Community participation in mosquito breeding site control: an interdisciplinary mixed methods study in Curaçao

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Abstract

Background: As the arboviral diseases dengue, chikungunya and Zika emerge in the Americas, so does the need for sustainable vector control policies. To successfully achieve mosquito control, joint efforts of both communities and governments are essential. This study investigates this important, but by-and-large neglected topic.

Methods: In June and July 2015, a cross-sectional mixed methods study applying a survey questionnaire (response rate of 82.5%; n = 339), in-depth interviews (n = 20) and focus group discussions (n = 7; 50 participants) was performed in Curaçao. The study was designed based on an integrated theoretical framework of the Health Belief Model and the Theory of Planned Behaviour.

Results: Participants showed a good knowledge of, and a high-level performance of mosquito breeding site control (MBSC) practices. Personal protection against mosquitoes (e.g. topical repellents) was perceived as relatively less effective thus practiced to lower extent compared to MBSC practices (i.e. larval source management). A lower intention to perform MBSC was independently associated with: (i) satisfaction on governmental MBSC (P = 0.012); (ii) barriers to perform MBSC practices, i.e. ‘Government doesn’t control other breeding sites’ (P = 0.005), ‘Don’t know how to control breeding sites’ (P = 0.041), and ‘a mosquito does not transmit dengue’ (P = 0.016), (iii) attitudes towards MBSC (P = 0.001) and self-efficacy (person’s perceived ability to act) to perform MBSC (P = 0.002). Mixed-methods evidence highlights three possible ways of improving community participation in MBSC. First, it highlights the need for ongoing media coverage, targeting (i) communities’ perceptions on transmission routes of dengue and chikungunya, and (ii) presence of car tires in yards. Secondly, it shows that promotion of governmental activities in MBSC can enhance MBSC of communities, if people develop a sense of responsibility to perform MBSC at their own properties. Thirdly, this study describes the presence of key persons in communities, who could be engaged in mosquito control policies to improve MBSC in neighbourhoods.

Conclusion: This study reveals gaps between policy and communities’ lived realities. These gaps might be overcome with the proposed interventions, resulting in a higher performance of MBSC in the community in Curaçao. Furthermore, this study shows how interdisciplinary mixed methods research can provide important, comprehensive, and in-depth insights to inform mosquito control policies.

Keywords: Mosquito breeding site control, Community mobilization, Curaçao, Chikungunya, Dengue, Mixed methods, Theory of planned behaviour, Health belief model, Integrated vector control, Aedes aegypti

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Background

The arboviral diseases dengue, chikungunya and Zika impact seriously on public health in endemic countries. Untreated dengue can evolve into severe variants and eventually cause shock or death [1]. Chikungunya is known for its chronic, lingering, mainly musculoskeletal complaints with a major impact on quality of life [2–6]. Zika is ill-famed for congenital Zika syndrome [7], Guillain-Barré syndrome frequency [8], sexual transmissibility [9] and a rare but life-threatening immune-induced thrombocytopenia [10].

These viruses are transmitted by *Aedes* spp., mainly *Ae. aegypti* and *Ae. albopictus*, that flourish in large parts of Southeast Asia, the Americas and Africa, and beyond. In these regions, dengue outbreaks occur on a regular basis [11]. In Curacao, where dengue is endemic for all four serotypes [12], chikungunya caused a major outbreak in 2014–2015 where approximately 50–75% of the population was infected [6]. High proportions of chikungunya infected individuals (64%) still suffered from the long-term effects of this disease [6]. In January 2016, the first locally transmitted Zika case in Curacao was reported, heralding an epidemic [13].

Despite the high burden of disease that dengue, chikungunya and Zika cause, marketed vaccines are not available yet. Treatment strategies for all three diseases currently focus on symptom relief. Outdoor personal protection against mosquitoes relies mainly on topical repellents, but these face numerous practical concerns and are often not suitable for efficient long-term use [14, 15]. Meanwhile, the only effective way to reduce the burden of these diseases is prevention, which is mainly dependent on vector control [16, 17].

New methods of vector control using genetic manipulation of *Ae. aegypti* or endosymbiotic bacteria are promising for large-scale field application [18], but are not yet widely used for vector control. Efficacy of long-lasting insecticides applied to curtains or bed nets is poor [19], given the day-biting behaviour of the *Aedes* spp. Application of insecticides is challenged by growing resistance to temephos and pyrethroids of larvae and adult mosquitoes of the *Ae. aegypti* [20]. In the meantime, larval source control remains an effective mosquito control strategy [18, 21].

Identifying and eliminating standing pools of water on a large scale is impractical, expensive and not suitable for sustainable vector control, if conducted solely by government bodies [18]. Meanwhile, examples of mosquito control strategies with community involvement are successful in the short and long term [21–24]. Consequently, complimentary efforts are needed from centralized (governmental) initiatives and the community to enhance effectiveness and sustainability of mosquito control methods [16, 21].

It remains challenging to achieve community participation in mosquito breeding site control (MBSC). Preventive health behaviours are driven by many social and psychological factors, which need to be addressed for forging and implementing of an effective health policy [25, 26]. As crucial as it is, community participation in vector control for dengue and chikungunya remains a neglected topic in scientific literature. The scarcity of community-based, mixed-method approaches using theoretical frameworks in this field are illustrative for the detachment of theory and practice, recognized as a problem in global health research [27–30].

Several health behaviour theories have been developed to understand determinants of behaviour and to provide a basis for effective health policy [25]. Two important theories for preventive behaviour are the Health Belief Model (HBM) and the Theory of Planned Behaviour (TPB). Both theories are validated, and effectively applied in preventive behaviour interventions. Central concepts in the HBM are the ‘perceived susceptibility’ and the ‘perceived severity’ of the condition, leading to the ‘perceived threat’ of the condition. The HBM proposes that the perceived threat of a condition, the perceived benefits and barriers of preventive behaviour, the self-efficacy (a person’s perceived ability to perform the behaviour) and the cues to action predict behaviour [30, 31] (Additional file 1: Figure S1). The Theory of Planned Behaviour (TPB) combines the attitude towards behaviour, subjective norms and perceived behavioural control, resulting in behavioural intentions and behaviour [32]. The HBM and TPB are theories with unique value for health-promotion interventions. Hence, a combination of theories may result in the most effective interventions [25, 33]. In this study, the HBM was applied to understand the risk perceptions of participants and by combining the TPB we were able to measure their perceived control and subjective norms that influence intentions for MBSC.

To our knowledge, no studies combining qualitative and quantitative research methods based on the TPB or HBM to investigate community participation in MBSC have been published to date. We address this knowledge gap here by (i) describing communities’ perceptions and practices of preventive behaviours in MBSC; (ii) analysing communities’ behavioural intentions to control mosquito breeding sites, based on the TPB and the HBM; and (iii) proposing targets for health interventions to enhance community participation in MBSC. The study aims were addressed using qualitative and quantitative approaches on sociological, psychological and epidemiological grounds. This study design enables an in-depth, comprehensive and interdisciplinary understanding of the topic, to date unique in its field.

Methods

Study design

In June and July 2015, a cross-sectional mixed method study using individual questionnaires, in-depth interviews
(IDIs) and focus group discussions (FGDs) was performed to assess community participation in MBSC in Curaçao. The study was designed based on an integrated theoretical framework of the HBM and TPB (Additional file 1: Figure S1).

**Study site**

Curaçao is a Caribbean island in the southern Caribbean Sea located around 100 km off the Venezuelan coast. In October 2010, Curaçao became an autonomous country within the Kingdom of the Netherlands [34]. Curaçao has a surface area of 444 km² and a population of approximately 150,000 inhabitants [35]. It is home to people from different ethnic backgrounds, with an Afro-Caribbean majority [36]. Most of the population resides in the capital Willemstad and its surroundings, located in the central-south part of the island (Fig. 1), the main economic area of the country [35]. Curaçao is a relatively wealthy Caribbean island with a GDP per capita of 22,600 dollar (2012). It has a semi-arid climate with a rainy season from September to January and a dry season from February to June [37, 38]. Generally, all people have access to potable tap water which means that water storage is limited. The central government of Curaçao is responsible for vector control in all neighbourhoods. Vector control activities are performed by the vector control unit of the government. Routine surveillance concern inspection and application of larvicides and fogging at sites at risk for mosquitoes. During epidemics these activities are intensified and focused on properties around suspected arboviral transmission.

**Quantitative methods**

**Study population**

Adult subjects with a serologically or clinically confirmed chikungunya infection (of which two were self-diagnosed) during the 2014–2015 chikungunya epidemic were selected from a representative patient sample from 20 general practitioners across the country. Eligible individuals were invited and interviewed at their homes.

**Data collection**

An individual questionnaire containing pre-coded questions was designed in Dutch. After a pilot-study, it was adapted and translated into Papiamentu, Spanish and English. Training was provided to interviewers prior to field mobilization. All interviewers were local, experienced interviewers working for the Central Bureau of Statistics of Curaçao and speaking all four mentioned languages. The questionnaire addressed socio-demographic characteristics and chikungunya chronic disease persistence by applying the Curaçao Long-term Chikungunya Sequelae Score (CLTCS Score), to measure perceived severity of long-term chikungunya disease. This score was calculated using four (5-point Likert-item) questions. More information on the methodology of the scale can be obtained from a recent publication [6].

**Constructs of the HBM and TPB**

The behavioural target was defined as follows; ‘to check the house and yard for mosquito breeding sites every week and eliminate the breeding sites if necessary, in the coming rainy season’. This behavioural target was measured by assessing the Behavioural Intention to perform Mosquito Breeding Site Control (BIMBSC) (Additional file 2). The constructs of the HBM and TPB and their modifying variables (satisfaction on government’s mosquito control action, and knowledge on transmission route of chikungunya and dengue) were measured using multiple five-point Likert items or binary items which were analysed separately or merged into a Likert scale after analysis for internal consistency. Questions were adapted from literature where possible [33, 39].

**Knowledge**

Participants indicated from which sources they received their information relating to chikungunya and dengue among the presented media and education sources. Two ‘interpersonal sources’ were also assessed: general practitioner and family/friends/neighbours. The subject’s perception of chikungunya and dengue transmission routes was tested by asking him/her to indicate all possible transmission routes of these diseases among the presented options.
Attitudes and behaviours towards personal protection and mosquito breeding site control

Data on perceptions and performance of personal protection against mosquitoes and MBSC practices was obtained. Participants rated proposed measures on their effectiveness and frequency of performance, applying a five-point Likert item.

Data analysis

SPSS Data Entry Station (SPSS Inc. 1996–2003, version 4.0.0) was used for quantitative data entry. Data were checked for consistency and analysed anonymously. Participants were divided by geozone [35] (neighbourhood), which were visualized in Fig. 1 using ArcGIS (ArcGIS Desktop: Release 10.3. Redlands, CA: Environmental Systems Research Institute). Associations between categorical variables were analysed using Chi-square test or Fisher’s exact test when appropriate. Continuous data was compared using a Mann-Whitney U-test or a Student’s t-test. The concepts of the HBM and TPB were tested for their internal consistency using the Cronbach’s Alpha test. If the Cronbach’s Alpha was > 0.60, the items were combined resulting in a Likert scale representing the measure for the corresponding construct of the HBM/TPB. If Cronbach’s Alpha was < 0.60, items were analysed separately, or only the most representative item to measure the concept was used. The questions assigned to constructs of the HBM and TPB are presented in Additional file 2, and their Cronbach’s Alpha in Additional file 1: Table S1. All concepts of the HBM and TPB and the modifying variables were Z-transformed, and correlations were performed using Spearman’s rho. A binary logistic regression was performed to identify which concepts of the HBM and TPB were independently associated with the BIMBSC. Significance was determined at 5% level. Data were analysed using SPSS (SPSS Inc., version 22.0, Chicago, Illinois).

Qualitative study methods

Study population

Participants of the IDIs were adult laboratory-confirmed chikungunya patients. Concerning the FGDs, seven representative population groups (50 participants in total) of Curaçao were selected based on socio-economic status (Additional file 1: Table S2): (i) residents born in the Netherlands; (ii) local youth; (iii) interviewers of the survey; (iv-vii) people from the neighbourhoods of Rooi Santu, Seru Fortuna, Souax and Koraalspecht. The focus group with the survey interviewers aimed at understanding underlying reasons for particular survey results. Participants for the qualitative methods were recruited via snowballing (recruitment strategy to recruit participants who are difficult to identify), key informants, and via neighbourhood centres.

Data collection

Qualitative research methods consisted of IDIs and FGDs based on the Grounded Theory. The Grounded Theory is an analytical strategy to make visible the steps in analyses, to move from data to theoretical explanations [40]. The HBM and the TPB were used to develop a theoretical framework, which is presented in Additional file 1: Figure S1. Interview guides were made based on this framework and adapted after pilot interviews. The FGDs consisted of 4–10 individuals with similar socio-economic backgrounds. The FGDs were applied in Dutch or Papiamentu, depending on participant(s) preferences. Interviews were recorded, translated, transcribed and analysed using codes and code families (see below).

Data analysis

Qualitative data were analysed using Atlas.ti (version 7.5.4). Data were examined using codes, which refer to an issue, topic, idea or opinion evident in the data [40]. We employed two cycles of inductive (emerging from data) and deductive (pre-defined from theory) coding. In the first cycle of analysis, 20 codes were used when analysing the FGDs and IDIS. These codes were assigned to 9 code families, which were analysed in the second cycle of analysis. The code families represented perceptions towards: actions of the government in mosquito control, personal protection against mosquitoes, transmission route of chikungunya, information sources on chikungunya/dengue, community initiatives in mosquito control, performance of MBSC, barriers to MBSC, value of MBSC, and waste management.

Results

General characteristics of the study population

A total of 411 individuals were invited in June and July 2015 to join this study, of which 339 participated (response rate: 82.5%). Table 1 summarizes the socio-demographic characteristics of the study population. The reasons for non-contacting (selected individuals who were not reached) and non-response were presented elsewhere [6]. Fig. 1 shows the mean number of participants per 1000 inhabitants per geozone. The BIMBSC score ranged from 3 (lowest intention) to 15 (highest intention) (Q1 = 12; median = 15; Q3 = 15). Of the participants, 63.0% (n = 208) scored the highest possible BIMBSC score. The characteristics of the participants of the IDIs and FGDs are presented in Additional file 1: Table S2.

Communities’ attitudes and practices towards MBSC

Different possible measures preventing mosquitoes from breeding and preventing people from being bitten by mosquitoes were assessed for effectiveness and actual use. The answers were ordered by actual use and are
presented in Figs. 2, 3; Additional file 1: Tables S3 and S4. Concerning the MBSC measures, people valued the measures preventing stagnant water as most effective. The majority stated that they exercised these measures ‘often’ (score = 4) or ‘always’ (score = 5). Those who possessed car tires indicated that they removed them infrequently (median: 2 ‘sometimes’), while in general this was perceived as a very effective precaution. Spraying insecticides, scrubbing away mosquito eggs and adding Abate [insecticidal granules (temephos)] to water containers were perceived as effective measures, but to a lesser extent. Consequently, they were also performed in a lower degree (Fig. 2, Additional file 1: Table S3).

Communities’ attitudes and practices towards prevention of mosquito bites
In general, people perceived the measures to prevent themselves from being bitten as less efficient than the measures to prevent mosquitoes from breeding (Figs. 2, 3; Additional file 1: Tables S3 and S4). The measures were ordered based on the actual use, and presented in Fig. 3. The majority of the participants reported using measures to prevent themselves from being bitten at least ‘regularly’ (score ≥ 3) by eliminating mosquito breeding sites, using a fan, healthy eating, spraying with insecticides and by using insecticides inside the house and in the yard (Additional file 1: Table S4). There was

| Table 1 Socio-economic characteristics of the study population, stratified by their score of behavioural intention to perform mosquito control (BIMBSC score) |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Age                            | BIMBSC score < 15 | BIMBSC score = 15 | P-valuea      |
| Total (n = 339)                | Total (n = 122)   | Total (n = 208)  |                 |
| n (%)                          | n (%)            | n (%)            |                 |
| 18–40 years                    | 75 (22.1)        | 32 (26.2)        | 43 (20.7)      |
| 41–60 years                    | 172 (50.7)       | 54 (44.3)        | 111 (53.4)     |
| > 60 years                     | 92 (27.1)        | 36 (29.5)        | 54 (26.0)      | 0.263           |
| Sex                            |                 |                 |                 |
| Female                         | 247 (72.9)       | 87 (71.3)        | 154 (74.0)     |
| Male                           | 92 (27.1)        | 35 (28.7)        | 54 (26.0)      | 0.590           |
| Education                      |                 |                 |                 |
| Illiterate/primary school      | 80 (23.6)        | 25 (20.5)        | 49 (23.6)      |
| Secondary school               | 128 (37.8)       | 52 (42.6)        | 75 (36.1)      |
| Intermediate vocational school | 84 (24.8)        | 30 (24.6)        | 53 (25.5)      |
| University (of applied sciences)| 47 (13.9)        | 15 (12.3)        | 31 (14.9)      | 0.663           |
| Occupationb                    |                 |                 |                 |
| Unemployed/student/housewife/voluntary | 63 (18.6) | 17 (14.0)        | 44 (21.2)      |
| Paid job (domestic or manual)  | 144 (42.6)       | 53 (43.8)        | 87 (41.8)      |
| Paid job (not domestic nor manual) | 67 (19.8) | 25 (20.7)        | 40 (19.2)      |
| Retired                        | 64 (18.9)        | 26 (21.5)        | 37 (17.8)      | 0.427           |
| Incomec                        |                 |                 |                 |
| 0–999 ANGd,e                    | 35 (10.5)        | 15 (12.8)        | 20 (9.7)       |
| 1000–2499 ANG                   | 136 (41.0)       | 50 (42.7)        | 82 (39.6)      |
| 2500–4999 ANG                   | 118 (35.5)       | 36 (30.8)        | 78 (37.7)      |
| > 5000 ANG                      | 43 (13.0)        | 16 (13.7)        | 27 (13.0)      | 0.592           |
| Disease status chikungunya (CLTCS) |                 |                 |                 |
| Recovered                      | 126 (37.2)       | 44 (36.1)        | 81 (38.9)      |
| Mildly affected                | 121 (35.7)       | 48 (39.3)        | 71 (34.1)      |
| Highly affected                | 92 (27.1)        | 30 (24.6)        | 56 (26.9)      | 0.635           |

aP-value corresponds to the comparison of the proportions between the groups BIMBSC <15 and BIMBSC = 15 (maximum score)
bTotal is 338, total < 15 group is 121
cTotal is 332, total < 15 group is 117, total 15 group is 207
dAntillian Guilder; 1 ANG = 0.56 USD
eMinimum wages 2015 = 1420 ANG (based on a 40 h workweek). Nine participants missed data on their BIMBSC and were excluded from analysis
Fig. 2 Measures taken by the community preventing mosquitoes from breeding in yards/houses (perceptions of effectiveness and actual use). The blue bar represents the actual taking of a precautionary measure (1, never; 2, sometimes; 3, regularly; 4, often; 5, always), whereas the red bar represents the perceived probability that the measure prevents mosquitoes from breeding (1, not at all; 2, does not; 3, maybe; 4, does; 5, definitely). The bottom edge shows the 25th percentile, the top edge shows the 75th percentile and separation of light and dark (blue or orange) shows the median. When the lighter part is not visible, the median and the 25th percentile coincide in the same value. When the darker part is not visible, the median and the 75th percentile coincide in the same value.

Fig. 3 Measures taken by the community preventing oneself from being bitten by mosquitoes (perceptions of effectiveness and actual use). The blue bar represents the actual taking of a precautionary measure (1, never; 2, sometimes; 3, regularly; 4, often; 5, always), whereas the red bar represents the perceived probability that the measure prevents the mosquitoes from biting them (1, not at all; 2, does not; 3, maybe; 4, does; 5, definitely). The bottom edge shows the 25th percentile, the top edge shows the 75th percentile and separation of light and dark (blue or orange) shows the median. When the lighter part is not visible, the median and the 25th percentile coincide in the same value. When darker part is not visible, the median and the 75th percentile coincide in the same value.
the perceived susceptibility of the participant to the acquisition of chikungunya and dengue was moderately low (Q1 = 13, median = 15, Q3 = 19; range of possible scores: 7–35), while the perceived severity of chikungunya and dengue showed moderately high scores (Q1 = 35, median = 40, Q3 = 45; range of possible scores: 10–50). The scores of the other constructs of the HBM and TPB were assessed as ‘moderately high’ or ‘high’. Tables S1 and S5 in Additional file 1 show the scores of the constructs of the HBM and TPB and their Cronbach’s Alpha value.

Barriers towards mosquito breeding site control
The scores of the perceived barriers towards MBSC (1: no barrier at all – 5: fully agree that the issue is a barrier) for the community are presented in Table S6 in Additional file 1. The assessed barriers were in general not perceived as major issues, except for the barrier: ‘Government doesn’t control other breeding sites’ (Q1 = 2, median = 4, Q3 = 5).

Multivariate analysis of the BIMBSC
To assess the associations between the psychological constructs and the BIMBSC, univariate analyses on the general characteristics were performed between those with a BIMBSC score < 15 (lower intention) vs ≥15 (maximum intention) (Table 1). The concepts of the HBM and the TPB were tested with the BIMBSC score using a Mann-Whitney U-test (Additional file 1: Table S1). Consequently, a binary logistic regression was performed including the variables associated at a significance level of $P \leq 0.20$. Variables were back-wise eliminated until only significant variables were left. The final model is presented in Table 2.
a negative effect: media and education sources promoted satisfaction on governmental actions on mosquito control, which in turn was associated with a lower BIMBSC.

**Improving messages to the public: Quantitative analysis of transmission route of chikungunya and dengue**

Media and education sources enhanced BIMBSC via improvement of perceptions on transmission route of chikungunya and dengue (Fig. 5). In this section, the perceptions on the transmission routes are investigated in depth, with the aim to provide grounds for effective messages to the public.

Quantitative analysis showed that most people believed that chikungunya and dengue were transmitted by mosquitoes (chikungunya: 81.3% and dengue: 90.1%) (Fig. 6, Additional file 1: Table S9). However, only 49.9 and 54.4% of the participants (referring to chikungunya and dengue, respectively) believed that this was the only route of transmission of both diseases. The remaining participants believed that next to a mosquito, also other transmission routes existed for chikungunya and dengue, of which ‘the air’ (33.8 and 20.4%, respectively), ‘bad hygiene’ (19.3 and 24.6%, respectively) and ‘water’ (11.0 and 16.2%, respectively) were among the most commonly mentioned transmission routes of chikungunya and dengue (Fig. 6, Additional file 1: Table S9).

**Improving messages to the public: Qualitative analysis of the transmission route of chikungunya**

Different opinions about the transmission route of chikungunya were expressed in the group discussions. Among these, the transmission route ‘virus, via mosquito’ was regularly mentioned. However, doubts about this theory were expressed, based on personal observations. Participants found it difficult to understand that transmission through mosquitoes could have caused such an explosive epidemic, while mosquitoes had been living on Curaçao for many years:

*Man, aged 60-70 years, FGD: ‘because always always always we have mosquitoes here. In the last two years we have chikungunya. That surprises the population. Because always, always we have had mosquitoes here.’*

Hence, different perceptions on transmission routes besides the biomedical one existed, i.e. transmission

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**Table 2** Final model of factors independently associated with a maximum intention vs a lower Behavioural Intention to perform Mosquito Breeding Site Control (BIMBSC)

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier: ‘Don’t know how to control breeding sites’</td>
<td>0.77 (0.59–0.99)</td>
<td>0.041</td>
</tr>
<tr>
<td>Barrier: ‘Government doesn’t control other breeding sites’</td>
<td>0.67 (0.51–0.89)</td>
<td>0.005</td>
</tr>
<tr>
<td>Attitude towards behaviour (performing MBSC)</td>
<td>2.14 (1.56–2.93)</td>
<td>0.001</td>
</tr>
<tr>
<td>Self-efficacy&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.54 (1.17–2.04)</td>
<td>0.002</td>
</tr>
<tr>
<td>Satisfaction on governmental MBSC</td>
<td>0.71 (0.54–0.93)</td>
<td>0.012</td>
</tr>
<tr>
<td>Believing that dengue is transmitted by a mosquito&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2.93 (1.22–7.05)</td>
<td>0.016</td>
</tr>
</tbody>
</table>

<sup>a</sup>Self-efficacy: the belief that a person is capable of performing the health behaviour

<sup>b</sup>Using the normalized value (z-value), OR = 1.38, 95% CI: 1.06–1.79, P = 0.016

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![Fig. 4 Information sources on chikungunya and dengue. GGD - Medical and Public Health Service of Curaçao](image-url)
through the air, (poor) hygiene, a virus (no mosquito), water, or ‘it goes around’ (Additional file 1: Table S10).

**Intervention 2: Effects of the government’s MBSC actions on individual BIMBSC**

**Quantitative analysis of governmental actions** Two independently associated determinants of the BIMBSC concerned perceptions on governmental actions in mosquito control. Dissatisfaction demonstrated both negative and positive effects on the BIMBSC (Additional file 1: Table S5). The score of the satisfaction on government’s action was moderately low (Q1 = 1, median = 3, Q3 = 4), and demonstrated an independent negative association with the BIMBSC ($P = 0.012$) (Table 2). The lack of government’s action in MBSC was perceived as a barrier (Q1 = 2, median = 4, Q3 = 5), more often for those participants scoring a lower BIMBSC ($P = 0.005$) (Table 2).

**Qualitative analysis of governmental actions** Most interviews brought up the topic of ‘waste problem’ (garbage) when talking about MBSC. The latter indicates that improper planning regarding waste disposal in Curacao was linked to the presence of mosquito breeding sites by the community. Accordingly, participants expressed discontent with the government’s role in managing waste in Curacao, but also regarding the spraying of insecticides and the low visibility of the government’s actions against mosquito breeding sites. Although spraying of insecticides was observed and appreciated by the participants, dissatisfaction existed on the infrequency and unprecise manner of how this spraying was performed.

*Man, aged 70–80 years, FGD:* ‘I think that they only have one little trailer with a spray system in Curacao that drives around the whole island.’

*Women, aged 60–70 years, FGD:* ‘Yes! With 90 km an hour, I have seen them.’

Discontent with the government actions led to community mobilization in mosquito control in the neighbourhoods Souax and Seru Fortuna, guided by community key persons.

*Man, aged 60–70 years, FGD:* ‘I don’t agree with how he (the minister) talks because he places all the responsibility (to clean their neighbourhoods from waste) on the common people, and sidelines the government completely. (...) Ask for assistance of the neighbourhoods and there are many neighbourhoods willing to organize, there are many people who are willing to seriously put effort in this. And we are willing to help. (...) The last time we fixed the problem ourselves. With a truck and [empty] warehouse etc. Without their (the government’s)

**Fig. 5** Influence of media and education sources on the BIMBSC via psychological constructs. The media and education sources show positive relations with an individual’s BIMBSC via the variables in the green box. The media and education sources show a negative relation with an individual’s BIMBSC via the variable in the red box. Relations with the BIMBSC are significant independent associations. Relations with the media and education sources are significant associations revealed by a Spearman’s rho test. Knowledge on transmission routes of dengue and chikungunya was significantly correlated (Spearman’s rho = 0.393, $P < 0.001$). A ‘minus’ indicates a negative association, a ‘plus’ indicates a positive association. Self-efficacy refers to the belief that a person is capable of performing the health behaviour.

**Fig. 6** Perceived transmission routes of chikungunya and dengue.
decision we removed the waste, for nothing. But the
government should not think that this is going to be done
all the time through us.’

Other participants argued that MBSC policies of the
government would enhance MBSC of the community.
Consequently, more communication and exposure of
government’s actions against mosquito breeding sites
(i.e. surveillance and application of larvicides and adulti-
cides, cleaning of waste) could motivate them to also ‘help’ and to perform MBSC.

Although explanations existed of how discontent with
government's actions in MBSC coincided with community
initiatives to control mosquito breeding sites, there was a
strong call for more action from the government's side.
Out of the FGDs, a topic list was made on the actions that
participants wanted the government to do (Table 3).

**Intervention 3: Promoting community participation via key persons**

The participants of the FGDs and IDIs demonstrated
willingness to help or cooperate in MBSC, or, maybe
even perceived as more important, in cleaning up their
neighbourhoods. Different initiatives were described in
which communities were mobilized to clean the neigh-
bourhood. Guided by community key persons (which
could be individuals or neighbourhood centres), commu-
nity mobilization was achieved in Souax (described ear-
lier), Rooi Santu, Seru Fortuna and in Piscadera. In Seru
Fortuna, a day was organized to clean the neighbour-
hood. One of the participants stated that this has
boosted awareness and willingness to clean houses and
gardens in the neighbourhood.

*Man, aged 40–50 years, IDI: ‘We did it. And it was in
the news, ‘Oh the people of Seru Fortuna themselves
have... eh yes, hand in action and they cleaned their
part’, and then the others in their street also did it
(cleaned their properties). Ooh it is like that, positive,
it reaches others: ‘I am also going to clean my part
(property)’. This time I am late (referring to the
cleaning of his own property).’*

The participant expressed that more initiatives to clean
Seru Fortuna were planned, also targeting the involve-
ment of youth and children. These ‘cleaning days’ would
be made as attractive as possible to involve more people
by providing food, drinks and a pleasant experience.
Another initiative to involve local youth in the cleaning of a
street was initiated by an individual. He narrated how he
was cleaning one street where a lot of waste is dumped.

*Man, aged 60–70 years, IDI: ‘It is street keep Curaçao
clean’. I am cleaning a street where is now a lot of garbage.
(.) And these (street) signs I am going to hang up.’*

A school was invited to draw the ‘keep Curaçao clean’
(street) signs in different languages. In this way, local
youth was involved in MBSC and awareness of the con-
sequences of poor waste management was raised. The
initiatives described above were organized by communi-
ties or individuals, independent from coordination of the
government.

**Discussion**

This study used an interdisciplinary mixed methods ap-
proach, to understand perceptions and attitudes of the
community towards mosquito breeding site control
(MBSC). Furthermore, it aimed to provide a theoretical
basis for intervention methods to improve community
participation in MBSC, based on the TPB and the HBM.
Three intervention methods were proposed to enhance
community action towards MBSC: (i) ongoing media
attention; (ii) visibility of governmental MBSC policies; and
(iii) engagement of key persons in local communities.

Individuals recognized water source management as
an effective way to reduce mosquito breeding sites, and
stated that they performed this often. This reflects a
good knowledge and a high reported performance of
MBSC. Participants perceived removing car tires from
yards to be highly effective, but relatively few of them re-
ported performing this behaviour. Whilst being difficult
to clear from water, car tires provide formidable breed-
ing conditions where mosquitoes flourish [41]. It has
been recognized that tires may greatly contribute to a
mosquito population [42]. Hence, car tires in yards may
represent an important source of mosquitoes on Cura-
çao. People expressed moderate confidence and reported
moderate application of personal protection against
mosquito bites. Repellents containing DEET, or wearing
long-sleeved clothes are widely recommended in health

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Actions that people want the government to take in mosquito control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended actions</strong></td>
<td></td>
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<tr>
<td><em>More spraying of insecticides</em></td>
<td></td>
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<tr>
<td><em>Continuing program of information dissemination through media</em></td>
<td></td>
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<tr>
<td><em>Inform the community on governmental actions on mosquito control</em></td>
<td></td>
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<tr>
<td><em>Active tracing and managing of possible mosquito breeding sites in the neighbourhoods</em></td>
<td></td>
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<tr>
<td><em>Clean up the garbage dumps in the neighbourhoods</em></td>
<td></td>
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<tr>
<td><em>Improve roads</em></td>
<td></td>
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<tr>
<td><em>Educate children in schools on mosquito breeding site management</em></td>
<td></td>
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<tr>
<td>An ‘environment-police’, which can be called if illegal waste dump is observed</td>
<td></td>
</tr>
<tr>
<td><em>More attention to prevention: ‘act proactive, not reactive’</em></td>
<td></td>
</tr>
</tbody>
</table>

*The order of the topics does not represent importance*
in this study, might contribute to increase the favourable
and severity of chikungunya and dengue demonstrated
form MBSC and the higher perceived benefits of MBSC
preventive activities. The low perceived barriers to per-
serve as a cue to action for the community to perform

(iii) use of community key persons.

The multivariate analysis revealed the constructs and
variables independently associated with the BIMBSC,
namely attitudes towards MBSC, self-efficacy of MBSC,
believing that a mosquito transmits dengue, satisfaction
and dissatisfaction on governmental actions. The stron-
gest independent predictor of the BIMBSC was the atti-
tudes towards MBSC. The presented qualitative data
relating to communities’ perceptions and actions pro-
vided in-depth insights into these attitudes. Self-efficacy,
which is the belief that a person is capable of performing
the behaviour, has shown to be in particular important
for performing repeated health behaviours [47]. This
study shows the same regarding MBSC.

The multivariate analysis, together with the qualitative
data were the basis for three possible intervention stra-
geties to improve the BIMBSC: (i) media and education
coverage (cues to action); (ii) government’s action; and
(iii) use of community key persons.

Intervention method 1: Education and media coverage
(cues to action), grounded in local realities
Education and media coverage warning of epidemics
serve as a cue to action for the community to perform
preventive activities. The low perceived barriers to per-
form MBSC and the higher perceived benefits of MBSC
and severity of chikungunya and dengue demonstrated
in this study, might contribute to increase the favourable
impact of cues to action (media and education) [29]. As
was suggested in literature [31, 33] (and shown in this
study), cues to action enhanced behaviour (BIMBCS) via
other constructs of the HBM and the TPB (Fig. 5).

Based on our findings, messages to the public
should include the transmission route of chikungunya
and dengue. Half of the participants believed that the
only way of transmitting dengue or chikungunya was
via a mosquito, while the remaining participants be-
lieved that (apart from a mosquito) other transmis-
sion routes existed like transmission via air, water or
through poor hygiene practices. Not recognizing that
mosquitoes could transmit dengue had direct negative
consequences on BIMBSC. Since knowledge on trans-
mission routes of chikungunya and dengue were cor-
related, targeting both diseases in campaigns may have
a favourable effect on mosquito breeding site
control practices. Participants of the FGDs suggested
that education in schools can carry messages from
children to parents, and might be a suitable interven-
tion to enhance community knowledge of MBSC
(Table 3). This is in agreement with other studies
[48]. The results of the qualitative analyses revealed
different underlying attitudes and beliefs on transmit-
sion, which could specifically be targeted in education
or in media campaigns (Additional file 1: Table S10).

Intervention method 2: Governmental action
Cooperation in water source management between com-
munity and government is crucial in mosquito control
[21]. When people were satisfied with the government’s
actions, they showed lower BIMBSC-scores. On the
other hand, when they placed the responsibility to con-
roll mosquito breeding sites solely on the government,
they also had a lower BIMBSC-score (Table 2, Fig. 5).
Messages to the public could potentially tackle these
phenomena. First, people should be aware that, although
crucial, MBSC measures taken by the government are
often not enough to adequately control the mosquito
population. This means that even if an individual is sat-
sified with governmental actions, his/her own MBSC re-
mains important. Secondly, the government should be
aware that its actions in MBSC have potentially direct
and indirect positive effects in mosquito control. The
direct effect is achieved via the government’s water
source management in public spaces. A potential indir-
egct effect may be reached via media coverage of the
MBSC activities performed by the government, which in
turn lowers the barriers for individuals to perform
MBSC (Fig. 5). Again, these messages will have higher
impact if grounded in local realities [26]. The results of
the qualitative research of this study can be used to
achieve this (Table 3, Additional file 1: Table S10).
Intervention method 3: Key persons/community initiatives
The described individual and community initiatives regarding waste management demonstrated the presence of key persons for MBSC in Curaçao. These key persons were locals, willing to act proactively and had the ability to motivate community participation in MBSC. Neighbourhood centres and key persons can play an important role [26, 49] as ‘ambassadors’ of MBSC in their community, by raising awareness and initiating mosquito breeding site control actions. Furthermore, they may provide valuable information to the government concerning community realities with regard to MBSC.

Limitations and strengths
This study was limited by its cross-sectional design. Future performance of MBSC was predicted using ‘behavioural intentions’. While the behavioural intention is recognized as the best predictor for behaviour, it is no substitute for actual behaviour. Furthermore, the study population of the survey consisted only of people who were (clinically or 

Conclusions
The results of this study show how health belief theories serve to understand community participation in MBSC. The outcomes of this study can be used for health policies in Curaçao. The policies should target (i) improving community access to information on transmission routes of dengue and chikungunya; (ii) reducing the practices of storing used car tires in yards; (iii) enhancing visibility of government’s MBSC and the communities’ sense of responsibility to perform MBSC; and (iv) creating a network of local key-persons/ ‘ambassadors’ of MBSC who promote MBSC in their own neighbourhood. The qualitative research provided in-depth understanding of quantitative associations, which helps to target the public in an efficient and culturally sensitive way. To close the gap between science, implementation and communities’ lived reality, it is important that similar mixed-method approaches in different countries are conducted to promote one of the most effective strategies in MBSC, which is community participation.

Additional files

- Additional file 1: Table S1. Univariate analysis of the concepts of the Health Belief Model and Theory of Planned Behaviour vs the behavioural intention score to perform mosquito breeding site control: BIMBSC-score (< 15 vs ≥15).
- Table S2. Characteristics of the focus groups. All participants of the in-depth interviews had a laboratory-confirmed chikungunya infection. Table S3. Measures to prevent mosquitoes from breeding indoor and/or outdoor.
- Table S4. Measures preventing mosquito bites.
- Table S5. Scores of concepts of the Health Belief Model and Theory of Planned Behaviour.
- Table S6. Barriers for eliminating breeding sites.
- Table S7. Information sources of chikungunya and dengue. More answers were possible. Table S8. Spearman’s correlation matrix of concepts significantly associated with ‘number of media and education sources’.
- Table S9. Knowledge on chikungunya and dengue transmission routes. More answers were possible. Table S10. Reported modes of infection in focus groups.

Abbreviations
BIMBSC: Behavioural intention to perform mosquito breeding site control; CLTCs: Curaçao long-term chikungunya sequences; FGDs: Focus group discussion; HBM: Health Belief Model; ID: In-depth interview; MBSC: Mosquito breeding site control; TPB: Theory of planned behaviour

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Availability of data and materials
The data supporting the conclusions of this article are included in the article and its additional files. Public availability of raw data could potentially compromise participant privacy. Participants did not consent to have their full transcripts made publically available.

Authors’ contributions
Conceived and designed the experiments: JE, AB, AD, AT and IG. Performed the data collection: JE. Coordinated the data collection: JE and IG. Analysed the data: JE (qualitative and quantitative data), AB (qualitative data), JGB (quantitative data), HTV (quantitative data). Wrote the first draft of the paper: JE and HTV. Critical revisions of the manuscript: MPG, AD, AT, JGB and AB. All authors read and approved the final manuscript.

Ethics approval and consent to participate
The study was approved by the Medical Ethical Board of the Sint Elisabeth Hospital Curaçao (METC SEHOS; reference number: 2015–002). All participants signed a written informed consent.

Consent for publication
Not applicable.
Competition of interests
The authors declare that they have no competing interests.

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