority (2.1%) actually do so. We did not find an association between dengue knowledge and mosquito control practices (models 5 and 6). However, even studies in endemic countries examining this association have shown mixed results, suggesting that factors other than dengue knowledge and endemicity play a role in the use of mosquito control practices.[18 20] As nuisance biting tends to be experienced at night, it would be important to reinforce the message that *A. aegypti* mosquitoes are predominantly day biters and therefore measures to reduce nuisance biting are not necessarily highly effective in preventing dengue.

Notably, the presence of children 5 years and under in a household was also significantly associated with household members reporting that they carry out measures to control mosquitoes possibly out of parental concern for their young children's health, this was similarly found to be the case in the dengue-endemic city of Iquitos.[26]

Children may react more strongly to mosquito bites than adults, seeing a child with inflamed itchy bites that cause discomfort and prevent them from sleeping could be a strong motivation to prevent bites.[36]

We recognise some limitations to this study including its relatively small sample size from only one location in Lima. Although Oasis is not dissimilar from many parts of Lima and general lessons can be taken, extrapolating these results to other populations should be done with caution. Unfortunately, we did not collect data on the number of households or individuals that refused to participate; thus, we are unable to assess the response rate in our population and whether refusal to participate may have introduced any selection bias. Furthermore, houses were only visited during the day and thus most professional working routine office hours would have been excluded from participating. This is reflected in the female-to-male ratio of 4: 1 of our sample.

Translating knowledge of dengue into appropriate community action in places like Lima where transmission is likely to increase will be a challenge for the future. Understanding people's current KAP is important for guiding public health interventions. Although there seems to be a baseline understanding of dengue, knowledge of how the disease is transmitted could be strengthened. Communicating campaign information to those that manage households (predominantly women in this population) has obvious advantages, but reaching out to those not at home in the day time could help broaden community knowledge of the disease. In line with the WHO's IVM approach to the control of vector-borne disease, entomological and disease surveillance systems need to be strong so that public health campaigns in locations like Lima can be timed well and target the correct populations.

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