Preventing the next Aedes-borne arboviral disease epidemic

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Preventing the next *Aedes*-borne arboviral disease epidemic

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CHAPTER 1

General introduction and scope of the dissertation

Arboviruses (arthropod-borne viruses) are transmitted via blood-feeding arthropods such as mosquitoes, flies, and ticks (1). *Aedes* mosquitoes are the most important arboviral vectors. The two main species, *Aedes aegypti* and *Aedes albopictus,* allow the transmission of viruses such as dengue virus (DENV), chikungunya virus (CHIKV), and Zika virus (ZIKV) (2, 3). The DENV and ZIKV belong to the family Flaviviridae (genus Flavivirus), and the CHIKV is a member of the family Togaviridae (genus Alphavirus) (4, 5). These arboviruses caused outbreaks in several countries belonging to Africa, America, Asia, the Caribbean, and the Pacific (6). More recently, DENV and CHIKV have been reported in Europe, revealing the expansion of these viruses to new and unexpected geographical areas (7, 8). Globalisation, unplanned urbanisation, unreliable public services, climate change, and the deterioration of institutions (e.g., health systems) responsible for mosquito control cause the further expansion of arbovirus.

The global incidence of DENV infection has grown, with about half of the world's population now at risk (9). According to the World Health Organization (WHO), dengue is the most prevalent, dangerous and rapidly spreading arbovirus worldwide (10). Still, dengue is classified as a neglected tropical disease. WHO classifies dengue into two categories: DENV infection with or without warning signs and severe dengue (10). Severe dengue is defined by plasma leakage and/or fluid accumulation leading to shock or respiratory distress, and/or severe bleeding, and/or severe organ impairment (10, 11). Severe DENV infection is a leading cause of serious illness and death in some countries located in Asia and Latin America (10). There are four genetically distinct serotypes of DENV (DENV-1, DENV-2, DENV-3 and DENV-4) and multiple lineages of each serotype, which are often geographically based (12). Recovery from infection of one serotype provides long-term immunity; however, cross-immunity to another serotype after recovery is only partial and temporary. Secondary infection by other serotypes even increases the risk of severe dengue, the antibody-dependent enhancement (ADE) phenomenon (9, 13). In Curaçao, all four dengue serotypes (DENV 1–4) have circulated during the past two decades. According to local health authorities, dengue epidemics occur cyclically, and no severe dengue cases have been reported yet in Curaçao.

Chikungunya derives from a word in the Kimakonde language, meaning "that which bends up" and indicates a hunched posture resulting from recurrent joint pain (14). CHIKV was first identified in Tanzania in 1952 and caused occasional outbreaks in Africa and Asia. Since 2004, chikungunya has spread rapidly and caused outbreaks in over 60 countries throughout Asia, Africa, Europe and the Americas (15). In 2013, CHIKV emerged in the Caribbean, leading to more than 1 million cases in the Americas within a year (15). Due to the challenges in accurately estimating CHIKV infections annually, there is no actual estimate for the number of people affected by the disease globally (15). The symptoms (fever, muscle pain, headache) of the

CHIKV infection can be similar to other arboviruses such as dengue; therefore, the disease may be misdiagnosed. Infected individuals usually have mild symptoms, and the infection may go unrecognised (15). However, some cases progress to a chronic stage, during which they may experience debilitating and persisting articular pain for months to years (16). Approximately 3% to 28% of people infected with chikungunya virus will remain asymptomatic (17). In Curaçao, CHIKV caused an outbreak in 2014–2015, affecting up to 50% of the population, according to the local health authorities. A study that followed infected patients (n=248) in Curaçao found that at 2.5 years after disease onset, 43% of the patients had recovered, and 35% and 22% of the patients were still mildly and highly affected, respectively (18).

Besides DENV and CHIKV, ZIKV also caused explosive outbreaks in Africa, the Americas, Asia and the Pacific (19, 20). The symptoms are generally mild and include fever, rash, conjunctivitis, muscle and joint pain, malaise or headache. ZIKV infection was linked with microcephaly and other congenital malformations, known as congenital Zika syndrome (21). In addition, a link between ZIKV infection and Guillain-Barré syndrome, neuropathy and myelitis was found (21-24). Although these linkages were found during ZIKV infection outbreaks, research is still ongoing to investigate the causal effect of the mentioned virus on pregnancy outcomes and neurological disorders. In 2016, ZIKV caused an outbreak in Curaçao. The Department of Epidemiology and Research of the Ministry of Health, Environment and Nature (MoHEN) reported that from December 2015 up to August 2017, 2314 laboratory-confirmed ZIKV infection cases were recorded (25). However, it should be noted that confirmed cases only represent a fraction of those who were infected, as up to 80% of the individuals with ZIKV infection are asymptomatic (26). Local health authorities expect that almost half of the population has been infected with ZIKV. Also, the local health authorities indicated that no cases of congenital Zika syndrome have been reported in Curaçao.

The treatment of DENV, CHIKV and ZIKV infections relies on supportive care and symptom relief since no antiviral treatment is available. No approved vaccines are available for ZIKV and CHIKV (27, 28). Trials of ZIKV and CHIKV vaccines are ongoing. There is a licensed dengue vaccine (Dengvaxia vaccine) available. However, it is not suitable for large-scale use (29). The WHO recommends Dengvaxia for persons aged 9–45 years with confirmed previous DENV infection. The vaccine is only for individuals with confirmed previous DENV infection. Individuals not previously infected with DENV who receive the vaccine might be at risk of developing severe dengue if infected with DENV after being vaccinated because of the ADE phenomenon (13, 29). Since there is no antiviral treatment or suitable vaccine for large-scale use, preventing and controlling DENV, CHIKV and ZIKV infections hinge on controlling the mosquito vectors and interrupting human-vector contact.

Countries around the world struggle to develop and implement successful *Aedes* control interventions. Despite the novel technologies to suppress the mosquito populations, such as mosquito population replacement methods and genetic techniques, no country has designed or implemented a sustainable integrated *Aedes* control intervention. Curaçao also faced challenges with developing and implementing an effective *Aedes* control approach. To overcome the difficulties in *Aedes*-borne infection disease (ABID) control interventions, first, the challenges with regards to *Aedes* control at the macro-level (health system), meso-level (community), and the micro-level (individuals) of that specific country need to be determined. Therefore, this dissertation's overall aim is to investigate the context and concepts shaping the health system, community and individual prevention and control interventions/ behaviour for ABIDs in Curaçao. Several specific aims (see chapters 2-7) are derived from the overall aim.

The overall theoretical framework that guides this doctoral research is the Social Amplification of Risk Framework (SARF). The SARF is an established theoretical framework for understanding how risks are perceived, interpreted, and amplified or attenuated as they are communicated throughout the community (30). The SARF offers the opportunity to explore the essential components of communication processes and the channels through which intervention messages are diffused from macro-level (institutions) to meso-level (community), then to micro-level (individual). The SARF can be used to explain the effect of the social context on risk perception (30). For this doctoral research, the SARF was extended with the WHO health system building blocks to assess the health system's performance and bottlenecks/challenges in ABIDs prevention and control (31). The Health Belief Model (HBM) was also integrated into the SARF to understand individuals' decision-making processes and health-seeking behaviour (micro-level) (32). The conceptual framework of this study is inspired by the structure of a conceptual framework developed by Bailey et al. (33).

Scope of the dissertation

Chapter 2. ***Effectiveness of Aedes-borne infectious disease control in Latin America and the Caribbean region: a scoping review.*** The second chapter of this dissertation is a scoping review that aims to synthesise evidence concerning the effectiveness of *Aedes aegypti* and *Aedes albopictus* prevention and control interventions performed in Latin America and the Caribbean Region (LAC) (2000-2021). The scoping review is based on the methodology by Joanna Briggs Institute for conducting a scoping review (34). Both scholarly journal articles and grey literature were searched. Countries in the LAC region can use the scoping review findings to evaluate, compare, and develop more sustainable strategies based on the lessons learned in the mentioned region.

Chapter 3. ***Evaluating and strengthening the health system of Curaçao to improve its performance for future outbreaks of vector-borne diseases.*** Chapter 2 provides a broader perspective on *Aedes* control interventions and their barriers in the LAC region. In chapter 3, we narrowed the context and focused on the performance of the health system of Curaçao. The study presented in chapter 3 aims to examine the performance of the health system of the Dutch Caribbean Island of Curaçao regarding the prevention and control of vector-borne diseases in the last decade by using the WHO health system building blocks framework (macro-level). The study's findings uncovered potential organisational bottlenecks that have negatively affected the health system of Curaçao.

Chapter 4. ***Understanding risk communication for prevention and control of vector-borne diseases: a mixed-method study in Curaçao.*** The study presented in chapter 4 aims to understand risk communication regarding ABIDs in its social context to strengthen risk communication strategies in Curaçao. The study was designed based on the HBM and the Theory of Planned Behaviour. In addition, the SARF and the theory of cultural schemas were used to understand risk communication in the social context. The study focuses on the macro and the meso-level and their possible influence on the micro-level (individual risk perception).

Chapter 5. ***The impact of health risk communication: a study on the dengue, chikungunya, and Zika epidemics in Curaçao, analysed by the social amplification of risk framework (SARF).*** Based on the gaps in the evidence we found in the study presented in chapter 4, we designed the study discussed in chapter 5. The study presented in chapter 5 goes a step further by analysing the newspaper's content and comparing people's perceptions with perceptions of experts/government officials. In addition, the contribution of newspaper content to people's perceptions regarding the prevention and control of ABIDs was assessed. The study is based on the SARF and the theory of heuristics. The study also focuses on the macro and the meso-level and their possible influence on the micro-level (individual).

Chapter 6. ***Waste management, tourism and control of vector-borne diseases in Curaçao: A call to sustainable actions.*** Environmental management, including solid waste management, plays an essential role in *Aedes* control because, when appropriately applied, it can be a helpful tool to reduce the availability of mosquito breeding sites. The study presented in chapter 6 aims to explore (i) current waste management practices, (ii) influences of the tourism industry on waste management, and (iii) the implications of waste management on mosquito-borne disease control in Curaçao. In addition, to verify and illustrate the issue with waste management, a geographic information system was used to plot illegal dumping sites in Curaçao.

Chapter 7. ***Contexts motivating protective behaviours related to Aedes-*** **borne *infectious diseases in Curaçao.*** The study presented in chapter 7 aims to determine contexts motivating individuals' protective behaviours related to ABIDs in Curaçao. The study focuses on the micro-level (individual risk perception and health-seeking behaviour). The study in chapter 7 is designed based on the HBM. The findings of this study can be used to create a bridge to connect the individuals with the health system to work towards a more bottom-up integrated *Aedes* control approach. Health professionals working for the health system of Curaçao can use this study's findings to deal with the barriers to promoting behavioural change and stimulating community participation.

The main findings of chapters 2 to 7 are summarised and discussed in Chapter 8, ***Summary and general discussion***. Chapter 8 also contains future perspectives based on the results obtained and discussed in this dissertation.

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CHAPTER 2

Effectiveness of *Aedes*-borne infectious disease control in Latin America and the Caribbean region: a scoping review*

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Abstract

Background

Aedes (Ae.) aegypti and *Aedes albopictus* are primary vectors of emerging or re-emerging arboviruses that threaten public health worldwide. Many efforts have been made to develop interventions to control these *Aedes* species populations. Still, countries in the Latin America and the Caribbean (LAC) region struggle to create/ design/develop sustainable and effective control strategies. This scoping review synthesises evidence concerning the effectiveness of *Ae. aegypti* and *Ae. albopictus* prevention and control interventions performed in LAC (2000-2021). The findings can be used to evaluate, compare and develop more effective control strategies.

Methodology

The review is based on the methodology by Joanna Briggs Institute for conducting a scoping review. The MEDLINE (via PubMed and Web of Science), Cochrane Library, Scopus, EMBASE and ScienceDirect databases were used to search for articles. Grey literature was searched from governmental and non-governmental organisation websites. Four reviewers independently screened all titles and abstracts and full-text of the articles using the Rayyan web application, based on pre-defined eligibility criteria.

Results

A total of 122 publications were included in the review. Most studies focused on dengue virus infection and data on *Ae. aegypti*. Entomological data were mainly used to determine the intervention's effectiveness. An integrated control intervention was the most commonly employed strategy in both regions. Biological control measures, environmental management, and health education campaigns on community participation achieved more sustainable results than an intervention where only a chemical control measure was used. Challenges to implementing interventions were insufficient financial support, resources, workforce, intersectoral collaboration and legislation.

Conclusions

Based on the synthesised data, an integrated vector (*Aedes)* management focused on community participation seems to be the most effective approach to mitigate *Aedes*-borne infectious diseases. Maintaining the approach's effect remains challenging as it requires multisectoral and multi-disciplinary team engagement and active community participation. Future research needs to address the barriers to program implementation and maintenance as data on this topic is lacking.

Keywords: Zika Virus Infection, Vector Borne Diseases, Mosquito control, Public Health, Environment and Public Health, dengue

Introduction

Worldwide, there are approximately 3,500 registered mosquito species (1). Only a small portion of these species carry and transmit pathogens to humans (2, 3). Arboviral (arthropod-borne viral) diseases account for more than 17% of infectious diseases worldwide, affecting millions of people (4). The global incidence of dengue virus infection has increased 30-fold in the last decades (5). Dengue virus infection is an important public health issue with increasing morbidity and mortality in Latin America and the Caribbean region (LAC) (6). Besides the dengue virus, chikungunya and Zika viruses are also of concern. They have rapidly spread throughout the LAC region in the last eight years, resulting in epidemics and high levels of morbidity, creating an added burden on the region's health systems (7).

Mosquitoes of the *Aedes* genus are considered the most important vectors of the mentioned arthropod-borne viruses (8). In the LAC, *Aedes (Ae.) aegypti* is the primary mosquito vector of dengue, chikungunya, and Zika viruses (9). In addition, *Aedes albopictus* (the Asian tiger mosquito) has also been shown to be a competent vector of the above-reported viruses (10, 11). *Ae. albopictus* is of medical importance due to its aggressive daytime human-biting behaviour, ability to adapt to colder climates and live in artificial and natural containers close to humans, resulting in disease transmission in new geographical areas. Since *Ae. albopictus* is also present in the LAC, countries in this region must consider this mosquito species' possible implications for transmitting viruses (12, 13).

In the last decades, efforts have been made to develop vaccines, drugs, and mosquito control interventions to prevent and control diseases transmitted by *Ae. aegypti* and *Ae. albopictus* (*Aedes*-borne infectious diseases [ABIDs]). A licensed dengue vaccine is available; however, it is not widely used due to safety concerns (14). For chikungunya and Zika virus infections, *Aedes* control is currently the only method available to prevent and control transmission. *Aedes* control aims to limit the transmission of pathogens by reducing or eliminating human contact with the mosquito.

The World Health Organization (WHO) recommends using an Integrated Vector Management (IVM) program to manage mosquito populations (15). The characteristic features of the IVM program include (i) selection of methods based on knowledge of local vector biology, disease transmission and morbidity; (ii) utilisation of a range of interventions (e.g., biological, chemical control measures, community mobilisation), often in combination and synergistically; (iii) collaboration within the health sector and with other public and private sectors; (iv) engagement with local communities and stakeholders; (v) a public health regulatory and legislative framework; (vi) rational use of insecticides; and (vii) good management practices. Ideally, the proper implementation of an IVM program could help countries deal with ABIDs. However, many countries, including countries in the LAC region, face challenges such as insufficient resources, collaboration within the health sector and with the public and private sector, workforce, training, and/or issues with immigration or cross-border transmission, which obstruct the development and implementation of the IVM program (16, 17). Also, social-cultural, environmental, and climatic parameters (e.g., urbanisation, building environment, and climate change) limit the scope of surveillance and entomological control (18). On top of the mentioned challenges, other emerging infectious disease pandemics/ epidemics, such as the (COVID-19) SARS-CoV-2 pandemic, continues to impose substantial stress on health care systems, further jeopardising *Aedes* control interventions.

Previous outbreaks of ABIDs have shown the weakness in managing infectious disease spread in the LAC region (17, 19). Based on the history of *Ae. aegypti* and *Ae. albopictus*, it is undeniable that other ABIDs (e.g., Mayaro, Yellow fever, Venezuelan Equine Encephalitis and West Nile virus infections) represent emerging threats favoured by climate change, globalisation, and travel/ trade (20-22). The danger of the emerging or re-emerging of diseases transmitted by *Ae. aegypti* and *Ae. albopictus* requires us to learn from our experiences. Also, we need to work towards more sustainable integrated *Aedes* control strategies, taking the current challenges of countries in the LAC region into account.

There are recent comprehensive reviews about interventions to control *Ae. aegypti* (23). However, to our knowledge, reviews covering more than one *Aedes* species and ABID are lacking in scientific literature. Therefore, our review attempts to synthesise the evidence (scholarly journal articles and grey literature) regarding the effectiveness of *Ae. aegypti* and *Ae. albopictus* prevention and control interventions (against dengue, chikungunya and Zika virus) performed in LAC in the last twenty-one years (2000-2021). Furthermore, the reported challenges, lessons learned and recommendations to deal with the practical challenges in applying *Aedes* control interventions will be documented in the review. Countries in the LAC region can use the evidence generated from this article to (i) evaluate their IVM program holistically, (ii) compare their *Ae. aegypti* and *Ae. albopictus prevention and* control strategies with neighbouring countries, and (iii) apply lessons learned to develop more sustainable *Aedes* control approach to prevent and manage ABIDs in the era of COVID-19 pandemic and beyond.

Materials and Methods

This scoping review is based on the framework proposed by Arksey and O'Malley, which has been further developed by Levac *et al.* and the methods by Joanna Briggs Institute (JBI) (24-26). The JBI framework recommends organising the review process in at least five stages: (i) identifying the research question, (ii) identifying relevant studies, (iii) study selection, (iv) charting the data, and (v) collating, summarising and reporting the results. The scoping review also adheres to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist (S1 Table) (27). The protocol of this scoping review has been registered in Open Science Framework (OSF), link: https://osf.io/dkzht/wiki/home/.

The eligibility criteria for the review were based on the 'Population-Intervention-Comparison-Outcome' (PICO) framework and not the PCC (Population-Concept-Context) framework suggested by JBI. The PICO framework was chosen because it leads to comprehensive search strategies and yields more precise results. The included studies followed the following requirements:

Population: The population included residents of the Caribbean islands and countries of the Latin American region of all age groups irrespective of gender, income, occupation, or other demographic characteristics. Each article was screened to check if the reported study population met our eligibility criteria. Articles that included hospitalised individuals with metabolic or fatal diseases/ terminal illnesses were excluded from the review.

Intervention: The primary concept of this scoping review is *Ae. aegypti* and *Ae. albopictus* prevention and control interventions, including (i) insecticide-treated materials (e.g., curtains, nets or screens), (ii) usage of larvicides in breeding sites, (iii) usage of adulticides (e.g., outdoor fogging and indoor residual spraying), (iv) lethal oviposition trap-based mass interventions, (v) container management/reduction, (vi) health education, (vii) community engagement, (viii) media campaigns, (ix) biological control measures (e.g., usages of other living organisms, such as larvivorous fish and *Wolbachia*), (x) mosquito coils/ repellents, (xi) interventions focussed on behavioural change, advocacy (informed influence activities on policymakers from civil society), and (xii) integrated surveillance, epidemiological or entomological surveillance as part of a control program. All field experiments that were not population-based simulations or semi-field trials were excluded.

Comparison: The comparison of the interventions for ABIDs was no intervention or the usual/ older intervention. The comparison groups or control groups could be a combination of interventions, such as biological control measures and community engagement in one group and the same interventions in two other groups individually. Such comparisons assisted in testing the effectiveness of a specific intervention. The studies that used surveillance data to assess intervention effectiveness and the pre-post study designs with no comparison groups were also included in this review. Cross-sectional studies were included when the collected data were compared with previously collected data (e.g., surveillance data).

Context: This scoping review focused on countries located in the LAC region. The Latin American region consists of the following countries: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Panama in North and Central America. Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela are the countries in South America (28). The Caribbean region consists of the following islands: Anegada, Anguilla, Antigua, Aruba, Bahamas, Barbados, Barbuda, Bonaire, Cayman Islands, Cuba, Curaçao, Dominica, Dominican Republic, Grenada, Grenadines, Guadeloupe, Haiti, Hispaniola, Jamaica, Jost Van Dyke, Martinique, Montserrat, Nevis, Puerto Rico, Saba, Saint Croix, Saint Martin, Saint Kitts, Sint Eustatius, Saint Barthélemy, Saint John, Saint Lucia, Saint Martin, Saint Thomas, Saint Vincent, Tortola, Trinidad and Tobago, Turks and Caicos Islands, Virgin Gorda, and Water Island (28).

Outcome: The reviewers included publications that report the effect of the intervention (s) on (i) egg, larva, pupa or adult mosquito density, including entomological indexes such as; the Breteau index [(number of containers infested / total houses inspected) x 100], the container index [(number of containers infested / total containers inspected) x 100], the house index [(number of houses infested / total households) x 100], pupae per person index [number of pupae per household population] and pupae per Hectare index [number of pupae per household area], (ii) ABID incidence, (iii) knowledge, attitude, and practice (KAP), and (iv) environmental adaptations such as the reduction of mosquito breeding sites.

Time-frame, language and other criteria: This scoping review does not focus on intervention cost, but studies containing information on both cost and effect of intervention were considered. The included articles were (i) published between January 1st 2000, and May 28th 2021, and (ii) were written in English, Spanish and Portuguese. An article was excluded if it (i) contained only entomological surveillance, epidemiological or prevalence data without a link to *Ae. aegypti* and *Ae. albopictus* prevention and control strategies; (ii) outcome of interest not reported, (iii) not available in full-text; and (iv) written in French. Publications from French-speaking islands/countries were included if the publication was written in English, Spanish or Portuguese. The reviewers did not exclude an article based on the year of data collection; all publications starting from the year 2000 were included.

Electronic databases and other sources: The MEDLINE (via PubMed and Web of Science), Cochrane Library, Scopus, EMBASE and ScienceDirect databases were searched for articles. Additionally, Google Scholar and the Google search engine searched for the first 100 relevant results. Grey literature regarding *Ae. aegypti* and *Ae. albopictus* prevention and control interventions were searched on the governmental and non-governmental organisation websites such as the WHO library database, UNICEF, and Latin American and Caribbean Health Sciences Literature.

Study design: This scoping review shows evidence from primary studies or journal articles or organisational reports, or dissertations (e.g., cross-sectional studies-analytical, case-control studies, cohort studies, randomised and non-randomised controlled trials, impact evaluations, qualitative and mixed-methods studies). We decided not to include systematic or scoping or narrative reviews and meta-analyses because we were interested in the singular study findings. All such 'reviews' reference lists were searched for additional primary studies on the research topic during the full-text screening stage. Conference proceedings, letters to the editor, editorials, and commentaries were excluded.

Search: Two team members (PP and VJ) experienced in searching databases designed the search strategy (S2 Table). Keywords were identified based on three domains; (i) mosquito-borne infectious diseases, (ii) location, and (iii) *Ae. aegypti* and *Ae. albopictus* prevention and control interventions using Medical Subject Headings [MeSH], existing literature reviews, and subject experts' opinions. The keywords were combined with appropriate boolean operators to search for articles in electronic databases, and similar keywords were used for grey literature. Proximity operators, truncation and wildcards were used for keywords to increase the sensitivity of the search. The search was initially conducted on PubMed and then tailored to other databases. PRESS checklist was used to review the search strategy's quality (29).

Selection of studies: The compiled search results were de-duplicated using EndNote 20 and exported to rayyan.ai to screen blinded (30). The reviewers stored the articles and other data files using cloud storage technology. The selection of studies was performed by four reviewers independently (VJ, MG, PP, TL), and disagreements were resolved in discussion with the team. The articles were screened twice (i) in the title and abstract screening stage and (ii) in the full-text screening stage. The selection process is presented in the PRISMA flow chart (31). Three reviewers (VJ, PP, TL) piloted data extraction on a sample of the included studies (5% of the complete list of retrieved studies) to ensure that the data extraction technique was consistently applied. The data extraction was conducted by three reviewers (VJ, PP, TL) using a charting table. Data were extracted for the following variables: study identifiers, locations, study design, methods, demography information, intervention, comparison, outcome, challenges and recommendations.

A second reviewer (VJ) cross-checked each entry. The reviewers discussed doubts until consensus was reached or consulted a fourth reviewer to resolve the disagreements.

Data analysis: The data were analysed using Microsoft Excel using basic formulae and data for the figure. Frequencies and percentages were calculated for the variables of interest for summarising the data, and a 'characteristics of included studies' table was prepared from the data charting sheet. Advanced analysis was not performed, and the quality assessment of the included studies was not carried out as both are not processes suggested by the JBI guidelines (26).

Results

The results are presented here by the following key themes: (i) characteristics of the included publications, (ii) differences and similarities between regions, (iii) interventions, (iv) challenges and lessons learned, and (v) strategies employed or recommended to improve the effectiveness of *Aedes* prevention and control measures.

Characteristics of the included publications
A total of 11,222 (11,118 articles from databases and 104 articles from other sources, e.g., google or reference list search) articles were identified by the reviewers in the initial search. After eliminating duplicates, the remaining articles were screened by reading their title and abstract. One hundred twenty-eight articles from databases and 101 articles from other sources were qualified and further screened by reading the full-text. Eighteen of the 128 articles from the databases and 89 articles from other sources were excluded based on the exclusion criteria. A total of 122 articles were included in the scoping review. Fig. 1 shows a flow diagram of the selection process.

Of these 122 articles, 90 were from the Latin America region (32-121), and 31 (122-152) were from the Caribbean region. One publication contained information from both regions (153). The characteristics of the included studies are presented in S3-S5: Tables. Most studies from the Latin America region were from Brazil (n = 30) (35-64), Mexico (n = 21) (90-109, 120) and Colombia (n = 18) (65-82) (Table 1). Most studies from the Caribbean region were from Cuba (n = 16) (122-137), Puerto Rico (n = 11) (139-149), and Trinidad (n = 2) (150, 151) (Table 1). Basic characteristics of the included studies are presented in Table 1, and the number of publications for each year (2000-2021) is illustrated in Fig 2.

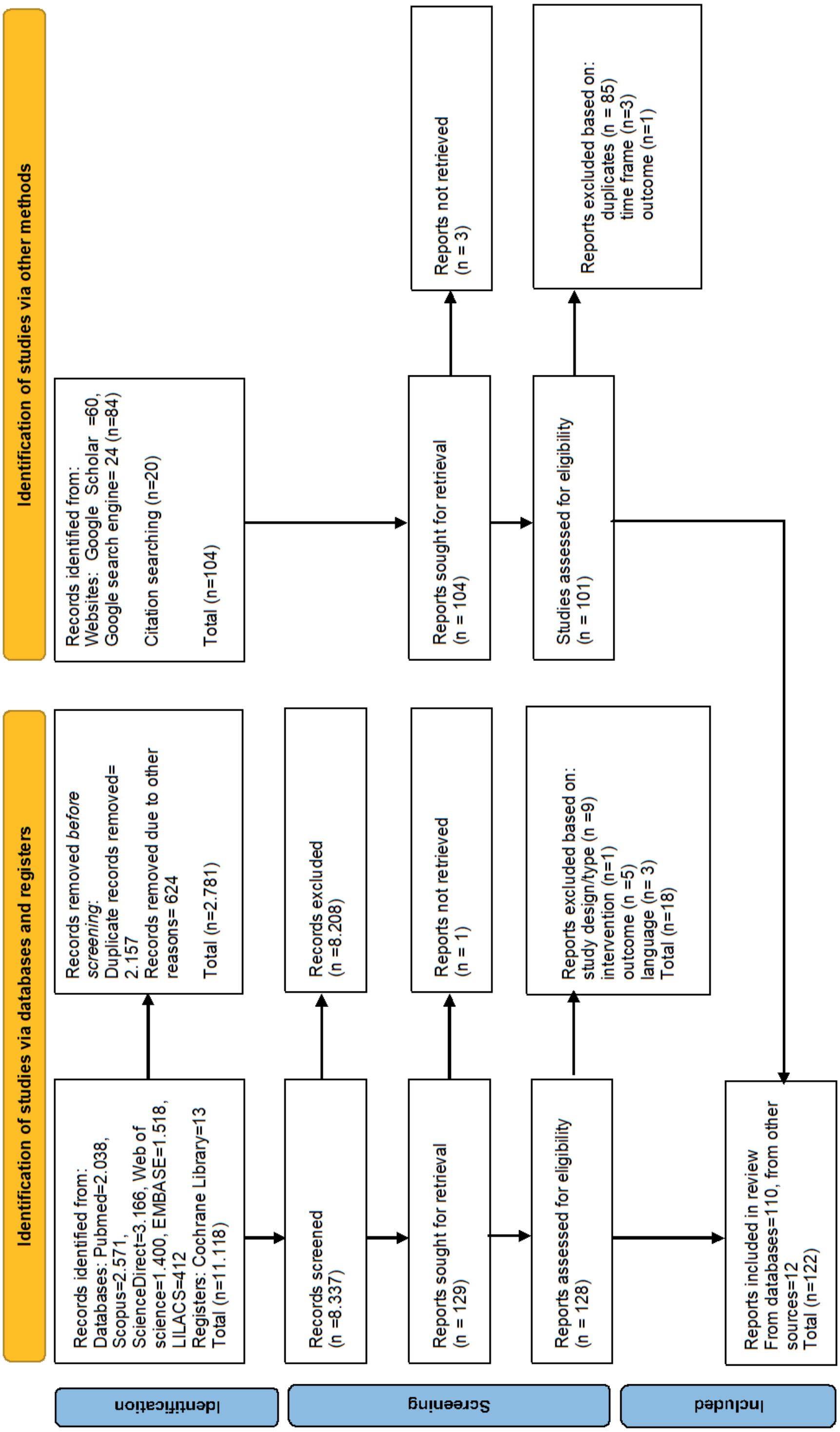

Fig 1. PRISMA 2020 flow diagram

Table 1. Characteristics of the included studies

	Caribbean n (%) (n = 31)	Latin America n (%) (n = 90)
Type of Publication		
Journal article	30 (96.8)	88 (97.8)
Report	1 (3.2)	0
Thesis/ dissertation	0	2 (2.2)
Language		
English	26 (83.9)	66 (73.3)
Spanish	5 (16.1)	16 (17.8)
Portuguese	0	8 (8.9)
Country (Top 3)		
Brazil	0	30 (33.3)
Mexico	0	21 (23.3)
Colombia	0	18 (20.0)
Cuba	16 (51.6)	0
Puerto Rico	11 (35.5)	0
Trinidad	2 (6.4)	0
Setting		
Urban	10 (32.2)	41 (45.6)
Rural	0	4 (4.4)
Both	3 (9.7)	7 (7.8)
Not mentioned	18 (58.1)	38 (42.2)
Study designs		
Randomized controlled trial	0	5 (5.6)
Non-randomized controlled trial	15 (48.4)	29 (32.2)
Cluster randomized trial	7 (22.6)	24 (26.7)
Pre-post (before-after) study	6 (19.4)	17 (18.9)
Mixed method study	2 (6.4)	2 (2.2)
Record surveillance	1 (3.2)	9 (10.0)
Cross-sectional study	0	3 (3.3)
Other*	0	1 (1.1)
Demographics mentioned		
Yes	6 (19.4)	33 (36.7)
No	25 (80.6)	57 (63.3)
Type of disease		
Dengue	22 (71.0)	75 (83.3)
Zika	1 (3.2)	0
Chikungunya	1 (3.2)	0
Other (combination)	7 (22.6)	15 (16.7)

	Caribbean n (%) (n = 31)	Latin America n (%) (n = 90)
Type of mosquito		
Ae. aegypti	29 (93.5)	74 (82.2)
Ae. aegypti and *Ae. albopictus*	2 (6.5)	13 (14.4)
Aedes	0	2 (2.2)
Not mentioned	0	1 (1.1)
Type of intervention (s)		
A. Application of larvicide (biological and chemical)**	2 (6.5)	4 (4.4)
B. Adulticiding (spraying of insecticide indoor/outdoor)	0	10 (11.1)
C. Biological control (usage of larvivorous fish and *Wolbachia*)	0	3 (3.3)
D. Environmental management (removal or covering of breeding sites, and usage of insecticide-treated curtains/ screens)	2 (6.5)	14 (15.6)
E. Traps (including lethal traps for immature forms and adult mosquitoes)	4 (12.9)	7 (7.8)
F. Genetically modified mosquitoes	0	1 (1.1)
G.Health education and community mobilisation	5 (16.1)	17 (18.9)
H. Integrated approach***	16 (51.6)	26 (28.9)
A&B	1 (3.2)	0
A&D	0	3 (3.3)
B&D	1 (3.2)	0
B&G	0	1 (1.1)
D&G	0	4 (4.4)
Type of outcomes		
A. Entomological data (e.g., survey of mature/ immature mosquitoes)	9 (29.0)	40 (44.4)
B. Incidence of mosquito-borne infectious diseases	1 (3.2)	2 (2.2)
C. Knowledge-Attitude-Awareness-practices-perceptions	2 (6.5)	4 (4.4)
A&B	4 (12.9)	10 (11.1)
A&C	5 (16.1)	12 (13.3)
Other****	10 (32.3)	22 (24.4)

Note: The reviewers included one report documenting interventions performed in countries located in both Latin America and the Caribbean region. This report (USAID, 2019) is written in English, focusing mainly on Zika, but dengue was also mentioned. The following interventions were performed: biological and chemical control measures, environmental management, usage of traps and health education. The outcomes were: entomological data, removal of mosquito breeding sites, and improvement of knowledge, attitude and practices. The study designs were classified as non-randomized control trials.
Demographic information: study participants' age, gender, and income or employment status.
* Economic modelling assessment.
** Application of larvicide (biological and chemical): *Bacillus thuringiensis var. israelensis*, Diflubenzuron, Novaluron, Spinosad, Temephos and Pyriproxyfen.
*** Integrated approach refers to a control strategy with more than three components (e.g., health education, environmental management and application of larvicide.
**** Type of outcome: More than three types of outcomes (e.g., self-reported dengue symptoms and anti-dengue IgM seropositivity rates combined with entomological parameters) or a type of outcome that has not been categorised, including removal of mosquito breeding sites, community participation, maintenance of activities through capacity building, Disability-adjusted life years (DALYs) and cost of interventions.

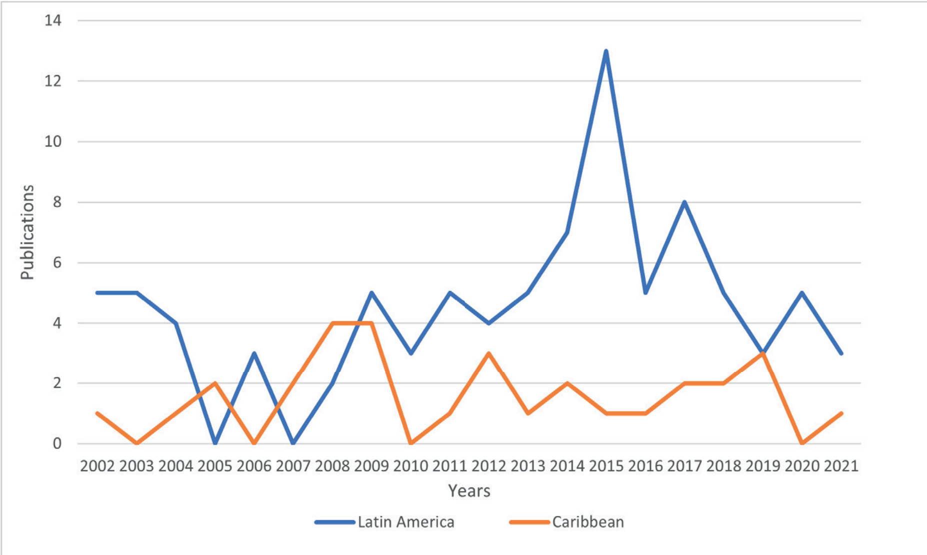

Fig 2. The number of publications per year (2000-2021)

Differences and similarities between the Caribbean and the Latin America region

Most of Latin America and the Caribbean region's publications have focused on the dengue virus infection, urban areas, and *Ae. aegypti* mosquitoes (Table 1). The *Ae. albopictus* mosquito has received more attention in Latin America than in the Caribbean. Chemical control measures were often applied in both areas compared to biological control measures. Mostly entomological data were used to determine the intervention's effectiveness, and it was more often used in Latin America than in the Caribbean region (Table 1). Health education campaigns were the most commonest employed (single) intervention to control ABIDs in both regions.

Interventions

Application of larvicide in mosquito breeding sites

A study conducted in Brazil assessed the effect of a conjugate of *lysinibacillus sphaericus (Lsp)* and *Bacillus thuringiensis var. israelensis (Bti)* on *Aedes* eggs and adult mosquito populations (60). No significant reduction in the *Ae. aegypti* adult population was proven, but a significant reduction in egg density was observed in the second year compared to the first year. In Puerto Rico, *Bti* was applied at a rate of 500 grams/ Hectare using vehicle-mounted aqueous wide-area larvicide spray applications (149). This study found that *Bti* was successfully deposited into jars in both open and covered locations. After the intervention, differences in ovitrap densities were observed between the intervention and control group resulting in 62% (P = 0.0001) and 28% (P < 0.0001) reductions in adult female *Ae. aegypti* mosquitoes (149). In Colombia, treating street catch basin with 2 grams of pyriproxyfen (approx. 0.05 mg/mL) was associated with a reduction in the incidence of dengue (rate ratio 0.19, 95% CI 0.12–0.30, P < 0.0001) (74). Two studies conducted in Brazil used pyriproxyfen to control *Aedes* mosquitoes (52, 56). One study found that dissemination of pyriproxyfen dust-particles from dissemination stations led to a ten-fold decrease in adult mosquito emergence from sentinel breeding sites (52). The second study also showed the beneficial effect of mosquito-disseminated pyriproxyfen. After the intervention, *Aedes* juvenile catch decreased by 79%–92%, and juvenile mortality increased from 2%–7% to 80%–90%. Also, the mean adult *Aedes* emergence fell from 1.077 per month (range 653–1,635) at baseline to 50.4 per month during the intervention (range 2–117) (56). In Peru, mosquito breeding sites were treated with pyriproxyfen, but no significant effects (Breteau index: −1.05 with a 95% CI: −12.64–10.53 and pupae per person index: 0.365 with a CI: −0.030–0.760) were observed (120). The observed beneficial effect could be due to the type of strategy (mosquito-disseminated insecticide) and not the kind of larvicide used.

A trial in Mexico assessed the effect of the application of spinosad (1 part per million [ppm], equivalent to one gram of active ingredient in one million millilitres of water), spinosad (5 ppm), 0.4 gram 1% temephos granules, and 50 µl Vectobac AS12 *(Bti)* on immature forms of *Aedes* mosquitoes located in car tires (92). Both spinosad treatments (1 and 5 ppm) provided 6-8 weeks of effective control *of Ae. aegypti and Ae. albopictus* in the dry and the rainy season. *Bacillus thuringiensis var. israelensis* controlled *Aedes* larvae for one week. The duration of larvicidal activity of 1% temephos granules was intermediate between the spinosad treatments and *Bti.* The usage of temephos granules resulted in 4 weeks of complete control. A study in Trinidad that treated breeding sites with temephos (2-3 weeks before the onset of the rainy season) reported a significant decline of the *Ae. aegypti* population (P > 0.01), from a Breteau index of 19.0 to 6.0 and a pupae per person index of 1.23 to 0.35 (151).

The evidence shows the beneficial effect of larvicide application in mosquito breeding sites before and during the rainy season. The application of *Bti*, pyriproxyfen, spinosad and temephos in mosquito breeding sites led to a decline in the immature and adult *Aedes* mosquito populations. The usage of pyriproxyfen in breeding sites was associated with a decline in the incidence of dengue virus infection. However, it is essential to mention that the observed positive effect of pyriproxyfen is possibly caused by the method of disseminating the larvicide and not the larvicide itself.

Spraying of insecticide (indoor/outdoor)

Two studies that used insecticide spraying in Argentina (32, 34) and Peru (114, 115) were identified. After applying insecticide, these studies reported a reduction in *Aedes* mosquito larval indices and/ or adult density. In Brazil, the spraying of insecticide (malathion) using heavy equipment was associated with fewer cases of ABIDs compared to the control group (application of insecticide with portable equipment) (58). Another study in Brazil found that ultra-low insecticide spraying avoided about 24% of symptomatic dengue cases in the study area throughout the 2015-2016 (December 1, 2015 - June 30, 2016) dengue epidemic (62). In Costa Rica, the application of ultra-low volume at the front door and in each room provided three weeks of significant control ($P < 0.05$) (83). A study in Mexico that used metofluthrin emanators to reduce indoor adult *Ae. aegypti* abundance reported substantial reductions in abundance rate ratios for total *Ae. aegypti*, female abundance, and females that contained blood meals (2.5, 2.4, and 2.3-times fewer mosquitoes respectively; $P < 0.001$) (106).

Insecticide spraying led to a decline in *Aedes* mosquito density and incidence of ABIDs. The reported beneficial effect is up to seven months; thus, data on the longterm effect is lacking. The usage of heavy equipment led to more beneficial effects than portable equipment.

Biological control

Two studies assessed the effect of usage of larvivorous fish in mosquito breeding sites in Latin America. In Brazil, usage of the fish *Betta splendens* led to a reduction in the presence of immature forms of *Ae. aegypti* mosquitoes (70.4% [January 2001] to 7.4 % [January 2002] to 0.2% [December 2002]) (39). In Mexico, larvivorous fish in breeding sites was associated with lower levels of recent dengue virus infection in children aged 3–9 years (OR 0.64; 95% CI 0.45–0.91) (102). Another study in Brazil released *Wolbachia*-infected eggs as an intervention. The study reported a successful invasion and long-term (the post-release phase, spanning mid-January 2017 to December 2019) establishment of the bacterium across the study site (64). The study results support the view that *Wolbachia*-infected mosquitoes have low susceptibility to dengue and Zika virus infections, with reduced viral replication and dissemination to humans (64). The evidence above highlights biological control measures' beneficial and longterm effects on *Aedes* populations.

Environmental management

Scheduled and periodic container washing led to a decline in *Aedes* (larvae) index in Peru (112). In Venezuela, no significant difference in reducing the Breteau index (0.84 with a 95% CI: −8.94–10.62 and pupae per person index: −0.023 and a 95% CI: −0.749–0.703) was observed after covering drums with insecticide-treated nets (120). A study in Brazil indicated that a long-term decrease in adult female population density was achieved only when water tanks and metal drums were covered with nylon net (45). Another study conducted in Brazil that placed concrete in the bottom of storm drains indicated that after the intervention, water accumulated in 5 (9.6%)

of the storm drains (P < 0.001), none (0.0%) had immature forms of *Aedes* species (P < 0.001), and 3 (5.8%) contained adults' mosquitoes (P = 0.039) (59). Covering only the most productive breeding sites of *Ae. Aegypti* with netted lids also produced beneficial results (65). The positive benefits of the prevention of water retention were also observed in a study conducted in Colombia (81).

Another study conducted in Colombia assessed the effectiveness of using long-lasting insecticide-treated curtains alone or in combination with container covers (76). Long-lasting insecticide-treated curtains alone reduced the Breteau index from fourteen to six in the intervention group (the Breteau index in the control group was eight and reduced to five). A significant reduction in pupae per person index (P = 0.01) was observed when long-lasting insecticide-treated curtains were combined with the usage of container covers (76). A similar study was conducted in Guatemala. Significant differences were observed when treated materials and other interventions targeting productive breeding sites (e.g., larviciding with temephos, elimination of breeding sites) were combined. The combined approach led to significant differences in reductions in the total number of pupae (P = 0.04), the house index (P = 0.01), pupae per person and the Breteau indices (P = 0.05) (86). A study conducted in Mexico showed the long-term (more than two years) benefits of using insecticide-treated screens combined with treating the most productive breeding sites of *Ae. aegypti* (97). In Mexico and Venezuela, a combined approach (using insecticide-treated curtains and treating water containers with pyriproxyfen chips or cover water containers) was also applied (108). In both countries, entomological indices after the intervention were significantly lower than baseline. However, no significant difference between the control and the intervention group was observed due to the spillover effect (an indirect effect on a subject/ area not directly treated by the experiment).

In Mexico, insecticide-treated curtains usage was associated with fewer intradomicile dengue virus transmission (95), dengue virus-infected *Ae. aegypti* female mosquitoes (95, 104), and *Ae. aegypti* mosquitoes' abundance (98, 103, 104, 107). In contrast with the benefits reported in the studies that used insecticide-treated curtains, a study conducted in Peru indicated that despite the widespread use of treated curtains, individuals living in the intervention area were at greater risk of seroconverting to dengue virus (average seroconversion rate of 50.6 per 100 person-years CI: 29.9–71.9), while those in the control area had an average seroconversion rate of 37.4 per 100 person-years (CI: 15.2–51.7) (116). A false sense of security may have caused the higher risk of dengue virus exposure observed in the mentioned study.

Two studies conducted in Uruguay distributed plastic bags for collecting unused small containers (117, 118). One study indicated that the vector densities in the intervention group, on average, increased less than those in the control group (from spring to autumn) after implementing the interventions (collection of small containers and covering of large containers). However, the difference was statistically not significant (117). In the other study, the average pupae per person index decreased in the intervention group 11 times and in the control group four times ($P < 0.05$). Although the difference was not statistically significant, the container index, house index, and Breteau index decreased in the intervention group more than those in the control clusters (118).

One study in Cuba and Haiti used long-lasting insecticide-treated curtains or bed nets to control *Aedes* mosquitoes (135, 138). In Cuba, no effect of the insecticide-treated curtains on *Aedes* infestation levels (house index and Breteau index) was observed (study period 18 months) (135). In contrast, the study in Haiti demonstrated significant differences between the intervention group and the control group. At one month post-intervention (usage of insecticide-treated bed nets), all entomological indices declined (house index in the intervention group declined with 6.7 (95% CI -10.6, -2.7; $P < 0.01$) and Breteau index reduced by 8.4 (95% CI -14.1, -2.6; $P < 0.01$) (138). At five months, all indices remained low, and some were significantly lower than baseline in the control group (138). Also, an IgM serosurvey demonstrated a 5.3% decrease (95% CI 5.0-25.5%, $P < 0.01$) in the number of IgM-positive individuals from baseline to the last survey.

In general, environmental management, especially combined approaches (e.g., using insecticide-treated screens and treating the most productive breeding sites), led to beneficial and even longterm effects (≥ two years). However, it is crucial to be aware that the community perceptions/ participation and negligence of potential mosquito breeding sites can negatively affect the approach mentioned above's effectiveness.

Traps

In Latin America, eight studies that used traps as control measures were identified (38, 42, 43, 50, 54, 67, 72, 73). Five studies were conducted in Brazil, and three were performed in Colombia. One study conducted in Brazil found that sticky traps (MosquiTRAP) did not reduce the adult *Ae. aegypti* abundance and dengue infections were equally frequent in the intervention and the control group (54). In contrast with the findings summarised above, other studies that combined a type of insecticide with traps demonstrated more beneficial results. For example, a study in Brazil that used traps with insecticide-treated ovistrip (impregnated with deltamethrin) reported a significant reduction in densities of *Ae. aegypti* for most comparators ($P < 0.01$), as shown by fewer positive containers and pupae/house at the intervention site compared to the control group (38). Two other studies in Brazil used ovitraps with *Bti* for a massive collection of *Aedes* eggs (42, 43). Both studies indicated that massive egg collection by using ovitraps with *Bti* can affect the population density of *Aedes* mosquitoes. Two studies in Colombia also used ovitraps with *Bti*, and a significant reduction in entomological indices was observed (67, 72). The third study conducted in Colombia found that the ovitraps with the highest vector reduction combined deltamethrin/towel/10% hay infusion (73). Another study performed in Brazil used BG-Sentinel traps for massive trapping of *Aedes* mosquitoes (50). The findings of the mentioned study indicated that massive trapping with BG-Sentinel traps significantly reduced the abundance of adult female *Ae. aegypti* mosquitoes during the rainy season. However, no effect was observed in the dry season. Also, dengue infections were lower in the area that used the traps compared to the control area; however, this was not statistically significant (50).

Five publications in the Caribbean region (all from Puerto Rico) reported using autocidal gravid ovitraps (AGO traps) as the primary control intervention (141-144, 148). Two studies reported significant reductions in mosquito density (141, 142). There were significant reductions in the captures of female *Ae. aegypti* (53–70%) in the study area. The presence of three to four AGO control traps per house (in 81% of the houses) prevented expected outbreaks of *Ae. aegypti* after rains. Mosquito captures in BG-Sentinel, and AGO traps were significantly and positively correlated, indicating that AGO traps are valuable and inexpensive mosquito surveillance devices (141). One study reported a lower incidence of chikungunya virus infection in the intervention compared to the control group, resulting from tenfold lower mosquito densities in the intervention areas with AGO traps (143). Two other studies also reported similar results (144, 148).

The evidence on traps suggests that sticky traps are less effective than ovitraps (combined with a type of insecticide) and traps to capture adult mosquitoes. Ovitraps and traps to capture adult mosquitoes led to a significant reduction in entomological indices and a decline in the incidence of ABIDs.

Genetically modified mosquitoes

One study released transgenic male *Ae. aegypti* mosquitoes with the OX513A line to assess the related changes in the distribution of infestation and abundance of *Ae. aegypti* populations six and eighteen months after the intervention in two areas in Brazil (57). An average suppression of ± 70% of the wild population due to the release of transgenic males was observed in the mentioned study. In one of the areas, the mosquito population remained suppressed for 17 weeks, whereas in the other area, the suppression lasted 32 weeks (57). The reported results highlight the benefits of using genetically modified mosquitoes in *Aedes* mosquito control.

Health education and community mobilisation/participation

In Latin America, schools were a popular setting to provide health education concerning diseases transmitted by the *Aedes* mosquitoes discussed in this scoping review (36, 70, 77, 79, 80, 88, 89, 93, 96, 100). The health education interventions implemented at schools increased awareness of *Aedes* biological characteristics (36, 96) and dengue prevention and control practices (70, 88). Also, infestation rates of immature forms of *Aedes* mosquitoes in schools were reduced (77, 79, 89). A health education program implemented in Mexico also influenced the parents' behaviour (93). According to the mentioned study, the entomological indices decreased significantly ($P < 0.05$) in houses in the intervention area, apparently because parents acted on the comments of the children and eliminated or monitored mosquito breeding sites (93). A study that evaluated a health education campaign's sustainability (two years post-intervention) to prevent dengue in schools reported that the intervention's effects were not sustained. The intervention still affected the KAP of the schoolchildren; however, the results were not statistically significant (80).

Health education campaigns implemented among the community members also showed beneficial results in the Latin American region; (i) improvement of knowledge and reduction of mosquito breeding sites (37, 48, 75) and (ii) reduction of entomological indices (91). A study that used a learning platform on mobile devices to improve KAP reported significant changes in attitudes and behaviour ($P = 0.032$) concerning actions to prevent arboviral diseases (61). Another study that disseminated information via mobile phones suggested that repeated exposure to health information encourages householder's uptake of preventive measures against dengue (113). One study that assessed the impact of mass-media communication campaigns indicated that although intervention coverage was adequate (59,4% of the population), the reach (people that could recall the content of the information) was low (22,3%). Also, no association between the intervention and the presence of breeding sites was found (71). Another study reported that mass communication campaigns influenced the population's KAP (136). However, information gaps continue to exist, and actions beyond just providing information are required for better results. A study that combined mass communication campaigns with a school and museum-based educational program reported that exposure to the intervention was associated with increased knowledge about dengue. (139). Also, the intervention was associated with an increased proportion of tires protected from rain and a decreased proportion of water storage containers positive for mosquito larvae (139).

A health education campaign based on an eco-health approach, focusing on community mobilisation, house inspection, and covering water containers with insecticide-treated aluminium covers showed an average decrease between 0.12 (-0.25 - 0.01) and 0.26 (-0.42 - -0.10) cases of dengue daily (1.82 cases per week or 7.8 cases per month or 95 cases per year) (82). The benefits of health education campaigns focussing on community mobilisation and participation have been demonstrated in other study settings in the Latin American region (53, 66, 68, 78, 101, 109, 111). Most studies on health education and community mobilisation/ participation in the Caribbean region were conducted in Cuba (122-125, 127-129, 131, 132). Health education and community mobilisation/ participation led to a decline in entomological indices (122-125, 128, 129, 131), breeding sites (127), and behavioural change (128). One study attributed the success of the intervention to community involvement in the vector control intervention (132). The beneficial impact of health education focussing on community mobilisation was also observed in Puerto Rico (146).

The evidence concerning health education campaigns highlights the beneficial effect of health education on KAP of school children/ community members and entomological indices. However, the evidence also suggests that only education provision is not enough to control *Aedes* mosquitoes in the long run. Health education campaigns must include community participation/ mobilisation efforts to be successful. Furthermore, the government, including the health systems, must formalise mosquito control programs and health education campaigns through regulations to support interventions. Without regulations, it is hard to maintain program implementation.

Integrated interventions

A study that evaluated the impact of the Brazilian national dengue plan (information campaigns, epidemiological surveillance and vector reduction interventions, e.g., usage of larvicide temephos and spraying of insecticide) indicated that the goals concerning the reduction of dengue incidence (50% reduction in dengue cases) and larval infestation (less than 1%) were not achieved in most municipalities (municipalities in the Southeast and Centre-West regions of Brazil) (44). Another study that evaluated Brazil's national dengue control plan, in the municipality of Caruaru, attributed the program's lack of success to insufficient household coverage (46). More positive results were achieved when the national program was extended (in two municipalities of Pernambuco -Brazil: Ipojuca and Santa Cruz) with the following interventions: ovitraps loaded with *Bti*, source elimination campaigns and indoor collections of adult mosquitoes using aspirators, targeting places considered highly important for virus transmission (49). After two years of sustained control, a 90% decrease in egg density was registered at one study site. Data from another study site showed a sharp decline in the mosquito population (49). The incorporation of the community mobilisation concept into the Brazilian national plan was linked with the reduction of the total number of dengue cases between 2009 and 2010 in Ipatinga city (55). Combining the family health program with the national dengue control program can also provide beneficial results, as observed in a Brazilian study (São José do Rio Preto) (40). Significant changes in KAP were achieved, and the house index was reduced (6.9% before and after 4.4%, with a significant difference, P = 0.040) (40).

A study in Mexico that combined epidemiological surveillance, environmental management through social mobilisation, and chemical control also demonstrated beneficial results (99). Statistically significant differences ($p < 0.001$) in the relative abundance of *Ae. aegypti* larvae before and after applying larvicide temephos and removing water containers were reported (99). For example, in La Paz, the average house index was reduced from 16 - 83% to 0 - 5% after the interventions for three years. Beneficial results were also observed in the positive container index and the Breteau index in La Paz and other areas (Cabo San Lucas and San Jose del Cabo), where the interventions were implemented (99). The beneficial effects of combining interventions were also documented in another study conducted in Mexico (94). Two years of implementing an integrated intervention reduced the peak of dengue cases recorded in the rainy season in Colima, Mexico (94). However, more research is needed to determine the actual effect of the intervention since different factors (e.g., amount of rainfall) can influence the outcome of this study.

Other studies also demonstrated the benefits of combined interventions (33, 41, 51, 63, 84, 85). In Brazil, one study that combined the application of insecticide temephos, environmental management and health education campaigns did not observe positive results (35). The lack of effect is possibly caused by negligence in eliminating breeding sites observed in the group that also applied temephos and the dilution of the insecticide in non-removable containers. A study in Nicaragua also did not demonstrate a positive effect of temephos combined with other interventions (110). In the mentioned study, temephos exposure was not associated with a reduction in any entomological indices, and in some cases, temephos exposure was even associated with higher entomological outcomes (110).

In Cuba, an intervention combining the distribution of new ground-level water tanks and intensive use of an insecticide was conducted (126). The container index decreased significantly from 0.7% to 0.1% one month after the intervention. Six months later, the mentioned index increased to 2.7% due to the uncovered new water container (126). In Trinidad, an intervention combining the application of temephos in water containers, fenthion at walls of houses of suspected dengue cases and fogging using malathion failed to achieve the desired target of reducing mosquito densities to below the disease transmission threshold or possibly a Breteau index of five (150).

Another study conducted in Cuba implemented a community-based intervention focussing on (i) training a local task force, (ii) organising community working groups, (iii) enhancing collaboration between the government and the community, (iv) and creating a formal link with the routine vector control programme (130). This intervention led to a lower attack rate of dengue fever (8.5 per 1000 inhabitants) in the intervention group compared to the control group (38.1 per 1000 inhabitants). A study in Puerto Rico reported a reduction in mosquito density after implementing an intervention that consisted of environmental management, usage of larvicide (Altosid Pro-G), and placement of three AGO traps in the backyards of houses (145). Density changed from 27.7 mosquitoes/trap/week before to 2.1 after intervention (92.4% reduction), whereas after treating the original control area (cross-over), density changed from 22.4 to 3.5 (84.3% reduction) (145). The mentioned results were confirmed by another publication (147).

The evidence presented above highlights the importance of combining interventions to mitigate ABIDs. An integrated approach can reduce entomological indices and the incidence of ABIDs. However, an integrated approach can also fail to achieve the desired effect if the community is not involved, mosquito breeding sites are not properly removed or treated, and insecticide is ineffective.

Challenges and lessons learned

Another objective of this scoping review was to describe the challenges and lessons learned reported in the publications. The challenges and lessons learned are presented here by the following key themes: (i) knowledge concerning *Aedes* control and ecological adaptability, (ii) resources and capacity, and (ii) infrastructure and context of the community.

Knowledge concerning *Aedes* control and ecological adaptability

The first step towards *Aedes* control is understanding the mosquitoes' basic biological and ecological characteristics. In most included studies, lack of community involvement, motivation, and community and health workers' understanding of *Aedes's* control immediate and long-term impact have been reported as significant barriers to successful program implementation (37, 68, 126). Deciding on the methods for controlling calls for a deeper understanding of the operational aspects of mosquito control (the local conditions) and the ecological adaptability of the *Aedes* mosquitoes. For example, one study observed the evolution of mosquito resistance due to intense insecticide application (51). Nowadays, *Ae. aegypti* can also use cryptic and non-clear aquatic habitats as oviposition sites. This change in the ecology of the mosquito can affect the results of the traditional surveillance and control methods. Furthermore, it is essential to understand community perceptions, control behaviour, and preferred control interventions (54). For example, using a chemical substance such as temephos was linked with an increased risk of dengue infection, resulting from a false sense of security engendered by knowledge of pesticides in water storage (109).

Resources and capacity

Insufficient resources, specifically human resources, to perform mosquito control is also a potential contributing factor that hinders mosquito control intervention's success (46). For a sustainable intervention, the key is to have the political will to provide adequate and uninterrupted supplies (80). A study in Guatemala reported financial constraints and scarcity of vehicles, fuel, and personnel to obstruct the sustainability of interventions (87). Another study indicated that providing adequate basic utility services (e.g., garbage collection) to the communities could have a major bearing on the sustainability of the community-based mosquito control intervention, facilitating the successful implementation of the *Aedes* control program (124). Proper public management (e.g., development and approval of health regulations and public health interventions, intersectoral coordination and creation of linkages between organisations to create a platform to negotiate solutions) is an essential factor that is required to achieve sustainable results (124). Targeting long-term behaviour change among the community members is imperative for sustainability. Actively involving household members in basic mosquito control measures is a good start to avoid dependency on the program implementer and ensure program sustainability (117). Mosquito control is a shared responsibility and requires coordination and support from all relevant sectors [46, 86]. Programs need to be evaluated, and networks among the stakeholders need to be maintained.

Infrastructure and context of the community

Important factors that might influence the effectiveness of *Aedes* mosquito control are the housing and surrounding conditions, methods of waste disposal, and socioeconomic status of the community (58). Hence, detailed assessments of all public services, such as waste management, sewerage systems, etc., should be made to inform entomological surveys of *Aedes* mosquitoes (140). The success of *Aedes* control intervention is also dependent on the socio and geopolitical condition of the community. In areas where community organisations are fragile or non-existent or in a conflicted community with a history of violence and unrest, social participation is slim to none (53, 109).

Strategies employed or recommended to improve the effectiveness of *Aedes* control interventions

The last objective of this scoping review is to list the employed or recommended strategies to improve the effectiveness of *Aedes* control. The recommendations are listed below:

(i) Community participation enhances the success of *Aedes* control interventions (78, 85, 111, 118, 122, 123, 146). Schools are an important setting that needs to be considered when designing community participation strategies since beneficial results have been booked with health education campaigns employed at schools (36, 49, 79, 100).

(ii) The use of a multi-sectoral approach or inter-sectorial integration (40, 89, 90, 127, 128, 139), integrated *Aedes* control approaches (97, 111, 147), and prioritizing ABIDs (local government providing financial and administrative support) (121, 122) were stated as common reasons for the success of an intervention.

(iii) The effectiveness of the intervention improved when qualified staff planned and implemented an intervention (46, 68), and the community accepted the intervention technique and believed in its effectiveness (107).

(iv) Interventions were effective when health education messages were repeated throughout the intervention (113).

(v) The health workforce should be trained and capable of identifying the most productive breeding sites (74). The workforce should keep standard operating procedures for entomological and epidemiological surveillance, and data should be consistent and follow standardised measurement tools for inspection activities (68, 128). Furthermore, the workforce should assess the short term and long-term impact of the *Aedes* control program because these assessments facilitate program implementation in the long run and sustainability. To assess immediate outcomes, periodic monitoring and evaluation are recommended to inform what works and needs to be amended (68). Having a list of program indicators could be beneficial for program implementers to quantify and draw inferences on the outcomes against the input, which can be helpful for the allocation of resources.

(vi) It is also important to consider conducting a cost-benefit analysis as the intervention progresses, considering the direct cost of implementing the intervention and the potential consequences (91).

(vii) Lastly, the workforce should consider factors (e.g., meteorological conditions such as wind speed, direction, or temperature) contributing to differences in larval mortality related to application data (149). Another factor that can invariably affect implementation if not counter for is the seasonal variation of pupal productivity (86). Therefore, a baseline pupal survey should be repeated every season to take seasonal variations of *Aedes* populations into account when designing an intervention.

Discussion

This scoping review synthesises evidence concerning the effectiveness of *Ae. aegypti* and *Ae. albopictus* prevention and control interventions performed in LAC in the last twenty-one years (2000-2021). To our knowledge, this review provides the most updated overview of evidence regarding the effectiveness of *Aedes* prevention and control interventions in the region mentioned above. Most of the data were from studies in Brazil, followed by Mexico and Colombia. Cuba has most of the publications in the Caribbean region, followed by Puerto Rico and Trinidad.

The synthesised data showed that combined interventions were more effective than a single approach. Another review supported our findings by reporting that it is unlikely that any single intervention will be fully effective against *Aedes* mosquitoes and encourages the development and usage of an IVM program to control the mentioned mosquito species effectively (154).

Although our scoping review has a broader scope than a previously published systematic review and meta-analysis on the effectiveness of interventions for the control of *Ae. aegypti* in the LAC region (155), the same conclusions concerning the beneficial effect of an IVM program are drawn. An IVM program has been pointed out as the most effective approach to reducing *Ae. aegypti* immature forms and adult mosquitoes (155, 156). The WHO and the PAHO insist that the IVM approach is the solution to mitigate ABID transmissions (15). However, many factors such as insufficient funding, resources, workforce, and political priorities (e.g., prioritising SARS-CoV-2) obstruct the implementation and maintenance of the IVM program nowadays. Besides, the focus of many health systems is not on mosquito control since many countries face a range of more immediate problems. On one hand, it is easy to recommend developing and implementing an IVM program. On the other hand, maintaining a cycle of periodic implementation of the program is challenging—this leaves the door open for future epidemics.

The most important question that remains is, how can we sustain the effectiveness of the IVM program? One way to counter this is through routine monitoring and evaluation, building the capacity of the community, building a network of relevant stakeholders (local and international), and taking the local challenges of the health system and the community into account when designing the IVM program. However, all these would require multisectoral and multi-disciplinary team engagement and active community participation. An IVM without community participation and the political commitment of the governments is not sustainable. (155, 157).

The effectiveness of the interventions included in this review was reduced by the following factors, the spillover effect (76, 108, 138), small sample size (117), providing educational strategies to deploy control measures in the control group (68), parallel government campaigns (76, 85, 86, 88, 129, 137), insecticide resistance (35, 110, 150) or media freedom to change or stop the distribution of information (71). Also, most interventions were followed for a short period, which led to limited evidence on the sustainability of the employed interventions. Future research should focus on *Ae. Albopictus* and its active role in transmitting ABIDs. Also, researchers might consider studying the impact of an IVM approach on various ABIDs (e.g., dengue and Zika combined) since this evidence is also missing in the scientific literature. Furthermore, more research and dialogue on the barriers of an IVM program are needed to work toward more sustainable programs. This scoping review also aimed to synthesise evidence on how other countries in the LAC region dealt with their challenges, but this information was not available in all the included publications. Therefore, we recommend future research to address this topic to provide more practical advice to countries struggling with their *Aedes* control approaches. Lastly, we encourage countries with more advanced techniques and qualified workforce to support countries with less developed health systems.

Limitations and strengths

Since the quality of the included studies was not assessed in this scoping review, the included studies' results need to be interpreted with caution. Quality assessment is essential for systematic reviews and meta-analysis, but it is not required for scoping reviews (26). The main strength of this scoping review is the extensive literature, grey literature and reference list search that was conducted to find relevant publications. Another strength is the methodology used; each phase in data search, screening and extraction was piloted and cross-checked to reduce the chance of bias.

Conclusion

Prolonged community participation is key to sustaining the effectiveness of *Aedes* control interventions. The major conclusion of the synthesised data was the higher effectiveness of the integrated *Aedes* control approach over single strategies. Although it is known that an integrated approach in combination with community participation can be effective, many barriers still obstruct the development and implementation of such an approach, jeopardising the health system's preparedness and performance. Future research and recommendations need to focus more on IVM program implementation and maintenance barriers since this information is lacking in scientific literature.

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CHAPTER 3

Evaluating and strengthening the health system of Curaçao to improve its performance for future outbreaks of vector-borne diseases*

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Abstract

Background: Vector-borne diseases (VBDs) such as dengue, chikungunya, and Zika pose a significant challenge to health systems in countries they affect, especially countries with less developed healthcare systems. Therefore countries are encouraged to work towards more resilient health systems. This qualitative study aims to examine the performance of the health system of the Dutch Caribbean island of Curaçao regarding the prevention and control of VBDs in the last decade by using the WHO health system building blocks.

Methods: From November 2018 to December 2020, a multi-method qualitative study was performed in Curaçao, applying content analysis of documents (*n* = 50), five focus group discussions (*n* = 30), interviews with experts (*n* = 11), and fifteen observation sessions. The study was designed based on the WHO framework: health system building blocks. Two cycles of inductive and deductive coding were employed, and Nvivo software was used to analyse the data.

Results: This study's data highlighted the challenges (e.g., insufficient oversight, coordination, leadership skills, structure, and communication) that the departments of the health system of Curaçao faced during the last three epidemics of VBDs (2010-2020). Furthermore, low levels of collaboration between governmental and non-governmental organisations (e.g., semi-governmental and private laboratories) and insufficient capacity building to improve skills (e.g., entomological, surveillance skills) were also observed. Lastly, we observed how bottlenecks in one building block negatively influenced other building blocks (e.g., inadequate leadership/governance obstructed the workforce's performance).

Conclusions: This study uncovers potential organisational bottlenecks that have affected the performance of the health system of Curaçao negatively. We recommend starting with the reinforcement of oversight of the integrated vector management program to ensure the development, implementation, and evaluation of related legislation, policies, and interventions. Also, we recommend evaluating and reforming the existing administrative and organisational structure of the health system by considering the cultural style, challenges, and barriers of the current health system. More efforts are needed to improve the documentation of agreements, the recruitment, and the evaluation of the workforce's performance. Based on our findings, we conceptualised actions to strengthen the health system's building blocks to improve its performance for future outbreaks of infectious diseases.

Keywords: Caribbean Region, Dengue, Zika Virus, Chikungunya virus, Mosquito Control, Communication, Developing Countries.

Background

Dengue (DENV), chikungunya (CHIKV), and Zika (ZIKV) viruses are responsible for significant epidemics worldwide (1). In Curaçao, dengue is endemic with the co-circulation of the four viral serotypes (DENV-1 to -4) (2). The CHIKV and ZIKV caused an epidemic in 2014-2015 and 2016-2017, respectively (3). In the Caribbean, these vector-borne diseases (VBDs) are transmitted to humans by the bite of infected *Aedes aegypti* females mosquitoes (4). Preventing or reducing DENV, CHIKV, and ZIKV transmission depends entirely on controlling the mosquito population or interruption of human–vector contact. Factors that influence the rapid expansion of these VBDs are climate change, population growth, urbanisation, international travel and trade, lacking vector control infrastructure/services, and less developed health systems (5). VBDs pose substantial challenges to health systems in the countries they affect, especially resource-limited countries or Small Island Developing States (SIDS).

In the last decennium, much attention has been paid to health system strengthening because there has been a growing acknowledgement that a less developed health system is one of the main obstacles to overcome to achieve successful and sustainable public health interventions (6). The World Health Organisation (WHO) has developed a framework called “The health system Building Blocks” that aims to promote a common understanding of what a health system is and what constitutes health system strengthening (7). These building blocks define the health system's desirable attributes and offer a mechanism to recognise bottlenecks in structure and performance. A health system consists of all organisations, people, and actions whose primary intention is to promote, restore or maintain health (7).

In the WHO framework, a health system is conceptualised as consisting of six building blocks: (i) leadership/governance; (ii) health information system; (iii) financing system; (iv) health workforce; (v) medical products/vaccines/technologies; and (vi) service delivery, as well as process elements (e.g., access, coverage, quality and safety), and outcomes (8). According to the WHO, the leadership/governance and the health information systems provide the basis for policy and regulation of all the other health system blocks (8). Leadership/governance involves ensuring a strategic policy framework, adequate oversight, attention to system design, and accountability. An efficient health information system ensures the production, analysis, dissemination, and use of reliable and timely information (7). A good financing system raises adequate funds so that people can use the needed services and are protected from impoverishment (7). A well-performing health workforce works in responsive, fair, and efficient ways to achieve the best health outcomes possible, given available resources and circumstances (7). A well-functioning health system ensures equitable access to essential medical products and technologies and ensures quality, safety, efficacy, and cost-effectiveness. Good service deliveries deliver efficient, reliable, personal and non-personal health interventions to those in need, wherever and whenever care is needed, with minimum waste of resources (7). Health system strengthening means improving the six building blocks mentioned above and managing their interactions in ways that achieve more equitable and sustained improvements across health services and health outcomes. Both technical and political knowledge and action are required (7).

The WHO framework is valuable because it provides a common language among experts and a good discourse structure on health system affairs (9). However, for applied research, it needs to be adapted and made context-specific (10). It has also been argued that the mechanical segmentation of effects by the WHO building blocks, without recognition of their interactions, inhibits the system's understanding (10). Despite the shortcomings, the WHO building blocks framework has become the framework most often used to strengthen the health system. It has been used to determine the overall performance of public healthcare facilities (11), the implications of health sector reforms (12), and the baseline status of health facilities (13). Furthermore, it has been used to understand the impact of interventions or programs on the health system in the field of HIV/AIDS (14), malaria (15), measles, and polio (10).

The recent epidemics of VBDs in Curaçao highlight the need to evaluate the health system's performance. This qualitative study aims to examine the performance of the health system of Curaçao regarding the prevention and control of VBDs in the last decade by using the WHO health system building blocks. This aim will be addressed by assessing and evaluating the structure, organisation, functions, processes, and actions performed by the health system concerning the prevention and control of VBDs. The gained knowledge will be used to conceptualise actions to improve the performance of the health system. This study's findings highlight policy and implementation problems worthy of attention and suggest potential solutions to health system bottlenecks. Also, our findings may help better understand the interactions between the building blocks. This knowledge will lead to the strengthening of the health system of Curaçao for future epidemics of not only VBDs but also other infectious diseases (e.g., COVID-19). Furthermore, other SIDS can also benefit from our results and recommendations.

Method

Study design

This multi-method qualitative study is based on the interpretive paradigm, and it was performed from November 2018 to December 2020. The study was designed based on the theoretical framework of the WHO health system building blocks. The mentioned framework was applied at the time of data collection, analysis, and result interpretation. A combination of different qualitative research methods was used. First, content analysis of governmental documents was carried out to understand the governmental structure more in-depth and to gain insights into all that has been written (e.g., protocols, laws, and action plans) on prevention and control of VBDs in Curaçao. Information drawn from the content analysis was used to design topic guides for focus group discussions (FGDs) and interviews with experts. Second, FGDs and interviews with experts were performed to gain insights into motivations, practices, institutional issues, experiences and perceptions of the health system's workforce. Information drawn from the FGDs and interviews with experts was used to validate and support information drawn from the content analysis. Third, observations (e.g., observe house inspections performed by the vector control unit) were conducted to understand further institutional bottlenecks and the working procedure of the health system's workforce. The observations were used to validate and support the information drawn from the content analysis, FGDs, and interviews with experts.

Study site

In October 2010, the Netherlands Antilles (The Netherlands Antilles was a constituent country of the Kingdom of the Netherlands and consisted of several islands located in the Caribbean Sea) was dissolved, and Curaçao became an autonomous country within the Kingdom of the Netherlands. The island has a surface area of 444 km^2 and has a moderate tropical climate with two seasons (rainy and dry season), with an average temperature of 25-28 °C. According to the Central Bureau of Statistics of Curaçao, the estimated population was approximately 158 665 inhabitants on January 1st, 2019 (16). There are different ethnic backgrounds, with an Afro-Caribbean majority and minorities such as Dutch, French, Latin American, South- and East-Asian, Portuguese and Levantine people (3). Papiamentu, Dutch, and English are the official languages of Curaçao, with Spanish also being widely spoken.

Study population

A total of five FGDs (n = 30) were conducted with professionals that have worked for the Ministry of Health, Environment, and Nature of Curaçao (MoHEN). Three of the five FGDs were conducted with professionals that have worked in the vector control unit (VCU), one was held with previous ministers of health, and one with health professionals that have worked in the policy, communication, vector control, and Epidemiology & Research Unit (ERU). Interviews were conducted among eleven experts. The characteristics of the study population are presented in Additional file 1: Table S1. The number of FGDs and interviews with experts were determined after data saturation, where information starts to repeat itself, had been reached. Study participants were recruited using key informants such as heads of departments, and experts were chosen based on their characteristics such as experience and knowledge. The study sample consists of professionals from all six WHO building blocks analysed in this paper.

Data collection

Content analysis

Downe-Wambolt defines content analysis as "*a research method that provides a systematic and objective means to make valid inferences from verbal, visual, or written data in order to describe and quantify specific phenomena.*" (17). In health sciences, content analysis has been employed to achieve different aims, for example, to evaluate health campaigns (18) or to determine the main challenges of processes related to health service (19). In this study, the content analysis of documents (e.g., reports, protocols, images, radio, and television spots) was conducted first because it provides data on the context within which the study participants and departments had operated during the epidemics of VBDs. Documents bear witness to past events (e.g., conducted vector control interventions), provide a means of tracking change and development, and highlight the conditions that influence the phenomenon under investigation (20). The following inclusion criteria were applied: (i) the document was original, (ii) it was related to DENV, CHIKV, and ZIKV, and (iii) it was developed and used by governmental officials within the 1 January 2010 - 28 February 2020 time frame. This time frame included the last massive outbreak of DENV infection in 2010/2011 and the CHIKV and ZIKV infection epidemics in 2014-2015 and 2016-2017, respectively. The following exclusion criteria were applied to the documents: (i) the document had no publication date and author details, (ii) it was not related to governmental actions with regards to prevention and control of DENV, CHIKV, and ZIKV. After correcting for irrelevant or repetitive documents, a total of 50 items were included in the content analysis. An overview of the items used in the content analysis of documents is presented in Additional file 2: Table S2.

Focus group discussions and interviews with experts

Five FGDs and 11 interviews with experts were conducted in the second phase of data collection. The topic guides were semi-structured to cover the six health system building blocks and the health system bottlenecks that were drawn from the content analysis of documents (Additional file 3-8: Text S1-S6). The topic guides were piloted and adjusted before the data collection. The FGDs and interviews were conducted in Papiamentu or Dutch, recorded, and transcribed.

Observations

Based on the information collected during the interviews and the FGDs with health professionals, we conducted five follow-up observation sessions during inspections of the VCU to verify reported data related to prevention and control measures and their related challenges. The VCU organised six training sessions with regards to mosquito species in Curaçao, prevention and control of mosquito-borne diseases. We participated in these training sessions to determine the knowledge and entomological skills of the workforce of the VCU. Also, presented challenges of the workforce were recorded. Furthermore, we participated in four meetings organised by the VCU, the Department of risk communication (RC) and ERU to observe how departments collaborate to work on international health regulations, RC, prevention and control of VBDs. The observations were recorded as notes and pictures. One observer and one note-taker conducted the observation sessions. The collected information was compared at the end of each observation session to identify potential discrepancies. Additional observation sessions were conducted to clarify these differences and reach common conclusions.

Data analysis

The data coming from FGDs and interviews with experts were analysed using different codes, which refer to an idea, issue, topic or opinion evident in the data. Some of the codes were raised by the study participants themselves (inductive). In contrast, others were prompted by the interviewers using topics in the interview guide that were derived from literature and existing theories (deductive). We employed two cycles of inductive and deductive coding. In the first cycle, codes were used when analysing FGDs and interviews with experts. These codes were assigned to ten categories, which were analysed in the second cycle of analysis. The following categories were identified: (i) leadership/governance, (ii) financing system, (iii) medical products and technologies, (iv) health information system, (v) workforce, (vi) service delivery, (vii) trust, (viii) prevention, (ix) evaluation, and (x) recommendation (Additional file 9: Table S3). The analysis of the content of documents and observations was as follows: first, all text was read several times for familiarisation with the content. Second, data from the content analysis of documents and observations were coded using the coding list used for the FGDs and interviews with experts. The same coding list was used because it offered the opportunity to link and compare the data. This data analysis method facilitated the data interpretation to elicit meaning, compare data, gain understanding and develop empirical knowledge. The data was analysed using Nvivo (version 12 Pro). All quotes in the current research were transliterated to keep the context intact.

Results

The results are presented here with the following key themes: leadership/governance, health information system, financing system, health workforce, medical products and technologies, and service delivery. Each paragraph starts with a structural bottleneck and ends with its implication for the health system's performance.

Leadership/governance

It is essential to understand the organisational structure of the MoHEN to understand each department's responsibilities regarding the prevention and control of VBDs. The organisational structure of the MoHEN is illustrated in Fig 1. Regarding the prevention and control of zoonotic diseases, the Policy Department is responsible for making laws for the Department of Technical Hygiene and Care (THZ). The THZ, which is part of the Department of Medicine and Health Affairs, is responsible for implementing and enforcing the laws (Curaçao: Business plan, Ministry of Health, Environment and Nature, pg: 10-11). Different experts have confirmed the mentioned task division. However, at the same time, they indicated that the mentioned departments do not perform their tasks as it is documented. Also, they indicated that the collaboration between the Policy Department and other departments of the MoHEN is minimal. The following quote portrays this issue:

> *Moderator: Okay, there is no law or protocol?*
> *Female 1: No, look.*
> *Male 2: We met a few times.*
> *Female 1: Yes, but with the dengue team (microbiologist, head of the THZ, entomologist, epidemiologist, medical doctors, communication expert).*
> *Male 2: The team never received feedback. There was no feedback.*
> *Female 1: We asked for the protocol every time. Yes.*
> *Male 1: Look, the process to develop a law/protocol is not clear for us (policymakers working for the Policy Department) neither. We complained many times about this issue within the department. The problem remains the same. Again the departments that work in the field know the content of their work; they are the experts, not someone that sits in the Policy Department. The policymakers working for the Policy Department need to guide the departments to develop their protocols/law/guidelines, but the content needs to come from the departments, and this is not happening.*
> - FGD with health professionals working for the MoHEN

Insufficient collaboration causes issues such as the development of laws/protocols/guidelines for preventing and controlling VBDs to fall short on certain ends. This issue has been confirmed by notes derived from meetings organised by the Department of Medicine and Health Affairs. The following observation note portrays this issue:

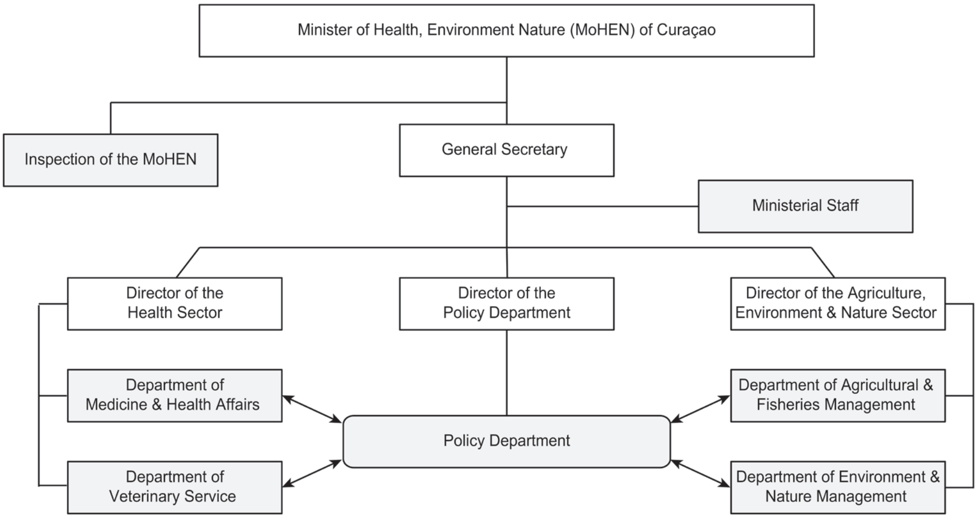

Figure 1. Organisational chart of the Ministry of Health, Environment and Nature of Curaçao. Adapted from Curaçao: Business plan, Ministry of Health, Environment and Nature (p. 10), by MoHEN, 2011. Adapted with permission.

The RC department organised a meeting to discuss a health promotion campaign for mosquito-borne diseases in Curaçao. The meeting included professionals from different departments, such as the VCU and the ERU. When the topic "collaboration" was introduced, one of the health professionals asked permission to express her concern.

She was not happy and showed signs of frustration. For example, she tapped her fingers and scratched the back of her head. When she got permission to speak, she said the following: **"***We have a Policy Department, but the professionals working for this department do not know what they need to do. The "real" professionals are working for the departments that are responsible for the implementation of the law/policy. It does not make sense. There is no collaboration between the Policy Department and the departments that are responsible for the implementation of the law. That is why there is no law.***"**

The other health professionals agreed with her statement by saying: "*You are right*" or "*Exactly*" or "*I could not agree more*".

At that moment, everybody started to talk, and the moderator of the meeting had no control over the invited health professionals. It looked like everybody was not happy with the current collaboration.
-Observation notes of a meeting held on October 22, 2018.

Data drawn from FGDs and interviews with experts revealed that the collaboration between departments is lacking because the workforce's work procedure is not documented in any policy or law. Two evaluation reports confirmed the fact that there is no overall strategic policy framework that guides departments during epidemics of infectious diseases. There is a range of laws, technical briefs and plans that address the prevention and control of VBDs; however, these laws/plans have their shortcomings. There is a law on infectious diseases (verordering bestrijding van besmettelijk ziekten P.B.1921, no 61), that has been used to guide the prevention and control of new VBDs. However, its usability was questioned in two evaluation reports and by different experts. The evaluation reports and interviewed experts indicated that the law is outdated since it was created in 1921. Also, the law does not contain information concerning the work procedure and responsibilities of needed professionals, departments, and organisations to prevent and control VBDs. These shortcomings obstruct collaboration, oversight and accountability within the health system of Curaçao.

A regulatory law on pesticides (Landsverordering bestrijdingsmiddelen P.B. 1961, no 116) was introduced in 1961 by the government of the Netherlands Antilles. This law addresses rules for importing and using insecticides; however, it does not address the safe use of insecticides and their application in nature. Data that was drawn from an evaluation report written by two external medical entomologists in 2016 confirmed this issue. More recently, a local medical entomologist explained that since there is no regulation on the safe use of insecticides and application in nature, private and governmental pest controllers can use insecticides that negatively affect our environment without prosecution. The workforce of the VCU stated that the reported lack of regulations concerning the safe use of insecticides and their application in nature weakens the authority and control mechanism of the MoHEN. Both external and local medical entomologists reported that the existing law on pesticides had not been updated or revised since 1961 by the government of the Netherlands Antilles or Curaçao.

Many participants reported that the organisational structure of the MoHEN introduced after October 2010 (thus, when the Netherlands Antilles was dissolved and Curaçao became an autonomous country within the Kingdom of the Netherlands) was just copied from that of the Netherlands. This process took place without taking the workforce's capacity or cultural, financial and social factors of Curaçao into account. All the interviewed ministers of health and the majority of the interviewed experts indicated that the organisational structure of the MoHEN is weak and observed that its deterioration would continue if the system is not adequately evaluated and adjusted. The following quote portrays this issue:

> *"The MoHEN has deteriorated in the last years. The deterioration started after October 10th, 2010. Especially the VCU, which is part of the Department of Technical Hygiene and Care. A large group of personnel retired, some passed away, and some left. In other words, the work of the VCU is non-existent. The ERU follow notifications of PAHO or WHO, but the health system cannot act on the health threats proactively. This was the problem during the epidemic of chikungunya and Zika in Curaçao."*
> -Stephan, Policy-maker/ general practitioner

Other collected data related to this theme revealed that this organisational problem causes issues such as inadequate tasks and power division. Also, it negatively affects how decisions are made and activities are carried out.

We found that lack of documentation and collaboration between departments obstruct policymaking and the health system's management. Experts indicated that most of the agreements concerning VBDs were made verbally and were not documented during the epidemics. Only one document (Integrated Management Strategy for Dengue Prevention and Control in Curaçao, 2012) was found that contains agreements made by a multidisciplinary team regarding the prevention and control of DENV infection. We found that the lack of documentation leads to delays in key processes or holds up projects, restricts collaboration, and causes loss of data, communication gaps, uninformed decisions and lack of transparency.

Experts working for the ERU, VCU, and the Policy Department indicated that there was a plan (Project plan: Breeding sites elimination and cleaning action Curaçao, November 2014) that addresses the prevention and control of the *Ae. aegypti* mosquito during the CHIKV infection epidemic. However, this plan was made without collaboration, and it was not shared within the health system. The performed document analysis verified the existence of this plan, and the interviews conducted with experts and FGDs highlighted the fact that only one participant, who developed the plan, was aware of the plan's content. The mentioned plan only focuses on a public health campaign conducted during the CHIKV infection epidemic. It describes a part of the task of the VCU, Selikor (an organisation assigned to perform waste management) and a designated organisation that focussed on clearing streets. However, relevant departments/organisations/professionals such as the ERU, general practitioners (GPs), and laboratories are not mentioned, and an extended description of the multidisciplinary collaboration is not present in the plan. The reported lack of documentation and collaboration causes frustration among co-workers. The following quote portrays this issue:

Male 1: But explain this to me, so you have made a plan/protocol for the VCU?
Male 3: Yes.
Male 1: For vector control?
Male 3: Yes.
Male 1: Where is it now?
Male 3: I do not know; the general secretary has it now.
Male 1: But you cannot say that. The management team needs to approve it first. Did you discuss this with the management team?
Male 3: I do not know. Who is part of the management team?
Male 1: The general secretary (SG), director of the sectors (SD) and the director of the Policy Department are members of the management team. However, nobody else from the MoHEN (e.g. epidemiology) has received this plan?
Male 3: I do not know.
Female 1: I am glad that this group discussion is being recorded. In front of all my colleagues here, he said that he made a protocol for the VCU. A few minutes ago, we spoke about the importance of collaboration and that we need to work together, and look, he worked again on his own.
Male 1: He made it on its own, again! Moreover, he is implementing his protocol.
Moderator: So this is an excellent example?
Male 1: Yes.
-FGD with health professionals working for the MoHEN

The quote above portrays how separated from each other, in a siloed manner, the employees of the MoHEN work. In addition, interviewed experts indicated that leadership skills and knowledge regarding VBDs among the personnel with leadership functions were insufficient. This issue obstructs guidance and collaboration in developing protocols for the prevention and control of VBDs. For example, obtained data collected from documents and interviews with experts highlighted the fact that policies/protocols/plans (e.g., surveillance of microcephaly or pregnant women*)* were also lacking during the Zika epidemic.

Health information system

Data that was drawn from this qualitative study highlighted the following challenges regarding the collection, analysis and dissemination of information concerning VBDs within and outside the health system of Curaçao.

Challenges associated with entomological practices

Experts indicated that the VCU, which is responsible for collecting information related to mosquitoes and their breeding sites, has been facing challenges to recruit and maintain professionals with the capacity to collect entomological data. This challenge, in turn, obstructs the data collection on local mosquito fauna. A report written by two external medical entomologists confirmed this statement. Additional file 10: Table S4 presents published data concerning mosquito species of Curaçao. Both the report and some experts agreed that information concerning local mosquito fauna is scarce and old (from the late 1940s). A local medical entomologist elaborated on this topic and reported six more species (i.e., *Aedes infirmatus*, *Aedes sollicitans*, *Aedes triseriatus*, *Aedes vexans*, *Coquillettidia perturbans*, *Aedes condolescens*) that need to be added to the list. However, the presence of these additional species needs to be verified. The workforce of the VCU also confirmed this issue. They stated that the surveillance of mosquito species is non-existent. The following quote portrays this issue more in-depth.

> *Moderator: Okay, let's continue with the next topic. We spoke about the problem concerning documentation. The steps that need to be taken are not clear. We spoke about the challenges that departments of the government had during the epidemics. We spoke about laws and structure. Let us talk about surveillance, surveillance of the vector. Can you describe how surveillance of mosquitoes was performed during the epidemics? And currently? Do we monitor mosquito species present in Curaçao, and do we test the mosquitoes to check for viruses?*
> *Male 4: What do you mean? The control that we are performing now?*
> *Moderator: No, I am talking about the surveillance of the vector, not vector control. For example, the ERU is responsible for the surveillance of cases of VBDs, and the VCU is responsible for the surveillance of the mosquitoes.*
> *Male 4: Look, we had a surveillance system, but currently, we are not monitoring mosquitoes because we do not have the means to do it. We need to create a structure for the surveillance of mosquitoes to have continuity. I mentioned this in the policy that I made for the VCU.*
> *Moderator: Thus, currently, there is no surveillance of mosquitoes?*
> *Male 4: No, there is no surveillance of mosquitoes. We are using old information and data that you (PhD students) are currently collecting.*
> -FGD with health professionals working for the MoHEN

Since there is no ongoing surveillance of mosquitoes, there is no monitoring of the insecticide resistance status of *Aedes* populations. This leads to minimal dissemination of information concerning the vector of DENV, CHIKV and ZIKV within the health system.

The reliability of collected entomological data

Some experts have questioned the analysis, interpretation, and entomological data usage. According to an evaluation report, the ERU analyses collected data concerning larvae and pupae to determine entomological indices (e.g., household index, container index) for the VCU. Interviewed experts working for the ERU reported this written task division and indicated that the mentioned data analysis happened once. The data were collected in 2015 (not the entire year) by the VCU and analysed in 2016. Experts working for the ERU reported that the data analysis was obstructed because the collected data were unreliable. The data were collected by a workforce with limited capacity concerning entomological field techniques. Data drawn from the FGDs and interviews with experts revealed that the lack of entomological information affects the performance of VCU negatively because changes in geographical distribution and density of the vector are not taken into account to guide vector control strategies. Also, these missing data obstruct the evaluation and adjustment of vector control strategies, in turn negatively affecting decision-making processes.

Challenges associated with surveillance systems

Some experts have also questioned the surveillance systems (laboratory and syndromic surveillance systems) that the ERU uses to detect the presence and activity of VBDs in Curaçao. Data drawn from this qualitative study highlighted the following two critical bottlenecks which obstruct the surveillance of cases of VBDs:

1. Delays in disseminating information: The timeframe to report the laboratory-confirmed cases to the ERU was greatly extended in the last five years. Delays in disseminating information concerning laboratory-confirmed cases could have caused delays in detecting the onset of VBDs in Curaçao. The following quote portrays this issue:

   "Before 2008, the dissemination of information concerning laboratory-confirmed cases was conducted in a timely fashion. However, after 2008 a deterioration in the dissemination of laboratory information was observed. This is possibly caused by the competition between laboratories, lack of guidance and policy concerning the surveillance of VBDs. So, the information that I am receiving from the laboratory cannot be used to detect epidemics of VBDs because it takes months before the information is reported. We are walking behind the facts."
   -Sarah, epidemiologist

2. The surveillance system's sensitivity: Several experts have stated that prevention and control actions to combat the CHIKV infection epidemic started late. One expert indicated that the syndromic surveillance system was not sensitive enough to detect the CHIKV infection epidemic's onset. The

epidemiologist responsible for the surveillance system during the epidemic of CHIKV infection concluded in late 2014 that the method (mean incidence) used to identify the epidemic of CHIKV infection was less sensitive than the Endemic Channel method. The Endemic Channel method was introduced during the CHIKV infectious epidemic (beginning 2015); this method uses the previous seven years' surveillance data (e.g., fever as a proxy for some VBDs) to determine three threshold levels. These cut-offs would allow the epidemiologist to identify how the current incidence would relate to past data, indicating if the observed incidence is below expected (success), as expected (safe) or higher than expected (alert). The Endemic Channel method is more suitable for detecting epidemics in small countries with small data sets. This statement has been confirmed with the information illustrated in Fig 2.

3

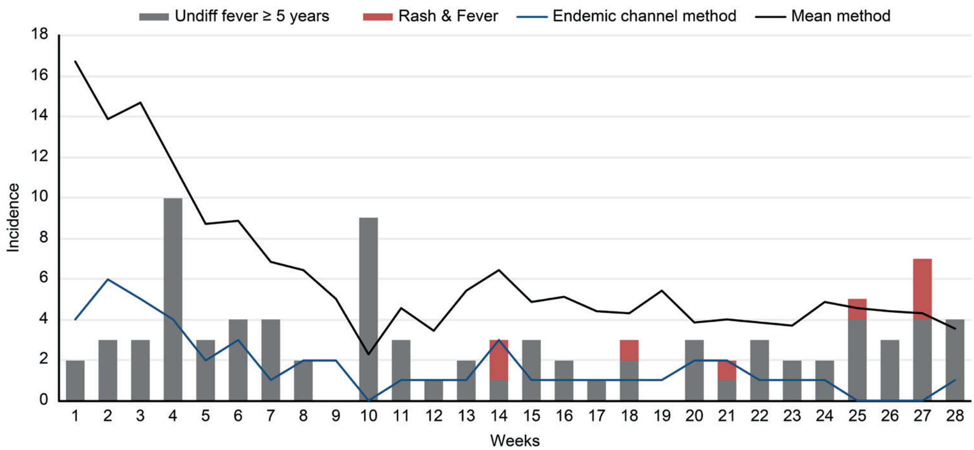

Figure 2. Comparison of two cut-off values to detect outbreak/epidemics.
Reprinted from Syndromic Surveillance 2020 by the Department of Epidemiology and Research Unit Curaçao, 2020. Note: Both methods use fever and rash as a proxy for DENV, CHIKV and ZIKV infection.

Despite the information from PAHO/WHO alerting all countries of the Americas, these two bottlenecks could be possible explanations for the reported delay in detecting the onset of the CHIKV infection epidemic. The reported delay in detecting the onset of the CHIKV infection epidemic might have obstructed the response of the ERU to inform needed stakeholders (e.g., GPs, VCU, communication department, laboratory etc.) to start with actions related to the prevention and control of VBDs.

Challenges associated with disseminating information

All interviewed experts indicated that the dissemination of information within the health system and to the community or other stakeholders was minimal during the last three epidemics of VBDs, especially during the CHIKV infection epidemic. For example, GPs, an important stakeholder group, have stated that the government's communication needs to be improved because limited instructions and updates were offered during the epidemics. Also, it has been stated that information with regards to VBDs did not reach every GP. The following quotes portray the mentioned communication problems:

> *"GP: I think that the flowchart of information needs to be improved. Look, the national epidemiologist reaches a specific group of GPs that are members of the association of GPs. It is always the same GPs that are present during presentations and meetings organised by the association. For example, when you go to meetings organised by the association, about 40 of the 100 GPs are present. Thus, there is a group that you are not reaching.*
> *Interviewer: That is a piece of useful information.*
> *GP: For example, in most cases, GPs who speak Spanish are not present: thus, they are a group that is difficult to reach. Also, with e-mails.*
> *Interviewer: Do you notice that fewer Spanish-speaking GPs attend the meetings?*
> *GP: Yes, they are doing their best to change how they share information. The information is shared in Papiamento or English. However, English can be challenging to understand."*
> -Sol, geriatrician

> *"It is interesting because many people were tested without no valid reason, like old females. Why? Was the protocol not clear for the GPs?"*
> -Sarah, epidemiologist

> *"GP: In the case of CHIKV infection, I had the idea that the GPs were confused; the recommendations were not concrete, testing or no testing? I think the capacity to test was limited. I am not sure about the problem, but the recommendations were not clear. The community was sick, and it was challenging to contact The MoHEN. I called a few times to ask for advice."*
> -Sol, geriatrician

Communication problems within and outside the health system have been discussed in different documents; for example, in an evaluation report, written by the "Court of Audit Curaçao", entitled "Report Chikungunya" and observation notes of meetings organised by the workforce of the health system. The evaluation report mentioned above confirmed the reported lack of communication between stakeholders, including GPs, and highlighted that the absence of a communication strategy plan obstructed communication between the stakeholders during the epidemic of CHIKV infection.

Financing system

The method used to raise funds for the departments responsible for preventing and controlling VBDs has been discussed in five documents (two evaluation reports, the budget of the MoHEN 2019-2022, and two observation notes), FGDs and interviews with experts. The government of Curaçao mainly generate funds for its ministries through taxes. There is no specific fund destined for the MoHEN. The MoHEN develop a budget each year and submit its financial request to the government; the budget is reviewed to set priorities. We could not locate and review the assigned budget to prevent and control DENV, CHIKV and ZIKV infection epidemics. Lack of documentation could explain why we did not get an overview of the budget and the expenses made in the last years.

A budget made for 2019-2022 was obtained, and it indicates funds that are meant to be available for the prevention and control of VBDs. For example, 25.000 NAF (Antillian Guilders) (±13.740 USD, 1 USD= 1.82 NAF) was available for detection and control of pests (e.g., the use of insecticide or pesticide), 50.000 NAF (±27.470 USD) for health promotion, including RC, 50.000 NAF for the training of the workforce of the THZ, 25.000 NAF for purchase of machines and 7.500 NAF (±4120 USD) for other materials (e.g., uniforms, gloves etc.). These amounts were budgeted for 2019, 2020, 2021, and 2022 respectively. This budget was presented and discussed during FGDs and interviews with experts; remarkably, most interviewees never saw this budget. Data drawn from these interviews/discussions indicated that a critical bottleneck in the financing system is the manner of making the budget for the departments of the MoHEN. Some experts stated that during the CHIKV infection epidemic, the budget of the departments of MoHEN was made by a government official with authority. The budget was never presented or discussed with the involved departments. The following quote portrays this issue:

> *"Male 1: Yes, what he needs to do is, talk with the heads of departments every year, to plan, to know what the departments need to function. Ask what they need for the next year? How much personnel is needed? Materials? Talk about these factors and develop a budget. He added all the expenses together, for example, health promotion materials and came with a budget for all departments. He needs to explain how much each department needs for health promotion and give each department their money when it is needed. That is what he needs to do, but this never happened.*
> *Male 2: He needs to respect the budget too.*
> *Female 1: Yes, respect it because currently, they are using the budget of one department to cover financial issues of another department."*
> -FGD with health professionals working for the MoHEN

The reported lack of collaboration in drafting the budget of MoHEN leads to a budget that is not realistic and suitable to cover the expenses of the involved departments during the epidemics. For example, a policymaker indicated that during the ZIKV infection epidemic, 50.000 NAF was available for health promotion; however, the actual expenses were 150.000 NAF (±82.420 USD). The presented budget for 2019-2022 also confirmed the fact that the budget does not take economic inflation into account because the same amount of money has been budgeted for each year. Besides, both an evaluation report and the majority of interviewed experts indicated that the funds allocated for specific expenses (e.g., working materials, training, etc.) are not available when needed. The workforce of the VCU elaborated further on this topic and stated that due to limited financial support, there were limited materials (e.g., insecticide), personnel, and training for personnel during the CHIKV infection epidemic. The following quotes portray this issue:

> *"Male 2: There was no workforce at that moment.*
> *Female 2: Workforce, there was no personnel to perform control of mosquitoes.*
> *Male 2: We need to blame the government again because there were no inspectors to perform vector control.*
> *Female 4: Yes.*
> *Moderator: Thus, when the CHIKV infection outbreak started, there were no inspectors to perform vector control?*
> *Male 2: No, nobody.*
> *Female 4: No.*
> *Moderator: Thus, you looked for personnel during the epidemic of CHIKV infection?*
> *Male 2: Yes.*
> *Female 4: Twenty kids, twenty young people.*
> *Female 2: Educated fieldworkers who worked for the MoHEN retired, and new employees were not recruited."*
> -FGD with the workforce of the VCU

> *" Male 1: We need uniforms; my white shirt is almost brown now.*
> *Female 3: Our badges expired long ago."*
> -FGD with the workforce of the VCU

> *" Moderator: You are working now with Abate?*
> *Male 1: Yes.*
> *Moderator: Do you have the possibility to wash your hands after using Abate?*
> *Male 1: No.*
> *Female 2: That is what he explained.*

Female 1: We got a hand sanitiser to disinfect our hands.
Male 1: No mask or gloves were given. We need to supply ourselves with what we need.
Female 1: Nothing was given to us."
-FGD with the workforce of the VCU

Remarkably, funds are being allocated for the prevention and control of VBDs. However, it is not being used as planned in reality or does not cover the actual expenses. Experts stated that the performance of departments has deteriorated due to the budget retrenchments that happened in the last two decades. No investments were made to maintain the capacity and quality of vector control, research, and communication practices. Previous ministers of health have confirmed this issue, and according to one interviewed minister, the government needs to change its approach to deal with the health sector, especially with prevention. The government does not see its expenses as investments to improve the health sector. This mindset leads to more budget retrenchment.

The health workforce

The MoHEN Business plan (2011-2014) provides information concerning the required formation for a well-functioning unit to prevent and control zoonotic diseases in Curaçao. This estimated formation has been compared with the available workforce during the epidemics of VBDs (Additional file 11: Table S5). After comparing this information, it can be stated that the departments responsible for the prevention and control of VBDs are understaffed. For example, according to the Business plan, the ERU needs nine full-time employees (FTEs) (Additional file 11: Table S5). However, during the last three epidemics, the ERU consisted of three employees; one medical doctor/ epidemiologist (1 FTE) and two other health professionals specialised in epidemiology and public health (2 FTEs).

As shown in Additional file 11: Table S5, and according to an evaluation report (written by two external medical entomologists), the VCU had no head, entomologist, or any employee able to identify mosquitoes to species level during epidemics of CHIKV and ZIKV infection. Besides, the VCU field workers had their contracts renewed several times because they have short-term employment contracts. The field workers elaborated further on this topic and stated that the insecurities concerning their contracts reduce their motivation to perform their duties. Also, most of the field workers feel that they are being used and are not valued. The following quotes portray the concerns of the field workers:

> *"Male 1: We got more things to do and what happened is that our work got mixed-up. That is the reason why I told my coordinators that they are using us. We, as field workers, are being used. We are here to prevent and control mosquitoes; thus, we need to work only with mosquitoes. We cannot work with all types of vectors because we do not have the education. We need to stand up and say we came here to work with mosquitoes.*
> *Moderator: Okay.*
> *Male 1: That is what we need to do."*
> -FGD with the workforce of the VCU

> *" Female 1: Look, the field workers that are working for the VCU are not inspectors specialised in vector control. I know that you are recording, but this is the truth. They are not inspectors.*
> *Interviewer: I understood that they are not inspectors for vector control, but they have worked with different types of vectors.*
> *Female 1: Yes, they are not educated inspectors. They are being used as a shield, and that is the problem. It is criminal because the government creates a false sense of security. That is not okay."*
> -Elsa, entomologist/ policymaker/ registered restricted pest controller

As shown by the quotes above, the field workers are called "vector inspectors" however, according to an evaluation report and interviews with experts, these field workers only received training, limited to two weeks, in mosquito prevention and control strategies. Thus they are not certified to do all types of work related to vector control. Due to limited financial resources, minimal training opportunities were offered to the workforce in the last ten years. Most of the certified inspectors have retired, and during the epidemics, the VCU only had three certified inspectors. Besides the VCU and the ERU, the Department of communication also faced issues related to its workforce. Several interviewed experts indicated that the Department of communication employees do not have the education, skills, and creativity to develop a strategic communication plan to reach most of the community. Both participants of the FGDs and interviews have questioned the manner of recruiting the health system workforce. Some experts have stated that some health professionals have been recruited based on bureaucracy and not on professionalism. Mentioned issues with the workforce have been discussed with the Policy Department and the director of the health sector. The data of this study revealed that these issues are known. However, limited actions have been carried out to improve the workforce's capacity in the last ten years.

Medical products and technologies

The treatment of dengue, chikungunya, and Zika relies on supportive therapy and symptom relief since no antiviral treatment is available. According to the interviewed GPs, the health system of Curaçao had ensured equitable access to medical products during the epidemic of CHIKV infection. Besides medical products, the health system needs to arrange or collaborate with organisations to access the required technologies, such as diagnostics tools. Since laboratories play an essential role in diagnosing these diseases, input and collaboration between laboratories and the health system have been discussed during FGDs and interviews with experts. Several interviewed experts questioned the collaboration between the laboratories and the health system. They stated that the agreements made between MoHEN and laboratories, especially Analytisch Diagnostisch Centrum (ADC) laboratory, the public health laboratory, are not documented. This causes no or delay in reporting laboratory-confirmed cases of VBDs, no sustainable collaboration, and a lack of cost-effectiveness. The following quote illustrates the mentioned issues:

> *"Male 2: The performance of ADC is not in concordance with the guidelines of a public health laboratory. That is not good.*
> *Male 1: The government never defined ADC's role as "the national public health laboratory". The government just mentioned its role, but it has not been documented.*
> *Male 1: They have a severe problem.*
> *Female 1: Yes, they have a problem.*
> *Male 2: Yes, there is a problem. When I started with my job in 2008, the government gave the national laboratory 2.8 million guilders for public health issues (e.g., to pay laboratory tests).*
> *Male 1: Annually.*
> *Male 2: Annually? Really?*
> *Male 1: Yes.*
> *Male 2: But it strange, because if the government needed laboratory tests, they needed to pay for the tests again.*
> *Male 1: Yes, we [MoHEN] needed to pay again.*
> *Male 2: This happened during the dengue outbreak.*
> *Male 1: And in the period of Zika, we [MoHEN] paid ADC more money."*
> -FGD with health professionals working for the MoHEN

An interview with a representative of ADC was conducted to hear their side of the story. However, limited information concerning the collaboration and agreements between the health system and ADC was provided. ADC only indicated that they need to diminish information concerning VBDs when the health system asks for it (e.g., during an epidemic). In contrast, the health system expects their collaboration during the entire year for the surveillance of VBDs.

Larval control was performed using Aquabac™ 200g granules, guppies (*Poecilia reticulata*) or Abate™. In some cases, kerosene was sprayed in cisterns and sometimes in mangroves. Adult mosquitoes were treated with chemical control measures in response to complaints of a severe nuisance. Adulticiding was performed through hot fogging with Masterline™ Aqua-kontrol 30-30 (a synergised [combining with piperonyl butoxide] synthetic pyrethroid, with permethrin as active substance) with thermal foggers London™ fogger ULV Model 1800E, around 5 a.m. or 6 p.m. The interviewed workforce of the VCU indicated that when the CHIKV infection epidemic started, there was insufficient working material, including personal protective equipment, biological and chemical products. The performed observations also confirmed the reported problem with limited resources. The fieldworkers worked with Abate™ without proper protection, such as gloves, safety glasses or adequate clothing to minimize exposure to the chemical substance. During their fieldwork, they do not have access to water to wash their hands after using the mentioned substance. Also, tools (e.g., tubes, pots, a hand lens etc.) needed to perform basic entomological research were lacking.

Service delivery

According to observation notes, the VCU has offered the following free services to the community and organisations to prevent and control mosquitoes during the last three epidemics of VBDs: (i) inspect houses of infected locals and their neighbours for mosquito breeding sites, (ii) provide larvicide (e.g., Abate™), (iii) fumigation, (iv) provide guppies (*Poecilia reticulata*), and (v) perform health promotion. Several experts questioned the service delivered by the VCU. They indicated that the service delivered was obstructed by the following factors; insufficient larvicide, educated field workers, entomological field equipment, financial support, guidance, and collaboration between governmental and non-governmental organisations. Two evaluation reports have confirmed the mentioned statement.

Furthermore, an evaluation report written by two external entomologists indicated that little scientific literature had been used to update vector control practices in the last decade. A local entomologist has confirmed this statement by giving the following example: Abate™ was previously primarily used, but it was replaced with an environmentally friendly substance, Aquabac™. In 2018, Abate™ was re-introduced by the former head of the VCU without taking related consequences (e.g., insecticide resistance) into account. The following quote illustrates this issue:

"*Female 1: Yes, we had all that stuff [larvicide]. I introduced a growth hormone. What is its name again?*
Interviewer: Bti Bacillus something.
Female 1: Bacillus thuringiensis israelensis (Bti)(Aquabac™)
Interviewer: But Bti was replaced with Abate.
Female 1: That is a bad idea. In many aspects, it is a bad idea.
Interviewer: But as a toxicologist, he should know that.
Female 1: But he does not understand environmental health. Look, please consider this information and take it with you. Maybe you know this already. Abate is still helpful to combat larvae; vectors are predominantly resistant to many substances nowadays. Thus, Abate needs to be your last resource. If you are using it in the long term, you need to plan to switch the substances you are using.
Interviewer: Thus, it is like you start treating everybody in the hospital with Colistine?
Female 1: Exactly. It's a bad idea, and I told them,".
-Elsa, entomologist/ policymaker/ registered restricted pest controller

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Abate™ and Aquabac™ usage within the VCU was also a concern of many experts. They stated that the fieldworkers do not know how to work with larvicide (Abate™) and Aquabac™. The fieldworkers themselves have confirmed this statement. The following quote illustrates this issue:

"Male 1: The employee that hands out Abate; he works in the storeroom; he does not know how to deal with Abate and Bti. He cannot give the correct information. He got some information, and that is what he is using. Just let me ask them [field workers], how much Bti or Abate do you need to treat a small pool? They do not know.
Moderator: Thus, what you mean is that the guideline to use Abate and Bti is not clear? Moreover, you are using these products based on feelings?
Male 1: Yes.
Male 2: Yes. Just like that."
-FGD with the workforce of the VCU

As shown by the quote above, the lack of knowledge and skills concerning the usage of biological and chemical substances to prevent and control VBDs obstruct the health system's performance.

Lastly, some experts stated that the vector control during house inspections has deteriorated because the fieldworker's work has not been evaluated and supervised by educated inspectors in the last decade. This causes distrust towards the VCU and their collected entomological data. Field excursions with the fieldworkers demonstrated unethical behaviour (e.g., falsified house inspection) that diminishes trust towards the VCU. On the other hand, no access to properties and inhabited houses also obstructs the fieldwork of the VCU. According to some experts and observation notes, many assigned houses are not inspected since the owners are not at home during the working hours of the VCU. Another bottleneck is the planning to perform vector control in a year. Vector control starts at one side of the island and finishes on the other. There are no assigned teams for specified neighbourhoods. Several experts have questioned this approach since it has been shown to be inefficient in preventing and dealing with an epidemic. They also stated that prevention, including RC and mosquito control measures, had been implemented reactively (in response to epidemics, severe nuisance, and infected cases) and not from a proactive perspective.

Discussion

Information concerning health system performance among SIDS currently lacks in the scientific literature; therefore, research is needed to assess health system bottlenecks to work towards more resilient systems. This qualitative study aimed to examine the performance of the health system of Curaçao regarding the prevention and control of VBDs in the last decennium by using the WHO health system building blocks. The performance of the health system of Curaçao was negatively affected by insufficient collaboration between governmental and non-governmental organisations (NGO's), leadership skills, coordination, structure, communication within and outside the health system, qualified health workforce, and capacity-building. Other SIDS in the Caribbean (21) and the Pacific (22) also struggle with similar organisational bottlenecks as a result of their size, limited resources, geographic dispersion and dependence on foreign markets and financing (23). Most studies, including the studies mentioned above, focussed on one section of the health system and thus failed to holistically research health system performance. Our study went a step further by using a well-known theoretical framework to highlight the complexity of this matter. We observed how building blocks influence each other. Therefore improving the health system building blocks without recognising their interaction will lead to unsuccessful health system structures and management systems, which will continue to fail to address the existing health challenges (24). Currently, the health system of Curaçao faces challenges in controlling COVID-19. Guidelines, oversight, collaboration, and communication are still insufficient. Thus, the above mentioned organisational bottlenecks continue to impose barriers to the health system's performance in the current pandemic of COVID-19.

Our findings also highlight some aspects of the organisational culture of the health system of Curaçao. We found that the workforce works in a siloed manner to avoid being blamed for mistakes. Also, they believe they must interact with people in ways that will not threaten their employment security because bureaucracy still plays an essential role. The characteristics of avoidance, conventional, and approval culture styles are associated with the passive/defensive culture style (25). Organisations with passive/defensive cultures have many unresolved conflicts, and the workforce often reports lower levels of job satisfaction and motivation (26). These aspects were also observed in this study. This study gave some valuable insights into the culture of the health system of Curaçao. However, to study this complex mechanism more profoundly, the literature suggests using the Organisational Culture Inventory tool (25).

This study showed how different health system bottlenecks had obstructed the development, approval, and implementation of laws/guidelines and interventions, such as the Integrated Vector Management (IVM) program in Curaçao. A common challenge observed in our study and others in implementing the IVM program is the lack of stakeholder engagement and support (27, 28). Stakeholder participation in IVM reduces overlap, avoids duplication of activities, and saves costs by making better use of existing human and financial resources (29). All stakeholders need to recognise the significance of the IVM program and commit to implementing the program. Otherwise, VBDs control will remain fragile in the country. According to the WHO, the IVM program requires good coordination and oversight to allocate funds and adequate human capacity and to monitor and improve stakeholder engagement (30). Therefore, we developed an action plan (Table 1 in the Addendum, pages 233-234) to reinforce oversight of the IVM program of the health system of Curaçao. This action plan will provide guidance, create transparency, and establish a platform to communicate and collaborate within the health system.

Qualitative research is often criticised because the findings cannot be generalised and do not prove causality. However, when studying organisational processes, perceptions, and experiences of people, qualitative studies provide the opportunity to explore the reasons, motivations, and procedures that affect the functioning of the health system. To minimise the mentioned limitations and improve this study's quality, we combined four qualitative research methods to provide a confluence of evidence that breeds credibility. Furthermore, the sample size can be considered small for this type of research. However, this sample is believed to be fairly representative of the distribution of people in the health system's hierarchy; age, gender, experience, education, and the participant’s job confirm this.

Conclusions

Based on our findings, we can conclude that the performance of the health system of Curaçao was not optimal during the last epidemics of VBDs. Various internal and external factors negatively influenced the performance of the health system in the last decade. There is a strong need for an overall policy, proper job descriptions, a trained health workforce, structural communication, and collaboration. Therefore we recommend (i) reinforcing the oversight of the IVM program and administrative structure and (ii) evaluating and reforming the organisational structure of the health system of Curaçao by using our developed action plan. Undoubtedly other SIDS can also benefit from our action plan since; (i) they cope with similar organisational bottlenecks, and (ii) such an action plan covering all health system building blocks to improve health system performance concerning prevention and control of VBDs for SIDS is lacking.

Abbreviations

ADC: Analytisch Diagnostisch Centrum, AIDS: Acquired Immunodeficiency Syndrome, Bti: *Bacillus thuringiensis israelensis*, CHIKV: Chikungunya Virus, COVID-19: Coronavirus Disease, DENV: Dengue Virus, EEE: Eastern Equine Encephalitis virus, ERU: Epidemiology and Research Unit, FGDs: Focus Group Discussions, GPs: General Practitioners, HIV: Human Immunodeficiency Virus, IVM: Integrated Vector Management, MoHEN: Ministry of Health, Environment and Nature, NAF: Antillian Guilders, NGO's: Non-governmental Organisations, PAHO: Pan American Health Organization, RC: Risk Communication, SD: Director of the Sector, SG: General Secretary, SIDS: Small Island Developing States, SLE: Saint Louis Encephalitis virus, THZ: Technical Hygiene and Care, USD: United States Dollar, VBDs: Vector-borne diseases, VCU: Vector Control Unit, VEE: Venezuelan Equine Encephalitis virus, WHO: World Health Organization, WN: West Nile virus, ZIKV: Zika Virus.

Ethics approval and consent to participate

The Medical Ethical Board of the Sint Elisabeth Hospital Curaçao approved this study (METC SEHOS; reference number:2017-003). All participants signed a written informed consent. All data were anonymised and stored in files accessible only to the principal investigators.

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CHAPTER 4

Understanding risk communication for prevention and control of vector-borne diseases: a mixed-method study in Curaçao*

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Abstract

Background

Risk communication (RC) is an essential tool for the prevention and control of diseases as it impacts risk perception, increases awareness and might change behaviour. It is the interactive exchange of information about risks among experts and people. Effective RC can minimize the impact that diseases such as dengue, chikungunya and Zika have on populations. This study aimed to understand RC regarding vector-borne diseases in its social context and from the viewpoint of the audience to strengthen RC strategies in Curaçao.

Methods

In 2015, a cross-sectional mixed-method study applying focus group discussions (n=7), in-depth interviews (n=20) and a structured survey questionnaire (n=339) was done in Curaçao. The study was designed based on the Health Belief Model and the Theory of Planned Behaviour. In addition, the Social Amplification of Risk Framework and the theory of cultural schemas were applied to understand RC in the social context.

Results

Television, radio and newspapers were the most important channels of information regarding dengue and chikungunya. Moreover, individuals also reported receiving information via social media, the internet and family/friends. Interestingly, the use of internet to obtain information diminished with age, while females were more likely to use internet compared to men. These key findings were statistically significant. An important outcome was that the risk perception towards chikungunya at the beginning of the outbreak was attenuated. This might be due to the (perceived) lack of RC before the epidemic. This same risk perception was amplified later during the outbreak by the increased exposure to information. Lastly, we show how cultural schemas influence people's perception regarding preventive measures and treatment of chikungunya and dengue.

Conclusions

Data obtained emphasise the importance of understanding the *user* of media platforms and sharing information in a timely fashion through a transparent process with the content that convinces people of the seriousness of the matter.

keywords: Zika, dengue, chikungunya, mixed-methods, social amplification of risk, Caribbean

Author summary

Vector-borne diseases (VBDs) such as dengue, chikungunya and Zika are an increasing public health concern worldwide. The mentioned VBDs are transmitted to humans through the bite of an infected mosquito from the *Aedes* species. Preventing or reducing VBDs continues to depend mainly on vector control and interrupting human-vector contact. Risk communication (RC) is the interactive exchange of information about hazards among experts and individuals. As it influences individuals' behaviour, a better understanding of how it works is vital to improving RC strategies in the context of VBD prevention and control strategies. Our study highlighted the complexity of this matter as we found that there are multiple factors, including the volume of information, trust, experience with a similar disease and cultural schemas that determine how people cope with risk and information. We recommend broadening the use and scope of media platforms to share information and to customise the messages taking the cultural schemas of the community into account.

Introduction

Dengue, chikungunya, and Zika are an increasing global public health concern as a result of their dramatically increased burden of disease and rapid geographical spread (1-4). Dengue is the most important arthropod-borne viral disease in humans. It is endemic in 125 countries mostly in America, South-East Asia and Western Pacific regions (5). Approximately 4 billion people are now at risk of dengue (2). A dengue virus (DENV) infection causes a flu-like illness and occasionally progresses to severe forms of dengue: dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) (5). Individuals infected with chikungunya virus (CHIKV) generally have symptoms such as high fever, skin rash and debilitating polyarthralgia, which usually persist 1-2 weeks. However, a proportion of cases progresses to the chronic stage of CHIKV infection, in which some symptoms, such as arthralgia, last for months to years (6, 7). Zika virus (ZIKV) infection has been linked to adverse fetal outcomes, including microcephaly and other congenital abnormalities in the developing fetus and newborn. Also, it has been associated with Guillain- Barré syndrome (GBS)(3), but one must take into account that GBS is also associated with other bacterial and viral infections, e.g. Campylobacter jejuni, Influenza and other Vector-Borne Diseases (VBDs) such as dengue and chikungunya (8-10). These VBDs present with flu-like symptoms and are generally self-limiting, barring the development of the aforementioned complications (11).

In the Caribbean, the primary vector of DENV (Flavivirus), CHIKV (Alphavirus) and ZIKV (Flavivirus) is *Aedes aegypti* (12). *Ae. aegypti* is a tropical and subtropical mosquito species widely distributed around the world, mostly between latitudes 35 ^{0}N and 35 ^{0}S (13). Given the vector distribution, countries located in the tropical and subtropical regions are susceptible to its invasion and spread (13). In Curaçao, a Caribbean island within the Kingdom of the Netherlands, all four serotypes of dengue (DENV 1-4) have circulated during the past two decades (14). According to local health authorities, dengue epidemics occur cyclically. CHIKV caused a significant outbreak in 2014-2015, affecting up to 50% of the population (Ministry of Health, Environment and Nature of Curaçao, 2016). In 2016, the introduction of ZIKV caused another major outbreak in the country. The Department of Epidemiology and Research of the Ministry of Health (MoH) reported that since December 2015 up to August 2017, a total of 2314 laboratory-confirmed ZIKV cases were recorded. However, it should be noted that confirmed cases only represent a fraction of those who were infected, as up to 80% of the individuals with ZIKV infection are asymptomatic and not everyone experiencing symptoms, which may be very mild, will visit a health facility (15). The MoH estimates that at least 50% of the local population had been infected with ZIKV (I. Gerstenbluth, personal communication). This is comparable to the reported attack rates in French Polynesia (66%) and Yap Island (73%) (16, 17).

The treatment of dengue, chikungunya, and Zika relies on supportive treatment and symptom relief since there is no antiviral treatment available. Considering the possible complications of these viral diseases, prevention, prompt diagnosis and adequate intervention at the onset of disease symptoms are the main options for reducing the burden of disease. To date, no vaccines are available for Zika, and chikungunya (3, 18). There is a licensed dengue vaccine available. However, it is not suitable for large-scale use (19). Thus, the prevention or reduction of the transmission of the mentioned VBDs hinges primarily on control of the mosquito vectors *(e.g. environmental management, biological and chemical control)* and interruption of human-vector contact *(e.g. individual protection including the use of repellents, clothing that minimises skin exposure, and household protection including window and door screens, and air-conditioning)*(13, 20).

Risk communication (RC) refers to the exchange of real-time information, including advice and opinions between experts and individuals facing threats to their health, economic or social well-being (21). It is an essential tool for the prevention and control of diseases because it can supply individuals with the knowledge needed for an optimal decision-making process (22, 23). The Health Belief Model (HBM) is one of the most widely used and validated theoretical models to understand the decision-making process and the health-seeking behaviour of individuals (24). Core concepts in the HBM are the perceived susceptibility and the perceived severity of the condition, leading to the perceived threat. The perception of threat is integral in the decision-making processes of individuals because it plays an essential role in motivating health behaviour change (25). An essential concept in the HBM that influences the perceived risk and health-seeking behaviour is called "cues to action". Cues to action refer to strategies that activate readiness. According to a recent study published by Metta et al., individuals' previous experiences in managing conditions similar to malaria were considered to be cues to action, because their past experiences seem to have informed their self-medication decisions in the context of malaria (26). According to Hochbaum (1958), cues to action could be cultural schemas of individuals or information that individuals receive from media, informal and formal networks (27). Cultural schemas are deeply internalised and largely unconscious networks of associations built up over time that facilitate perception, interpretation, and action (28). Thus, cultural schemas are frameworks of a specific culture that exist in an individual's thoughts and have the ability to instigate actions. The cultural schemas are also shaped by the political context, which then influences the relation between the State and the individual/community(29).

Risk perception is also essential for RC because it determines which hazards individuals care about and how they deal with them. RC models such as risk perception, mental noise, negative dominance, and trust determination have been developed to understand how individuals perceive risk, how they process risk information, and how they make decisions about them (22). However, recent research indicates a general shift in focus towards models emphasising the importance of social-cultural factors for public acceptance of risk messages (30). The Social Amplification of Risk Framework (SARF), developed by Kasperson et al. has been prominent on research agendas in trying to understand the gaps between risk perception research and the social context (31). The framework seeks to explain how information processes, institutional structures, the behaviour of social groups, and individual responses shape the social experience of risk (32, 33). The SARF states that risk events interact with individual psychological, social and cultural factors in ways that risks are amplified, receiving public attention, or attenuated, receiving less public attention (32).

As essential as it is, RC in the context of vector/mosquito-borne disease remains a neglected topic in the scientific literature (22, 34-38). Although the mentioned studies give useful insights, they fail to explain RC through the individual point of view and in the social context. Therefore in this paper, we aim to understand RC regarding VBDs in the social context and from the audience's point of view. The audience in this study refers to people that experienced VBDs and that live in Curaçao. It is essential to take the audience's perception into account when studying RC because it permits RC experts to understand the audience's expectations, opinions and beliefs. The aim of this study will be addressed by seeking to understand (I) the user of the channels of information, (II) the risk perception regarding dengue and chikungunya, (III) the influence of cultural schemas on information, perceptions and preferences, and finally (IV) the information channels that individuals consider trustworthy. This knowledge will lead to applicable community-focused health messages and strengthen the preparedness and performance of RC for future epidemics in Curaçao, and other countries vulnerable to VBDs. We will use a mixed-methods approach based on the SARF, HBM, and the cultural schemas theory to investigate RC regarding VBDs.

Methods

Study design

In June and July 2015, a cross-sectional mixed-method (quantitative and qualitative) study using focus group discussions (FGDs), in-depth interviews (IDIs), and individual questionnaires (survey), was performed to assess community participation in Mosquito Breeding Site Control (MBSC) in Curaçao (39). The study was designed based on an integrated theoretical framework of the HBM and Theory of Planned Behaviour (TPB). This current study used the SARF, HBM and the theory of cultural schemas, as an analytical interpretive framework, to understand RC among the recruited study participants of the aforementioned cross-sectional mixed-method study. Three concepts of the HBM were incorporated in the SARF. The SARF was applied to explore which channels of information inform individuals about VBDs and the concepts of perceived susceptibility and perceived severity of the HBM were applied to understand the risk perception of the study population. The information coming from different channels was considered as a cue to action. The theory of cultural schemas was also incorporated in our integrated conceptual framework to understand the cultural dimensions in the processing of information at the individual level. Both SARF and cultural schemas were not applied at the time of data collection but were used for analysis and result interpretation. In this study, the qualitative data were analysed first and were validated and supported through quantitative analyses.

Study site

Curaçao (capital Willemstad) is an island in the southern Caribbean Sea, located ±65 km north of the Venezuelan coast. It has a surface area of 444 km^2. In October 2010, Curaçao became an autonomous country within the Kingdom of the Netherlands. The government of Curaçao is established under the framework of a parliamentary democracy, with a Prime Minister functioning as the head of government (40). According to the Central Bureau of Statistics (CBS) of Curaçao, the estimated population was approximately 160,337 inhabitants, with an average population density of 361/km^2 on January 1st, 2017 (41). There are different ethnic backgrounds, with an Afro-Caribbean majority and minorities such as Dutch, French, Latin American, South- and East- Asian, Portuguese and Levantine people (42). Official languages of Curaçao are Papiamentu, Dutch and English. However, Spanish is also widely spoken. The majority of the population of Curaçao is concentrated around the main economic areas of the island, the south-central part, where the oil refinery, the harbour, the government, and virtually all large employers are located (43).

Qualitative methods

Study population

Seven representative population groups of Curaçao were selected to participate in FGDs (n=50 participants)(39). The following groups were included; (I) residents born in the Netherlands; (II) local youth; (III) interviewers of the survey; (IV-VII) individuals from the neighbourhoods of Rooi Santu, Seru Fortuna, Souax and Koraalspecht) (S1 Table). The neighbourhoods Rooi Santu, Seru Fortuna, Souax and Koraalspecht comprise individuals of all socio-economic statuses. FGDs with the interviewers of the survey and residents born in the Netherlands were used as comparison groups. An FGD with the local youth was conducted to compare the experiences and perceptions of the local youth with adults. The IDIs were conducted among twenty adults with laboratory-confirmed CHIKV infection. The number of FGDs and IDIs needed in the study was determined after data saturation had been reached (44). Study subjects for qualitative research were recruited using the snowball recruitment technique, key informants, and via community centres (39).

Data collection

The FGDs consisted of 4-10 individuals per group with a similar socio-economic background. The FGD was conducted in Dutch or Papiamentu, depending on the preferences of the participants (39). IDIs and FGDs were recorded in Dutch and Papiamentu, translated to Dutch, transcribed and analysed using codes and code families.

Data analysis

Qualitative data were analysed using several codes, which refer to an idea, issue, topic or opinion that is evident in the data (45). Some of the codes were raised by the study participants themselves (inductive) while others were prompted by the interviewers using topics in the interview guide that were derived from literature and existing theories (deductive). We employed two cycles of inductive and deductive coding. In the first cycle, 59 codes were used when analysing the FGDs and IDIs. The coding list of both the FGDs and IDIs can be found in the supporting file S2 Table. These codes were assigned to 9 code families, which were analysed in the second cycle of analysis. The following code families were identified; (I) channel of information, (II) the user of the channel of information, (III) preferred channels of information, (IV) risk perception, (V) transmission routes, (VI) symptoms, (VII) preventive measures, (VIII) treatment options, (IX) trust in the channel of information. The qualitative data were analysed using Atlas.ti (version 8.2.0).

Quantitative methods

Study population

During the 2014-2015 chikungunya epidemic, adult subjects with serologically or clinically confirmed CHIKV infection were selected from a representative patient sample from 20 general practitioners (GP) across the island (39). Two of the subjects were self-diagnosed. Eligible subjects were either contacted by phone or visited at their residence for inclusion. Subjects consenting to participate in the study were interviewed at their homes. A total of 339 individuals joined the study (response rate: 82,5%). The characteristics of the study participants of the survey are presented in S3 Table.

Data collection

A questionnaire containing pre-coded and open questions was designed in Dutch and piloted, adapted and translated into English, Papiamentu, and Spanish. Local, experienced interviewers working for the CBS of Curaçao and speaking the above mentioned four languages conducted the interviews. The questionnaire addressed socio-demographic characteristics and chikungunya chronic disease persistence by applying the Curaçao Long-term Chikungunya Sequelae Score

(CLTCS Score) to measure the perceived severity of long-term chikungunya disease (46). The concepts of the HBM *(e.g., perceived susceptibility, perceived severity and cues to action),* aspects of risk communication *(e.g., channels of information)*, transmission routes and treatment options of dengue and chikungunya infection were measured using multiple 5-point Likert-items *(e.g. 1: do not agree at all to 5: fully agree)* or binary items *(e.g. "yes or no").*

Data analysis

SPSS Data Entry Station (SPSS Inc. 1996-2003, version 4.0.0) was used for quantitative data entry. All quantitative data were analysed by IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. Associations between categorical variables were analysed using the Chi-square test, the Fisher's exact test or the Fisher-Freeman-Halton exact test when appropriate. Cramér's V and Phi coefficient were used to measure the strength of association between two nominal variables (47, 48). Multicollinearity was assessed using the variance inflation factor (VIF). In this study, no collinearity was found. Univariate and multivariate logistic regression models were computed to examine the association between channels of information and socio-demographic characteristics. Characteristics that were significantly associated with the dependent variable, at a 0.10 alpha level in univariate analyses, were included in the multivariate regression model (49). The Enter method was used. For all other analyses, significance was determined at an alpha level of 0.05.

Ethics statement

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. The data was anonymised and stored in files accessible only to the principal investigators.

Results

The results are presented here by the following key themes; the user of the channels of information, the risk perception towards dengue and chikungunya, the influence of cultural schemas on information, perceptions and preferences and trust in the channels of information. The characteristics of the participants of the FGDs and IDIs, and the survey are presented in the supporting file: S1 and S3 Tables.

The user of the channels of information

The majority of the participants of both FGDs and IDIs reported having received information regarding dengue and chikungunya mainly via television, radio, and newspapers. A close analysis of the qualitative data revealed that the interpersonal channels of information *(e.g. friends, family members and colleagues who were infected with CHIKV, conventional and alternative medicine practitioners)* had also played an essential role in the provision of information regarding these diseases. These results are in line with those obtained in the cross-sectional study and published previously (39). This paper went a step further in understanding RC by analysing the associations between channels of information *(e.g. television, radio, newspaper, internet sites, social media, GP and family/friends)* and socio-demographic characteristics *(e.g. age, gender, education, income and occupation)* of the participants of the mentioned cross-sectional study.

Univariate analyses showed that the younger participants *(18-50 years n=163)* were more likely to receive information regarding chikunguya via social media (18.4% vs 5.7%, p <0.001), internet (24.5% vs 6.9%, p <0.001) and family/friends (49.7% vs 35.1%, p=0.01) compared to the older participants *(≥ 51 years n=174)*(S4 Table). In the context of dengue, the younger participants *(18-50 years n=161)* were more likely to receive information via their GPs (22.4% vs 10,1%, p= 0.003), social media (13.7% vs 3.6%, p <0.001), and internet (19.3% vs 6.5%, p <0.001) compared to the older participants *(≥ 51 years n=168)*(Table 1). Futhermore, women *(n=246)* were more likely to receive information regarding chikunguya from the internet (18.3% vs 7.7%, p=0.02) and family/friends (46.7% vs 29.7%, p <0.001) compared to men *(n=91)*(S4 Table).

We also found that the tendency to use the internet for information on dengue increased with the level of education (Table1). The same trend was observed in the usage of internet and social media to seek information regarding chikungunya (S4 Table). This trend also holds true with respect to the usage of GPs as a source of information on dengue (Table 1). We also found a significant association between the usage of newspapers as a channel of information regarding dengue and level of education (Table 1).

With regards to employment, we found that the usage of internet and social media as channels of information on chikungunya was higher in individuals that had a paid job compared to individuals who were unemployed or retired (S4 Table). Individuals with paid jobs were more likely to receive information regarding dengue from their GPs compared to individuals who were unemployed or retired (Table 1). Univariate analysis also showed that the usage of television as a channel of information regarding dengue diminished with increasing income (Table 1). Although not significant, the use of internet and social media showed an increasing trend with income (S4 Table). Only the significant associations are presented in table 1.

Table 1. Selected comparisons between socio-demographic characteristics and the use of channels of information regarding dengue

Age vs GPs	**Users n (%)**	**Total number of subjects**	***p*-value**
18-50 years ≥ 51 years	36 (22.4) 17 (10.1)	161 168	0.003^
Age vs Social media	**Users n (%)**	**Total number of subjects**	***p*-value**
18-50 years ≥ 51 years	22 (13.7) 6 (3.6)	161 168	< 0.001^
Age vs Internet	**Users n (%)**	**Total number of subjects**	***p*-value**
18-50 years ≥ 51 years	31 (19.3) 11 (6.5)	161 168	< 0.001^
Education vs Internet	**Users n (%)**	**Total number of subjects**	***p*-value**
Illiterate and primary school Secondary school Intermediate vocational school Higher vocational education	3 (4.0) 13 (10.6) 13 (15.5) 13 (27.7)	75 123 84 47	< 0.001^
Education vs GPs	**Users n (%)**	**Total number of subjects**	***p*-value**
Illiterate and primary school Secondary school Intermediate vocational school Higher vocational education	9 (12.0) 26 (21.1) 6 (7.1) 12 (25.5)	75 123 84 47	0.01^
Education vs Newspapers	**Users n (%)**	**Total number of subjects**	***p*-value**
Illiterate and primary school Secondary school Intermediate vocational school Higher vocational education	26 (34.7) 73 (59.3) 42 (50.0) 27 (57.4)	75 123 84 47	0.01^
Occupation vs GPs	**Users n (%)**	**Total number of subjects**	***p*-value**
Unemployed Paid job (manual) Paid job (not manual) Retired	5 (8.2) 24 (17.3) 18 (26.9) 6 (9.7)	61 139 67 62	0.01^
Income *(ANG/month)*[1] **vs Television**	**Users n (%)**	**Total number of subjects**	***p*-value**
0 – 999 1000 – 2499 2500 – 4999 ≥5000	27 (81.8) 101 (75.4) 86 (74.1) 24 (55.8)	33 134 116 43	0.04^

[1]Antillean Guilders, 1 ANG= 0.54 USA dollars and 0.47 EUR.
^ Chi-square test

Most of the socio-demographic characteristics used in this study were associated with both social media and internet usage to seek information regarding chikungunya. Therefore, logistic regression was performed to understand these associations further. The use of the internet and social media are strongly correlated *(Phi Coefficient and Cramer's V test: 0.48, p=0.00)* (48). Therefore, we focus only on the association between the use of the internet and socio-demographic characteristics.

Univariate analysis revealed a negative association between age and the use of the internet, while female gender was positively associated with internet usage. The use of internet increased with the level of education. Individuals having a paid (non-manual) job were 2.72 times more likely to use the internet compared with unemployed individuals. Furthermore, individuals earning ≥5000 guilders per month were 3.23 times more likely to use the internet compared to individuals who earned ≤999 guilders per month (Table 2). After adjusting for education, occupation and income, age and gender were still significantly associated with the use of the internet (Table 3). The data of this study showed that as age increases the use of the internet decreases 5% per each year of age. Also, female subjects were 3.05 times more likely to use the internet compared to male subjects.

Table 2. Univariate analysis of socio-demographic characteristics associated with the use of the internet to seek information regarding chikungunya

	Use of the internet				
Variable	**Users n (%)**	**Total number of subjects**	**Crude OR**	**95% CI for exp b**	***P*-value***
Age *(years)*[3]	52 (15.4)	337	0.95	0.93 – 0.97	< 0.001*
Gender[3]					
Male	7 (7.7)	91	1	-	-
Female	45 (18.3)	246	2.69	1.16 – 6.20	0.02*
Education[3]					0.02*
Illiterate and primary school	4 (5.0)	80	1	-	-
Secondary school	21 (16.5)	127	3.76	1.24 – 11.41	0.02*
Intermediate vocational school	15 (18.1)	83	4.19	1.33 – 13.24	0.01*
Higher vocational education	12 (25.5)	47	6.51	1.96 – 21.63	< 0.001*
Occupation[1,3]					0.01*
Unemployed	7 (11.1)	63	1	-	-
Paid job (manual)	25 (17.5)	143	1.69	0.69 – 4.15	0.25
Paid job (not manual)	17 (25.4)	67	2.72	1.04 – 7.10	0.04*
Retired	3 (4.7)	64	0.39	0.10 – 1.60	0.19
Income *(ANG/month)*[2,4]					0.17
0 - 999	3 (8.6)	35	1	-	-
1000 – 2499	16 (11.9)	135	1.43	0.39 - 5.23	0.58
2500 – 4999	21 (17.8)	118	2.31	0.65 – 8.26	0.20
≥5000	10 (23.3)	43	3.23	0.81 – 12.83	0.09*

[1]The variable unemployed includes student, housewife and volunteer.
[2]Antillean Guilders, 1 ANG= 0.54 USA dollars and 0.47 EUR.
[3]For two participants the data regarding internet usage was missing. These two participants were excluded from the data analysis (n=337).
[4]For eight participants the data regarding internet usage was missing. These eight participants were excluded from the data analysis (n=331).
***Significance was determined at an alpha level of 0.10.

Table 3. Multivariate analysis of socio-demographic characteristics associated with the use of the internet to seek information regarding chikungunya

	Use of the Internet		
Variable	**OR**	**95% CI for exp b**	***p*-value***
Age *(years)*	0.95	0.93 - 0.98	< 0.001*
Gender *(Female)*	3.05	1.21 – 7.67	0.02*
Education			0.76
Illiterate and primary school	1	-	-
Secondary school	1.70	0.51 – 5.73	0.39
Intermediate vocational school	1.83	0.50 - 6.61	0.36
Higher vocational education	2.15	0.53 – 8.70	0.28
Occupation[1]			0.60
Unemployed	1	-	-
Paid job (manual)	2.00	0.73 – 5.45	0.18
Paid job (not manual)	1.84	0.59 – 5.76	0.29
Retired	1.64	0.30 – 8.94	0.56
Income *(ANG/month)*[2]			0.97
0 - 999	1	-	-
1000 – 2499	0.93	0.24 – 3.64	0.91
2500 – 4999	1.09	0.27 – 4.45	0.91
≥5000	1.18	0.25 – 5.61	0.84

*$p< 0.05$.
[1]The variable unemployed includes student, housewife and volunteer.
[2] Antillean Guilders, 1 ANG= 0.54 USA dollars and 0.47 EUR.
No significant interaction was observed between gender and age.
Note: Nagelkerke R^2=0.175 (17.5%), Omnibus *(p=0.00),* and Hosmer and Lemeshow *(p=0.62)* show a good fit of the model.

The qualitative data of our study support the results concerning the effect of age on the use of the internet, including social media use. An FGD conducted among the local youth (age range 19-24 years), e.g. showed that the younger generation received information regarding chikungunya mainly via social networks (Facebook). The younger participants of our study preferred to receive health information from social media because it offered them the opportunity to receive real-time information:

> Moderator: *“Uhm, let us start, where did you get information about chikungunya? Where do you get it?”*
> Female 1: *“Family.”*
> Moderator: *“Family.”*
> Female 1: *“From people who had chikungunya.”* Female 2: “I have received information from Facebook. On social media.” (laugh)
> Moderator: *“You are used to it.”*
> Male 1: *“I think, Facebook.”*
> Moderator: *“Okay. You are on that thing all day.”*
> (The youth was laughing)
> Moderator: *“All right.”*

> Male 1: *"Yes, it is easy. I do not want to wait until 20:00 for the news. The news circulates very fast on Facebook."* Male 2: *"Yes! Social media".* Female 1: *"On the other hand, many people were sharing their stories on Facebook. You know, tips. Thus, what to do and what not to do."* Male 1: *"Yes, it belongs to social media."*
> Moderator: *"Is that true? That people post everything on Facebook?"*
> Female 2: *"Yes!"* Male 1: *"To share their experiences."* Female 3: *"Not their bodies, but their experiences."*
> FGD, The local youth (age range 19-24 years)

In general, the participants of both FGDs and IDIs indicated that information regarding dengue is shared by the local health authorities on a regular basis. Because of this, people have become familiar with the disease as well as with necessary preventive measures. However, when it comes to chikungunya, the participants of both FGDs and IDIs were not satisfied with the local health authorities. According to the majority of the participants, the official information regarding chikungunya coming from the local health authorities was late:

> *"People were criticising, ah, it went like a type of epidemic on the island. People had the idea that the minister did not act on time to stop the epidemic. I am not sure about the impact of the governmental programs, the programs regarding fumigation, on the community. However, people had the idea that the governmental actions were like too little too late (Dutch proverb: mustard after the meal), and it was on a small scale. Thus, the governmental actions were too late to prevent the epidemic."*
> Female, teacher, age not documented, IDI.

The qualitative data analysis revealed that, as a result of the perceived delay in official information regarding chikungunya, people started to search for information. In order to verify and validate their opinions, they started to share their opinions regarding the transmission routes, symptoms, prevention and treatment options with people in their surroundings. Some participants reported turning to friends and family members for assistance in assigning meaning to the symptoms they were experiencing, and for advice on how to treat their condition. This could explain why many participants reported having received information regarding chikungunya via interpersonal channels.

Risk perceptions toward dengue and chikungunya

A considerable proportion of the participants of this mixed-method study agreed that everyone in the community was potentially susceptible to DENV infection, regardless of his or her age. According to the participants of both FGDs and IDIs, DENV infection is not a severe disease, because the symptoms are flu-like. However, they were well-informed about the severe consequences of DENV infection. In the case of the survey participants, 67% and 60% of them fully agreed that DENV infection is a serious condition and that people who are infected could die of the infection, respectively. Based on these results, the majority of the participants had a moderate-high perceived susceptibility and a moderate-high perceived severity of DENV infection.

In the case of CHIKV infection, the majority of the participants of both FGDs and IDIs did not expect to be infected with CHIKV because they were not informed, before the epidemic, about a possible CHIKV infection outbreak. The qualitative data suggested that the perceived susceptibility and the perceived severity regarding CHIKV infection were attenuated due to the lack of RC. However, both were amplified when the television, radio, newspaper, and people started to share information regarding the high burden of chikungunya during the epidemic. When prompted to discuss gender and age differences related to CHIKV infection, a proportion of the participants of the FGDs and IDIs perceived that the youth was less at risk of CHIKV infection as their immune system was stated to be better than children, adults and older adults. However, the rest of the participants agreed that everyone in the community was susceptible to the condition, regardless of gender and age. The same shared perception was observed among the survey participants as almost half of the participants (47%) reported that not everyone in Curaçao ran a high risk of being infected with CHIKV. When participants were asked about the severity of CHIKV infection, all the participants of the qualitative study stated that it was a severe disease and 72% of the participants of the survey fully agreed with this statement. Based on these results, the majority of the participants had a moderate-low perceived susceptibility and moderate-high perceived severity regarding CHIKV infection.

The influence of cultural schemas on information, perceptions and preferences

Information regarding the knowledge of the transmission route, preventive measures and treatment options of our study participants, was published previously (39, 44). In this study, we explored which channels of information influenced the perceptions and preferences of the study participants. The results are presented here by the following key themes: the transmission route, preventive measures and treatment options.

The transmission routes

Most of the participants of the FGDs and IDIs indicated that CHIKV and DENV are transmitted by infected mosquitoes. However, some of the participants reported that CHIKV was also transmitted via air, unhygienic conditions, water or contact with an infected individual. These results are in line with the published results of the quantitative survey (39). From the participant's narratives, we extracted the following shared culture-bound perceived etiologies: all viruses are the same, a virus is contagious, and something contagious is transmitted via contact with an infected person, air or water.

> *"I think it is a virus. I never thought that it was through a mosquito because I have been bitten several times by mosquitoes. It is a virus; It is like the flu (common cold)."*
> Female, housewife, age not documented, IDI.

The culture-bound perceived etiologies mentioned above were the basis for doubting the vector transmission route of DENV and CHIKV.

Preventive measures

Various preventive measures were mentioned during the FGDs and IDIs. Participants suggested spraying insecticides in and outside the house, using plagatox (a mosquito incense usually made into a spiral with insecticidal dried powder or paste), larvicide *(e.g. Abate)* or repellent, the disposal of tires and bottles, removal of stagnant water breeding sites, cleaning of yards, and wearing long-sleeved clothing. Also, some participants indicated that eating healthy, using vitamins, and having a good immune system protects them against CHIKV and DENV infection:

> Female 1: *"Hmm, yes. In my case, someone told me that I need to take precautionary measures. So, I started buying vitamins at that moment. So, I was using vitamins during my chikungunya infection, and I am still buying vitamins every month, in order to maintain a good immune system. So that I do not get that disease anymore."* Female 2: *"Yes, so she thinks that eating healthy will protect her and you from being bitten. Right?"* Female 1: "*Yes, No. In my opinion, it is not about eating healthy; it is about vitamins. It is not about eating healthy, but the immune system needs to stay high so that it (chikungunya) does not come back.* "Female 2: *"Yes, so that they do not get the disease anymore."*
> FGD 7, with survey interviewers.

According to the qualitative data, people thought that chikungunya was similar to a common cold so that they had the perception that healthy food and vitamins would improve or optimally maintain their immune system and subsequently also prevent them from acquiring CHIKV infection. These perceptions are based on the cultural schemas regarding preventive measures of the common cold. The most frequently recommended preventive measures reported in the FGDs and IDIs are presented in S7 Table. The data shown in this table highlights the diversity of information and perceptions that individuals have regarding preventive measures in the context of VBDs.

Treatment options

The narratives of participants revealed that the individual's shared cultural schemas regarding the treatment of diseases, *(e.g. the doctor knows how to cure diseases, herbs can cure diseases and fluid keeps ill people hydrated and reduces fever)* played an essential role in forming their perceptions and expectations regarding the treatment of, mainly, the CHIKV infection.

The participants reported that people went to the GP several times to seek medical care because the provided treatment, which was the use of painkillers *(e.g. paracetamol),* was not providing satisfactory results. According to the qualitative data, people were not satisfied with the provided care of the GP, because the GP did not have a cure for CHIKV infection. Furthermore, some participants indicated that when they failed to find a cure for CHIKV infection, they became confused:

> *"Yes, because eh, I was angry, because eh, nobody was able to tell me what I needed to do. People were recommending different things; use corticosteroid injections, because you never know, maybe you can develop rheumatism in a later stage. There were too many insecurities."*
> Female, translator, age not documented, IDI.

The qualitative data revealed that alternative medicine practitioners provided information regarding the use of papaya leaves to treat VBDs. The extract of papaya leaves was recommended because it was believed to increase the platelet levels in patients infected with DENV and CHIKV, and in turn, reduced the severity of the infection. Although the use of herbs was recommended by alternative medicine practitioners, it should be stated that herbs are a popular and traditional treatment option to treat diseases among people living on the island. The positive experiences of treating the common cold and other diseases with herbs had motivated infected individuals to use alternative medicine, such as papaya, mango and soursop leaves, to treat CHIKV and possibly DENV infection. The results of the survey showed that 30.5% of 339 participants reported having used papaya leaves, and 28.5% of 337 study participants used mango leaves to treat the CHIKV infection (Fig 1). The use of mango leaves was also recommended by alternative medicine practitioners, although the benefits are not documented. Also, a close analysis of the qualitative data revealed that the expectations regarding the results of the mentioned herbs were not met and this caused more confusion among the infected chikungunya patients:

"No, I heard about papaya leaves via my neighbour. She went back to the doctor after using papaya leaves because she wanted to try an injection. People were saying so many things, and when I asked: and did it work? They were still complaining. Weird, huh?"
Female, translator, age not documented, IDI.

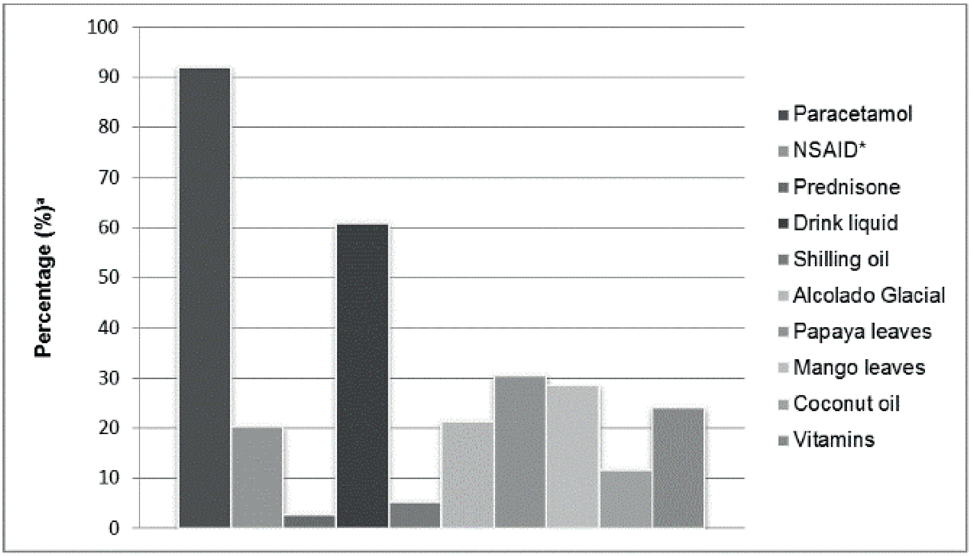

Figure 1. Treatment options for CHIKV infection.
[a] Values are percentages of available participants who reported the remedies that they used to treat the CHIKV infection. Various options could be indicated. *The variable Non-Steroidal Anti-Inflammatory Drugs (NSAID) consists of the following medications ibuprofen, diclofenac and celecoxib. For one participant the data was missing on the following treatment strategies: paracetamol, drink liquid and Alcolado Glacial. This response was excluded from the data analysis (n = 338). For two participants there were missing data on the following treatment strategies: NSAID, coconut oil, mango leaves, shilling oil, vitamins, and Prednisone. These too were excluded from the data analysis (n = 337).

Some participants of the FGDs and the IDIs had the perception that drinking plenty of liquids, mainly water, would help them combat the CHIKV infection. The survey showed that 61% of 338 participants reported drinking plenty of liquids to treat the mentioned disease. Drinking water or other types of refreshments were primarily used for keeping individuals who are sick hydrated and to reduce fever. Also, people have the perception that water helps cleanse the body and subsequently removes waste, including disease, from the body.

Furthermore, the quantitative data showed that a proportion of participants used Shilling oil and Alcolado Glacial to treat the symptoms of CHIKV infection. Alcolado Glacial is a mentholated splash lotion that is produced in Curaçao, and the benefits of it have been passed on from generation to generation. People use it for many purposes, for example, to relieve pain and flu-related symptoms.

This mixed-method study revealed that people used multiple treatment options to treat CHIKV infection (Fig 1). According to the participant's narratives, people used several treatment options as they were in a situation of insecurity due to the fact that there was no treatment to cure the CHIKV infection:

> Moderator: *"Okay, Many people used different types of medication. Can you explain why people use so many different medications?"*
> Male 1: *"When someone sees another person using a medication, he or she will ask for the details or the person using the medication will share the details. I mean, the person that is ill wants to get better. Thus, he or she will also try the medication."* Male 2: *"Yes, powerlessness."* Female 1: *"It becomes an act of powerlessness. Because if you get so much information, in the end, you will not know what the truth is, and you will try what you hear. I am a person that can say no. I say, no! I am not drinking everything because with those things (alternative medicine) you have to be careful, because it does not work every time. You have to follow your feelings. When it (feelings) says okay you can try it, go ahead! However, do not drink everything that people recommend because you do not know what it does to you. It can be poisonous and make you sicker."* Male 1: *"Good."*
> FGD 3, Souax

Noticeably, people were desperately searching for an effective cure. Fig 1 shows the wide range of interventions people were exploring to treat CHIKV infection.

Trust in the channel of information

Some participants of the qualitative study opinionated that the government did not have a plan to inform the community and combat the epidemic, there was not enough workforce, and the government had other priorities at that specific point in time. Furthermore, some participants doubted the information provided by their GP. These disappointments with the government and the GPs could be linked to reduced trust in RC.

> Male 1: *"The information regarding the vector of chikungunya was lacking. People were not aware of the possible actions that they could take. I think that chikungunya is a virus, and there is no medication against viruses. The consequence is that you cannot walk and as what (female name X) said, you need to rest. If someone says that he or she has medication for the virus, the person needs to know the effect of it. I heard that people tried everything that was recommended by the doctors. Painkillers were*

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> *prescribed most of the time. This is clear, it is not a medication, but it helps to reduce the symptoms. The consequence was that people got confused because they thought that they got medication to cure the disease, while you as a health professional knew that there is no cure."* Male2: *"Painkillers."* Male 1:" Yes*, that does not help. I do not believe that it helps."*
> FGD 3, Souax

Both qualitative and quantitative data reveal that interpersonal channels of information played an essential role in the provision of information regarding DENV and CHIKV infection. As mentioned above, some participants reported turning to friends and family members for assistance in understanding their condition. This action could indicate the trust that the participants have in information coming from their family and friends. Some participants reported taking actions that family or friends were taking:

> "*My niece and her mother had it before me. So, I heard about chikungunya from them. Everyone had chikungunya, and my sister did not go to the doctor, although my niece did. That is why I did not go to the doctor anymore."*
> Female, accountant, age not documented, IDI.

Many participants had a firm belief in the efficacy of local herbs provided by alternative medicine practitioners. According to the qualitative data, the information regarding the benefits of herbs and the use of alternative medicine practitioners have been handed down from generation to generation. It has been stated by several participants of the FGDs and IDIs that positive experiences of using herbs as a treatment option had influenced how people trust the information coming from alternative medicine practitioners nowadays.

Discussion

The main aim of this study was to understand RC regarding VBDs in the social context and from the audience's point of view. We found that television, radio and newspapers were the three primary channels of information about dengue and chikungunya. However, interpersonal channels of information such as family, friends and neighbours also played an essential role in providing information regarding the mentioned VBDs. Our results are in line with those of others (50-52). We also found that the use of internet to find information on VBDs varied by participant's age and gender. The use of internet diminished with increasing age and women were more likely to use internet compared to men. These results are in line with the findings of the CBS of Curaçao (CBS, ICT & Media survey 2017) and with the literature (52, 53). Our multivariate model, including age, gender, education, occupation and income, explains only 17.5% *(Nagelkerke R^2=0.175)* of internet usage. Using the internet for information on chikungunya may be less influenced by common socio-demographic characteristics and may be better explained by other factors such as personality traits *(e.g. extraversion)* (54).

The qualitative data of our study showed how the risk perception regarding CHIKV infection was attenuated due to the lack of RC before the epidemic and how the risk perception was amplified by the increased exposure of information, as well as the direct and indirect experience of the physical manifestation of CHIKV infection in the peak of the chikungunya epidemic. Based on the participant's narratives, we believe that the media including television, radio, newspapers and interpersonal channels of information played an essential role in the amplification of the risk of individuals, especially in the context of chikungunya. The findings of a recent study published by Chan et al. support our results (34). Chan et al. showed that changes in the volume of information in media were followed by several changes in individuals risk perceptions and protective behaviour regarding the Zika virus in the United States (34). They also found that social media coverage was positively correlated with changes in risk perception while television and newspapers were positively correlated with changes in protective behaviours. These findings revealed that the influence of media on risk perceptions and behaviour could vary by the volume of information and type of channel of information (34). However, more research is needed to investigate these differences.

With regards to the risk perception of people, our results showed that the majority of the participants had a moderate-high perceived susceptibility and a moderate-high perceived severity of DENV infection. However, the qualitative data show that people considered it also to be “merely flu-like”. We believe this relatively high perceived disease severity of DENV infection is biased by the knowledge of the participants gained over the last years. It is possible that the participants are aware of the threat of DENV infection and report it, but that on the other hand, they do not really consider DENV infection as a threat as there have hardly been any reports of severe dengue disease on the island. This phenomenon could well be the reason for an initially reduced risk perception of the CHIKV infection. More research is needed to understand the feeling of threat with respect to VBDs among individuals living in Curaçao and to assess the role of other factors, e.g. heuristics, in this context.

Furthermore, we found that individual cultural schemas played an essential role in forming individuals’ perceptions regarding the preventive measures and treatment options of VBDs, especially in the case of chikungunya. The information regarding the influence of cultural schemas on the perceptions and behaviour of individuals in the context of VBDs is lacking. A recent paper published by Metta et al. showed that cultural schemas played a role in malaria self-care among adults in Tanzania, especially regarding the use of herbs in healing multiple conditions (26). A similar cultural schema was observed in our study, with regard to using herbs to treat CHIKV and possible DENV infection. We showed that individuals' cultural schemas are possible cues to action, which instigated the health-seeking behaviour of individuals. Also, the results of our study showed that people got confused when their reality *(e.g. herbs did not cure or reduce the symptoms of the CHIKV infection)* did not fit in their cultural schema *(e.g. herbs heal diseases).* RC experts will need to include aspects of cultural *schemas (e.g. the use of herbs in the treatment of disease)* in their RC strategies.

Lastly, the data of this study also highlighted trust issues between the community and the local health authorities, including the general practitioners. As the participants perceived that information regarding CHIKV infection came when the community was already experiencing the condition, they expressed disappointment and showed signs of reduced trust in the health authorities. There was less trust in the government because people perceived that the measures performed by the government were not enough to protect them against health insecurities; in this case, the CHIKV infection epidemic. This implies that governmental actions during this epidemic would have influenced people's trust in the government. There was less trust in general practitioners because the patients doubted the efficacy of the treatments. We believe that the power relations between health practitioners and patients are changing in Curaçao. Health practitioners can no longer assume that patients will trust them because of their power/position in society. Trust has been found to play an essential role in predicting risk perceptions and behaviours of individuals (55). In the case of distrust, people will doubt the information that the channel is providing and this in turn will affect not only their risk perception and their behaviour but also RC efforts as such in a negative way. In other words, negative trust issues should be addressed in RC.

Limitations and strengths

The current study was limited by its cross-sectional retrospective design and is susceptible to recall bias. The study participants consisted of more females than males; this might limit the generalisability of our results. However, this might not be a significant issue, because women are mainly responsible for the housekeeping, family care and the provision of information to the family (56, 57). The wide confidence intervals that were found for all socio-demographic characteristics may be explained by the small number of participants in each category. Therefore, "age" was used as a continuous variable in the regression model. A strength of the study was its mixed-method design. Also, our study design offered the opportunity to understand RC from the audience's point of view, which could help RC experts to understand their target population comprehensively. Even though our sample size is small, our results on internet use correlate with the results of the CBS which was based on a representative sample of the population.

Conclusions and recommendations

The findings of this study form an important contribution to the research field of RC, because to our knowledge, no studies combining qualitative and quantitive research methods based on the SARF, HBM and cultural schemas theory to understand RC from the audience's perspective have been published to date. We found that there are different factors *(e.g. 1. the timing of sharing information, 2. the channel of information, 3. the volume of information, 4. trust in the source of information, 5. previous experience with a disease, and 6. cultural schemas)* that influence how people deal with risk. Health authorities should target these factors in future RC strategies. We recommend broadening the use and scope of media platforms to share information on a timely basis and with the content that convinces people of the seriousness of the matter. The health authorities can customise their channels of information by using more social media platforms to reach the younger generation and other groups in the community. We recommend to evaluate the manner in which social media was used and to what extent people were aware of the existence of these platforms to achieve the desired impact. As the health authorities are mistrusted by the public, more efforts need to be made to provide accurate information to the community through a transparent process. Lastly, further research should take more individual characteristics such as cultural schemas and heuristics into account when studying the influence of RC on risk perception and behaviour of individuals.

Note

- Alternative medicine practitioners are care providers who use natural methods, like herbs to treat diseases.
- G&Gz "Uitvoeringsorganistatie Geneeskundige en Gezondheidszaken" is the executive branch of the Ministry of Health, Environment & Nature of Curacao. G&Gz was previously called GGD "Gemeentelijke Gezondheidsdienst".
- CBHRI: Curaçao Biomedical & Health Research Institute.

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CHAPTER 5

The impact of health risk communication: a study on the dengue, chikungunya, and Zika epidemics in Curaçao, analyzed by the social amplification of risk framework (SARF)*

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Abstract

Epidemics of dengue, chikungunya, and Zika have been threatening the Caribbean. Since risk communication (RC) plays a fundamental role in preventing and controlling diseases understanding how RC works is essential for enabling risk-reducing behavior. This multi-method qualitative study compares news reports with local's and health professional's perspectives, currently lacking in RC research. It was found that RC strategies were obstructed by a lack of governmental structure, organization, and communication. The content analysis showed that the majority of newspaper articles contained negative reporting on the government. Furthermore, the study shows how trust and heuristics attenuate or amplify people's risk perceptions and possibly positively and negatively influence people's risk-reducing behavior. A transcending approach *(e.g., structural, cooperative, and multidisciplinary)* of the prevention and control of vector-borne diseases and the corresponding RC is recommended.

Keywords: risk communication, social amplification of risk, risk perception, vector-borne diseases, trust, qualitative research methods, the Caribbean

Introduction

Vector-borne diseases (VBDs) such as dengue, chikungunya, and Zika present a threat to human health in many regions of the world and cause international concern (Reynolds et al., 2017). The spread of VBDs is driven by global travel and trade and complex demographic, social, and environmental factors (Semenza, 2016). Dengue virus, chikungunya virus, and Zika virus infection cause various clinical manifestations that range from mild to life-threatening symptoms (Mayer et al., 2017). A dengue virus infection causes a flu-like illness and occasionally progresses to severe dengue forms such as dengue hemorrhagic fever and dengue shock syndrome (WHO, 2020). Chikungunya virus infection generally causes high fever, skin rash, and debilitating polyarthralgia. The mentioned symptoms typically resolve within ten days. However, a proportion of cases progresses to the chronic stage of chikungunya virus infection, in which some symptoms *(e.g., arthralgia)* last for years (Elsinga, Gerstenbluth, et al., 2017). In most cases, Zika virus infection causes no or mild symptoms, but complications such as microcephaly and Guillain-Barré syndrome have been linked with the disease (Kazmi et al., 2020).

In Curaçao, a Caribbean island, the chikungunya and Zika virus caused significant outbreaks in 2014-2015 and 2016-2017, respectively. Moreover, dengue virus infection epidemics occur cyclically. These diseases also threaten other islands in the Caribbean (Rico-Mendoza et al., 2019). In the Caribbean, the primary vector of dengue, chikungunya, and Zika virus is *Aedes Aegypti* (Kotsakiozi et al., 2017). The lack of a (ready and suitable) vaccine causes the reduction of the transmission of these VBDs to rely on preventing mosquito bites, preventing sexual transmission in case of Zika virus, and controlling the vector and its breeding sites (Beltrán-Silva et al., 2018; Clapham & Wills, 2018; Goyal et al., 2018; Paixao et al., 2018; Petersen et al., 2016; Singh et al., 2018). Hence health communication in terms of risks of the diseases, prevention, and control programs are of primary importance.

Risk communication (RC) is defined as: '*(…)* an interactive process of exchange of information and opinion among individuals, groups, and institutions about the nature of risk, concerns, *(…)* or reactions to risk messages or to legal and institutional arrangements for risk management (Covello et al., 2001). RC is an essential tool for preventing and controlling diseases as it influences risk perception, increases awareness, and might lead to change in behaviors and/or stimulate risk-reducing behavior (Infanti et al., 2013). It is therefore essential to understand the impact of RC on the community. Kasperson et al. (1988) developed the Social Amplification of Risk Framework (SARF), which has been used widely to research and explain RC, where and how information is amplified or attenuated in the communication chain, and how risk perception influences behavior and situations (Kasperson et al., 1988). The SARF is based on the thesis that hazardous events interact with social, psychological, cultural, and institutional processes that can intensify or attenuate individual and social perceptions of risk and shape risk behavior (Kasperson et al., 1988).

The roots of social amplification of risk lie in direct personal experience with the risk and secondary information received about the risk (Kasperson et al., 1988). It has been stated that personal experience and trust in the messenger have the most substantial impact on risk perception (Wachinger et al., 2013). Thus when a person considers the potential personal harm, the believability of information provided depends much on the trust and confidence a person has in the messenger (Kasperson, 1986). The belief in the accuracy of the information tends to be greater if a factual statement is repeated multiple times by different sources (Kasperson et al., 1988). Also, heuristics or cognitive shortcuts act as an amplifier or attenuator of risk perception (Kasperson et al., 1988). Heuristics are mental processes that help individuals solve problems and learn new concepts when there are limited time and resources to make a judgment (Bailey & Hutter, 2006; Institute of Medicine, 1997). People can automatically process information using heuristics rather than through systematic analysis (slow thinking system) when confronted with a (new) threat.

Past research has applied the SARF to understand RC in public health emergencies (Barnett & Breakwell, 2003; Busby & Duckett, 2012; Chong & Choy, 2018; Kasperson & Kasperson, 1996; Kasperson et al., 1988; Petts & Niemeyer, 2004; Raupp, 2014; Rickard et al., 2013; Rossmann et al., 2018; Strekalova, 2017; Wirz et al., 2018), but literature concerning RC in small developing countries and countries in the Caribbean region is lacking (Wirz et al., 2018). In 2019, the SARF was used to understand RC regarding VBDs in Curaçao, determine the association between socio-demographic variables and channels of information, and the influence of cultural schemas on perceptions (Mulderij-Jansen et al., 2020). The mentioned study gives useful insights, but it does not take the impact of the content of the provided health information and heuristics into account. Therefore, the current study goes a step further by analyzing the newspaper's content, comparing people's perceptions with perceptions of experts/government officials and the information provided by the newspapers, and understanding the newspaper's influence on people's perceptions. To our knowledge, the comparison of newspaper content with perceptions of locals and experts/government officials lacks in RC research. The role of trust, previous experience with VBDs, and heuristics on risk perception regarding VBDs will also be studied in combination with the SARF to understand the amplification and attenuation of risk more profound. The findings and recommendations of this research can be used to strengthen RC strategies in Curaçao. Undoubtedly, other islands in the Caribbean *(e.g., Dutch Caribbean islands)* can use this study's findings to improve their RC approaches. Besides that, amidst a current COVID-19 pandemic, this research can make a useful contribution in examining and shaping RC policies worldwide.

Methods

Study Design

In 2018, a qualitative study using in-depth interviews with local people and experts/government officials and a content analysis of newspapers and other visual materials *(e.g., folders, poster, etc.)* was performed to examine the experiences and processes related to the risk of VBDs on people living in Curaçao. The study was designed based on an integrated theoretical framework of the SARF, heuristics theory, previous experience with VBDs, and trust. The time-frame that the research focused on was the beginning of 2010 until the end of 2017. Within the mentioned time-frame, the last big dengue virus infection epidemic occurred in 2010/2011, while the chikungunya and Zika virus infection epidemics occurred in 2014/2015 and 2016/2017, respectively (Figure 1). Articles for the document analysis were used within the time-frame mentioned above. The participants recruited met the following criteria: they currently live and have lived in Curaçao between 2010 until the end of 2017.

Figure 1. *Simplistic time-frame overview of the VBD epidemics in Curaçao.*

Data Collection and Study Population

In-depth Interviews

Interviews with experts/government officials were held to obtain information on the government policy, RC strategies, and the health system's performance during the dengue, chikungunya, and Zika virus infection epidemics. The term experts/government officials regard policymakers or health professionals working for the government. Moreover, to further research the newspapers, an interview was conducted with a media expert who writes articles regarding public health in the media. In total, four experts/government officials were interviewed. In-depth interviews with local people were performed to investigate risk perception, trust, heuristics, and previous experience with VBDs. The interviews were held in two socioeconomically different neighborhoods (low and middle socioeconomic status (SES) and high SES) to aim for heterogeneity within the study population (n=18) (Supplemental file 1:Table 1). Low/middle and high-SES neighborhoods were selected based on neighborhood classifications made by the Central Bureau of Statistics, Curaçao (CBS, 2001). Gatekeepers and the snowball technique were used to recruit study participants. The number of interviews needed in this study was determined after data saturation was reached, meaning that when the information was repeated during new interviews, it was decided to stop recruiting participants. Both interview guides (for locals and experts) contained similar questions that offered the opportunity to compare the responses (Supplemental file 2). The interviews were conducted and recorded in Papiamentu or Dutch, translated if necessary to Dutch, transcribed, and analyzed. Interviews with experts and locals were conducted in April and May 2018.

Content Analysis

Written messages in the form of information materials are and have been fundamental in RC. For the visual materials sampling strategy, readily available information on the island *(e.g., in community centers, medical centers, etc.)* and information materials from the Ministry of Health, Environment and Nature of Curaçao (MoH) storage were sought and photographed for the content analysis. A total of six flyers, posters, and booklets developed by the MoH were collected. This number can be explained by different factors, for example, lack of documentation, loss of documents throughout the years, and limited developed information materials.

Articles of two local newspapers (Dutch “Amigoe” and Papiamentu “Extra”) were sought for the content analysis. From the Dutch newspaper, 23 articles were gathered on dengue, 62 on chikungunya, and 100 on Zika within the time-frame 09-23-2010 until 11-02-2017 (mm-dd-yyyy). The other newspaper (Papiamentu) has an online database that goes back to 07-15-2016, which resulted in 49 more articles on Zika. No articles on dengue and chikungunya at the time of their epidemic were found in their database. To ensure the inclusion of timely relevant articles in the content analysis, an overview of the PAHO and the WHO epidemiological reports was created and used to select articles (Supplemental file 3:Table 2)(PAHO, 2019a, 2019b, 2019c). After correcting for irrelevant or repetitive articles, a total of 14 articles on dengue, 32 on chikungunya, and 108 on Zika were included in the content analysis (Supplemental file 4: Table 3).

Data Analysis

Conventional (inductive) and directed (deductive) content analysis methodologies were used to analyze the data. The conventional content analysis went as followed: (a) data were read word by word to derive codes, (b) notes about the data were made, and (c) codes were sorted into categories based on observed links. The directed content analysis went as followed: (a) key concepts of the SARF, the theory of heuristics, trust, and previous experience with the disease were identified and used as categories and codes, and (b) any data that could not be coded from the existing coding scheme were coded inductively. The research team critically monitored and evaluated the phases mentioned above to increase coding accuracy and trustworthiness

(Hsieh & Shannon, 2005). The data was translated and analyzed by two persons simultaneously. By coding the same data set at the same time, initial difficulties could be discussed. A disagreement between coders meant that a definition had to be expanded or revised, which is how the coding list was made (Elliott, 2018). After that, the coded data was reviewed by another author, where a qualitative comparison of the codes was conducted. The analysis was conducted by coding the articles, expert interviews, and visual materials with the same coding list using NVivo for Mac (11.4.3). A word cloud for the code "government" was created to analyze the frequency and meaning of words used regarding the government in newspaper articles. For the in-depth interviews with locals, a different coding list was used to focus more on analyzing participant's perceptions, experiences, and opinions. The coding list for newspapers, expert interviews, and visual materials contained category codes such as; information, prevention methods, government, trust, responsibility, approach, and cooperation institutions (Supplemental file 5: Table 4). Category codes used to analyze in-depth interviews with locals were: information source, knowledge, responsibility, trust, perception dengue/chikungunya/Zika, heuristics, perception media, perception government, false/unclear information, risk-reducing behavior, and improvement (Supplemental file 6: Table 5). Narrative analysis methodology was also used to analyze the coded data, including notes about this study's data. Narrative analysis was used to examine individual experiences regarding VBDs and how risk and risk information concerning these diseases was processed. All quotes in the current research were transliterated to keep the context intact. The study used multiple methods and data sources to study the same phenomenon to produce findings that breed credibility (Renz et al., 2018).

Ethics statement

Ethical approval was obtained from Utrecht University, and the minister of the MoH of Curaçao was informed on the research. All participants signed an informed consent prior to the interview. The raw data will not be publicly available because the participants did not consent to have their full transcript available for the public. The data are archived at Utrecht University. Request to access the data can be sent to the corresponding author: e-mail address: v.i.c.jansen@umcg.nl

Results

The following key themes will be presented in the results: channels of information, the content of newspapers, the perceptions of locals compared to experts/government officials' perceptions and information provided by the newspapers, and finally, influences on risk perception such as trust and heuristics. The characteristics of the participants (n=18) are presented in Supplemental file 1, Table 1. It was decided not to include the participant's names and the neighborhood they inhabit to guarantee their anonymity.

Channels of Information

The locals reported having received information regarding dengue, chikungunya, and Zika via newspapers, radio, television, family, friends, doctors, social- and international media. The locals did not mention the government directly as a channel of information. However, health professionals working for the MoH create and publish flyers, posters, and statements to be spread. Therefore, the mentioned flyers, posters, and information published by the newspapers, television, and radio stations could be from the government.

Even though the government published information regarding VBDs, during the in-depth interviews with locals, it became apparent that a pamphlet with information about chikungunya produced by the MoH did not reach the participants. Only one participant recalled that she had seen the pamphlet. According to an RC expert of the MoH, a pamphlet about chikungunya was made in four languages: Papiamentu, Dutch, English, and Spanish (these languages are widely spoken on the island), and a postal company was paid to distribute those to the community. However, during the communication campaign evaluation, it became clear that the pamphlets were not distributed as agreed. Another government official also mentioned the above-reported issue:

> *"So at a certain moment, one can deliver all the perfect content, but there must be someone or a structure that knows how to sell it to people. And there are more issues; for example, if you have done all your work that you are supposed to do (e.g., make a pamphlet or poster), it does not mean that it will end up where you want it to end up."*
> -Government official

Moreover, it was mentioned by a few participants that they received information in a language they did not understand, as portrayed by the quote below.

> *"Well, we did get a lot of pamphlets in the mailbox, and I suppose those came from the MoH. I don't know. The only thing I find stupid is that the pamphlets are only in Papiamentu. And then I think, okay; 52 different nationalities are living on the island, not everyone speaks Papiamentu or can read it."*
> -Female, (living in high SES area)

The public and the government could be missing out on vital risk information by a lack of structure and communication between institutions, as shown in the quote below. Moreover, the problem of insufficient funding for prevention and control arises during in-depth interviews with government officials:

> *"You have to make sure you don't get into a pressured situation. And for that, you need enough workforce/employees, resources, and planning. You need high-speed communication. When one of these three is lacking, you will face the chance that things get out of hand. We saw that with chikungunya."*
> -Government official close to policy

> *"Just like it always has been, people are more inclined (and certainly politicians) to put money into something where you see immediate results. (...) But prevention isn't something you see. You avoid problems, so you do not see the problems. But the importance of that often does not come across."*
> -Government official (public health worker)

Moreover, participants showed little knowledge concerning the transmission of the diseases in this research. Most answers contained the simplistic answer "if mosquito bites you," but other forms of transmission *(e.g., sexual transmission of Zika)* or the full transmission cycle (human–mosquito–human) were not mentioned. The vector's description was mostly incorrect. People referred to the vector of dengue, chikungunya, and Zika virus as the "mosquito with the white paws". Knowledge with regards to health risk-related information was missing. This shows that the impact of health RC has not reached its full extent, it might be that RC is not reaching locals as mentioned before, or the RC is not increasing knowledge as it should be.

Content of Newspapers

To understand media report's influence on people's perceptions, the content of the newspapers analyzed in this study will be discussed. Most articles contained information on prevention methods, number of infections and deaths, mishandling of the epidemics by the government, lack of cooperation between institutions, the unpreparedness of the community, economic effects, global warnings, tourism, urging of locals to act, waste management, and general information on symptoms, transmission, and tests of VBDs. Information on the fact that dengue, chikungunya, and Zika virus share the same vector is lacking. Moreover, while analyzing the created word cloud, it became apparent that the number of articles with a negative undertone regarding the government outweighs the positive ones by far. Of the 155 articles included in this study, 92 (59,4%) articles mentioned the government negatively versus 12 (7,7%) articles that mentioned the government in a positive matter. Next to 33 articles containing general negative statements concerning the government, distinctions of negative reporting were made as follows: 15 articles contained government officials questioning each other or being questioned by the newspaper, 18 on the unpreparedness for the epidemics, 10 on limited staff, and 16 articles on the delays in governmental actions and communication. Below, quotes from two newspapers show examples of negative comments on the government.

> *"The MAN group has asked questions to Minister Ben Whiteman of Health, Environment, and Nature about the chikungunya virus. The political party thinks that the information about the disease got off to a late start and that the minister had assessed the situation poorly."*
> ("MAN ask questions on chikungunya," 2014, November 11)

> *"According to the general practitioners, the GGD [G&Gz] should have developed a policy for every general practitioner to follow from the start. They did report that there would be a general policy, but this never happened. The consequences of the lack of planning and not having a general policy caused that every doctor did what they wanted to do."*
> ("Different general practitioners gave their opinion," 2016, October 31)

In an interview conducted with a media expert, it became clear that the newspapers strongly influenced the public in Curaçao. Generally, the MoH provides media sources with press releases. However, the media sources are free to publish these, make changes to them, or even decide not to publish them. The freedom that the media has given the opening for possible attenuation by media sources because the RC could be presented but stopped at that station if the press releases are not published or adjusted.

Comparing Perceptions of Locals with Perceptions of Experts/ Government Officials and Newspapers

The comparison of local's perceptions versus those of experts/government officials and information from newspapers will be discussed based on the chikungunya and Zika virus infection epidemics. The overall consensus of the participants regarding the RC about chikungunya was that it came too late. It was brought up during in-depth interviews with locals and government officials that information started to reach the public at the peak of the epidemic. Some participants already experienced the effects and impacts of chikungunya virus infection first-hand before receiving risk information.

> *"With chikungunya, we were just too late. We were just way too late. It was already known that it was coming; there is a new virus in this region, other countries already had it. We are an island with continuous traffic from everywhere. So, you could bet everything that it would come here, but we just started too late. This happened because it is not clear who*

should do that. There is no central focal point within the Ministry to say what we have to do regarding the epidemics. (...) We took a big hit with that chikungunya. With Zika, not, fortunately, but with chikungunya, we did. So many victims with long-term complaints."
-Government official (public health officer)

According to the majority of health experts, the first cases of chikungunya virus infection were not timely reported, and a trained workforce to actively jump into action was lacking. A close analysis of the qualitative data suggests that the risk might not have been seen as important as it should have, leading to attenuated risk perception and response within the government and the media. The content analysis reveals that published articles with regard to chikungunya began to increase only after the peak of the epidemic. There were very few articles that warned the public that the chikungunya virus might arrive in Curaçao. Once the epidemic was in full swing, the number of articles in newspapers increased rapidly, and overall more attention was given to the chikungunya virus infection epidemic. The chikungunya virus infection epidemic was perceived as something threatening, and participants reported that they were scared of the infection.

"*Well, that chikungunya epidemic was a real wow for me. Unbelievable how fast that happened, what an impact it had on your personal life, but also the people around me. (...) I could have never imagined that it could have such an impact. While you know about certain malaria etcetera, what causes it, and what the consequences are, chikungunya was unknown here."*
-Female, (living in high SES area)

In the Zika virus infection epidemic, perceptions of locals and experts/government officials and newspaper information differed. RC on Zika began before the epidemic hit the island. The newspapers picked up on the risk and published a large number of articles. Information on the symptoms, transmission, and health risks of Zika virus infection was written in the media, as was written on chikungunya at the time of the chikungunya virus infection epidemic. However, the difference was that Zika virus infection was portrayed more as a global threat in the newspapers (as shown by the quotes below).

"The WHO convenes an emergency meeting on Monday to determine whether the spread of the Zika counts as a so-called global emergency. WHO Director Margaret Chan stated in Geneva today that the UN organization is extremely alert."
("First local Zika virus infection detected," 2016, January 28)

> *"It seems as though people are not taking Zika seriously enough. We cannot stress it enough that at least pregnant women have to deal with it seriously, in the sense that they have to do everything to ensure that mosquitos do not bite them."*
> ("Mysterious virus possibly different Zika mutation," 2016, October 28)

However, information regarding Zika did not seem to be received by the community since the participants were not very impressed by Zika virus infection, nor saw any real danger in the disease. According to the participants, it was only a discussion topic among young - or pregnant women. Participants showed that at a social and individual level, the risk perception was attenuated despite the newspaper's coverage of the disease. Some participants even mentioned they did not notice the RC on Zika or did not pay much attention to the disease. Furthermore, the possible connection of the Guillain-Barre syndrome and microcephaly were not mentioned much in the interviews, and this could also account for attenuation in the risk perception with regards to Zika virus infection. However, it is interesting because the newspapers published news articles on Zika virus infection and its complications quite extensively.

Influence of Trust on Risk Perception

To explore how trust played a role in information people have received, it is necessary first to note the different sources that are trusted or not by the participants. The pamphlets and posters found in healthcare facilities are trusted and seen as reliable sources of information. Only low SES participants acknowledged the television as a trustworthy source. General practitioners and people with previous experience with VBDs were frequently mentioned as trusted information sources.

> *"I trust the experience of people. So, when someone tells me that they were having pain somewhere and they used a bit of Glacial [popular multipurpose menthol liquid in Curaçao], I am more likely to trust that than when the doctor tells me something."*
> -Female, (living in low SES area)

Furthermore, the government was listed the most as a trustworthy information source, or more specifically, pamphlets, meetings, and home inspections organized by the government were mentioned. Participants often described information from the government as "official information" and therefore trusted by them. Social media and journalists were indicated as less trustworthy. Interestingly, the perceptions of locals on the trustworthiness of the government change throughout the SARF. As an information source, the government is perceived as trustworthy. Nevertheless, in the behavioral response stages of the SARF, this study found a lack of mutual trust, as portrayed in the quote below, where the reduction of mosquito breeding sites is discussed:

> *"Responsibility lies with the government and the people themselves. If you use a bottle, wait until you get home and throw it in the garbage. It is impossible that the people of the government do not see this. The neighborhood is dirty and needs to be cleaned. So, the government needs to encourage and control people to do their part, but the government also has to take care of their part."*
> -Male, (living in low SES area)

It became apparent during this study that the locals did not trust the government to take their responsibility and execute the correct risk-reducing behavior, but the government neither trusted the locals to execute correct risk-reducing behavior. Although some locals reported the government as a trustworthy information source, some also reported that the government lacked information or knowledge on the diseases, therefore not trusting their provided information. The lack of trust in information from the government influenced the risk perception negatively, which was mostly the case with chikungunya and Zika:

> *"Well, they [the government] do not know anything about Zika yet, so what kind of information could they give? There were mostly questions about whether or not it's true. What do we do with the information about the babies? Is it even a consequence of Zika? Cause no one proved that. So yeah, that caused some fuss. However, there were many people as well who just thought, well, I do not believe that for one second."*
> -Female, (living in high SES area)

Heuristics and its Influence on Risk Perception, Prevention, and Control of VBDs

Heuristics act as mental shortcuts that could cause or enhance amplification or attenuation of an individual's risk perception. These are often based on or derived from past experiences, perceptions, influences, or events. This research found that heuristics contributed to the attenuated risk perception, mostly concerning dengue. The participants perceived that mosquitos will always be around, or negligent neighbors make it impossible to eradicate all possible breeding sites.

> *"You will always have the problem that if your neighbors keep 3 barrels of water and car tires lying around, you will still have a problem. So yes, it's about protecting against mosquitoes, but the funny thing is that you*

learn to deal with it as something that is just there. (...) I try to protect myself, and if it is very bad, I also spray myself, yes. For example, now all of a sudden, I have mosquitoes at home again, but then I think, well, what else can I do?"
-Female, (living in high SES area)

"Little can be done for complaints about stagnant water."
("Not much to do against complaints stagnant water," 2010, December 7)

The perceptions mentioned above regarding the vector of dengue virus (mosquitoes will always be around) and preventive/control measures (negligent neighbors and government make it impossible to eradicate all mosquito breeding sites) were frequently mentioned when asking the participants for a solution for diseases transmitted by mosquitoes. Locals perceived the dengue virus infection as a normal phenomenon because dengue and its vector have been around for an extended period. Mentioned perceptions helped the participants cope promptly with their perceived risk and allowed them to make judgments quickly. These heuristics could have caused the attenuation of risk for other diseases transmitted by mosquitoes. The participants also reported that their input to reduce transmission is not significant to stop or prevent diseases transmitted by mosquitoes, making them pay less attention to these types of diseases and probably, attenuating their risk perception for other mosquito-transmitted diseases.

Another influence on risk perception is the mishandling of the risk by institutions in the past. Participants indicated that risk management with regards to dengue virus infection was minimal or non-existent:

"With dengue? No. The only thing they [the government] did with dengue is spraying that mess [insecticides]. However, real information on how to prevent and stuff, no. Look, we know that we live in the tropics, and we all know to look out for water and so. The standard we know, but more..? No, we did not get much extra information."
-Female, (living in high SES area)

"The present government, do you think they can help us? The only thing they do is argue and argue. When something is wrong, they do not come to help the public. It is only when elections are coming up that they remind people [of the risks of VBD's]."
- Female, (living in low SES area)

Perceived mishandling of the dengue virus infection epidemic caused the credibility of the risk information regarding chikungunya to be perceived as less. The newspaper's content confirmed the government's mishandling during the dengue and the chikungunya epidemic, which in turn caused less risk information credibility. The observed reduction in risk information credibility could also explain some individual's minimal risk-reducing behavior regarding preventing and controlling mosquito bites during the dengue, chikungunya, and Zika epidemics.

Discussion

Qualitative methods were used to (a) understand how risk was communicated during the dengue, chikungunya, and Zika virus infection epidemics, (b) compare the content of newspapers with the perceptions of locals and experts/government officials, and (c) explore the influence of trust and heuristics on risk perception. This study's results concerning the channels of information are in concordance with the findings of a recent study conducted in Curaçao (Mulderij-Jansen et al., 2020) and Jamaica (Shuaib et al., 2010). In Jamaica, investments have been made in media campaigns concerning dengue virus infection; however, an assessment to determine the impact of such interventions has not been conducted. In contrast, this study went a step further by analyzing the positive or negative influence of newspapers and governmental actions on people's risk perception regarding VBDs.

This study shows that the MoH of Curaçao faces challenges such as no funding for prevention and vector control interventions, no policy in place, no properly defined task division between governmental departments, and inadequate workforce and resources. These are common challenges of Small Island Developing States (Jenkins et al., 2011). Locals, experts/government officials, and the content analysis indicated that the MoH was late with RC concerning chikungunya. Furthermore, it was found that some information materials produced by the MoH were either not appropriately distributed, received in a language that participants were unable to understand, or not received at all. The reported lack of coordination and structure within the MoH might have obstructed RC strategies.

In the case of Zika, RC provided by the MoH started before the epidemic, and the media coverage was very high during the epidemic. However, it is remarkable that the participant's risk perception was attenuated during the peak of the epidemic because neither the MoH nor the media had changed their RC tone, namely: Zika virus infection is a serious threat to human health. A possible explanation for the observed attenuated risk perception could be that Zika virus infection's physical manifestations were milder than those of chikungunya virus infection (Elsinga, Grobusch, et al., 2017). With regards to dengue, the participants had difficulties recalling RC strategies, low media coverage was observed, and the participants reported a lack of RC efforts. The study participants did not consider dengue virus infection to be a threat, perhaps because the last outbreak took place in 2010, and no severe case of dengue virus infection has ever been reported on the island. Another study in the Caribbean (Sint Eustatius) also indicated that the community often did not identify dengue as a severe concern (Leslie et al., 2017). Observed attenuated risk perception could also be ascribed to the previous experience with the relatively mild physical manifestation of dengue virus infection (heuristic) or habituation. An unchanging stimulus could produce habituation, and when the stimulus is presented to an individual repeatedly over time, less attention is given to that stimulus exposure (Wogalter & Mayhorn, 2005).

Furthermore, there might be a lack of mutual trust between the government and the public. Information materials produced by the government were perceived as trustworthy sources in the current research. However, the trust in another to execute correct risk-reducing behavior was lacking on both the government's and local's sides. It has been stated that personal experience and trust in authorities have the most substantial impact on risk perception (Wachinger et al., 2013). The government officials indicated that they did not trust the locals to execute the correct risk-reducing behavior, and the locals indicated that they did not trust the government to perform their duties regarding risk-reducing behavior *(e.g., cleaning up breeding sites)*. In the pursuance of trust, a source must have credibility. Credibility is gained from long-term evidence and commonly shared experience that a source is, amongst other things, competent and consistent in its performance, communication efforts, and fairness (Renn & Levine, 1991). On the other side of mutual trust, it is believed that the public's self-directed change is brought about by heightened awareness and knowledge of health risks (Bandura, 1990).

The locals indicated that the governmental actions concerning RC, prevention, and control measures for dengue virus infection were minimal or non-existent and started late in the chikungunya virus infection epidemic. The community's expectations towards the government were not met, and the developed experience regarding the government's mishandling (heuristics) caused distrust. On top of that, the newspapers published many articles highlighting the failures of the government. The newspaper's content confirmed the local's negative perceptions with regards to the government and enforced distrust. When looking at the SARF, it is arguable that since both the locals and the government lack mutual trust in performing risk-reducing behavior, this has influenced both parties' behavioral response stages during the dengue, chikungunya, and Zika epidemics. The current research makes a useful contribution in showing how a lack of mutual trust between experts and locals can transpire into the behavioral stages of the SARF, which provides important research areas for future epidemics and the ongoing COVID-19 pandemic.

The study was limited by its retrospective design and is susceptible to recall bias. Another limitation is that solely the influence of the content of newspapers was researched. Other information sources such as general practitioners, schools, community centers, internet searching, social media, television, and radio were not further examined during this research. The information channels mentioned above could also impact RC, risk perception, and risk-reducing behavior in a way as described by the SARF. Moreover, the newspaper written in Papiamentu offered only access to articles on Zika; thus, the influence of media during the chikungunya and dengue epidemics presented in this study could be biased to the disadvantage of Papiamentu speaking participants.

Conclusions and recommendations

The current study found that negative reporting by newspapers influenced risk perception, (mutual) trust was lacking between experts/government officials and locals in the execution of prevention and control of VBDs, and local risk perceptions were influenced by heuristics positively and negatively. In this research, certain risk-reducing behavior topics were touched upon, but not in-depth worthy enough to study the behavioral responses and make valid comments in the responses stage of the SARF. Adding to that, the perceptions found in this study, particularly those of distrust, could disperse political and social impacts, or in other words, the ripple effects (Kasperson et al., 1988). The above provides interesting research areas to be further examined. We recommend studying the influence of other channels of information on the risk perception and behavior of people. Finally, a multidisciplinary team, with members of different (governmental) departments to tackle the prevention and control of VBDs on a timely basis, is recommended. Agreements and work procedures should be documented to enable transparency and communication. In a world that is currently facing a pandemic of COVID-19 virus infection, this research's findings could be used as a stepping stone to examine and shape current health RC policies around the world.

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CHAPTER 6

Waste management, tourism, and control of mosquito-borne diseases in Curaçao: A call to sustainable actions

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Abstract

Background: Tourists play an essential role in spreading mosquito-borne diseases (MBDs). They also add an extra burden to waste management (WM) efforts in countries with less developed WM systems. Since environmental management, including solid WM, plays an essential role in mosquito control, this qualitative study explores current WM practices, the influences of the tourism industry on WM, and the possible implications of WM on MBD control in Curaçao. Methods: A mix of qualitative data collection methods, namely, transect-walks (n=10), semi-structured interviews (n=26), and observations (12), were performed (March–April 2019 and August 2020). In addition, in February 2021, illegal dumping sites were plotted using a geographic information system. Results: We found that social (e.g., lack of community awareness and involvement in WM), economic (e.g., poverty), environmental (e.g., illegal dumping), and governmental factors (e.g., lack of enforcement of regulation and intersectoral collaboration) influence WM negatively. Despite the initiatives to use recycling services and biodegradable utilities, most of the solid waste generated by the tourism industry and the community ends up in the landfill. Conclusions: The untreated solid waste located at illegal dumping sites, households, and the landfill can increase the availability of mosquito breeding sites, increasing the vulnerability of MBDs outbreaks.

Keywords: Dengue, Chikungunya virus, Zika virus, Environment, Prevention, Small Island Developing State

Introduction

Islands are recognised as being ecologically and economically fragile, primarily due to their size, limited resources, geographical dispersion, and isolation (1). Thus, many small islands developing states (SIDS) rely heavily on the tourism sector to support their economic development. However, tourists have dynamic interactions with microbes and places, resulting in the emergence of infectious diseases, such as mosquito-borne diseases (MBDs) and, most recently, COVID-19 (2). These diseases have a massive global impact in terms of economic disruption, increase local populations' vulnerability, add to the strain on local and international public health resources, and, above all, impact human health.

From an ecological perspective, small islands in the tropics are at risk of MBDs because they are more affected by warm temperatures and precipitation, which is worsened by a lack of waste management (WM) strategies (3), water supply (4), and sanitation (5). In addition, the local government has limited capability to implement mosquito control and manage outbreaks (6). During the past decade, epidemics of MBDs have been threatening the Caribbean islands (6, 7). For example, in Curaçao, the chikungunya virus (CHIKV) and Zika virus (ZIKV) caused major outbreaks in 2014-2015 and 2016-2017, respectively (Ministry of Health, Environment, and Nature of Curaçao, 2016). Also, dengue epidemics occur cyclically (Ministry of Health, Environment, and Nature of Curaçao, 2016). Behavioural change at various levels (e.g., individual, community, public, and private sector) is needed to prevent and control MBDs, combined with access to sanitation, water and proper WM. There is a need for intersectoral collaboration to manage MBDs effectively. Tourists and travel organisations also play a significant role in contributing to the prevention and control of MBDs.

To our knowledge, most of the studies in MBD research focus on the clinical, epidemiological, and behavioural aspects of MBDs. However, broader societal and systematic issues such as WM have received less attention. According to a recently published review, more qualitative studies in MBD and WM are needed to understand interventions' social and cultural determinants, including implementation processes and sustainability of interventions (8). WM plays an essential role in mosquito control because it can interrupt the vicious cycle of mosquito breeding sites (MBS), mosquito and MBDs, by reducing artificial water-holding containers (9). Waste of households such as bottles, containers, used tires, and electronic equipment (e.g., refrigerators) are resistant to different weather conditions. Therefore, when mentioned waste is placed in the environment, it can remain for an extended time and become artificial water-holding containers that are, in turn, suitable MBS, particularly for the *Aedes* spp (10). The presence of used tires and bottles as waste in people's gardens has been associated with an increased risk of dengue infection (11, 12). Especially, vehicle tires have played an important role in the spread of dengue because they seem to be a preferred breeding site for *Aedes Aegypti* (13) and *Aedes Albopictus* (14). Since *Aedes Aegypti* (primary vector of MBDs in the Americas (15)) can breed in many sites, WM becomes a key control measure to control MBS.

WM remains a problem for SIDS due to the increase in waste generation (due to population growth, many imported materials, and waste production of the tourism industry, including stay-over and cruise-ship) without any effective WM strategy. To date, waste infrastructure developments in many SIDS have failed to produce sustainable outcomes (16). This failure can be attributed to limited waste disposal space, recycling opportunities, regulations, enforcement, and barriers to removing waste. It is generally known that solid WM is the local government's responsibility, whereas the citizens are not expected to contribute. However, the efficiency of the operation of solid WM depends on effective collaboration between the governments and the citizens (17). The improvement and maintenance of public infrastructure and essential services can help reduce MBS. Therefore, this qualitative study explores current WM practices, the influences of the tourism industry on WM, and the possible implications of WM on MBD control in Curaçao. Our findings could highlight the seriousness of the matter and support governmental institutions and non-governmental organisations (NGOs) in developing more sustainable WM strategies to reduce the risk of MBDs in the Caribbean. In addition, other SIDS can also benefit from our findings and recommendations.

Materials and methods

Study site

Curaçao is an island in the southern Caribbean Sea and has a surface of 444 km^2. In October 2010, Curaçao became an autonomous country within the Kingdom of the Netherlands. According to the Central Bureau of Statistics Curaçao (CBS), the estimated population was approximately 158.665 inhabitants on January 1st, 2018 (18). Curaçao has a mild tropical climate with an average temperature of 25-28 °C. Having shifted from its previous reliance on the oil refinery, Curaçao now relies heavily on tourism; the tourism sector contributes over 1 billion guilders [557.379.400.000,00 USD] to the economy, which accounts for approximately 18% of the country's Gross Domestic Product (GDP) and 26% of the contribution to foreign exchange (19). Tourism waste contributes around 20% of the total waste volume on the island (20). The landfill capacity is expected to reach its maximum in 2026 (21).

Data collection

The participant's recruitment was initiated by e-mail correspondence. During the data collection, the participants were recruited mainly via personal connections or other social contacts using the snowball sampling technique. To guarantee the anonymity of the participants, the names used are fictional. An overview of the participants is presented in Table S1.

This study collected information regarding WM and MBDs through primary qualitative data collection methods. The data was collected during March – April 2019 in Curaçao, during which 26 participants were interviewed. The participant's background ranged from being in the tourism industry, namely hotel, restaurant, tour agency manager/owner; government officials; NGOs; and private businesses. Qualitative research methods were used to understand processes, perceptions, and experiences related to WM, including tourism WM, profoundly. Qualitative research methods were also used to identify WM issues from the local perspective and understand the behaviour of the interviewees (22). This study used qualitative data collection methods, including transect walks, semi-structured interviews, and observations.

A transect walk is a systematic walk in the designated path along with key informants to explore the local situation by observing, asking, and listening (23). The transect walk was intended to be performed before an interview. However, several transect walks have been held during the semi-structured interviews or at the end of the interviews. The information gained during these transect walks was not recorded; instead, notes were taken during the walks. To further understand the WM and its possible implications on MBD control, a semi-structured interview was conducted to follow up on the information gathered from the transect walks. A semi-structured interview is a verbal interchange meant to extract information from another person and directed by an interview guide but allowing an open response from the interviewees to maximise the knowledge-producing potential (24). Different interview guides (Supplementary Materials: Interview guides) were used to stress the focus of the interviews on various topics, such as WM, tourism, and health.

Furthermore, the assessment of the status of WM on the island was broadened through observations. This technique mainly focuses on social interaction between different forms of social cohesion. The observations were translated into several photos and videos that demonstrate the actual conditions in the field.

Secondary data collection was performed to verify our findings. These data were acquired from available publications and online media news. In August 2020, two transect walks with two members of a non-profit environmental organisation called *"Amigu di tera"* (Friends of the Earth Curaçao) were conducted to validate the study's findings. From February 1st to 17th, 2021, illegal dumping sites were plotted using Google Earth, a geographic information system (GIS). The mentioned data were collected in collaboration with the Vector Control Unit (VCU) of the Ministry of Health, Environment & Nature of Curaçao (MoHEN).

Data analysis

Based on Hennink et al., inductive thematic analysis methods were applied to this study while following the deductive conceptual model and analysing the new information emerging from the interviews and observations. Extensive notes were taken during the transect walks, interviews, and observations. Furthermore, interviews were recorded and later transcribed to ensure the data was formatted correctly and then analysed to form conclusions (22). The analysis was carried out through thematic coding using NVivo 12 Mac software. The coding book can be found in Table S2. The participants signed an informed consent before their interview. The data were anonymised and stored in files accessible at Utrecht University and the University Medical Center Groningen, Department of Medical Microbiology and Infection Prevention, Groningen.

Results

Current waste management practices

It is essential to understand the stakeholder's roles and responsibilities behind the WM in Curaçao to understand WM's processes more profoundly. Following the dissolution of the Netherlands Antilles in 2010, the MoHEN was established. The MoHEN is responsible for making laws and executing strategies related to the environment, nature, and public health. At the moment of data collection of this study in 2019, MoHEN was still working on the solid waste management ordinance draft.

Selikor NV is a government-owned company that is responsible for processing solid waste generated in Curaçao. Selikor is accountable for managing the landfill, household, commercial, stay-over and cruise ship-generated waste, and clean streets in the touristic areas of Punda and Otrobanda. In 1985, Selikor opened the first landfill called Malpais, with a 45-hectare area. Selikor also owns a waste transfer station that is located in the eastern part of the island. People who cannot reach Malpais can dispose of their bulk of waste at that transfer station, and Selikor transfers the waste to the landfill. Selikor provides a collection point outside the landfill to recycle glass, batteries, and electronic parts. However, the majority of the participants of this study have questioned the recycling efforts of Selikor. They stated that the aims of Selikor concerning recycling are unclear, and they do not see what is happening with the collected glasses, batteries, and electronic parts. According to them, these objects are not being reused in Curaçao or exported. The flowing quote portrays this issue.

> *"When the glasses are being collected, especially by Selikor; they do nothing with them. They just put it in a big pile on the landfill. However, maybe in the future, they might do something with it."*
> -Julian, Tourism industry

Figure 1 confirms the perceptions concerning the recycling efforts of Selikor. Several piles of glass bottles were found during a visit to the landfill, and there was no evidence of recycling activity. However, Selikor encourages people to dispose of their glass bottles for recycling (25). The difference between reality and the information distributed creates distrust toward Selikor.

The government allows private companies to participate in WM, yet they are only allowed to work outside the work scope and area of responsibility of Selikor. Commercial waste companies are authorised to pick up the commercial waste and deliver it to the landfill. The distrust towards Selikor has opened more of the market for private WM companies. Several private recycling and upcycle companies are present on the island. Nevertheless, they face difficulties in handling the demand for recycling services that mostly come from the tourism industry. For example, Green Force Curaçao addresses seven hotels and several companies' recycling needs and focuses on recycling cardboard, three different types of plastics (PET, HPDE, and LDPE), used batteries, and aluminium cans. Those materials are being sorted and exported to other countries for further use. Households are free to drop off their recyclable materials at three different drop-off points or directly at their recycling station.

Figure 1. Pile of glass bottles at Malpais landfill.

The participants reported that despite Selikor's monopoly in WM, several private waste collection and recycling initiatives have been conducting their business on the island; see Table 1 for a complete list. Once, MoHEN tried to initiate a meeting with recycling companies to document their challenges, yet only a few recycling companies showed up. According to public health officials, this reflects the unhealthy competition and individuality between the recycling companies. Furthermore, during the data collection, most of the companies in table 1 were hard to reach; hence, except for those interviewed, their existence and scope of their work are still questionable.

Table 1. Recycling companies in Curaçao

Company	Ownership	Type of waste stream
Greenforce	Private	Plastic, aluminium, and beer crates
Recupal Curaçao N.V.	Private	Plastic
BioFuels Curaçao N.V.	Private	Frying oil waste
Living Green B.V.	Private	Wood and garden waste
Waste Oil Management Curoil	Private	Oil sludge and waste oil
Caribbean Recycling Company Holding (Selikor)	Government	Construction waste
Antillean Scrap Company Antillean Metal and Scrap Processing and Trading N.V.	Private	Metals and car wrecks
Jamaiquino	Private	Not specified
Sherd Express	Private	Not specified
Illegal Car Battery Collectors	Private	Not specified
Van Rumpt Recycling N.V.	Private	Paper and carton
2nd life Curaçao	Private	Not specified
Caribbean Waste Collective	Private	Not specified
Selikor Malpais/ Selikor Overslagstation Koraal Specht	Government	Plastic, aluminium, glass, beer crates
Zap Caribbean	Private	Batteries
ATCO	Private	Carton / paper
AVBC	Private	Carton / paper
CurRecycles Metals	Private	Car wrecks
Curaçao Waste Management	Private	Metal
ENI Recycling	Private	Kitchen appliances

Source: GMN, *n.d.*

The government and waste management

The government of Curaçao recognised WM as an urgent priority during the Third International Conference on SIDS (Ministry of Health, Environment, and Nature, 2014). However, this study found conflicting evidence, demonstrated by the following quote:

> *"Another thing is to prioritise it [waste management] because money is lacking. Do not get me wrong; healthcare is a priority,* and *education is a priority. However, if we reduce the cost related to expensive consultants that work on stupid projects, we can use that money [for waste management]."*
> Sophia, Private company

According to most participants, there were only a few government initiatives to support WM in the last five years. Due to financial problems, the government focuses only on issues that need more priority and put WM on hold. The problem with the oil refinery is a bigger problem for Curaçao; thousands of people face unemployment, making WM not the priority for the government.

Over the years, several recycling companies have tried to open their businesses; however, only a few companies have remained in operation due to the government's lack of support. So far, the government has been helping the recycling companies with the permitting process; however, the process will take longer when it comes to further expansion. This situation is the reason for the delay in the further development that Green Force has experienced.

> *"With the new investment coming, we can increase by 400% and add 16 more companies, two hotels, and three major projects. We have been waiting for five years already for a piece of land, the government promised us but so far no result."*
> Miguel, Recycling company

Furthermore, according to the public health officials, there are no regulations regarding the packaging of products that can enter the island, leading to more packaging that cannot be recycled, thus generating more waste that will end up at the landfill. A lack of regulation within WM is also mentioned in the National Report of Curaçao for the Third International Conference on SIDS (MoHEN, 2014). According to the mentioned report, regulations are not always effective in Curaçao because there is a lack of adequate institutional and human resource capacities to enforce the law.

The community and waste management

The tendency to blame the local population for the island's waste problem can be found in the local media reports (26-29). These media reports also highlighted the problem with illegal dumping. Professionals working in the tourism industry and WM officials indicated that the community had not been educated on WM. They stated that WM was never part of the educational curriculum or was discussed at schools in a limited way.

> *"And I bet you; you can ask ten local people 'what do plastics do to the environment?' They cannot tell you that. It is sad; you need to know what it is."*
> Carlos, Tourism industry

> *"For them (locals), it does not matter if you dump it in the natural area; look how cheap it is, they do not care. They do not recycle very much; they do not take time to separate. For them, it is important that you get to pick up the garbage once a week, and it is gone. After that, what happens? They do not care. The cheapest as possible."*
> Tim, Waste management official

The economic situation in Curaçao has also become one of the reasons for the relatively low awareness with regards to the WM of the local population. According to CBS, 25,1% of the local community is under the poverty line, and, understandably, they might not care about WM in the first place (30). Furthermore, the recent crisis with Venezuela has put Curaçao's economy into a budget deficit. Besides, 3000 people are facing unemployment due to the situation with the oil refinery (31). The connection between the economic crisis and waste behaviour is stated by the quote below:

> *"The bigger problem is the local population not being aware, that is the biggest problem … Poor people are in survival mode; they do not care. They are not thinking about the environment and stuff like that."*
> Miguel, Recycling company

Public health officials stress the importance of applying preventive measures since vector control needs to be done by everyone. The public health officials indicated that the local community is aware of the association between potential MBS and MBDs. However, they are not doing enough to avoid the possibility of having MBS at their properties. The local populations tend to accuse their neighbours of having MBS. Thus there is a gap between having knowledge and applying the knowledge. The following quote portrays this issue:

> *"The government tried with some programs: People need to clean their garden', they also checked out some stuff, they asked if they can walk around, but they cannot obligate you to clean up your property."*
> Gerard, Tourism industry

In 1996 Curaçao's first waste tax was implemented, requiring every household to pay 20 guilders (11,15 USD) per month. The waste tax has not changed for 23 years, yet not everybody can afford this mandatory fee. The money goes to the government, and the government pays Selikor. People who cannot afford the waste tax or are not registered (e.g., undocumented migrants) at Selikor dump their waste in the natural surroundings or the sea, usually called illegal dumping (Figure.2).

Figure 2. Illegal dumping site.

According to a recycling company, illegal dumping sites are scattered throughout the island, with the total number being around 3.200 sites. Observations performed in key neighbourhoods of Curaçao (e.g., Shut, Seru papaya, Muizenberg, Monte Carmelo, Suffisant, Koraal specht, Choloma, Fuik, and Montaña) confirmed the presence of illegal dumping sites (August 2020). Illegal dumping can be considered a business in some neighbourhoods such as Seru papaya and Choloma. Two participants elaborated further on this topic and stated that some people use governmental lots without permission to steal diabase. The created holes are being used to dump waste illegally. Local community members and organisations pay those people (who use governmental lots without permission) to dump all types of waste (e.g., pesticides, batteries) at the created dumping sites. Representatives of the *"Amigu di tera"* environmental foundation consider this an organised environmental crime out of control. Figure 3 provides an excellent illustration of illegal dumping sites scattered throughout the island.

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Figure 3. Illegal dumping sites (n=207) plotted with GIS

Remarkably, most illegal dumping sites are located at the centre of the island, close to the landfill. The government formed a task force called X-Team to fight illegal dumping and environmental crimes. The team was established in 2017 and falls under the MoHEN's jurisdiction; however, the illegal dumping remains untouched due to limited capacity and staff. Figures 2 and 3 illustrate the problem that Curaçao has with unlawful dumping of waste. Currently, there is no policy concerning the disposal of used tires. The majority of the displayed waste is a potential MBS.

Influences of the tourism industry on waste management

Waste behaviour among tourists depends on their origin. Tourists with advanced WM experience are more likely to use the recycling bins than tourists from countries with less developed WM. Professionals working in the tourism industry are aware that tourism development increases the amount of waste generated in Curaçao, threatening the local environment due to improper WM.

"We cannot deny the effect that tourists produce more waste than the locals. It is because if they are here, they tend to consume more, they eat a lot, they buy a lot, and those things produce waste. So I think the more tourism grows, the more we need to have a good waste system."
Max, Tourism official

An important factor that increases the total volume of waste in Curaçao is the imported products ordered by the local businesses, including the tourism industry, to fulfil the consumer's needs. As mentioned previously, there is no regulation for the packages of imported products, thus leading to more waste that will end up at the landfill. Figure 4 illustrates a proportion of the generated waste at the landfill and highlights the problem with untreated waste. Some participants reported that the landfill is a significant MBS during the rainy season. Their perception has been confirmed in figure 4.

Figure 4. Malpais landfill

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The tourism industry uses Selikor's service to handle solid waste, except for some hotels that approach private companies. Due to the lack of incentives and enforcement from the waste officials, the tourism industry has to approach the private recycling companies with their initiatives. Restaurants are more inclined to use biodegradable utensils such as paper straws and paper boxes instead of separating their waste even though they know the importance of recycling.

The professionals working in the tourism industry indicated that they have the means and power to apply recycling systems and use biodegradable products in their services. They acknowledged that recycling is vital for the environment. However, some still chose not to do it because using Selikor's service requires less effort. Thus there is no need to separate the waste or make additional efforts to deal with the produced waste. The perceived inadequacy of recycling facilities from Selikor and the fact that private recycling companies are not visibly on the waste management market leads to more landfill disposal since most waste is not recycled.

Curaçao's waste management and its possible implications on MBD control

An essential aspect of vector control is removing potential MBS, which can be achieved through proper solid WM. In the last decades, a large proportion of the community, private and governmental organisations were inspected by the VCU for MBS. In addition, the MoHEN provided information about WM and its link with MBS and organised cleaning events to remove MBS scattered through the island. However, according to public health officials, these actions are not enough to solve the problems that Curaçao faces regarding WM and MBS because recommendations provided during inspections are not mandatory. Since enforcement is lacking, the WM of the government hinges on the performed WM practices of the community and organisations.

Despite all efforts to develop WM regulations, up to this day, regulations and enforcement concerning WM to deal with MBS are lacking. The government provides means to dispose of generated waste through Selikor; however, as shown in this study, there is a group of people and organisations that do not use the services provided by Selikor. This, in turn, causes things such as illegal dumping sites. According to our observations, many potential MBS are not being taken into account during vector control and WM campaigns. For example, waste dumped in nature, on government lots, and stored at the landfill is not being inspected, treated, or managed by an assigned organisation to prevent mosquitoes from breeding. This leads to massive potential MBS scattered throughout the island, increasing the risk for MBDs during the rainy season.

The mentioned problem is not new; it was also present during the last epidemics of MBDs. Based on the MoHEN information (Epidemiology & Research Unit [ERU]), there are indications of a potential association between illegal dumping sites and the incidence of MBDs. According to the ERU, the first cases of DENV and CHIKV infection started in Suffisant, Muizenberg, and Monte Carmelo. According to our observations, these areas have many illegal dumping sites, sewages filled with waste or organic substances (e.g., trees), and water collection areas (dam), which can be potential MBS. Based on this information, neighbourhoods with these characteristics (e.g., poor waste management, sewage system, etc.) might have a higher risk for MBDs.

Discussion

To our knowledge, this is the first study in the Dutch Caribbean that explores the links between WM, MBDs and tourism. The current study aimed to explore WM practices, the influence of the tourism industry on WM, and the possible implications of WM on MBD control in Curaçao. The association between inadequate WM and the spread of MBDs has been reported in the literature (3, 9, 32). Proper WM can restrain the spread of MBDs since it reduces the number of MBS. Yet, in Curaçao, the initiatives to understand the importance of proper WM in the control of MBDs are lacking. Due to the lack of human and institutional capacities, governmental organisations related to WM fail in developing policy and sustainable interventions. Also, the economic situation that Curaçao is facing makes WM not a priority for both the government and the community. These are common challenges that SIDS are facing (16). Illegal dumping is also a problem that WM officials are dealing with; this is possibly caused by a lack of enforcement of the law regarding WM, education, and the community's critical financial situation. Outdoor solid waste disposal, including illegal dumping, can threaten vector control effectiveness due to increasing MBS availability (33). This, in turn, increases the risk for MBDs both for the island population and the tourists that arrive. These challenges make it very difficult for Curaçao and other SIDS to improve their WM and vector control. Our findings provide a basis to understand how social, economic, governmental, and environmental vulnerabilities of SIDS increase the risk for a MBD outbreak.

This study also highlights trust issues between local companies and Selikor as some participants perceived that the reported actions with regards to recycling are not in line with the current practices concerning recycling at the landfill. Trust has been found to play an essential role in the behaviour of individuals and organisations. Thus it can negatively affect WM efforts (34, 35). We also found a lack of collaboration and communication between NGOs, governmental organisations, and the community concerning WM for vector control. So there is a lack of community-based and industry-based vector control. Guerrero et al. acknowledge that the efficiency of the operationalisation of WM depends on collaboration between the governments and the population (17). Poor collaboration leads to poor WM, which leads to inadequate vector control, and increases the risk for MBDs. Thus, more effort is needed to improve the collaboration, communication, and trust between stakeholders, including the tourism industry, to work towards a more sustainable WM in Curaçao to enhance vector control efficiency.

Lastly, we found that the tourism industry is aware of its impact on the total waste volume in Curaçao and recognise the importance of WM. For example, some organisations in the tourism industry are engaged with recycling companies or use biodegradable products to improve WM. A possible explanation is that people at the top of the tourism industry had been exposed to the best practices in WM somewhere else and therefore are more engaged in implementing WM practices such as recycling. This exposure could explain the knowledge gap between the locals and the people in the tourism industry. Thus the observed lack of awareness of WM among the local population might be caused by the lack of education on WM.

Limitations

The current study was susceptible to recall bias because the last outbreaks of MBDs happened in the past. However, collected data concerning WM is less susceptible to recall bias since it focuses on the current WM situation. Qualitative study is often criticised because the findings do not prove causality. However, qualitative studies are more suitable for profoundly understanding organisational processes, perceptions, and experiences of people. To reduce the mentioned limitations and improve the study's quality, we combined three research methods (data triangulation) to provide a confluence of evidence that breeds credibility.

Conclusions and recommendations

The WM of Curaçao needs improvements to deal with the waste quantity and illegal dumping to enhance vector control and reduce the risk for future outbreaks of MBDs. We recommend the following to improve WM in Curaçao: (i) develop laws concerning recycling and illegal dumping, (ii) invest in law enforcement and monitoring systems, (iii) enhance collaboration and communication among stakeholders (e.g., existing private recycling companies), by developing a multi-disciplinary WM policy, that indicates the responsibility and working procedure of each stakeholder, (iv) assign a trained team to enforce, control, evaluate and adjust WM strategies to ensure continuity of activities, (v) expand WM education at schools to enhance awareness and citizenship, (vi) adjust tax fee concerning waste for people with low income, and (vii) perform vector surveillance at potential dumping sites to detect larvae and determine indices. There is no doubt that the economic situation of Curaçao is critical, and, understandably, WM is not a priority now. However, the implications of inadequate WM on public health need to be clear for all stakeholders (e.g., community, private, and government) to reset priorities and develop more cost-effective and sustainable WM strategies. Recommendation for future research: include WM profile (e.g., illegal dumping sites, sewage systems, etc.) of neighbourhoods into prediction models and estimate the correlation between the incidence of MBDs and WM profile of neighbourhoods using GIS. Amidst the current COVID-19 pandemic, responsible organisations for WM struggled to perform WM. Therefore, more efforts are needed to develop sustainable interventions to ensure proper WM during a pandemic to reduce the risk of the emergence of other infectious diseases, such as MBDs.

Institutional Review Board Statement: The study was approved by the Medical Ethical Board of the Sint Elisabeth Hospital Curaçao (METC SEHOS; reference number: 2015–002).

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CHAPTER 7

Contexts motivating protective behaviours related to *Aedes*-borne infectious diseases in Curaçao*

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Abstract

Background

Aedes aegypti, the vector of arboviral diseases such as dengue and Zika virus infections, is difficult to control. Effective interventions must be practicable, comprehensive, and sustained. There is evidence that community participation can enhance mosquito control. Therefore, countries are encouraged to develop and integrate community-based approaches to mosquito control to mitigate *Aedes*-borne infectious diseases (ABIDs). Health professionals must understand the contexts motivating individuals' behaviour to improve community participation and promote behavioural change. Therefore, this study aimed to determine how contexts shaped individuals' protective behaviours related to ABIDs in Curaçao.

Methods

From April 2019 to September 2020, a multi-method qualitative study applying seven (n = 54) focus group discussions and twenty-five in-depth interviews with locals was performed in Curaçao. The study was designed based on the Health Belief Model (HBM). Two cycles of inductive and deductive coding were employed, and Nvivo software was used to manage and analyse the data.

Results

In this study, low media coverage (external cue to action) and limited experience with the symptoms of ABIDs (internal cue to action) were linked with a low perceived susceptibility and severity of ABIDs (low perceived threat). The low perceived threat was linked with reduced health-seeking behaviour (HSB) to prevent and control ABIDs. We also found that the perceived barriers outweigh the perceived benefits of ABID prevention and control interventions, obstructing HSB. On the one hand, insufficient knowledge reduced self-efficacy but contrary to expected, having good knowledge did not promote HSB. Lastly, we found that our participants believe that they are responsible for preventing ABIDs (internal locus of control) but at the same time indicated that their success depends on the efforts of the community and the health system (external locus of control).

Conclusions

This study used the HBM to explain individual changes in HSB concerning ABIDs prevention and control in Curaçao. We can conclude that the perceived threat (perceived susceptibility and severity) and perceived barriers played an essential role in changing HSB. Health professionals must consider these two concepts' implications when designing a bottom-up approach for ABIDs control; otherwise, community participation will remain minimal.

Keywords: Caribbean Region, Dengue, Zika virus, Chikungunya virus, Mosquito Control, Health Belief Model, Environment and Public Health

Introduction

Aedes (Ae.) aegypti and *Aedes albopictus* mosquitoes have been implicated as potential vectors of dengue, chikungunya and Zika viruses (1, 2). In the Latin American region, the primary vector of these viruses is the *Ae. aegypti* mosquito (1). *Aedes*-borne infectious diseases (ABIDs) are expanding their spatial range, gradually emerging in previously unaffected areas and re-emerging in regions where these diseases have been eradicated (3). The prevention and control of the ABIDs mentioned above rely mainly on mosquito control because no antiviral treatment nor vaccines are available (4). There is a licensed dengue vaccine; however, it is not widely used due to safety concerns (5). Some temporary successes have been achieved in controlling ABID outbreaks; however, these have not persisted, partly because of the top-down approach, which was often vertically structured, without community involvement, and costly to be sustainable (6).

In the 1990s, the public health approach combining active surveillance, emergency response, case management, and community-based mosquito control became the basis for the World Health Organization global strategy for preventing and controlling ABIDs (7). Such an integrated approach has been implemented in different countries, and beneficial results have been reported (8, 9). Efforts have been made to implement integrated mosquito management in Curaçao. Nevertheless, successful program implementation has remained a challenge. Insufficiently qualified workforce, resources and engagement from the health authorities and communities have obstructed the implementation of mosquito control interventions (10).

Based on the failures of the top-down mosquito control approach, countries are encouraged to emphasise the bottom-up approach. The bottom-up approach refers to an integrated community-based approach to mosquito control by environmental management, emphasising health education and community ownership (11). The main aim of this approach is to convince people to take ownership of household and neighbourhood mosquito control. To improve community participation and promote behavioural change, health professionals need to understand the community's behaviour. Therefore, this study was designed to determine perceptions, beliefs and attitudes motivating individuals' protective behaviours related to ABIDs in Curaçao. This study is part of a larger research project, the ARBOCARIB project, where health system preparedness and performance, risk communication, social amplification of risk and individual protective behaviour regarding ABIDs have been studied (10, 12, 13).

Data from our previous research has highlighted how the macro-level (e.g., the performance of the health system concerning mosquito control and risk communication) and meso-level (e.g., social influence, cultural schemas) shaped individual protective behaviour concerning ABIDs in Curaçao (12, 13). Published data from our previous research support the literature suggesting that people's perceptions and actions are shaped by their environmental and socio-cultural context (14). Besides the macro and the meso-level, the micro-level (individual level) also needs to be explored. Therefore, in this current study, the Health Belief Model (HBM) will be applied to understand better the intricate processes underlying individuals' decision-making and health-seeking behaviour (HSB). We will explore the role of the following key concepts of the HBM (i) perceived susceptibility, (ii) perceived severity, (iii) perceived barriers, (iv) perceived benefits, and (v) self-efficacy on HSB (15). HSB in this study refers to any action or inaction undertaken by individuals to prevent or control ABIDs spread. The influence of cues to action (e.g., risk information) on the perceived threat (perceived susceptibility and severity) and self-efficacy will also be studied. Health professionals can use our findings to work towards more bottom-up *Aedes* control interventions.

Methods

From April 2019 to September 2020, a multi-method qualitative study using focus group discussions (FGDs) and in-depth interviews (IDIs) with locals was performed in Curaçao. The study was designed based on the theoretical framework of the HBM (15). In previous research, we have used some concepts of the HBM (perceived susceptibility, perceived severity and cues to action) to study the perceived threat of ABIDs (12, 13). However, this study goes a step forward by using the complete HBM to explain the underlying motivations for multifaceted and complex individuals' health-seeking decisions. The concept of external cues to action represents the influences of the macro and the meso-level on the perceived threat (perceived susceptibility and perceived severity) and self-efficacy. The study's conceptual framework was applied during data collection, analysis, and interpretation of results (Fig 1).

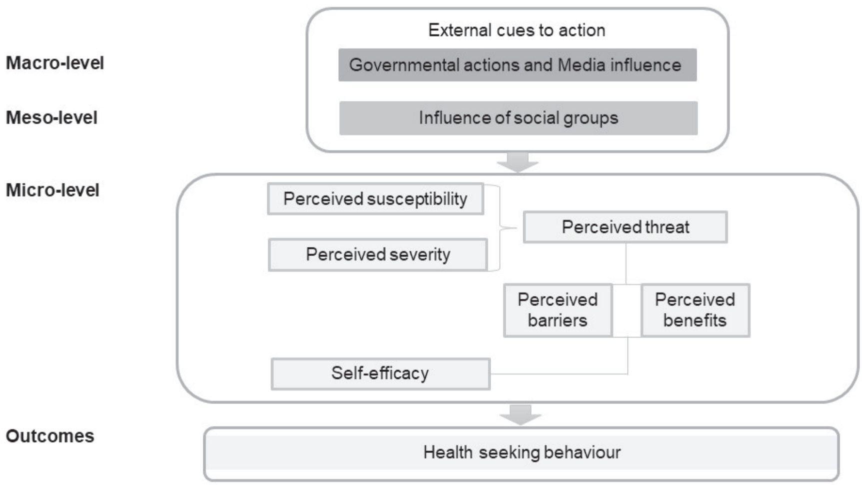

Figure 1. A conceptual framework for understanding individuals' decision-making process and health-seeking behaviour regarding ABIDs.

Study population

We collected data by conducting FGDs and IDIs on different individuals. Seven population groups of Curaçao were selected to participate in FGDs (n=54). The following groups were included: (i) local youth (high school students aged 15-20 years), (ii) individuals from the neighbourhood of Seru Papaya, (iii) Adventists, (iv) Jehovah's witnesses, (v) Protestants, (vi) Catholics and, (vii) employees of an insurance company. In total, 25 newly recruited individuals with different socioeconomic statuses (SES) were interviewed (participants of the in-depth interviews) (see Tables 1 and 2). The participant's reported education and occupation were used as a proxy to determine their SES. In this study, an individual with a low SES reported finishing primary school and was unemployed at the moment of data collection. An individual with a middle SES reported having a paid job or receiving a retirement fee and finishing secondary or intermediate vocational education. Individuals with a high SES reported having a paid job and finishing higher vocational education or university.

Data collection

FGDs were conducted first to gain an in-depth understanding of social issues regarding community participation in mosquito control. Seven FGDs with different social groups were performed. Twenty-five IDIs were conducted in the second phase of data collection to verify and support data drawn from the FGDs. The topic guides for the FGDs and IDIs were semi-structured to cover each concept of the conceptual framework of this study (See Additional files 1 and 2: Text S1-2 Topic guides FGD and IDIs). The topic guides were piloted and adjusted before the data collection. The FGDs and IDIs were conducted in Papiamentu or Dutch, recorded, and transcribed.

Data analysis

The data collected from FGDs and IDIs with community members were analysed inductively (codes raised by the study participants themselves) and deductively (codes derived from literature and existing theories) (Additional file 3: Table S1. Coding list). Two cycles of inductive and deductive coding were employed in the data analyses of the FGDs. In the first cycle, the data was assigned to codes, and these codes were assigned to 12 categories, which were studied in the second cycle of data analysis. We created the following categories by combining inductive and deductive codes: (i) knowledge about ABIDs, (ii) perceived susceptibility, (iii) perceived severity, (iv) perceived barriers, (v) perceived benefits, (vi) self-efficacy, (vii) trust, (viii) internal locus of control, (ix) external locus of control, (x) cues to action, (xi) HSB, and (xii) recommendations. The same method was used to analyse the IDIs with locals. Similar codes and categories were used to compare the data from the FGDs and IDIs. This data analysis method facilitated the data interpretation to elicit meaning, compare data, gain comprehended understanding and develop empirical knowledge. The data was analysed using Nvivo software (version 12 Pro). All quotes used in this article were transliterated to keep the context intact.

Results

Seven FGDs (n = 54) and 25 IDIs were conducted. Thirty-nine participants of the FGDs (72%) and nineteen interviewees (76%) were female. About two-thirds (64%) of the interviewees had a middle SES, and the mean age of the interviewees was 47.8 years. The characteristics of the interviewed community members are presented in Tables 1 and 2.

Table 1. Characteristics of the study participants of the FGDs with the community.

	(n) participants	Gender* F:M	Age range	SES**
FGDs (n=7)	**(n = 54)**			
Local youth***	8	2:6	17-20	High
Seru Papaya	12	12:0	42-73	Low-middle
Adventists	6	3:3	35-69	Middle-high
Jehovah witnesses	4	4:0	39-62	Low-middle
Protestants	8	4:4	33-67	Middle-high
Catholics	11	11:0	55-86	Low-middle-high
Employees of an insurance company	5	3:2	37-62	Middle-high

*F=Female. M=Male
**SES= socio-economic status
*** The parents of the students have a high SES.

Table 2. Characteristics of the study participants of the IDIs.

IDIs (n = 25)	SES^	Gender*	Age
01	Middle	F	35
02	High	F	59
03	High	F	29
04	Middle	F	28
05	Middle	M	30
06	Middle	F	49
07	Middle	F	57
08	High	F	54
09	High	F	67
10	Low	F	63

IDIs (n = 25)	SES^	Gender*	Age
11	Middle	F	81
12	Middle	F	46
13	Low	F	40
14	Middle	F	46
15	Middle	M	40
16	Middle	F	58
17	High	M	59
18	Middle	M	52
19	Middle	M	55
20	Low	F	55
21	Middle	F	46
22	Middle	M	35
23	High	F	64
24	Middle	F	22
25	Middle	F	25

*F=Female and M=male.
^SES= socio-economic status.

Over 75 codes were gathered into 12 categories organised into five themes. The themes refer to the concepts that influence decision-making processes and behaviour concerning the prevention and control of ABIDs. The following five concepts are discussed in this article: (i) perceived threat, (ii) perceived barriers, (iii) self-efficacy and (iv) internal and external locus of control, and (v) HSB.

1. Perceived threat

People associated high media coverage with high disease susceptibility and severity. Most participants from the FGDs and IDIs indicated that ABIDs were/are not a threat to their lives because limited attention from the government/health system and media channels was given to these diseases before, during and after the last three epidemics (dengue 2010, chikungunya 2014-2015, and Zika 2016). The following quotes portray this issue.

> *'Interviewer: Okay, do you feel at risk for one of these diseases?*
> *Female G: Hmm, no, no, I do not feel that. It is weird actually because the mosquitoes are still here. We still see the mosquitoes, but we are not paranoid about them anymore.*
> *Interviewer: Okay.*

Female G: But you do not know when there is another outbreak.
Interviewer: And can you explain why not? Because you said, the mosquitoes are still here.
Female G: Because you do not hear anything within the community or of infected people. Maybe there are people with the disease, but no information is given (information coming from the health system). These diseases are not relevant anymore, and you do not pay attention to them anymore. You go back to your everyday life.
P08- Female, inspectress (IDI).

'Interviewer: Okay, let us continue with the first topic. There are three topics. The first topic is risk perception, thus the feeling of being at risk of the disease. For example, do you feel at risk of these diseases?
Female T: Not now.
Interviewer: No? Why not?
Female T: Because nobody talks about them.
P25- Female, Social worker (IDI).

When discussing the media coverage of disease in general, some participants of the IDIs indicated that COVID-19 is more dangerous than ABIDs because the health system and the media channels shared more information about COVID-19 and its control measures than they did during the ABID epidemics. The following quote portrays this issue:

'Interviewer: Why do they pay more attention to COVID-19? They use all types of media channels nowadays. Why do you think this did not happen during those epidemics?
Female T: Hmm.. well, what I already said, it is the seriousness/ severity of the.
Interviewer: The disease?
Female T: The disease, yes.
Interviewer: Aha.
Female T: Maybe the symptoms of those diseases are mild, and you recover faster.
Interviewer: Aha.'
P25- Female, Social worker (IDI).

Women had a higher perceived threat of ABIDs than men, especially for Zika virus infection, because of the possible pregnancy complications in the newborn (microcephaly) that were mentioned in the media. Most of the study participants of the IDIs and FGDs, including high school students who participated in an FGD, reported that women had a higher perceived threat of Zika than men or the younger generation.

'Female 3: The worry remains. I was worried about being bitten. What if I was bitten, and what will happen to the baby. I wanted to know if the baby was okay when the baby was born. So the worry remains.
Moderator: Can I ask something?
Female 3: Oh yeah, sure.
Moderator: So, were women more worried than men during the Zika epidemic? Because you (women) can be pregnant?
Female 3: Yes.
Moderator: Do you all believe so?
Female 2: Yes, I remember that they recommended people (women) not to get pregnant that year.
Moderator: Okay.'
-FGD with Jehovah's Witnesses.

Besides women, people who acquired ABIDs or experienced how a close relative dealt with these diseases also reported being afraid and motivated to perform ABIDs prevention and control activities. In other words, the disease was not considered a threat or a priority when its implications did not directly affect that person (internal cue to action) or a close relative/people they knew. In this study, internal (being sick) and external cues to action (media coverage/ information coming from the community) triggered the decision to perform mosquito control measures. Thus, a lack of internal and external cues to action was linked with a low perceived threat and motivation to conduct prevention and control activities.

2. Perceived barriers

Different barriers that negatively influenced people's decision-making and HSB were mentioned during the IDIs and FGDs. One frequently mentioned barrier was the limited governmental involvement in mosquito control. Many participants indicated that the government had a passive attitude toward mosquito control in the last three ABID epidemics. The mentioned perception is portrayed by the quote below.

'Male L: Honestly, this is more a gut feeling; they (the government) fogged (spray insecticide) not to get rid of the problem, but for propaganda, the community wanted something to happen. So fog, see? We did something.
Interviewer: A false sense of security?
Male L: Yeah, that was the feeling I had, especially in the Zika epidemic. I did not see many activities during the period of chikungunya.'
P19, Male, teacher (IDI).

Mosquito control is challenging, but the lack of governmental and community involvement in mosquito control makes it harder to prevent and control outbreaks of ABIDs. There is a lack of collaboration between the government and the community. Most interviewees indicated that the vector control department did not act proactively, and some even thought that the department was not operating anymore. Furthermore, some people were unaware of the health system's services (e.g., free distribution of Abate and Gambusia fish). Participants of the FGDs further elaborated on this topic and indicated that the government's passive attitude did not motivate them to continue with needed interventions to control mosquitoes.

The community's passive attitude towards mosquito control also negatively influenced individuals' preventive behaviour. Some participants of both FGDs and IDIs indicated that many people removed mosquito breeding sites. However, a group of people did not perform the mentioned activity. The negligence of others led to more mosquitoes. Therefore, the efforts to reduce mosquito breeding sites were considered less effective. The following quote portrays this issue:

> *'Male 3: We are a community; it is sad to say so, but we do not like keeping our environment clean.*
> *Moderator: We do not like to maintain the environment clean?*
> *Male 3: laughs*
> *Male 3: Maybe it sounds like a joke, but I am honest.*
> *Female 1: Hmm, that is true.*
> *Male 3: We create conditions that can increase the chance for issues. Although they often say remove items that collect water, I cover and turn items that can collect the water; you can live close to me, and you are not doing these things.*
> *Moderator: So the situation remains the same (no effect)?*
> *Male 3: Yes, so there are many mosquito breeding sites.*
> *Female 1: Yes.*
> *-FGD with Adventists.*

The perception that mosquito control is challenging has reduced the motivation to act. The issue with waste management in Curaçao also has amplified the feeling that it is impossible to control the mosquitoes. Waste scattered throughout the island is considered potential mosquito breeding sites. Some participants indicated that they could clean up their gardens, but if there is waste in their neighbourhoods, all their efforts to reduce mosquito breeding sites are useless.

Furthermore, limited knowledge about control strategies was another barrier to preventing and controlling mosquitoes. Some people believe that the usage of vitamins is enough to prevent ABIDs. Besides, poverty and insufficient access to the health system to receive information and support with mosquito control strategies also influenced the preventive behaviour of some study participants negatively. This issue became evident during a FGDs with people living in a low-middle social-economic neighbourhood.

> *'Moderator: When you live in poverty, prevention is not your priority? That is what you are saying?*
> *Female 9: No.*
> *Moderator: Your priority is to survive?*
> *Female 9: Yes, to survive. Although we want to think about prevention, it remains at that stage, thinking because it is not something you can do. Many people that live here are aware of this issue. Many want to get the Abate (larvicide offered by the Health System) or go to a presentation about mosquito control. However, if the option is not close to you, you cannot reach it.'*
> *-FGD, Community centre Seru Papaya.*

The participants of the FGD conducted at the Community centre Seru Papaya also indicated that they did not have enough financial resources to maintain their houses free of mosquito breeding sites during the epidemics. For example, some reported having damaged cesspools that could also be potential mosquito breeding sites. Lastly, some participants of the IDIs indicated that they did not use repellents due to the bad smell and the product build-up on their bodies.

3. Self-efficacy

Due to a lower perception of benefits, the willingness of people to take action was also reduced. When the participants were asked about their confidence in their ability to take action to control mosquitoes, the majority of the participants had good knowledge about the control measures. They felt confident that their actions were suitable to control the mosquito population. However, a few participants indicated that they did not know how to prevent ABIDs, due to a lack of information.

> *'Interviewer: Okay, thus no action or consequences affected you? Hmm, currently, are you doing something to control mosquitoes?*
> *Female S: There is not so much you can do to control the mosquitoes. At least I do not know what I can do. If there is something, I would like to know if there is something because that bothers me. There are many mosquitoes at my house. Like, intolerable.*
> *Interviewer: Hmm.'*
> *P03, Female, entrepreneur (IDI).*

Insufficient information from the health system and media channels or mis-information about the control measures were concepts that negatively influenced some individuals' perceived self-efficacy. In addition, the lack of success and not experiencing beneficial results after implementing mosquito control measures also was another concept that reduced self-efficacy.

'Female L: But they say it does not matter if you cover the water tanks adequately. Thus the mosquitoes will find a way to enter (reach the water).
Interviewer: So you heard this?
Female L: Hmm, yes.
Interviewer: Where did you hear this?
Female L: From people.
Interviewer: Just from people.'
P06, Female, teacher (IDI).

'Male L: You cannot avoid them, some breeding sites, but the mosquitoes will further develop, although you are paying attention.
Interviewer: Thus, you have the perception that it is impossible to destroy all breeding sites.
Male L: I believe, It is difficult, or you need to find a way, use a magnifying glass in the gardens. However, you do not have the means to do so.
Interviewer: To do so.
Male L: Thus, in general, to combat mosquitoes, I believe it is something very complex.'
P19, Male, teacher (IDI).

As portrayed by the quotes, insufficient knowledge and misinformation about control measures and the perception that it is impossible to control mosquitoes reduced some participants' self-efficacy.

4. Internal and external locus of control

All participants had a sense of individual and collective responsibility for controlling mosquitoes. The participants were asked who is responsible for preventing and controlling ABIDs; they explained that the individual, the community, and the government, including the health system, are responsible for preventing and controlling the mentioned diseases. All the interviewed participants felt they were accountable for their well-being (internal locus of control). Still, they indicated that the health system was also responsible for preventing and controlling ABIDs during epidemics. The health system needs to make the regulations, develop interventions and support the community with the control of mosquitoes. Table 3 shows opinions on the above topic from the point of view of three generations living on the island.

Table 3. Opinions of three generations concerning prevention and control of ABIDs.

Generations	Opinions
Youth (high school students)	*Boy 1: It is not necessarily what you (the community and the health system) are doing. It depends on which stage of the process you are in. Are you (the health system and the community) trying to solve the problem by preventing mosquitoes from biting people? It should prevent the mosquitoes from being in the area in the first place.* *Moderator: Okay.* *Boy 1: That is why you have things like preventing standing water, cleaning the trash, removing mosquito breeding sites, and things like that.* *Moderator: Do you (all students) think that the government needs to be more involved in, for example, cleaning the island?* *Boy 2: Yes.* *Girl 1: Yeah.* *Boy 2: Yeah, not just for mosquitoes, just because we need to be trash less (less illegal dumping sites and waste that cannot be recycled).* *Girl 1: Yeah.* *FGD with high school students of the international school.*
Adult	*Female G: I believe that we (all) are responsible.* *Interviewer: Yes?* *Female G: I believe we (all) are responsible; if you start at your house, if each person starts at their house, I think we are a step ahead.* *Interviewer: Okay.* *Female G: If the government provides its tools to support. If the government puts containers in neighbourhoods, people can dispose of their waste.* P08, Female, inspectress, 54 years old (IDI).
Elderly	*Interviewer: When prevention and control actions need to be implemented for these diseases, who is responsible?* *Female G: Everybody.* *Interviewer: Everybody.* *Female G: Each on its own.* *Interviewer: With that, you mean the community or the government?* *Female G: The community and the government because the government is part of the community.* P11, Female, retired, 81 years old (IDI)

When governmental involvement is lacking, participants indicated that they do not feel motivated to participate in mosquito control. Collective responsibility plays an essential role in the interviewed participants' decision-making and preventive behaviour.

After examining the empirical material through different concepts of the HBM, we have learned that most participants performed preventive behaviour to protect themselves against ABIDs or were aware of the actions that could be done to prevent ABIDs. We found that preventive behaviours were activated when people had a high-risk perception (high perceived susceptibility and severity of disease), which was motivated by increased internal and external cues to action. The participants from the FGDs and IDIs indicated that they used repellents, Abate, larvivorous fish, and screens for doors and windows to protect themselves against mosquitoes. Also, removing mosquito breeding sites was often mentioned as a control action when they felt at risk of acquiring ABIDs. HSB was shaped not only by the concepts of the HBM but also by the contexts in which mosquito control occurs. The distrust in the government, including the health system, the lack of community participation in mosquito control and the unsolved issues with illegal dumping sites discouraged individuals from participating in the prevention and control of ABIDs.

Discussion

This study aimed to understand the intricate processes influencing individuals' decision-making and HSB concerning the prevention and control of ABIDs. In this study, both internal and external cues to action indirectly influenced HSB through the impact of perceived threats (perceived susceptibility and severity). Low media coverage and internal cues to action (limited or no experience with symptoms of a disease) were linked with a low perceived threat. This result is in agreement with the findings of two other studies (among different study populations, including people of all SES and age categories) performed in Curaçao (12, 13). Subsequently, we found that measures to control mosquitoes were not performed when the perceived threat of disease was low. Another study that researched the association between cues to action, perceived threat, and HSB indicated that internal and external cues arose an individual's perceived threat by influencing the perceived susceptibility and severity of a disease, which led to the performance of preventive behaviours (16).

Most participants (in all age categories) in our study showed good knowledge about the prevention and control measures of ABIDs. However, we found that good knowledge did not guarantee the performance of ABIDs control actions or the translation of knowledge into practice. A study in Venezuela indicated that despite a high knowledge level concerning measures to avoid mosquito bites, potential mosquito breeding sites were still present in two-thirds of the examined properties (17). In our study, properties were not examined to verify the mentioned results. However, most participants reported that they did not always protect themselves against mosquito bites and did not remove mosquito breeding sites frequently, even though they knew those actions were required to prevent ABIDs.

In this study, the perceived barriers played a prominent role in the decision-making process and HSB of the participants. The perceived barriers prevail over the benefits of preventive and control interventions to reduce the risk of ABIDs. Another study conducted in Northeast Thailand also found that the barriers to dengue control overshadowed the perceived benefits (18). In our study, the following barriers influenced HSB negatively: (i) the perceived passive attitude of the health system, including the government, (ii) lack of community involvement, (iii) the perception that mosquito control is challenging, and (iv) issues with waste management. Our previously published articles have also addressed the mentioned barriers (10, 12, 13, 19).

The participants reported that they were/are responsible for protecting themself from ABIDs (internal locus of control). However, they also indicated that if the health system and the community are not participating in mosquito control, they have a higher risk of acquiring ABIDs. During the last epidemics of ABIDs and at the time of data collection, the participants believed that the health system and the community had a passive attitude toward mosquito control. In other words, there is no collective responsibility for the implementation of mosquito control interventions. We found that the mentioned perception obstructed community engagement and participation in mosquito control in Curaçao.

Furthermore, the mosquitoes have more breeding sites due to the illegal dumping sites scattered throughout the island, increasing the mosquito abundance and risk for disease transmission (19). The community is aware of the negative consequences of the illegal dumping sites and perceives their efforts as ineffective. More efforts are needed to build trust and close the gaps between the community and the health system to improve community participation in mosquito control. The World Health Organization suggests that community involvement and engagement are essential for effective and sustainable results (20). Mosquito control without community participation is not sustainable. A recently published systematic review and meta-analysis covering Latin America and Caribbean studies found statistically significant and relevant public health outcomes in pooled effectiveness estimates for interventions focusing on health education and community engagement (21).

Based on our data, the following recommendations can be provided to work towards a more bottom-up approach. The health system needs to lead by example since the community needs a role model in mosquito control. The health system needs to develop mosquito control and waste management regulations. Regulations and enforcement concerning illegal dumping are required to support mosquito control interventions within the community. The community agreed that enforcement with consequences for the lawbreakers is essential to maintain respect for the regulations. Key decision-makers need to forge partnerships with community leaders for better communication and collaboration with the community. The participation of community leaders can stimulate social pressure among community members. Community participation can also be stimulated by sending reminders about mosquito control via traditional (e.g., television, radio, newspapers) and modern (e.g. social media or SMS) communication channels. SMS is a good option since not everyone has internet. Our participants indicated that they prefer visual communication over written communication. Furthermore, an educational curriculum needs to be developed to motivate and educate the younger generation; they are the future adults who eventually need to perform mosquito control interventions.

This study was limited by its design; since the research is based on qualitative methods, the findings cannot prove causality. Although proving causality is essential in science, this study aimed to understand decision-making processes and HSB regarding preventing and controlling ABIDs among individuals living in Curaçao. For this type of study, qualitative methods are required. Qualitative studies provide an explicit rendering of the structure, order, and patterns found among a group. In order to increase the credibility of the findings, two types of data collection methods were used to validate the information collected. These two methods help produce a more comprehensive set of findings.

Conclusion

This multi-method qualitative study used the HBM to understand concepts that influenced decision-making and the HSB of individuals. We found that cue to action played an important role in attenuating and amplifying risk perception concerning ABIDs. Our findings shed light on the view that having good knowledge of preventing ABIDs is insufficient to activate HSB. A critical barrier that needs to be addressed is the health system's and community's passive attitude toward mosquito control. The collective responsibility and collaboration between the community and the health system seem to be the key to improving mosquito control interventions. Efforts are needed to make the health system mosquito control interventions visible, and interventions need to be developed to increase trust and stimulate community participation. Our findings and recommendations can be used in health policies and interventions to improve community participation in *Aedes* control in Curaçao.

Abbreviations

ABIDs: *Aedes*-borne infectious diseases
F: Female
FGDs: Focus Group Discussions
HBM: Health Belief Model
HSB: Health-seeking Behaviour
IDIs: In-dept Interviews
M: Male
SES: Socioeconomic Status

Ethics approval and consent to participate

The Medical Ethics Board of the Sint Elisabeth Hospital Curaçao approved this study (METC SEHOS; reference no. 2017-003). All participants signed a written informed consent. In addition, all methods were performed in accordance with the relevant guidelines and regulations. All data were anonymised and stored in files accessible only to the principal investigators.

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CHAPTER 8

Summary and general discussion

Diseases transmitted by mosquitoes are a growing global public health concern due to their dramatically increased disease burden and rapid geographical spread (1, 2). Every year more than one billion people are infected, and more than one million people die from vector-borne diseases (VBDs), of which mosquito-borne diseases are responsible for a significant proportion (3). Besides all recommendations of the World Health Organization (WHO), Pan American Health Organization (PAHO), the Caribbean Public Health Agency (CARPHA), and novel mosquito control strategies that have been developed, countries are still struggling with preventing and controlling the transmission of *Aedes*-borne infectious diseases (ABIDs). Curaçao, a Caribbean island in the Kingdom of the Netherlands, also faced challenges in controlling the recent outbreaks of ABIDs, including dengue (2010), chikungunya (2014-2015), and Zika (2016) virus infections. Therefore, it is necessary to understand why health systems and public health institutions responsible for mosquito control fail to design and implement effective mosquito control interventions.

Based on this view, the studies described in this dissertation focus on synthesising evidence on *Aedes* control strategies' effectiveness in the Latin America and the Caribbean (LAC) region, understanding health system performance, risk communication and its impact on risk perception, and social amplification of risk. In addition, aspects that influence individuals' health-seeking behaviour (HSB) and the possible implications of waste management (WM) on mosquito control were studied. We have combined different research methodologies (qualitative and quantitative) and disciplines to study the above-mentioned research topics, including epidemiology, entomology, microbiology, and social and environmental sciences. Different theoretical frameworks and concepts were used to understand the intricate relationship between macro (health system), meso (social groups) and micro-level (individuals) vis-à-vis ABIDs prevention and control. Each study's data collection was divided into two or more rounds to sharpen interview guides and validate the collected data. This trajectory makes a unique methodological contribution to HSB research and increases the credibility and validity of the study findings.

The scoping review presented in ***chapter 2*** aimed to synthesise the evidence (scholarly journal articles and grey literature) regarding the effectiveness of *Aedes aegypti* and *Aedes albopictus* prevention and control interventions (against dengue, chikungunya and Zika virus) performed in LAC in the last twenty-one years (2000-2021). We found that most of the publications in the LAC region have focused on the dengue virus, urban areas, and *Aedes aegypti* mosquitoes. To determine intervention effectiveness, mostly entomological data were used. In agreement with the literature, we found that chemical control measures were more often applied than biological control measures (4-7). Although biological control measures, environmental management, and health education campaigns focused on community participation achieved more sustainable results than an intervention where only a chemical control measure was used (8-11). An integrated control intervention was the most employed strategy in both regions. The synthesised data showed that an integrated approach could be more effective than a single approach, in agreement with other reviews (11-13). We also found that community participation in the integrated approach was crucial for achieving sustainability.

The information mentioned above is not new; many organisations, including the WHO and PAHO, have recommended implementing an integrated mosquito approach (Integrated Vector Management) (14, 15). Different countries reported facing challenges with developing and implementing such an approach. So, we need to ask ourselves the following questions: Why are countries not applying the knowledge they possess, and what are the barriers to such an approach? The synthesised data of the scoping reviews indicated that many factors such as insufficient funding, resources, workforce, and political priorities (e.g., prioritising SARS-CoV-2 over ABIDs) had jeopardised the development and implementation of an integrated mosquito control approach (9, 16-18). To assess if the barriers mentioned above are also present in Curaçao, we conducted a study to examine the health system performance regarding the prevention and control of VBDs in the last decade using the WHO health system building blocks ***(chapter 3).*** Our findings highlighted the challenges (e.g., insufficient oversight, coordination, leadership skills, structure and communication) that the health system departments of Curaçao faced during the last three epidemics of VBDs (2010-2020). In addition, we found that low levels of collaboration between governmental and non-governmental organisations (e.g., semi-governmental and private laboratories) and insufficient capacity building to improve skills (e.g., entomological and surveillance skills) obstructed the performance of the health system negatively (19).

Many countries worldwide reported similar challenges; for example, in Hanoi City, Vietnam, the dengue control program was ineffective because of the lack of adequate engagement of the local government and health sector with the community. Lack of detailed policy guidelines, low enforcement of the related policy, and limited budget were crucial barriers to program implementation (20, 21). Based on our findings in ***chapters 2 and 3***, we can conclude that an important reason for the above-mentioned challenges is a lack of or vacillating political will to prioritise and invest in mosquito control. We have concluded that without political involvement, countries will continue to struggle with discontinuity of programs, lack of budget allocation, absence of an effective functional link between political decisions and recommendations of experts, and the lack of workforce and programmatic coordination within the health system (22).

Based on our findings and observations, the following aspects could have affected the political will to invest in mosquito control in Curaçao negatively: (i) politicians with insufficient knowledge about public health issues and management skills, (ii) pressure to demonstrate results in a short time (investment in acute care provide rapid results compared to prevention), and (iii) increasing central government debt of Curaçao. Hence, another important aspect that might have shaped how the government, health system and politicians function nowadays is the history of colonialism and the challenges that came with the dissolution of the Netherlands Antilles. Colonialism deeply affects a country's social fabric and inherently changes social, cultural, political, and economic structures in a way that continues to be felt decades after autonomy (23). For example, the observed distrust towards the government/ health system could result from the political instability caused by the history of colonialism that Curaçao experienced (chapters 4-5). Furthermore, the documented political instability might be why politicians decide to deal with more immediate problems and focus on short-term gains. This, in turn, pushed back the mosquito prevention and control agenda, which has been considered not an urgent problem since people got used to mosquitoes (chapters 3-6). Although the situation is alarming, there is currently no solution to these issues. However, we believe that documenting and highlighting the health system's bottlenecks that obstruct mosquito control can lead to more political awareness in the future.

Since the prevention or reduction of ABIDs transmission hinges on mosquito control and interruption of human-mosquito contact, we focused on risk communication which is an essential tool for preventing and controlling diseases as it impacts risk perception, increases awareness, and might change behaviour. We aimed to understand risk communication in its social context and from the audience's viewpoint ***(chapter 4).*** Furthermore, we determined the association between socio-demographic variables and channels of information and the influence of cultural schemas on perceptions (24). In ***chapter 5,*** we went a step further in our analysis and analysed the newspaper's content, compared people's perceptions with perceptions of experts/government officials and the information provided by newspapers. Also, the contribution of newspaper content to people's perceptions, the role of trust, previous experience with mosquito-borne diseases and heuristics on risk perception were studied.

We found that the traditional communication channels (e.g., television, radio and newspapers) were the most important information channels regarding dengue and chikungunya. Social media platforms were used, but not to a great extent. We believe that the younger generation received less information about mosquito-borne diseases since they preferred to receive information from the internet and social media platforms ***(chapter 4)***, in agreement with another study (25). The quantitative analysis of our study supported the qualitative data because we found that internet use decreases by 5% per year as age increases. Another important finding was that the risk perception (perceived susceptibility and perceived severity) toward chikungunya at the beginning of the outbreak was attenuated. The perceived lack of risk communication at the start of the epidemic possibly caused the observed low-risk perception. The same risk perception was amplified later during the epidemic by increased exposure (internal cue to action, e.g., experience with the symptoms of the diseases and external cues to action, e.g., high media coverage). Lastly, we found that cultural schemas played an important role in forming individuals' perceptions regarding preventive measures and self-care, especially regarding the usage of herbs in treating mosquito-borne diseases ***(chapter 4)***. A study in Tanzania reported similar cultural schemas and showed the possible influence of cultural schemas on people's decision-making and behaviour in treating malaria (26).

The findings presented in ***chapter 5*** suggested that risk communication strategies were obstructed by an insufficient governmental structure, organisation, communication and funding. The communication department of the Ministry of Health, Environment and Nature (MoHEN) made pamphlets to inform the community about ABIDs. However, due to logistic issues and poor coordination, a large group in the community did not receive or received information in a language they did not understand. Also, the lack of a trained workforce obstructed the performance of the communication department. The community perceived that risk communication started late during the chikungunya epidemic and felt that the government, including the health system, had failed to protect them from the novel virus (24, 27). Distrust towards the health system and among the health professionals working for the health system was observed ***(chapter 5)***. The distrust was empowered by the negative reports on the government shared by the newspapers. ***Chapter 5*** showed how trust and heuristics attenuate or amplify people's risk perceptions and possibly positively and negatively influence people's risk-reducing behaviour.

Our research on risk communication ***(chapters 4 and 5)*** highlighted the complexity of assessing, communicating and managing risk. Many components intersected with each other from many perspectives. We found that there are multiple factors, including (i) the volume of information, (ii) trust in the source of information, (iii) experience with a similar disease, (iv) cultural schemas and (v) heuristics that determine how people cope with risk and information. The communication department of the MoHEN of Curaçao also faced many challenges that affected its performance during the last 12 years. The barriers we reported that obstructed the health system's performance also affected the communication department. The following critical barrier needs to be pointed out because if the gaps in policy are appropriately addressed, the communication department of the MoHEN can collaborate and use the means, experience and capacity of the crisis communication team, which is a well-developed communication team. In

Curaçao, according to the crisis regulation (LANDSBESLUIT no. 15/2524), the crisis communication team can act when a threat is declared as a crisis (only the prime minister can officially declare a crisis). Based on our research, the assigned prime minister did not declare the last three ABID epidemics a crisis. Consequently, the communication team of the MoHEN itself needed to develop a risk communication strategy. The communication team of the MoHEN consisted of three employees with limited budget, skills and experience to design communication campaigns for an epidemic. The crisis regulation needs to be adjusted because it does not consider a pre-crisis phase. Thus, the crisis team start with crisis communication when the threat has been declared a crisis. In other words, for each crisis, communication will start late. The crisis regulation needs to consider a pre-crisis phase and support the small communication team working in each ministry to improve risk communication outputs. Risk communication is essential because people need scientifically proven information to seek care or find ways to protect themselves from acquiring a disease. Not protecting themself or seeking care leads to reduced well-being.

In **chapter 6,** we explored current WM practices, the influences of the tourism industry on WM, and the possible implications of WM on mosquito control in Curaçao. We focused on this topic because improving and maintaining public infrastructure and essential services, including WM, can help reduce ABID transmission. Literature indicated that the *Aedes aegypti* mosquitoes (vector of dengue, chikungunya and Zika) prefer to breed in man-made plastic containers (e.g., recyclable plastic containers, tires, and trash) (28, 29). Based on this view, waste can be used as breeding sites, increasing the risk of ABIDs transmission. We found that social (e.g., lack of community awareness and involvement in WM), economic (e.g., poverty), environmental (e.g., illegal dumping), and governmental aspects (e.g., lack of enforcement of regulation and intersectoral collaboration) influence WM negatively. Despite the initiatives to use recycling services and biodegradable utilities, most of the solid waste generated by the tourism industry and the community ends up in the landfill (the governmental waste dumping sites). The untreated solid waste at illegal dumping sites, households, and landfills might have increased mosquito breeding sites' availability in Curaçao. The current WM is inadequate to support mosquito control initiatives effectively. The findings and conclusions in ***chapter 6*** highlighted the importance of cross-sectional collaboration to tackle the complex interactions between the virus, mosquito and host.

The recommendations of WHO and our scoping review results suggested that an integrated mosquito control approach focused on community participation can be an excellent strategy to reduce the transmission of ABIDs. Still, maintaining the implementation of such an approach is difficult due to many challenges, including insufficient community participation. Health professionals must be aware of the barriers that obstruct community participation in order to rethink their integrated mosquito approach. Therefore, we aimed to determine the contexts motivating individuals' protective behaviour regarding ABIDs in Curaçao ***(chapter 7)***. The findings indicated that people's perceived barriers outweigh the perceived benefits of interventions to reduce ABIDs transmission. A critical barrier that needs to be addressed in this general discussion is the perceived lack of governmental support, including the minimal support of the health system in controlling mosquitoes. Our participants believed they were responsible for protecting themselves against mosquito bites and reducing mosquito breeding sites (internal locus of control). At the same time, they indicated that their success depends on the efforts of the community and the government/health system (external locus of control). Based on the information presented in chapters ***4, 5, 6 and 7,*** we can conclude that the community did not trust the government/ health system of Curaçao. The mismanagement of previous ABID epidemics, negative media coverage, unsolved issues with illegal dumping sites and the government not keeping its promises are factors that possibly encouraged distrust. Although the community showed good knowledge about the diseases and their control measures, this was not enough to stimulate action (e.g., reducing mosquito breeding sites around the house). Another study conducted in Venezuela also found similar results (30). In our research, trust played a significant role in HSB. Attention must be paid to these findings to improve community participation in mosquito control. Otherwise, the health system will continue failing to control ABIDs, because distrust does not lead to community and individual behavioural change (31).

Final remark and recommendations

COVID-19 has imposed extraordinary demands on the health system, but at the same time, it has shown us that we can accomplish many things if we work together. In addition, the COVID-19 pandemic has further highlighted the need for novel tools that are less labour-intensive. Although we are still fighting the COVID-19 pandemic, health professionals must be prepared for other potential threats. Based on the history of *Aedes* mosquitoes, it is undeniable that known and new ABIDs represent emerging threats. In other words, another *Aedes*-borne arboviral disease epidemic might be around the corner. Researchers and health professionals will ask themselves how we can prevent the next ABID epidemic in Curaçao or other islands/countries dealing with similar challenges? The findings presented in this dissertation provide helpful information to better understand mosquito control's complexity and improve ABIDs prevention and control interventions. During this PhD project, we had the unique opportunity to study mosquito control based on the funnel approach. We studied the research topics through macro, meso and micro lenses to understand which barriers obstruct health system performance, risk communication, and community and individual HSB in preventing and controlling ABIDs. Our recommendations to prevent the next ABIDs can be categorised into three pillars: (i) policy, regulation and political will, (ii) mosquito control interventions, and (iii) programmatic.

Policy recommendations

1. Policy, regulation and political will

Regulations and policies concerning infectious diseases prevention and control, insecticide usage, and the environment can provide guidance, increase accountability, and improve collaboration between ministries, departments and organisations responsible for mosquito control. Therefore, we recommend starting with updating the needed regulations and policies. In ***chapter 3***, we have conceptualised actions to update current regulations. The regulations/policies need to contain a task description of each stakeholder (e.g., laboratories) and ways to allocate funds to ensure the continuity of processes. Besides updating regulations, enforcement is also required to increase the effectiveness of mosquito control interventions. The regulations concerning mosquito control must pay attention to WM since the illegal dumping sites might reduce the impact of the mosquito control program. An interdisciplinary approach to mosquito control is recommended when designing regulations and policies to tackle ABIDs. At the same time, we must be aware that updating the regulations and policies alone is not enough to ensure program design and implementation because politicians in charge still need to prioritise and approve the regulations in the parliament. Therefore, researchers and health professionals must continue documenting and sharing information to increase awareness and political will.

Recommendations for intervention and program management

2. Mosquito control interventions

Mosquito control in Curaçao relies on health system efforts and follows a top-down approach. The community is less involved, making the program's effectiveness less sustainable. Health professionals need to rethink the working procedure of the vector control team to maximise the program's coverage and effectiveness. We also recommend planning the house inspections on the weekend because most householders are not at home during the current vector control working schedule (9:00 am - 04:00 pm, from Monday to Friday). Many houses on the island cannot be inspected, and the householders do not receive information about how to prevent mosquitoes from breeding. This also explains the perceived invisibility of the vector control team among the community members. We recommend publishing the working schedule of the vector control team so the community is aware of when the team is active in their neighbourhoods. We also recommend applying a more bottom-up approach where the community is more involved in mosquito control. However, the issues of distrust towards the government, including the health system, must be resolved to achieve behavioural change. The health system needs to lead by example in performing effective and continued mosquito control since the community needs a role model in mosquito control.

Furthermore, the vector control team must determine the effectiveness of Abate® (larvicide based on the active ingredient temephos). The vector control team has used Abate® for years, and no data on resistance has been collected. We also recommend using more biological control measures, such as Bacillus thuringiensis israelensis (Bti), larvivorous fish or Wolbachia, in the integrated mosquito control plan. Biological control measures have no or limited adverse impact on the environment.

In the last decade, mosquito control has been implemented reactively (in response to epidemics, severe nuisances and infected cases) and not from a proactive perspective. This working method must change if sustainable results want to be achieved. Mosquito elimination is challenging; one-time implementation of even an integrated mosquito control program will not be enough to eliminate mosquitoes (all four life stages: egg, larva, pupa and adult). There will always be untreated breeding sites with eggs ready to further develop into mosquitoes. To maintain the mosquito population low, the community and the health system need to work together to reduce as many breeding sites, eggs, larvae, pupae and adult mosquitoes as possible.

3. Programmatic

We recommend building effective partnerships among public health institutions, private and academic/research institutions, local communities and schools. To build alliances, efforts must be made to reduce distrust among these stakeholders. In addition, the government/ health system needs to find new ways to allocate funds for mosquito control because, without funding, it is challenging to maintain program implementation, recruit the required workforce and restock supplies.

Mosquito surveillance is essential for monitoring local mosquito populations to prevent them from reaching nuisance levels and transmitting diseases. Currently, mosquito surveillance is non-existent, and outdated literature is being used by professionals working for the health system of Curaçao. The vector control team must learn how to monitor mosquito populations and test them for the presence of viruses to improve program implementation and health system preparedness.

Furthermore, the health system and the laboratories need to start working together systematically to maintain and improve the surveillance of ABID cases. The mentioned type of surveillance is essential for monitoring disease trends and detecting outbreaks, providing health professionals with the information required to manage disease occurrence in a timely fashion. Without this collaboration, the health system will continue running behind the facts.

Future research

We encourage researchers to pay more attention to barriers obstructing health system preparedness and performance to find practical solutions to the health system bottlenecks. Also, more attention must be paid to risk communication and the term infodemic and their impact on risk perception and HSB of people. Risk communication is an essential tool to prevent and control disease; however, as our research showed, if there is distrust toward the source of information, the risk communication campaign will not be effective. This observation was also evident during the COVID-19 pandemic. Researchers must also be proactive in communicating their findings to the study participants, community and policymakers. At the end of the ARBOCARIB project, we organised different stakeholder meetings to communicate our findings. The study participants and the policymakers were grateful that we shared our results with them because, in most cases, they do not hear anything about the findings after data collection. With these stakeholder meetings, the motivation to continue participating in research was increased, and the participants felt appreciated and heard. We also recommend focusing more on participatory research. In this type of research, scientific investigation is combined with education and political action. The findings can be used to increase political will, show the positive impact of community empowerment, and increase health system engagement in preventing and controlling ABIDs. Lastly, future research must include WM profiles (e.g., illegal dumping sites, sewage systems, etc.) of neighbourhoods into prediction models and estimate the correlation between the incidence of MBDs and WM profile of neighbourhoods. Future research focusing on WM and ABIDs needs to collect or use ecological and epidemiological data to link waste, mosquito breeding sites and the incidence of ABIDs.

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ADDENDUM

Supporting Information

Chapter 2

S1: Table Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist.
S2: Table Listed essential concepts and keywords.
S3: Table Characteristics of studies identified in the Latin America region about *Ae. aegypti* and *Ae. albopictus* prevention and control interventions.
S4: Table Characteristics of studies identified in the Caribbean region about *Ae. aegypti* and *Ae. albopictus* prevention and control interventions.
S5: Table Characteristics of studies identified in the Latin America and Caribbean region about *Ae. aegypti* and *Ae. albopictus* prevention and control interventions.

Chapter 3

Table 1: Action plan to improve the performance of the health system of Curaçao.
S1: Table Characteristics of the study participants.
S2: Table Characteristics of the collected documents.
S3: Topic guide: FGD with the Vector Control Unit.
S4: Topic guide: FGD with health professionals.
S5: Topic guide: Interview with general practitioners and geriatrician.
S6: Topic guide: Interview with alternative medicine practitioners.
S7: Topic guide: Interview with a laboratory technician.
S8: Topic guide: FGD with previous ministers of health.
S9: Coding list.
S10: List of mosquito species of Curaçao.
S11: The workforce during the epidemics compared with the required workforce to perform prevention and control strategies with regards to VBDs.

Chapter 4

S1: Table Characteristics of the study participants of the FGDs and IDIs.
S2: Coding list for FGDs and IDIs.
S3: Socio-demographic characteristics of the survey participants.
S4: Selected comparisons between socio-demographic characteristics and the use of social media and the internet to seek information regarding chikungunya.
S5: Univariate analysis of socio-demographic characteristics associated with the use of social media to seek information regarding chikungunya.
S6: Multivariate analysis of socio-demographic characteristics associated with the use of social media to seek information regarding chikungunya.
S7: Preventive measures reported in the FGDs and IDIs.

A

Chapter 2
S1 Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Page 3
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Pages 3-4
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/ objectives lend themselves to a scoping review approach.	Pages 5-6
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Page 7
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Page 7
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Pages 7-10
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Pages 9-10
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	S2 table supplementary file
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Pages 10-11
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Page 11
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Page 11
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	NA
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Page 11

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 12
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	S-3,4,5 tables supplementary file
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	NA
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	S3,4,5 tables supplementary file
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Pages 12-30
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Pages 30-31
Limitations	20	Discuss the limitations of the scoping review process.	Page 32
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Pages 32-33
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Page 33

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.
* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.
† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).
‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

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From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

S2 Table Search strategy

Mosquito-borne disease	Location	Intervention
MeSH Vector Borne Diseases	MeSH Caribbean Region	MeSH mosquito control
MeSH Mosquito Vectors	MeSH Latin America	MeSH mosquito nets
MeSH Arboviruses	MeSH South America	Ti Ab mosquito control
MeSH Dengue	Ti Ab [Caribbean]	Ti Ab mosquito net
MeSH Zika Virus	Ti Ab [Anegada]	Ti Ab vector control
MeSH Chikungunya virus	Ti Ab [Anguilla]	Ti Ab insect repellent
MeSH Malaria	Ti Ab [Antigua]	Ti Ab residual spraying
MeSH Encephalitis, arbovirus	Ti Ab [Aruba]	Ti Ab integrated vector control
Ti AB Vector Borne Disease	Ti Ab [Bahamas]	Ti mosquito
Ti AB Mosquito-Borne Disease	Ti Ab [Barbados]	Ti control
Ti AB Mosquito	Ti Ab [Barbuda]	Ti prevent
Ti AB Arbovirus	Ti Ab [Bonaire]	Ti impact
Ti Ab Dengue	Ti Ab [Cayman Islands]	Ti evaluation
Ti Ab Zika	Ti Ab [Cuba]	Ti management
Ti Ab Chikungunya	Ti Ab [Curaçao]	
Ti Ab Malaria	Ti Ab [Dominica]	
Ti Ab Encephalitis, arbovirus	Ti Ab [Dominican Republic]	
	Ti Ab [Grenada]	
	Ti Ab [Grenadines]	
	Ti Ab [Guadeloupe]	
	Ti Ab [Haiti]	
	Ti Ab [Hispaniola]	
	Ti Ab [Jamaica]	
	Ti Ab [Jost Van Dyke]	
	Ti Ab [Martinique]	
	Ti Ab [Montserrat]	
	Ti Ab [Nevis]	
	Ti Ab [Puerto Rico]	
	Ti Ab [Saba]	
	Ti Ab [Saint Croix]	
	Ti Ab [Saint Martin]	
	Ti Ab [Saint Kitts]	
	Ti Ab [Sint Eustatius]	
	Ti Ab [Saint Barthélemy]	
	Ti Ab [Saint John]	
	Ti Ab [Saint Lucia]	
	Ti Ab [Saint Martin]	
	Ti Ab [Saint Thomas]	
	Ti Ab [Saint Vincent]	
	Ti Ab [Tortola]	
	Ti Ab [Trinidad and Tobago]	
	Ti Ab [Turks and Caicos Islands]	
	Ti Ab [Virgin Gorda]	
	Ti Ab [Water Island]	
	Ti Ab [Latin America]	
	Ti Ab [Belize]	
	Ti Ab [Costa Rica]	
	Ti Ab [El Salvador]	
	Ti Ab [Guatemala]	
	Ti Ab [Honduras]	
	Ti Ab [Mexico]	
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	Ti Ab [Chile]	
	Ti Ab [Colombia]	
	Ti Ab [Ecuador]	
	Ti Ab [French Guiana]	
	Ti Ab [Guyana]	
	Ti Ab [Paraguay]	
	Ti Ab [Peru]	
	Ti Ab [Suriname]	
	Ti Ab [Uruguay]	
	Ti Ab [Venezuela]	

Note: Ti and Ab mean title and abstract, respectively. MeSH means Medical Subject Headings.

Search log Pubmed and Scopus

	Database	Author responsible	Date of search	Search string	Hits	Search complete (Yes/ No)	RIS uploaded (Yes/ No)	Remarks (if any)
1	MEDLINE (via PubMed)	VJ	27-05-21	#1: ("vector borne diseases"[MeSH Terms] OR "mosquito vectors"[MeSH Terms] OR "arboviruses"[MeSH Terms] OR "Dengue"[MeSH Terms] OR "zika virus"[MeSH Terms] OR "chikungunya virus"[MeSH Terms] OR "Malaria"[MeSH Terms] OR "vector borne disease*"[Title/Abstract] OR "mosquito borne disease*"[Title/Abstract] OR "mosquito*"[Title/Abstract] OR "arbovirus*"[Title/Abstract] OR "Dengue"[Title/Abstract] OR "Zika"[Title/Abstract] OR "Chikungunya"[Title/Abstract] OR "Malaria"[Title/Abstract] OR "encephalitis, arbovirus"[MeSH Terms] OR "encephalitis arbovirus"[Title/Abstract]) AND 2000/01/01:2021/12/31[Date - Publication] #2: (("caribbean region"[MeSH Terms] OR "latin america"[MeSH Terms] OR "south america"[MeSH Terms] OR "latin americ*"[Title/Abstract] OR "caribbean*"[Title/Abstract] OR "Caribbean"[Title/Abstract] OR "Anegada"[Title/Abstract] OR "Anguilla"[Title/Abstract] OR "Antigua"[Title/Abstract] OR "Aruba"[Title/Abstract] OR "Bahamas"[Title/Abstract] OR "Barbados"[Title/Abstract] OR "Barbuda"[Title/Abstract] OR "Bonaire"[Title/Abstract] OR "cayman islands"[Title/Abstract] OR "Cuba"[Title/Abstract] OR "Curacao"[Title/Abstract] OR "Dominica"[Title/Abstract] OR "dominican republic"[Title/Abstract] OR "Grenada"[Title/Abstract] OR "Grenadines"[Title/Abstract] OR "Guadeloupe"[Title/Abstract] OR "Haiti"[Title/Abstract] OR "Hispaniola"[Title/Abstract] OR "Jamaica"[Title/Abstract] OR ("Jost"[All Fields] AND "van dyke"[Title/Abstract]) OR "Martinique"[Title/Abstract] OR "Montserrat"[Title/Abstract] OR "Nevis"[Title/Abstract] OR "puerto rico"[Title/Abstract] OR "Saba"[Title/Abstract] OR "saint croix"[Title/Abstract] OR "saint martin"[Title/Abstract] OR "saint kitts"[Title/Abstract] OR "sint eustatius"[Title/Abstract] OR "saint barthelemy"[Title/Abstract] OR "saint john"[Title/Abstract] OR "saint lucia"[Title/Abstract] OR "saint thomas"[Title/Abstract] OR "saint vincent"[Title/Abstract] OR "Tortola"[Title/Abstract] OR "Trinidad"[Title/Abstract] OR “Tobago”[Title/Abstract] OR “Turks”[Title/Abstract] OR “caicos islands”[Title/Abstract] OR “virgin gorda”[Title/Abstract] OR “water island”[Title/Abstract] OR “latin america”[Title/Abstract] OR “Belize”[Title/Abstract] OR “costa rica”[Title/Abstract] OR “el salvador”[Title/Abstract] OR “Guatemala”[Title/Abstract] OR “Honduras”[Title/Abstract] OR “Mexico”[Title/Abstract]	2038	Yes	Yes	-

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	Database	Author responsible	Date of search	Search string	Hits	Search complete (Yes/ No)	RIS uploaded (Yes/ No)	Remarks (if any)
				OR “Nicaragua”[Title/Abstract] OR “Panama”[Title/Abstract] OR “Argentina”[Title/Abstract] OR “Bolivia”[Title/Abstract] OR “Brazil”[Title/Abstract] OR “Chile”[Title/Abstract] OR “Colombia”[Title/Abstract] OR “Ecuador”[Title/Abstract] OR “french guiana”[Title/Abstract] OR “Guyana”[Title/Abstract] OR “Paraguay”[Title/Abstract] OR “Peru”[Title/Abstract] OR “Suriname”[Title/Abstract] OR “Uruguay”[Title/Abstract] OR “Venezuela”[Title/Abstract]) AND 2000/01/01:2021/12/31[Date - Publication]) #3:((“mosquito control”[MeSH Terms] OR “mosquito nets”[MeSH Terms] OR “mosquito control”[Title/Abstract] OR “mosquito net*”[Title/Abstract] OR “vector control”[Title/Abstract] OR “insect repellent*”[Title/Abstract] OR “mosquito*”[Title] OR “Control”[Title] OR “prevent*”[Title] OR “impact”[Title] OR “evaluat*”[Title] OR “manag*”[Title] OR “residual spraying”[Title/Abstract] OR “integrated vector control”[Title/Abstract]) AND 2000/01/01:2022/12/31[Date - Publication])) AND (humans[Filter]) #1 AND #2 AND #3				
2	Scopus	VJ	20-05-21	((TITLE-ABS-KEY (vector AND borne AND disease*) OR TITLE-ABS-KEY (mosquito AND vectors) OR TITLE-ABS-KEY (arbovirus*) OR TITLE-ABS-KEY (mosquito AND borne AND disease*))) AND ((TITLE-ABS-KEY (caribbean AND region) OR TITLE-ABS-KEY (latin AND americ*) OR TITLE-ABS-KEY (south AND america) OR TITLE-ABS-KEY (caribbean*) OR TITLE-ABS-KEY (anegada) OR TITLE-ABS-KEY (anguilla) OR TITLE-ABS-KEY (antigua) OR TITLE-ABS-KEY (aruba) OR TITLE-ABS-KEY (bahamas) OR TITLE-ABS-KEY (barbados) OR TITLE-ABS-KEY (barbuda) OR TITLE-ABS-KEY (bonaire) OR TITLE-ABS-KEY (cayman AND islands) OR TITLE-ABS-KEY (cuba) OR TITLE-ABS-KEY (curacao) OR TITLE-ABS-KEY (dominica) OR TITLE-ABS-KEY (dominican AND republic) OR TITLE-ABS-KEY (grenada) OR TITLE-ABS-KEY (grenadines) OR TITLE-ABS-KEY (guadeloupe) OR TITLE-ABS-KEY (haiti) OR TITLE-ABS-KEY (hispaniola) OR TITLE-ABS-KEY (jamaica) OR TITLE-ABS-KEY (jost AND van AND dyke) OR TITLE-ABS-KEY (martinique) OR TITLE-ABS-KEY (montserrat) OR TITLE-ABS-KEY (nevis) OR TITLE-ABS-KEY (puerto AND rico) OR TITLE-ABS-KEY (saba) OR TITLE-ABS-KEY (saint AND croix) OR TITLE-ABS-KEY (saint AND martin)	2571	Yes	Yes	-

Database	Author responsible	Date of search	Search string	Hits	Search complete (Yes/ No)	RIS uploaded (Yes/ No)	Remarks (if any)
			OR TITLE-ABS-KEY (saint AND kitts) OR TITLE-ABS-KEY (sint AND eustatius) OR TITLE-ABS-KEY (saint AND barthelemy) OR TITLE-ABS-KEY (saint AND john) OR TITLE-ABS-KEY (saint AND lucia) OR TITLE-ABS-KEY (saint AND thomas) OR TITLE-ABS-KEY (saint AND vincent) OR TITLE-ABS-KEY (tortola) OR TITLE-ABS-KEY (trinidad) OR TITLE-ABS-KEY (tobago) OR TITLE-ABS-KEY (turks) OR TITLE-ABS-KEY (caicos AND islands) OR TITLE-ABS-KEY (virgin AND gorda) OR TITLE-ABS-KEY (water AND island) OR TITLE-ABS-KEY (belize) OR TITLE-ABS-KEY (costa AND rica) OR TITLE-ABS-KEY (el AND salvador) OR TITLE-ABS-KEY (guatemala) OR TITLE-ABS-KEY (honduras) OR TITLE-ABS-KEY (mexico) OR TITLE-ABS-KEY (nicaragua) OR TITLE-ABS-KEY (panama) OR TITLE-ABS-KEY (argentina) OR TITLE-ABS-KEY (bolivia) OR TITLE-ABS-KEY (brazil) OR TITLE-ABS-KEY (chile) OR TITLE-ABS-KEY (colombia) OR TITLE-ABS-KEY (ecuador) OR TITLE-ABS-KEY (french AND guiana) OR TITLE-ABS-KEY (guyana) OR TITLE-ABS-KEY (paraguay) OR TITLE-ABS-KEY (peru) OR TITLE-ABS-KEY (suriname) OR TITLE-ABS-KEY (uruguay) OR TITLE-ABS-KEY (venezuela))) AND ((TITLE-ABS-KEY (mosquito AND control) OR TITLE-ABS-KEY (mosquito AND nets) OR TITLE-ABS-KEY (vector AND control) OR TITLE-ABS-KEY (insect AND repellent*) OR TITLE-ABS-KEY (prevent*) OR TITLE-ABS-KEY (evaluat*) OR TITLE-ABS-KEY (managˆ*) OR TITLE-ABS-KEY (residual AND spraying) OR TITLE-ABS-KEY (integrated AND vector AND control))) AND (humans) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2003) OR LIMIT-TO (PUBYEAR , 2002) OR LIMIT-TO (PUBYEAR , 2001) OR LIMIT-TO (PUBYEAR , 2000))				

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S3 Table Characteristics of studies identified in the Latin America region about *Ae. aegypti* and *Ae. albopictus* prevention and control interventions

	Country	Author, year	Objective (s)	Study design
1	Argentina	Masuh, 2003	To evaluate the efficacy of the fumigant canister CIPEIN pF-7 for mosquito control under field conditions.	Pre-post (before-after) study
2	Argentina	Gürtler, 2009	To determine the effect of a citywide intervention on *Ae. aegypti* larval indices and the reported incidence of dengue in Clorinda, north-eastern Argentina, over 2003–2007.	Pre-post (before-after) study
3	Argentina	Harburguer, 2011	To evaluate the efficacy of an experimental nonprofessional fumigant formulation against *Ae. aegypti* in the field, developed in alaboratory, and the residents' acceptance of this tool together with its role in community participation for indoor control activities.	'Non Randomised Controlled trial (NRCT)
4	Brazil	Camargo Donalisio, 2002	To evaluate the efficacy of temephos for the control of the larval population of *Ae. aegypti* as a part of a control program's routine.	NRCT
5	Brazil	Madeira, 2002	To evaluate a teaching method concerning the vector and dengue.	NRCT
6	Brazil	Chiaravalloti Neto, 2003*	To identify changes in knowledge and practices learned to prevent dengue fever in two areas of Catanduva, São Paulo State, from 1999 to 2001.	NRCT
7	Brazil	Perich, 2003	To test the lethal ovitrap against the dengue vector populations in urban areas of Brazil.	Randomised Controlled trial (RCT)
8	Brazil	Pamplona, 2004*	To evaluate the results of an intervention with the fish *Betta splendens* to control immature forms of *Ae. aegypti*, in cement tanks in the municipality of Canindé, Ceará.	Pre-post (before-after) study

Type of Intervention (s)	Outcome (s)	Main results
Application of insecticides. Fumigant canister CIPEIN pF-7 containing 120 g of fumigant mixture and 6 g beta-cypermethrin.	Breteau index, house index, and mosquitos' density	There was 100% initial mortality in each case after treatment with the fumigant canister. House and Breteau indices before the treatment were 51% and 106, respectively, falling to 23% and 44 after treatment.
Removal of mosquito breeding sites, treat water containers (non-drinking water) with 1% temephos or Bti, and application of ultra-low volume insecticide.	Breteau index, house index, pupae per 100 houses index, and incidence of dengue	House indices declined from 13.7% at baseline to 3.7% at the second focal cycle, and the Breteau index fell from 19.0 to 4.8. House indices were significantly reduced by 13–54% relative to pre-intervention indices in cycles 2–3, 5–7, 9, and 14. The reported incidence of dengue declined from 10.4 per 10,000 in 2000 (by DEN-1) to 0 from 2001 to 2006 and then rose to 4.5 cases per 10,000 in 2007 (by DEN-3).
Application of insecticides. Fumigant tablet containing 10% permethrin (3-phenoxyphenyl) methyl 3-(2,2 dichloroethenyl) -2,2-(dimethyl cyclopropane carboxylate), *cis:trans* relationship (45:55), and 2% pyriproxyfen (2-[1-methyl-2-(4-phenoxyphenoxy) ethoxy] pyridine). Ultra-low volume treatment, 10% permethrin plus 2% pyriproxyfen.	Breteau index, adult mosquito index, and community participation	The findings showed >90% adult emergence inhibition and 100% adult mortality with these treatments. More than 80% of the residents applied the fumigant tablet and preferred participating in a vector control program using a nonprofessional mosquito control tool instead of attending meetings and workshops promoting cultural changes.
Application of insecticide: temephos 1 ppm and source reduction.	Breteau index, and container index	The intervention area presented similar levels of *Ae. aegypti* larval infestation as the untreated area.
Health education campaign at school.	Knowledge	The students who received the intervention were more successful in identifying the cycle's stages, biological characteristics of the adult insect, and the mosquito's importance in health issues.
Health education campaign.	Knowledge attitude, practices (KAP) and Breteau index	Breeding sites were significantly reduced. The proportion of houses without breeding sites was significantly increased. There was an increase in the percentage of individuals who recognised the larval form of the vector in the study area.
Usage of lethal ovitrap	The total number of containers per house containing mosquito larvae and/or pupae, the mean number of mosquito pupae found per house, and adult mosquitoes	Post-intervention densities of *Ae. aegypti* were significantly reduced for most comparators ($P < 0.01$), as shown by fewer positive containers (4–5 vs 10–18) and pupae/house (0.3–0.7 vs 8–10) at intervention vs control group. Numbers of adult *Ae. aegypti* females indoors were consistently reduced in the intervention group at Areia Branca but not at Niloplis.
Usage of the fish *Betta splendens*	Immature forms *Ae. aegypti*	In January 2001, 70.4% of the water tanks presented mosquitoes. Following the intervention, in January 2002, only 7.4% were positive, and by December 2002, the rate had dropped to 0.2%.

	Country	Author, year	Objective (s)	Study design
9	Brazil	Chiaravalloti Neto, 2006*	To assess if the introduction of dengue control in the Family Health Program would produce gains in knowledge about dengue, its vector, and control measures concerning the traditional program, and to assess whether they would occur changes in practices for vector control in the populations served.	NRCT
10	Brazil	Favier, 2006	To determine the influence of climate and environmental vector control with or without insecticide on *Ae. aegypti* larval indices and pupae density.	NRCT
11	Brazil	Regis, 2008	To evaluate a new approach to dengue vector surveillance based on permanent egg collection using a modified ovitrap and Bti.	Pre-post (before-after) study
12	Brazil	Santos, 2008*	To evaluate novel approaches to monitor and control *Ae. aegypti* in Recife Metropolitan municipalities, from 2001 to 2007.	NRCT
13	Brazil	Pessanha, 2009*	To describe and evaluate dengue patterns after the implementation of the National Dengue Control Plan.	Record-surveillance
14	Brazil	Maciel-de-Freitas, 2011	To evaluate the impact of eliminating the most productive container types on *Ae. aegypti* population density in Brazil's dengue-endemic urban center.	Pre-post (before-after) study
15	Brazil	Costa, 2011*	To evaluate the "vector control *(Ae. aegypti)*" component of the National Plan control of Dengue, regarding the infrastructure of equipment and human resources and the quality of vector control actions in the city Caruaru, from 2008 to 2009.	Record-surveillance

Type of Intervention (s)	Outcome (s)	Main results
Combining the Family Health Program and the Dengue Control Program. House inspection, elimination of potential breeding sites of *Ae. aegypti,* and reorganise the work of the vector control team by carrying out visits to unregistered non-residential properties and vacant lots.	KAP and building index	There were significant changes concerning the increased knowledge about the disease and reduction in mosquito breeding sites. The building index measured in the intervention region were 6.9% (before) and (after) 4.4%, with a significant difference (p = 0.040). The findings show that integration between the programs is possible and could help optimise resources.
Application of insecticides. Four interventions with the combination of environmental management and insecticide/biological control treatment (Methoprene, Bti, or Temephos).	Percentage of premises with potential breeding sites, the mean number of potential breeding sites per premise, house index, container index, and Breteau index	Environmental vector control strategies dramatically decreased infestation in the five areas. No significant differences could be detected between control strategies with insecticide and without.
Mass collection of *Ae*. Eggs with ovitraps with Bti.	*Ae*. eggs density	Massive egg collection carried out at one of the sites prevented such a population outbreak. Egg counts made it possible to identify spots where the vector population is consistently concentrated over time, pinpointing areas that should be considered a high priority for control activities.
Mass collection of *Ae*. Eggs with ovitraps with Bti.	*Ae*. eggs density	The massive collection and destruction of *Ae. aegypti* integrated with the elimination or treatment of breeding sites can negatively affect the population density of this species. The studies demonstrated that the use of control ovitraps treated with Bti can be operationalised on a large scale, in the context of small or large municipalities, with the advantage of removing large amounts of eggs.
National control plan: health education campaigns, epidemiological surveillance, vector reduction.	Incidence of dengue and larval infestation	The goal concerning dengue incidence reduction (50% reduction in dengue cases) was not achieved in 143 of 292 (49%) municipalities analysed. The cities participating in the larval research in October 2005 and October 2006, 54.9% (45/82) in 2005 and 64.6% (53/82) in 2006 did not reach the goal of reducing the larval infestation to less than 1%.
Target the most productive container types: containers were covered using nylon net to prevent mosquito oviposition.	Breteau index, container index, house index, pupae/person index, and pupae per hectare	The most productive containers were: water tanks and metal drums. A short-term decrease in weekly adult female *Ae. aegypti* density after covering 733 water tanks with nylon net was observed. A long-term reduction in female adult population density was achieved only when both water tanks and metal drums were covered. Pupae per person, per hectare, and per house also decreased.
National Plan control of Dengue: (i) house visits, inspection of strategic points and vacant lots, (ii) chemical treatment of identified foci; usually the larvicide temephos at a rate of 1 ppm was used, (iii) spraying of insecticide at ultra-low volume.	Breteau index, property index, pending rate, and the number of resources including human resources for vector control	In 2008 and 2009, the pending rate and the level of infestation (mosquito) were above the percentage allowed by the Ministry of Health. The coverage of control in these years was lower (67.92 in 2008 and 67.35 in 2009) than recommended (90%) by the National Plan. Similarly, the number of vehicles, equipment, and personnel was insufficient in those years.

	Country	Author, year	Objective (s)	Study design
16	Brazil	Luz, 2011	To calculate the health burden in terms of disability-adjusted life years lost to dengue and the cost-effectiveness of various interventions.	Economic modeling assessment
17	Brazil	da Silva, 2013*	To analyse the process of cooperation between health personnel and the school in potential dengue vector breeding sites in households.	Mixed method study
18	Brazil	Regis, 2013	To evaluate and improve the applicability of an environmental friendly vector monitoring and control system to reduce dengue virus transmission.	Pre-post (before-after) study
19	Brazil	Degener, 2014	To assess the effectiveness of BG-Sentinel traps for mass trapping at the household level to control the dengue vector, *Ae. aegypti*, in Manaus (Brazil) by performing a cluster randomised controlled trial.	CRT (Cluster randomised trial)
20	Brazil	Maciel-de-Freitas, 2014	To determine the impact of the standard vector control measures.	Record-surveillance
21	Brazil	Abad-Franch, 2015	To investigate mosquito-driven dissemination of PPF dust-particles from 100 'dissemination stations' deployed in a 7-ha sub-area to surveillance dwellings and sentinel breeding sites distributed over an urban neighbourhood of about 50 ha.	Pre-post (before-after) study

Type of Intervention (s)	Outcome (s)	Main results
Application of adulticides and larvicides in the field.	Disability-adjusted life years and cost of interventions	In our model, one or more applications of high-efficacy larval control reduced dengue burden for up to 2 years, whereas three or more applications of high-efficacy adult vector control reduced dengue burden for up to 4 years. For the entire 5-year period, 6 applications of high-efficacy adult vector control reduced the dengue burden to the greatest extent, resulting in 248 disability adjusted life years (DALYs) lost per million individuals.
Health education campaign at school.	*Ae. aegypti* breeding sites	During the first visit, 83 (89.3%) HHs had some kind of container suitable for *Ae.* breeding. After the health education campaign, the number of HHs with potential breeding sites decreased to (second visits) 65 (70%) and (third visits) 63 (68%).
National Program for Dengue Control: (i) application of temephos, (ii) campaign for source elimination (iii) application of (e.g., organophosporous or piretroids) adulticides through ultra-low volume, (iv) communication campaign, (v) usage of ovitraps loaded with Bti and (vi) indoor collections of adult mosquitoes using aspirators, targeting places considered as highly important for virus transmission.	The density of *Ae.* eggs and adult mosquito population	A 90% decrease in egg density was recorded in Santa Cruz do Capibaribe after two years of sustained control pressure imposed by suppression of >7,500,000 eggs and >3,200 adults, plus larval control by adding fishes to cisterns. In Ipojuca, 1.1 million mosquito eggs were suppressed, and a 77% reduction in egg density was achieved. Data from Ipojuca showed a sharp decrease in the mosquito population.
BG-Sentinel traps.	The number of *Ae. aegypti* female mosquitoes and incidence of dengue	The results indicated that mass trapping with BGS traps significantly reduced the abundance of adult female *Ae. aegypti* during the first five rainy months. No effect of mass trapping was observed in the dry season. Fewer *Ae. aegypti* females were measured in the intervention arm during the next rainy period, but no significant difference between arms was observed. The serological survey revealed that recent dengue infections were less common in the intervention area than in control areas, although this effect was not statistically significant.
Removal of potential breeding sites, water storage containers were treated with the larvicide diflubenzuron, and deltamethrin was sprayed for adult *Ae. aegypti* mosquitoes.	Breteau index and house index	94 325 containers were removed from these houses or treated. A slight decrease in vector density was detected; the house index was reduced from 1.7 before interventions to 1.37 immediately after the second survey.
Dissemination of PPF dust-particles.	Juvenile mosquito mortality, adult mosquito emergence in each sentinel breeding site -month, and breeding-site coverage	There was evidence of PPF contamination in 75.5%, 80%, 100%, and 94.4% of surveillance dwellings in months 11, 12, 13, and 14, respectively. Juvenile mosquito mortality in sentinel breeding sites (about 4% at baseline) increased by over one order of magnitude during PPF dissemination (about 75%). This led to a >10-fold decrease of adult mosquito emergence from sentinel breeding sites, from approximately 1,000–3,000 adults/month before to about 100 adults/month during PPF dissemination.

	Country	Author, year	Objective (s)	Study design
22	Brazil	Caprara, 2015	To control both productive container types and discarded containers through an Eco health approach and analyse its effectiveness in reducing *Ae. aegypti* vector density.	CRT
23	Brazil	Degener, 2015	To evaluate the effectiveness of *Ae.* aegypti mass trapping using the sticky trap MosquiTRAP (MQT) by performing a cluster randomised controlled trial in Manaus, state of Amazonas, Brazil.	CRT
24	Brazil	Alecrim, 2016*	To describe dengue control actions developed in Ipatinga in 2009 and 2010, signalling the impact of the measures implemented (control plan and campaigns) that positively or negatively influenced the reduction of dengue cases in the city.	Record-surveillance
25	Brazil	Abad-Franch, 2017	To test if mosquito-disseminated pyriproxyfen can effectively reduce mosquito populations at the spatial scale relevant for vector control and disease prevention.	Pre-post (before-after) study
26	Brazil	Garziera, 2017	To assess the related changes in the distribution of infestation and abundance of vector *Ae. aegypti* populations 6 and 18 months after releasing transgenic mosquitoes in two areas in Brazil.	Pre-post (before-after) study
27	Brazil	Piovezan, 2017	To compare the application of the insecticide malathion GT 96% by the method of nebulisation with portable equipment vs heavy equipment.	NRCT

Type of Intervention (s)	Outcome (s)	Main results
Health education campaign, focussed on community mobilisation, including clean-up campaigns, covering the elevated containers and in-house rubbish disposal without larvicide.	Breteau index, house index, container index, pupae per person index, community participation, and cost of the intervention	There was an important reduction in small water containers in the intervention clusters (100% elimination in all visited houses). Before and after the intervention differences were identified between the intervention and control areas. The house index, container index, Breteau index, and pupae per person index increased, as expected, from the dry season (before intervention) to the rainy season (after the intervention), but the increase was significantly higher in the control clusters (p-values: house index=0.029 container index=0.020, Breteau index=0.014, pupae per person index=0.023) demonstrating the protective efficacy of the intervention.
Usage of sticky trap MosquiTRAP (MQT).	The number of *Ae. aegypti* females, the frequency of dengue virus IgM seropositivity, perceived trap effectiveness, problems, improvements, user satisfaction and KAP	Entomological results indicated that MQT mass trapping did not reduce adult *Ae. aegypti* abundance. The serological survey indicated that recent dengue infections were equally frequent in the intervention and the control group.
The dengue plan: (i) community mobilisation, (ii) identification of the predominant breeding sites and the infestation situation, (iii) prioritise the groups that have higher rates of infestation and cases notified, in order to intensify actions and contain the situation, and (iv) garbage collection in order to eliminate breeding sites for the *Ae. aegypti* mosquito.	Incidence of dengue	Within 60 working days more than 70 thousand tons of garbage were collected across the city. All technical and educational means linked to the community mobilisation, were linked with the following finding, it was observed that the municipality obtained positive results in reducing the total number of dengue cases between the years 2009 and 2010.
Dissemination of pyriproxyfen.	Juvenile and adult mosquito density	Following pyriproxyfen dissemination, *Ae.* juvenile catch decreased by 79%–92% and juvenile mortality increased from 2%–7% to 80%–90%. Mean adult *Ae.* emergence fell from 1,077 per month (range 653–1,635) at baseline to 50.4 per month during pyriproxyfen dissemination (range 2–117).
Release of transgenic male *Ae. aegypti* mosquitoes with the OX513A line.	The number of eggs of *Ae. aegypti* (wild) per trap	In both trials, there was an average suppression of ca. 70% of the wild population due to the release of transgenic males compared to the pre-release period. In Juazeiro, in the post-intervention phase, the number of eggs per trap ranged between 0.06 and 14.41 (mean ± SE = 4.44 ± 0.44), and the ovitrap index (OI = number of ovitraps with eggs/total number of ovitraps recovered) ranged from 0.01 to 0.43 (0.13 ± 0.01). In Jacobina, during the post-intervention phase, the number of eggs per trap ranged between 1 and 7.2 (1.72 ± 0.72), and the OI ranged from 1 to 0.83 (0.095 ± 0.032). The mosquito population in Juazeiro remained suppressed for 17 weeks, whereas in Jacobina suppression lasted 32 weeks.
Application of insecticide (ultra-low volume) with malathion GT 96% using heavy equipment coupled to a vehicle.	Incidence of dengue and *Ae.* eggs	After the applications with heavy equipment, the number of cases of the disease reported in the month of April for the intervention group was less than half that of the control group.

	Country	Author, year	Objective (s)	Study design
28	Brazil	Souza, 2017	To assess the impact of placing concrete at the bottom of the storm drains to elevate their base to the level of the outflow tube, avoiding water accumulation, and placement of a metal mesh covering the outflow tube to avoid its clogging with debris, on mosquito and water retainment.	Pre-post (before-after) study
29	Brazil	Santos, 2018	To assess if a conjugate of 2 larvicides for *C.quinquefasciatus* and *Ae. aegypti* populations in two contiguous urban subareas in the neighbourhood of Água Fria in Recife City would be more effective than a single one.	NRCT
30	Brazil	Abel Mangueira, 2019	To evaluate and compare KAP related to the prevention of arboviruses before and after a two-month educational intervention using a learning platform on mobile devices (m-learning and m-health).	NRCT
31	Brazil	Marini, 2019	To estimate the proportion of cases avoided by ultra-low volume insecticide spraying in Porto Alegre, a Brazilian metropolis characterised by a subtropical climate, low dengue virus incidence, and negligible pre-existing immunity. To estimate the effectiveness of insecticide spraying on dengue virus containment.	NRCT
32	Brazil	González, 2020	To assess the impact of two sand fly insecticide interventions (insecticide spraying and insecticide-impregnated dog collars) on the peridomestic abundance and distribution of mosquitoes (Culicidae) and biting midges (Ceratopogonidae).	RCT
33	Brazil	Gesto, 2021	To evaluate Wolbachia's ability to invade mosquito populations and investigate the bacterium density level and the vector competence for zika and dengue virus in post-release field samples, contributing to a better characterisation of targeted populations in Southeastern Brazil.	NRCT
34	Colombia	Romero-Vivas, 2002	To study the effectiveness of simple netted lids to prevent oviposition.	NRCT
35	Colombia	Luna, 2004	To explain how qualitative and quantitative research, including formative research, and data analysis based on the Stages of Change Model, was used as the basis for planning of an integrated social mobilisation and communication approach.	Mixed method study

Type of Intervention (s)	Outcome (s)	Main results
The intervention consisted of placing concrete in the bottom of the storm drains, aiming to raise the bottom level equal to that of the outflow draining tube, and thus prevent standing water. In addition, a metal mesh was installed over the outflow drain tube to trap debris and prevent it from entering the drain and restricting water flow.	Accumulated water volume, adult and immature mosquitoes in storm drains	Before the intervention, water accumulated in 48 (92.3%) of the storm drains, and immature *Ae. aegypti* were found in 11 (21.2%) and adults in 10 (19.2%). After the intervention, water accumulated in 5 (9.6%) of the storm drains (P < 0.001), none (0.0%) had immatures (P < 0.001), and 3 (5.8%) contained adults (P = 0.039).
Application of lysinibacillus sphaericus (Lsp) and Bti.	*Ae*. eggs and adult population	A reduction in the *Ae. Aegypti* adult population was not proven in the area treated with the conjugate mixture, but a significant decrease in egg density was detected in year-2, compared to year-1.
Health education campaign. Learning platform on mobile devices.	KAP	The students changed their attitudes and behaviour (P = 0.032) concerning their engagements in actions for the prevention of arboviral diseases and several other activities related to house inspections and precautions with water tanks (P < 0.01).
Ultra-low volume insecticide spraying.	Mortality of *Ae. aegypti* mosquitoes and symptomatic dengue cases	We estimated induced mortality of 40% for mosquitoes and found that the implemented control protocol avoided about 24% of symptomatic cases in the area throughout the 2015–2016 epidemic period.
Application of insecticide: (i) pheromone + insecticide (PI group), and (ii) deltamethrin.	Adult mosquitoes	Analysis of mosquito abundances revealed a significant reduction (56%) in the PI group (IRR = 0.54, 95% CI: 0.30–0.97, *P* = 0.04). The PI intervention significantly reduced the abundance of mosquitoes inside houses (41%) and at chicken roosting sites (48%).
Release of *Wolbachia*-infected eggs.	Saliva samples from orally infected (Wolbachia+) *Ae.* mosquitoes	After the release of *Wolbachia*-infected eggs, a successful invasion and long-term establishment of the bacterium across the territory was observed. The refractoriness to dengue and Zika viruses, either thorough oral-feeding or intra-thoracic saliva challenging assays, was maintained over the adaptation to the natural environment.
Cover of the most productive breeding sites of *Ae. aegypti*.	The number of larvae and pupae of *Ae. aegypti*	During the trial, 56% of inspected containers had netted lids correctly in place. Of these, 78% had no mosquito larvae. Only 37% of uncovered containers were free of mosquito larvae, a significant difference was demonstrated when these inexpensive mechanical barriers were used (P < 0.001).
Health education campaign focussed on community mobilisation.	KAP, and house index	Twenty-seven percent of the people knew about and practiced specific actions to look for and control *Ae. aegypti* breeding sites. Immature forms of *Ae. aegypti* was fewer in the post-intervention evaluation compared to the pre-intervention survey. The house index decreased from 18% in 1998 to 5% in 2003.

	Country	Author, year	Objective (s)	Study design
36	Colombia	Ocampo, 2009	To evaluate two control methods for *Ae. aegypti* that can be used by the community: Lethal ovitraps and Bti briquettes.	NRCT
37	Colombia	Cáceres-Manrique, 2010**	To determine the efficacy of social mobilisation for its role in public empowerment in the improvement of dengue control measures.	NRCT
38	Colombia	Pacheco-Coral, 2010	To estimate the impact of the information, education, and communication strategy on *Ae. aegypti* infestation in homes in La Dorada, Colombia.	Cross-sectional study
39	Colombia	Vesga-Gómez, 2010**	To evaluate the effectiveness of primary-school 'children's play-based education for improving knowledge about dengue prevention, control and practice.	Pre-post (before-after) study
40	Colombia	Carabalí, 2013**	To evaluate the coverage and reach of an intervention based on mass-media communication of dengue surveillance reports and its effect on the presence of intra-domiciliary breeding sites for *Ae.* in Guadalajara de Buga, Colombia.	Cross-sectional study
41	Colombia	Alarcón, 2014**	To evaluate the impact of ovitraps loaded with Bti on traditional indexes as strategies for surveillance and control of *Ae. aegypti.*	NRCT
42	Colombia	Quimbayo, 2014**	To determine the most efficient type of lethal ovitrap for *Ae. aegypti* vector control by combining different types of insecticides, oviposition substrates, and attractant infusions.	NRCT
43	Colombia	Ocampo, 2014	To identify and continuously control the most productive *Ae.* (Stegomyia) breeding site in an endemic urban area in Colombia and followed the subsequent incidence of dengue.	NRCT

Type of Intervention (s)	Outcome (s)	Main results
The interventions were performed (i) lethal ovitraps, (ii) Bti, and (iii) lethal ovitraps in combination with Bti and education.	House index, pupal index, adult index, and knowledge	The interventions did not achieve significant differences in vector abundance among the treatments. The interventions achieved a significant reduction in entomological indices compared with those observed during the pre-intervention survey: house index 15.1% vs 8.5%, mean pupae per house 1.15 vs 0.073, and adult index 56.3% vs 34.8% ($p < 0.05$).
Health education focusing on community mobilisation.	KAP, *Ae. aegypti* infestation levels and cases of dengue	Significant differences between the control and the intervention group were observed in aspects relevant to control, such as knowledge about the disease and the characteristics of the vector, prevention, and control practices. The difference in the prevalence of dengue one year after initiation of the intervention was not significant 4.8% in the intervention group and 6.7% in control ($\chi2=3.4$, $p=0.065$).
Health education campaign, with mass media communication.	The presence of immature forms of *Ae.* and adult mosquitoes	Almost 80% of the interviewees acquired knowledge about dengue transmission through the strategy. No immature forms were found in houses where somebody washed the water tank at least once a week. There were also no larvae in homes where people had knowledge about larvae and dengue transmission.
Health education campaign at school.	KAP	Significant increases in knowledge about dengue were observed. The children fulfilled their commitment and creatively and inventively engaged in more activities.
Mass dissemination of surveillance results.	House index, the coverage, and reach of the intervention	The house index was 2.5%; coverage was 59.4% and reach was 22.3%. There was no association between the intervention and the presence of intra-domiciliary mosquito breeding sites.
Usage of ovitraps with Bti.	Breteau index, house index, and container index	A total of 501,425 eggs were collected. In Apartadó, significant differences were observed in the house, container and Breteau indexes.
The usage of lethal ovitraps and insecticides (deltamethrin and permethrin).	The number of *Ae.* eggs and larvae	In the field conditions, the ovitraps with the highest vector reduction were those combining deltamethrin/towel/10% hay infusion.
The intervention targeted only the approximately 4800 catch basins. Each catch basin was treated with 2 g of pyriproxyfen (±0.05 mg/mL).	Percentage of positive catch basins, house index, container index, Breteau index, pupae per person index, and incidence of dengue	Street catch basins were the potential breeding site most frequently found containing *Ae.* immature stages. Due to the high resistance to temephos, the intervention consisted of monthly application of pyriproxyfen in street catch basins. A significant decrease in catch basins positivity for *Ae.* larvae was observed after each monthly treatment ($p < 0.001$). Over the intervention period, a reduction in the dengue incidence was observed (rate ratio 0.19, 95% CI 0.12–0.30, $p < 0.0001$) after adjusting for autocorrelation and controlling with a neighbouring town.

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	Country	Author, year	Objective (s)	Study design
44	Colombia	Escudero-Támara, 2015**	To evaluate the effectiveness of an educational intervention to induce changes in behaviour to eliminate breeding places for the dengue vector in families from a community in the Municipality of Sincelejo, Colombia.	Pre-post (before-after) study
45	Colombia	Quintero, 2015	To determine the effectiveness of long-lasting insecticide-treated net window and door curtains alone or in combination with long-lasting insecticide-treated net water container covers in reducing dengue vector density, and feasibility of the intervention.	CRT
46	Colombia	Vargas, 2015**	To determine if a set of integrated interventions, implemented in rural educational institutions in the municipality of Apulo, Cundinamarca, improved the quality of water for consumption and reduced mosquito vector infestation, reducing risk factors for diarrhoea and dengue diseases.	NRCT
47	Colombia	Criado Morales, 2016**	To implement community participation as a methodology for preventing dengue.	Pre-post (before-after) study
48	Colombia	Overgaard, 2016	To investigate whether interventions targeting diarrhoea and dengue risk factors would significantly reduce absence due to diarrheal disease and dengue entomological risk factors in schools.	CRT
49	Colombia	Jaramillo, 2018**	To evaluate the sustainability of a set of interventions to prevent dengue and diarrhea in 33 rural schools in the municipalities (counties) of Anapoima and La Mesa, Colombia, two years post-project.	NRCT

Type of Intervention (s)	Outcome (s)	Main results
Health education.	KAP and presence mosquito breeding sites	After the intervention changes were made in the levels of inadequate knowledge about dengue and behaviour of the vector from 14.8% to 3.7% (p=0.109), in their inadequate beliefs from 20.4% to 5.6% (p=0.008) and in adequate practices from 24 to 87% (p=0.001). Of the participant groups, 64.8% were classified in the action stage. There was a reduction of the number of intradomicile *Ae.* breeding places from 92.6% to 35.2% (p=0.001).
The intervention delivered first, long-lasting insecticide-treated net curtains and secondly, water container covers to the intervention cluster.	Pupae per person index, Breteau index and container index	The Breteau index fell from 14 to 6 in the intervention group and from 8 to 5 in the control group. The additional intervention with long-lasting insecticide-treated net covers for water containers showed a significant reduction in pupae per person index (p=0.01). In the intervention group, the pupae per person index showed a clear decline of 71% compared with 25% in the control group.
Health education campaign at school, focussed on covering mosquito breeding sites and management of solid waste.	Breteau index, school index, container index, the pupa per person index, adult mosquito density and number of episodes and days missed from school due to dengue	Infestation rates in schools by immature forms of *Ae. aegypti* and of pupa/person were less in the post-intervention stage, being this last one statistically significant. No impact was achieved on the adult population of *Ae. aegypti*.
Health education campaign.	KAP, Breteau index, house index, and container index	Knowledge related to dengue increased by 4,5 %. Breteau index was zero in two of the six districts. Three districts did not exceed 5%.
Health education campaign at schools.	Adult female *Ae. aegypti* density, Breteau index, school index, container index, pupae per person, the proportion of schools with adult female Ae. aegypti (%)	Interventions had no apparent effect on adult female *Ae. aegypti* density (p = 0.32). However, the dengue interventions reduced the Breteau index on average by 78% (p = 0.029), with Breteau indices of 10.8 and 6.2 in the “dengue” education group and “dengue and diarrheal” education group, respectively compared to 37.5 and 46.9 in the “diarrheal” education group and control group respectively.
Health education campaign at schools.	KAP, mosquito breeding sites, and sustainability of the intervention	The total sustainability score for dengue prevention was unsustainable in all arms except for the health education focussed on dengue only, which had a moderate level. Maintenance of benefits and interventions was moderately sustainable, while capacity development and institutionalisation were not sustainable. The differences between the four arms were not statistically significant. The KAP of the students showed greater sustainability compared to the absence of potential breeding sites for *Ae. aegypti* in schools, with no statistically significant differences between the intervention arms.

	Country	Author, year	Objective (s)	Study design
50	Colombia	Ceron-Hernandez, 2020	To evaluate the physical modification of storm drains as a control measure of the dengue vector *Ae. Aegypti.*	RCT
51	Colombia	Quintero, 2020	To present the impact of an *Ae.* vector control intervention “Girardot Aedes-free” in reducing the number of reported dengue cases in Girardot, Colombia, between 2015 and 2017	NRCT
52	Costa Rica	Perich, 2003	To evaluate the efficacy of the insecticide formulation applied as either an ultralow volume or thermal fog spray application. To evaluate the effectiveness of low volume application of lambda-cyhalothrin in suppressing *Ae. aegypti* populations in Costa Rica.	NRCT
53	Costa Rica	Rodríguez, 2009**	To analyse the behaviour of the entomological indexes before and after the control interventions on the vector and identify the breeding sites of *Ae. aegypti.*	Pre-post (before-after) study
54	Ecuador	Mitchell-Foster, 2015	To investigate the effectiveness and feasibility of scaling-up an eco-bio-social approach for implementing an integrated community-based approach for dengue prevention in comparison with existing insecticide-based and emerging biolarvicide-based programs in an endemic setting in Machala, Ecuador.	CRT
55	Guatemala	Rizzo, 2012	To test the efficacy, cost and feasibility of a combined approach of insecticide treated materials alone and in combination with appropriate targeted interventions of the most productive vector breeding-sites.	CRT

Type of Intervention (s)	Outcome (s)	Main results
Installation of a filter bed that prevents water retention after a rain event (> 100 mm).	The presence of standing water in the storm drains and the number of *Ae. aegypti* larvae	Of the 21 modified storm drains, 5 contained standing water, and 19 of the 21 unmodified storm drains contained standing water. The average number of larvae per storm drain, was 3.2 in the modified ones and 31.9 in the unmodified ones (ratio of 0.10). Using negative binomial regression, the 95% confidence interval of the 0.10 ratio is 0.014 to 0.74 (a reduction between 98.6 and 26%), with a *p-value* of 0.016.
Health education campaign based on an eco health approach, focusing on community mobilisation. House inspection, covering water containers with insecticide-treated aluminium covers, focussing on the most productive containers.	Incidence of dengue	The analysis indicates that the intervention resulted in a decrease of an average of between 0.12 (-0.25,0.01) and 0.26 (-0.42, -0.10) cases of dengue daily (1.82 cases per week or 7.8 cases per month or 95 cases per year) in Girardo
Application of insecticides: (i) ultra-low volume at the front door, (ii) ultra-low volume in each room, (iii) thermal fog at the front door, (iv) thermal fog in each room, (v) low volume at the front door, or (vi) low volume in each room.	Mortality of adult mosquitoes	Sentinel caged mosquito mortality in open and sequestered locations was 97-100% for the ultra-low volume and thermal fog spray treatments, with control mortality less than 2%. Both ultra-low volume applications (front door and each room) provided 3 weeks of significant control ($P < 0.05$) based on adult *Ae. aegypti* house collections.
Garbage collection, source reduction, usage of abate as larvicide and heat treatment for adult vectors inside and outside the house.	Breteau index, house index and container index	The first survey showed house index values over 5 in 12 areas, whereas 5 exhibited increased values after the interventions during the second survey. Positivity percentages in swampy places were low, 3.6 and 2.9% before and after the interventions, respectively.
An integrated intervention strategy for dengue prevention, including a health education campaign at school and a clean patio and safe container program	Pupae per person index, house index, Breateu index, and KAP	The integrated intervention strategy was successful in reducing pupae per person index levels in intervention clusters versus control clusters, with the six paired clusters that followed the study design experiencing a greater reduction of pupae per person index compared to controls (2.2 OR, 95% CI: 1.2 to 4.7). A reduction in both house index and Breateu index at the houses of children that participated in the school program was observed.
Two interventions were performed. The first intervention (coverage of window and exterior doorways made of PermaNet 2.0 netting, factory treated with deltamethrin at 55 mg/m^2, and of 200 L drums with similar treated material). The second intervention (combination of treated materials and other interventions targeting productive breeding-sites i.e larviciding with temephos, elimination etc.)	Total production of *Ae.* pupae, pupae per person index, house index, container, Breateu index, the coverage, people's acceptance, and cost of the intervention	After covering 100% of windows and exterior doorways and a small number of drums in 970 households, tropical rains occurred in the area and lead to an increase of the vector population, more pronounced (but statistically not significant) in the control arm than in the intervention arm. In the second intervention the combined approach of insecticide treated materials and interventions against productive containers lead to significant differences on reductions of the total number of pupae ($P = 0.04$) and the house index ($P = 0.01$) between intervention and control clusters, and to borderline differences on reductions of the pupae per person and Breteau indices ($P = 0.05$). The acceptance of the intervention was generally high, particularly in families who had experienced dengue.

	Country	Author, year	Objective (s)	Study design
56	Guatemala	Ulibarri, 2016	To study the effectiveness of an integrated intervention of health worker training, a low-cost ecological mosquito ovitrap, and community engagement on *Ae.* spp. mosquito control over 10 months in 2015 in an urban remote community in Guatemala at risk of dengue, chikungunya and Zika virus transmission.	CRT
57	Honduras	Avila Montes, 2004**	To evaluate the effectiveness of a special course on environmental health and dengue, given to primary school students and intended to promote behavioural changes in the mothers of those students that would lead to the safe handling of water, adequate disposal of trash, and control of household breeding sites of *Ae. aegypti*, the mosquito vector for dengue.	NRCT
58	Honduras	Avila Montes, 2012**	To determine and assess the results obtained and the lessons learned from a health education program at schools during the 2005–2010 period.	Pre-post (before-after) study
59	Mexico	Espinoza-Gómez, 2002	To evaluate the effect of an educational campaign for reducing the breeding places of *Ae. aegypti*, the principal vector of dengue; and to compare its effects with the ones obtained by spraying of Malathion at ultra-low volume.	CRT
60	Mexico	Galván, 2004	To reflects on the use of ongoing formative research to identify and test appropriate household-based control methods for key *Ae. aegypti*-producing containers and the creation of an education/communication strategy for the dissemination of highly specific messages for the key containers.	Pre-post (before-after) study
61	Mexico	Marina, 2012	To evaluate the efficacy of Spinosad as a larvicide in car tire habitats.	NRCT

Type of Intervention (s)	Outcome (s)	Main results
A three-component integrated intervention consisted of: (i) web-based training of local health personnel in vector control, (ii) cluster-randomised assignment of ecological ovillantas or standard ovitraps to capture *Ae aegypti* mosquitoes, and (iii) community engagement to promote participation of community members and health personnel in the understanding and maintenance of ovitraps for mosquito control.	Ae. mosquito eggs, KAP of the community and the health workers	When ovillantas were used, significantly more eggs were trapped by ecological ovillantas than standard ovitraps over the 10-month study period (t=5.2577; p<0.05). The mean weekly egg count was higher in neighbourhoods with ovillantas with a mean of 19.26334 (SE 0.4707; 95% CI: 18.34056, 20.18613) than at the control sites using standard ovitraps, with a mean of 13.2787 (SE 0.8249; 95% CI: 11.66214, 14.89748). The difference was statistically significant (t= 5.2577; p< 0.05). Among both community members and health workers, the levels of KAP increased.
Health education campaign at school	KAP, house index, Breteau index, and container index	In the two intervention schools, there was a significant increase in the students' knowledge of the following three variables: dengue caused by a virus, life cycle of the vector, and reduction of breeding sites, (P < 0.0001 for all those increases in knowledge). There were also significant increases in the knowledge of the same variables among the teachers in the intervention schools. There was a statistically significant difference in the Breteau index values between the two control group schools and the one intervention school where the education course was implemented more adequately.
Health education campaign at school	House index, reservoir index, and Breteau index	A reduction of the larval index was observed. The intervention promoted community participation in environmental issues, emphasising *Ae*. control.
The interventions were (i) an educational campaign, (ii) malathion spraying at ultra-low volume, (iii) both treatments simultaneously	The number of positive containers with larva by house	The average of the positive containers by house was reduced from 0.97 to 0.77. A two-way analysis of variance showed that this reduction was more apparent in the houses that received educational campaign (F=8.4, p<0.005) with relation to the ones that received malathion spraying (F=0.38, p>0.5), while the combination of both treatments demonstrated a discrete negative interaction (F=6.52, p<0.05).
Health education campaign	KAP, house index, container index, and Breteau index	In general, a decline was seen post-intervention across the house index, container index, and Breteau index.
Application of spinosad (1 ppm), spinosad (5 ppm), 0.4 g 1% temephos granules, and 50 µl Vectobac AS12 (Bti)	Numbers of *Ae.* spp. eggs, larvae, and pupae	Spinosad treatments at 1 or 5 ppm provided 6–8 weeks of effective control of *Ae. aegypti,* and *Ae. albopictus* both in the dry season and the rainy season. The larvicidal performance of VectoBac 12AS was relatively poor with one week of complete control of *Ae.* spp. larvae. The duration of larvicidal activity of 1% temephos granules was intermediate between those of VectoBac and Spinosad treatments.

	Country	Author, year	Objective (s)	Study design
62	Mexico	Martínez-Ibarra, 2012	To evaluate the effects of a program aimed at very young children to control domiciliary *Ae. aegypti* populations in four neighbourhood districts of a medium sized city in Jalisco, western Mexico	NRCT
63	Mexico	Anguiano-Moreno, 2013**	To contribute to the control of dengue in the western central region of Mexico through risk reduction, maintain epidemiological control of dengue and prevent deaths from this cause in the state of Colima, through innovative strategies and efficient: social participation, prevention measures, and control, social communication, operational research, monitoring, and evaluation.	Record-surveillance
64	Mexico	Loroño-Pino, 2013	To determine the potential to reduce dengue virus transmission through insecticide-treated curtains use in individual homes.	CRT
65	Mexico	Torres, 2014**	To identify dengue-related knowledge, attitudes, and practices among primary school students in Tapachula, Chiapas, Mexico, before and after an educational intervention.	Pre-post (before-after) study
66	Mexico	Che-Mendoza, 2015	To assess the long-term (> 2 years) impact of long-lasting insecticide-treated house screens and targeted treatment in controlling domestic *Ae. aegypti* infestations, when deployed simultaneously, in an urban environment with high dengue transmission in Mexico.	CRT
67	Mexico	Manrique-Saide, 2015	To investigate the use of insecticide-treated screens permanently affixed to windows and doors in Mexico.	CRT

Type of Intervention (s)	Outcome (s)	Main results
Health education at school	KAP, container index, and house index	The entomological indices decreased significantly (P<0.05) in houses in the intervention area, apparently because parents acted on the comments and suggestions of the children and eliminated or monitored mosquito breeding sites.
The interventions: (i) social participation, (ii) three cycles of space spraying with phenothrin with heavy utra-low volume machines, (iii) house visit and treatment with temephos, (iv) chemical and physical control in abandoned houses, (v) a communication strategy "patio and the roof clean", (vi) dengue cases derived from high migration to the municipalities of Armería, Manzanillo, and Tecomán were monitored, and (vii) the kiosks participated in the intervention by selling Abate to the community	Incidence of dengue, house index, container index, and Breteau index	Dengue incidence decreased from 81.4% in 2010 to 79.1% in 2011. The positive house index was at 0.5% in 2010 and 0.6% in 2011, the positive container 0.2% in both years and Breteau by 0.7% in 2010 and 0.8% in 2011. The interventions reduced the peak of cases that had been recorded in the rainy season resulting from the transmission of dengue.
Usage of insecticide-treated (deltamethrin) curtains	Mosquito abundance, incidence of dengue in humans and *Ae. aegypti,* mosquito	Overall, insecticide-treated curtains reduced intradomicile dengue virus transmission. Homes with insecticide-treated curtains homes were significantly less likely to experience multiple dengue virus infections in humans than homes without insecticide-treated curtains. Dengue virus–infected *Ae. aegypti* females were reduced within the homes with insecticide-treated curtains.
Health education campaign at school	KAP	The students' level of knowledge was significantly higher after the implementation of the health education campaign. In comparison with the fifth-graders, the sixth-grade students both already had and also acquired significantly more knowledge of several aspects of the disease and the vector.
Long-lasting insecticidal net screens fitted to domestic windows and doors in combination with targeted treatment of the most productive *Ae. aegypti* breeding sites	Breteau index, container index, house index, and pupae per person index	Long-lasting insecticidal net screens clusters had significantly lower infestations compared to control clusters at 5 and 12 months after installation, as measured by adult and pupal-based vector indices. After the addition of targeted treatment to the intervention houses in intervention clusters, indices remained significantly lower in the treated clusters until 18 (immature and adult stage indices) and 24 months (adult indices only) after the intervention.
Usage of screens (Duranet, Clarke Mosquito Control)	House infestation and infestation density for *Ae. aegypti* mosquitoes	At 5 months post intervention, significantly fewer treated than control houses were infested with *Ae. aegypti* adult female mosquitoes (OR 0.38, 95% CI 0.21–0.69), blood-fed females (OR 0.36, 95% CI 0.21–0.60), and males (OR 0.39, 95% CI 0.19–0.77). A significant effect was still seen at 12 months for adult females and males but not for blood-fed females. Analyses of infestation density showed similar trends, with significantly fewer *Ae. aegypti* mosquitoes found in treated than in control houses.

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	Country	Author, year	Objective (s)	Study design
68	Mexico	Tavor-Zamora, 2015	To evaluate the effectiveness of chemical control of larvae of *Ae. aegypti* using different indices before and after application at three locations in Baja California Sur, Mexico.	Record-surveillance
69	Mexico	Hernandez-Suarez, 2016	To analyse the effect of reducing transmission in elementary schools (grades 1–9) on the dynamics of the epidemic at a regional level.	Record-surveillance
70	Mexico	Jiménez-Alejo, 2017	To assess the impact of the community action on pupal production of the dengue vector *Ae. aegypti* in both rainy and dry seasons.	CRT
71	Mexico	Morales-Pérez, 2017	To assess whether the use of fish is associated with a reduction in dengue virus infection.	Cross-sectional study
72	Mexico	Che-Mendoza, 2018	To evaluate the entomological impact of the insecticide-treated screening intervention on indoor *Ae. aegypti* populations in the city of Merida, Mexico.	CRT
73	Mexico	Loroño-Pino, 2018	To investigate the potential for a Casa Segura approach to control *Ae. aegypti* and dengue virus transmission in fraccionamiento style housing in urban/suburban and rural sites in Merida and surrounding towns in Yucat State, Mexico.	CRT

Type of Intervention (s)	Outcome (s)	Main results
The intervention: epidemiological surveillance, medical care for ill patients, and environmental sanitation through social mobilisation, which involves physical management (elimination, removal, and protection) of artificial containers and chemical control (application of granular temephos larvicide in water containers or spraying insecticide in the environment)	House index, container index, and Breteau index	Significant statistical differences ($p < 0.001$) were observed in the relative abundance of *Ae. aegypti* larvae before and after applying larvicide temephos and by removing water containers where mosquitoes reproduce. In La Paz, the average of the house index was reduced from 16- 83% to 0-5% after control during the 3 years. In Cabo San Lucas, the value was reduced from 2-40% to <1% and in San Jose del Cabo such variation was 4-46% to 0-7%. The index of positive containers before and after management varied in La Paz from 6-34% to 0-4.7%; in Cabo San Lucas from 0.2-23% to <1%, and in San Jose del Cabo from 0.6-11% to <1.2%. The Breteau index in La Paz varied from 48-358% to 0-12.5%, in Cabo San Lucas, values decreased from 3-67% to <1%, and in San Jose del Cabo from 3-174% to 0-16% after the intervention.
Health education campaign focused on training janitors to locate and avoid mosquitoes' breeding places, to maintain elementary schools free of mosquitoes	Incidence of dengue	By the end of 2007, a reduction in dengue infection rates was observed right at the beginning of the school year compared to the previous year. By week 35, 2 weeks after the beginning of classes, the infection rate (per capita) in 2007 was 0.03, compared to 0.26 in 2006.
Health education campaign focused on community mobilisation for control of *Ae. aegypti* breeding sites and in addition to continuing normal prevention efforts, such as application of temephos to HHs water containers	Pupae per person, pupae per household, container index, household index, and Breteau index	All entomological indices were lower in the intervention clusters than in control clusters in both the rainy season and the dry season. Pupae per household 0.46 (intervention group) and 0.82 (control group) in rainy season, and 0.41 (intervention group) and 0.83 (control group) in dry season. Household index 16% in the intervention group and 21% in the control group in the rainy season, and 12.1% in the intervention group and 17.9% in the control group in the dry season. Breteau index 27% (intervention group) and 36% (control group) in rainy season, and 19% (intervention group) and 29% (control group) in dry season. All differences between the intervention and control clusters were statistically significant.
The usage of fish in water containers	Container index and incidence of dengue	The presence of fish was associated with lower levels of recent dengue virus infection in children aged 3–9 years (OR 0.64; 95% CI 0.45–0.91).
The usage of pyrethroid-impregnated long-lasting insecticide-treated netting	House positivity for adult female ***Ae. aegypti***, house positivity for any ***Ae. aegypti*** adults, number of female ***Ae. aegypti*** per house, and the number of total ***Ae. aegypti***per house	Significant reductions in the indoor presence and abundance of *Ae. aegypti* adults (OR = 0.48 and IRR = 0.45, $P<0.05$ respectively) and the indoor presence and abundance of Ae. aegypti female mosquitoes (OR = 0.47 and IRR = 0.44, $P<0.05$ respectively) were detected in intervention clusters compared to controls.
The usage of insecticide-treated curtains	Adult mosquitoes density, dengue virus infections in *Ae. Aegypti* and humans	Insecticide-treated curtains reduced the indoor abundance of *Ae. aegypti* and the number of dengue virus-infected mosquitoes in homes in rural but not in urban/suburban study areas. The presence of non-treated screens also was associated with reduced numbers of mosquitoes in homes.

	Country	Author, year	Objective (s)	Study design
74	Mexico	Newton-Sánchez, 2020	To analyse the effect of a community participation programme based on the ecosystem model on the incidence of dengue in urban communities.	RCT
75	Mexico	Devine, 2021	To report the findings of a randomised field trial evaluating the entomological impact of passive emanators containing the volatile pyrethroid metofluthrin against urban *Ae. aegypti* in the state of Yucatan, Mexico	RCT
76	Mexico	Manrique-Saide, 2021	To evaluate the efficacy of protecting houses with the insecticide-treated screening on *Ae. aegypti* infestation and arbovirus infection during a Zika outbreak in Merida, Yucatan, Mexico.	CRT
77	Mexico and Venezuela	Kroeger, 2006	To measure the impact on the dengue vector population (*Ae. aegypti*) and disease transmission (dengue) of window curtains and water container covers treated with insecticide.	CRT
78	Nicaragua and Mexico	Andersson, 2015	To test whether community mobilisation adds effectiveness to conventional dengue control.	CRT
79	Nicaragua	Arostegui, 2017	To examine potentially protective effects of temephos on entomological indices under everyday conditions of the national vector control program.	Record-surveillance

Type of Intervention (s)	Outcome (s)	Main results
Health education campaigns: community participation focusing on the ecosystem	The incidence of dengue and Breteau index	The incidence of dengue in the intervention group was 2.58%/month (n = 818) and in control group 2.26%/month (n = 994), with a risk ratio of 1.14 (95% CI 0.89-1.45) and the population attributable fraction of 0.06 (95% CI - 0.056 to 0.16). The Breteau Index was reduced in the intervention group.
Usage of the metofluthrin emanators	Indoor *Ae. aegypti* adult abundance, female abundance, blood-fed abundance, and estimates of *Ae. aegypti* landing behaviour	After metofluthrin emanators installation, the entomological indices between the trial arms diverged. There were significant reductions in Abundance Rate Ratios for total *Ae. aegypti*, female abundance, and females that contained blood meals (2.5, 2.4, and 2.3-times fewer mosquitoes respectively; P<0.001).
Usage of insecticide-treated screening. Both the intervention and the control clusters received routine control	Indoor adult mosquito infestation and arbovirus infection among mosquitoes	Houses with insecticide-treated screening were 79–85% less infested with ***Ae***. Females mosquito than control houses for up to one year. Houses with insecticide-treated screening had significantly fewer infected female ***Ae. aegypti*** than controls during the peak of the epidemic (OR = 0.15, 95%CI: 0.08–0.29).
Insecticide-treated (lambdacyhalothrin or deltamethrin) curtains and water treated with pyriproxyfen chips or covered	Breteau index, house index, pupae per person index, container index, and IgM serology	In both study sites, entomological indices at the end of the trial were significantly lower than those at baseline, though with no significant differences between control and intervention arms. Prevalence of IgM measured at baseline was 16% and 21% in intervention and control clusters, respectively. After eight months, this had dropped to 8% in the intervention clusters but had not changed significantly in the control groups 18%.
Health education campaign focussed on community mobilisation	Incidence of dengue, house index, container index, Breteau index and pupae per person	Serological evidence from intervention sites showed a lower risk of infection with dengue virus in children (relative risk reduction 29.5%, 95% confidence interval 3.8% to 55.3%), fewer reports of dengue illness (24.7%, 1.8% to 51.2%), fewer houses with larvae or pupae among houses visited (house index) (44.1%, 13.6% to 74.7%), fewer containers with larvae or pupae among containers examined (container index) (36.7%, 24.5% to 44.8%), fewer containers with larvae or pupae among houses visited (Breteau index) (35.1%, 16.7% to 55.5%), and fewer pupae per person (51.7%, 36.2% to 76.1%). Temephos in household water containers was associated with higher levels of serological evidence of dengue infection.
The dengue control program of the Ministry of Health carries out 4–6 cycles of temephos abatement annually in all municipalities of Managua. In addition, the government program conducts spatial fumigation and educational activities about the elimination of *Ae.* breeding sites	Household Index, households with pupae, and pupae per person	Between 2005 and 2013, Temephos exposure was not significantly associated with a reduction in any of the three mentioned entomological indices. In six of 18 multivariate models at the six time points, temephos exposure was associated with higher entomological indices.

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	Country	Author, year	Objective (s)	Study design
80	Paraguay	Parra, 2020	To test whether community mobilisation reduces infestation levels.	NRCT
81	Peru	Machaca, 2002**	To show the results and impact achieved in the control and/ or possible eradication of dengue from the jurisdiction of Sechura.	Record-surveillance
82	Peru	Dammert, 2014	To determine the effectiveness of mobile phone technology in improving households' health preventive behaviour in dengue-endemic area.	CRT
83	Peru	Paredes-Esquivel, 2016	To investigate the efficacy of deltamethrin S.C. applied through indoor residual spraying of dwellings in reducing *Ae. aegypti* populations.	NRCT
84	Peru	Gunning, 2018	To evaluate the impact of 6 cycles of indoor ultra-low volume pyrethroid spray applications on *Ae. aegypti* populations.	NRCT
85	Peru	Lenhart, 2020	To quantify the impact of insecticide-treated curtains on dengue virus seroconversion as measured through plaque-reduction neutralisation tests.	CRT

Type of Intervention (s)	Outcome (s)	Main results
Health education campaign focusing on community mobilisation	House index	In July 2018, the most significant decrease was observed in the intervention group, with indices at 2.61% (intervention,-19.91%) and 9.87% (control, -5.73%). In April 2019, with half-flooded territories, the house index of both the intervention and control groups increased, but the increase was lessened in the intervention group.
Scheduled and periodic container washing campaigns	*Ae.*,container and Breteau index	The *Ae.* (larvae) index found at the beginning of the study (46%) decreased to 3.3% in 20 days. After the second data collection method till 1-12-2001, the larvae, container, and Breteau remained close to 0.
Health education campaign based on mass media communication	Health-preventive behaviour, house index, container index and Breteau index	The results suggest that repeated exposure to health information encourages HHs' uptake of preventive measures against dengue. With regard to framing effects, we do not find statistically significant differences between interventions, except for one outcome (the non-monetary message compared to the control group). The results imply that HHs in the intervention group experienced a decreased in the percentage of water-holding containers testing positive for dengue larvae (1.44% vs. 2.47% in the intervention and control groups) as well as the number of positive water-holding containers per household (10.66 vs. 18.91 in the intervention and control groups).
Application of insecticide: deltamethrin applied through residual indoor spraying	Breteau index, house index, and container index	The results showed that in an area with moderate levels of *Ae. aegypti* infestation, residual indoor spraying dramatically reduced all immature indices the first week after treatment and the adult index from 18.5 to 3.1, four weeks after treatment ($p < 0.05$). Even though housing conditions facilitated reinfestation with *Ae. aegypti* indices remained low compared to baseline and 16 weeks after insecticide application.
Application of ultra-low volume pyrethroid spraying	*Ae. aegypti* populatio density	Trail 1: Spraying reduced the mean number of adults captured per house by ±83 percent relative to the pre-spray baseline survey. Trail 2: The number of adults per house in the intervention area was reduced ±64 percent relative to baseline.
Usage of insecticide-treated curtains	Dengue seroconversion, adult and immature *Ae. aegypti* abundance	Seroconversion data showed that individuals living in the intervention cluster were at greater risk of seroconverting to DENV, with an average seroconversion rate of 50.6 per 100 person-years (PY) (CI: 29.9–71.9), while those in the control arm had an average seroconversion rate of 37.4 per 100 PY (CI: 15.2–51.7). Entomological indicators did not show statistically significant differences between intervention and control clusters.

	Country	Author, year	Objective (s)	Study design
86	Uruguay	Basso, 2015	To implement and evaluate innovative interventions that increase the effectiveness of institutions working on dengue prevention (Ministry of Public Health), and to encourage participation and empowerment of citizens to generate appropriate, sustainable recommendations.	CRT
87	Uruguay	Basso, 2017	To test if the distributions of plastic bags for all HHs to collect all discarded water containers reduce the number of pupae per person index.	CRT
88	Venezuela	Vivas, 2003**	To assess the value of a game known as "Jugando en salud: dengue" as a teaching/ learning tool for schoolchildren to control of *Ae aegypti* and prevent dengue in the municipality of Girardot, Aragua state, Venezuela.	NRCT
89	Venezuela, Mexico, Peru and other countries.	Tun-Lin, 2009	To test the non-inferiority hypothesis that a vector control approach targeting only the most productive water container types gives the same or greater reduction of the vector population as a non-targeted approach in different ecological settings and to analyse whether the targeted intervention is less costly.	CRT
90	Venezuela	Vanlerberghe, 2011	To assess the operational effectiveness of long-lasting insecticide treated materials, when used at household level, for the control of *Ae. aegypti* in moderately infested urban and suburban areas.	CRT

Note:
*****Portuguese
****** Spanish
CRT: Cluster randomised trial
RCT: Randomised Control Trail
HHs: Households
KAP: Knowledge, Attitude and Practices
NRCT: Non-randomised control trail
Bti: *Bacillus thuringiensis var israeliensis*
PPM: One part per million, equivalent to one gram of active ingredient in 1 million milliliters of water.

Type of Intervention (s)	Outcome (s)	Main results
Ecosystem management measures consisted of promoting and organising a campaign together with community members and public health institutions for the physical or functional removal of containers in and around their homes. The HHs received a plastic bag for collecting small unused water containers. Large tanks were mapped and covered.	Breteau index, container index, house index, pupae per person index, pupae/hectare index, and cost analysis	The number of containers accounted for in the HHs after the intervention diminished 47.4% when compared with the number of containers registered in the baseline survey. When comparing the increase from spring to autumn the vector densities in intervention clusters on average increased less than those in the control clusters, although the difference was statistically not significant.
Distribution of plastic bags for collecting unused small containers. Health education focussed on community mobilisation.	Pupae per person index, house index, container index, Breteau index, and community involvement	The average pupae per person index, decreased in the intervention clusters 11 times and in the control clusters only four times ($P < 0.05$). The container index, house index, and Breteau index decreased in the intervention clusters more than those in the control clusters, although the difference was statistically not significant.
Health education campaign at school	Knowledge and skills to control *Ae.* mosquito	The knowledge about dengue and the skills that were measured prior to following the prescribed program were lower (6.5 and 18.4 points, respectively) than those displayed in the final test (8.25 and 22.9 points, respectively; $P < 0,05$). Students that received the intervention also appeared to acquire more skills than those in the control group ($P < 0,05$).
Venezuela: cover drums with insecticide treated nets. Mexico: buckets and pot management. Peru: source reduction and treat water with pyriproxyfen.	Breteau index and pupae per person index	Difference in reduction for intervention group vs. control group was calculated as Breteau index and pupae per person from baseline to 5-months follow up: Peru (Breteau index: −1.05 with a 95% CI: −12.64–10.53 and pupae per person: 0.365 with a CI: −0.030–0.760). Mexico (Breteau index: −12.65 with a 95% CI: −28.77–3.47 and pupae per person −0.529 with a CI: −1.034–−0.024). Venezuela (Breteau index: 0.84 with a 95% CI: −8.94–10.62 and pupae per person: −0.023 and a 95% CI: −0.749–0.703).
Usage of insecticide treated materials, consisting of curtains and water jar-covers	Breteau index and pupae per person index	In both urban and suburban clusters, the Breteau index showed a sustained 55% decrease, while no pattern was observed at the municipal level. After controlling for confounding factors, the percentage insecticide treated curtain coverage, but not insecticide treated jar-cover coverage, was significantly associated with both entomological indices (incidence rate ratio = 0.98; 95%CI 0.97–0.99).

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S4 Table Characteristics of studies identified in the Caribbean region about *Ae. aegypti* and *Ae. albopictus* prevention and control interventions

	Country	Author, year	Objective (s)	Study design
1	Cuba	Sanchez, 2005	To document the effectiveness of a local-level intersectoral approach.	NRCT (Non-randomised controlled trial)
2	Cuba	Toledo, 2007	To achieve social mobilisation and wide community participation in *Ae. aegypti* control, we designed an intervention that built an alliance between primary healthcare staff and the communities they serve.	NRCT
3	Cuba	Toledo Romani, 2007	To evaluate the sustainability of the intervention strategy over a period of 2 years after the withdrawal of external support.	NRCT
4	Cuba	Sánchez, 2008**	To document the process and analyse the results of implementing a strategy aimed at increasing community participation in the fight against the dengue mosquito vector.	Pre-post (before-after) study
5	Cuba	Toledo, 2008	To identify key elements that should provide an added value and assure sustainable effects of the deployment of technical tools for *Ae. aegypti* control.	NRCT
6	Cuba	Díaz, 2009**	To describe the design, implementation and evaluation of an intersectoral strategy with an eco-health approach to prevent dengue transmission at the local level.	Pre-post (before-after) study

Type of intervention (s)	Outcome (s)	Main results
Communication and social mobilisation strategy to *Ae. aegypti* control. The control methods included eliminating containers, covering tanks, and cleaning public and inhabited areas.	KAP (Knowledge, attitude, practices), house index and container index	Good knowledge about breeding sites and disease symptoms increased significantly (by 49.7% and 17.1%, respectively) in the intervention area and the proportion of respondents eliminating containers in and around their houses (by 44%). The house index in the intervention area was 3.72% at baseline and decreased to 0.61% after one year.
Health education campaigns focusing on community mobilisation/ participation.	Community participation, behavioural changes and entomological indicators	At the end of the study, the number of uncovered water containers had decreased by 46.7% (P < 0.01), and the number of houses with unprotected artificial containers had decreased by 55.5% (P < 0.01). There was a significant reduction in the median container indices between 2000 and 2002. A significant reduction (P < 0.01) in the median house indices per block of houses, from 1.23% to 0.35% (72% reduction) in the intervention area and from 2.08% to 0.52% (75% reduction) in the control area.
Health education campaigns focusing on community mobilisation/ participation.	Maintenance of effects (entomological indices and behavioural changes), institutionalisation and maintenance of activities	In the intervention area, 87.5% of the water containers remained well covered in 2004, and 90.5% of the families continued to correctly use a larvicide, against 21.5% and 63.5%, respectively, in the control area. The house index declined from 0.35% in 2002 to 0.17% in 2004 in the intervention area, while in the control area, it increased from 0.52% to 2.25%.
Health education campaigns focusing on community mobilisation/ participation.	Community participation, larvae/ pupae index, and incidence of dengue	An increase in community participation was observed. At the end of two years of intervention, the rate of *Ae. aegypti* larvae and pupae deposits found per 100 households had declined 79%, and cases of dengue were not detected in any of the districts
The intervention combined two complementary technical interventions: (i) the distribution of new ground-level water tanks and (ii) the intensive use of an insecticide.	Community perceptions, household risk behaviour, positive containers, house index, and container index	Perceived self-efficacy to solve *Ae. aegypti* infestation and prevent dengue was not modified. No changes in behaviour were observed. The container indices decreased significantly from 0.7% before to 0.1% one month after the intervention in the study area. Six months later, they had increased to 2.7% and uncovered new water tanks constituted 75.9% of all breeding sites. Over the nine months after the intervention, the average monthly house indices were similar in the intervention and control areas.
Participatory research for dengue control, focussing on community mobilisation.	Community participation	In the beginning, 85% of the vector sources were tanks located in the patios of the houses, and two years later, the percentage reduced to 29%. It was found that 16% of the 4,878 courtyards in the territory were not cleaned up. Two years after the end of the study, these constitute less than 1%; the number of unprotected low water tanks decreased from 62% to 8% (n = 4,678).

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	Country	Author, year	Objective (s)	Study design
7	Cuba	Sanchez, 2009	To document the process, outcome and effectiveness of a community-based intervention for dengue control.	NRCT
8	Cuba	Vanlerberghe, 2009	To assess the effectiveness of an integrated community based environmental management strategy to control *Ae. aegypti*, the vector of dengue, compared with a routine strategy.	CRT (Cluster randomised trial)
9	Cuba	Toledo, 2011	To evaluate vector infestation levels and incidence and distribution of clinical dengue cases in the original intervention and control blocks.	CRT
10	Cuba	Castro, 2012	To test the effectiveness of a community empowerment strategy intertwined with the routine dengue vector control programme in La Lisa, Cuba.	CRT
11	Cuba	Sanchez, 2012	To evaluate the results obtained through intersectoral coordination and community empowerment in one study carried out during six years in Playa Municipality, Cuba.	NRCT
12	Cuba	Zayas, 2012**	To reduce the environmental factors of the community influencing *Ae. aegypti* infestation.	Pre-post (before-after) study

Type of intervention (s)	Outcome (s)	Main results
Intersectoral coordination intervention focusing on community empowerment.	Community involvement in decision making, execution, evaluation of dengue control activities and behaviour changes. The number of houses inspected, the number of positive containers (with *Ae. aegypti* pupae or larvae) and the Breteau index	Mean scores for participation in the pilot area were 1.6, 3.4 and 4.4 at baseline and two years after initiating intersectoral coordination and intersectoral coordination plus community empowerment interventions. 80% of HHs involved in the community empowerment intervention showed adequate behavioural patterns. Significantly lower Breteau indices were observed in the intervention areas than in the control area.
Health education campaign focusing on community engagement.	House index, Breteau index and pupae per person index	At baseline, the *Ae.* infestation levels were comparable between intervention and control clusters. These indices were significantly lower in the intervention clusters at the end of the intervention: rate ratio for house indices 0.49 (95% confidence interval 0.27 to 0.88) and rate ratio for pupae per person 0.27 (0.09 to 0.76).
Community-based strategy: (i) establishment and training of a formal task force, the community working groups. (ii) securing intersectoral coordination between the community working group and the existing local government and health structures. (iii) creation of formal links with the routine vector control programme.	Incidence of dengue and Breteau Index	During the outbreak, the attack rate of dengue fever was 8,5 per 1000 inhabitants in the intervention blocks and 38.1 per 1000 inhabitants in the control blocks, which corresponds to a relative risk of 4.5 (95% CI 3.1–6.5). There was a significantly higher proportion of unaffected in the intervention blocks, and affected blocks had fewer cases than affected control blocks.
Community empowerment intervention: organisation and management, entomological risk surveillance, capacity building, and community work for vector control.	Breteau index, KAP and community participation change	The community participation score increased from 1.4 to 3.4. In the intervention and control clusters, good knowledge of breeding sites increased by 52.8% and 27.5%, respectively. Over the intervention period, the Breteau index remained 53% (95% CI 22–92%) lower in intervention clusters than in the control clusters. The empowerment strategy increased community involvement and added effectiveness to routine *Ae. aegypti* control.
Health education campaign focusing on community empowerment.	Breteau index	The Breteau index in the control area showed the lowest value before the intervention. This was reversed one year after launching intersectoral activities for dengue control in the intervention area. Despite spraying actions in all areas, the differences in the Breteau index between intervention and control areas remain significant until December 2002. Although no differences were observed for the next two years, they became significant again in December 2004, corresponding with implementing the complementary community-based vector control strategy in the intervention area.
Health education campaign.	Removal of mosquito breeding sites and the positivity rate of the *Ae. aegypti* foci	The implemented strategy eliminated potential mosquito breeding sites. With this intervention, it was possible to reduce the infestation index of *Ae. aegypti* in high-risk blocks, from 0.5-0.02. Of 72 risks detected, 65 (90.3%) were resolved, and 7 (9.7%) remained pending.

	Country	Author, year	Objective (s)	Study design
13	Cuba	Montada Dorta, 2013**	To determine the effectiveness of pyrethroid insecticide beta-cypermethrin, formulated as sipertrin 5 SC, for the control of *Ae. aegypti*.	Pre-post (before-after) study
14	Cuba	Toledo, 2015	To evaluate the incremental effectiveness and cost-effectiveness of insecticide-treated curtain deployment in eastern Cuba, a setting with comprehensive routine *Ae.* control and already low *Ae.* infestation levels.	CRT
15	Cuba	Hernández, 2019**	To contrast the communication for arbovirus infection prevention implemented in Cuba with the population's knowledge, perceptions, and practices concerning these diseases and their primary vector, the *Ae. aegypti* mosquito.	Mixed method study
16	Cuba	Toledo, 2017	To evaluate the entomological and epidemiological effectiveness of periodical intra- and peri-domiciliary residual insecticide (deltamethrin) treatment and long-lasting insecticide-treated curtains.	CRT
17	Haiti	Lenhart, 2008	To investigate the efficacy of insecticide-treated bednets in reducing *Ae. aegypti* populations and dengue transmission.	CRT
18	Puerto Rico	Winch, 2002	To document how different organisations have implemented the community-based dengue prevention program. To measure current levels of KAP among program participants. To assess the extent to which knowledge about dengue is reflected in the adequate control of mosquito larval habitats.	Mixed method study
19	Puerto Rico	Barrera, 2008	To test the efficacy of treating all containers believed to produce most *Ae. aegypti* pupae in a short period to control the biting adult population.	NRCT

Type of intervention (s)	Outcome (s)	Main results
Three interventions with sipertrin 5 SC were performed: (i) residual treatment of resting sites-perifocal, (ii) impregnation of curtains, and (iii) combination of treatment 1 and 2.	Mosquito mortality	The greatest residual effect was obtained with the combined treatment, with an effectiveness of up to five months. In HHs undergoing resting site and perifocal treatment, residuality was four months. The product's effectiveness was highest on plastic and concrete surfaces, with a 95 to 100% mortality rate for three months. On metal surfaces, mortality was 85%.
Usage of the long-lasting insecticide-treated curtain (PermaNet).	House index, Breteau index, and cost analysis	Over the 18-month observation period after insecticide-treated curtain distribution, the adjusted house index rate ratio, intervention versus control clusters, was 1.15 (95% CI 0.57 to 2.34).
Mass communication (health education) campaign.	KAP	The mass communication campaign had influenced the KAP of the community. However, information gaps continue to exist, and actions are required beyond just the provision of information. Actors involved in the communication campaign, e.g., doctors, nurses, operators, promotion community leaders, were insufficient.
Intervention group 1: residual insecticide (25% deltamethrin granular formulation to be dissolved in water, 20 g in 8 L) was sprayed every four months. Intervention group 2: usage of long-lasting insecticide-treated curtains.	Incidence of dengue and immature *Ae.* infestation	Despite a significant reduction in *Ae.* indices (Rate Ratio (RR) 0.54 (95%CI 0.32–0.89) in the first month after periodical intra- and peri-domiciliary residual insecticide (deltamethrin) treatment, the effect faded out over time, and the incidence of dengue was not reduced. Overall, there was no protective effect of both interventions in this setting.
Usage of long-lasting insecticide-treated bednets.	Breteau index, house index, container, pupae per person index, and anti-dengue IgM seropositivity rates	At one-month post-intervention, all entomological indices declined, with house index and Breteau index in the intervention arm reduced by 6.7 (95% CI -10.6, -2.7; $P < 0.01$) and 8.4 (95% CI -14.1, -2.6; $P < 0.01$) respectively. By five months, all indices remained low, and house index, container index and Breteau index were also significantly lower than baseline in the control arm. An IgM serosurvey showed a 15.3% decrease (95% CI 5.0-25.5%, $P < 0.01$) in the number of IgM-positive individuals from baseline to the final survey.
Community-based prevention programs: (i) two school-based educational programs, (ii) posters and televised public service announcements, and (iii) children's museum exhibit on *Ae. Aegypti.*	KAP, house index, Breteau index, and container index	Exposure to the programs was associated with increased knowledge about dengue, increased proportion of tires protected from rain, and decreased proportion of water storage containers positive for mosquito larvae. Exposure to the elementary school program was associated with slightly lower indices of residential mosquito infestation.
All containers likely to be aquatic habitats were turned over, and containers too large to turn were treated with one ppm methoprene.	The number of resting adult mosquitoes and pupae density	The pre-intervention and post-intervention densities of resting *Ae. aegypti* adult mosquito was significantly larger in the intervention area, although pupae density in surface containers was low and similar in both towns at four weeks post-intervention. At three weeks post-intervention, the density of resting adults decreased by only 18% of pre-intervention levels but returned to pre-intervention levels five weeks after treatment. Geographical Information Systems identified significant clustering of adult mosquitoes, which led to the discovery of underground aquatic habitats (e.g., septic tanks) that produced large numbers of *Ae. aegypti* and *Culex quinquefasciatus* (Say) in the intervention area.

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	Country	Author, year	Objective (s)	Study design
20	Puerto Rico	Barrera, 2014	To test the effectiveness of the novel CDC autocidal gravid ovitrap (AGO trap) to control natural populations of *Ae. aegypti* under field conditions in two isolated urban areas (reference vs intervention areas) in southern Puerto Rico for one year.	NRCT
21	Puerto Rico	Barrera, 2014	To determine if the sustained reduction in the *Ae. aegypti* female populations observed during the first year of the investigation in an urban area was maintained over time. To examine if adding intervention traps to a site initially used as a non-intervention reference area would succeed in lowering the population abundance of female *Ae. aegypti* to levels that have been observed in a separate intervention site.	NRCT
22	Puerto Rico	Lorenzi, 2016	To assess the incidence of chikungunya virus infection in communities with ongoing *Ae. aegypti* mosquito trap intervention studies.	NRCT
23	Puerto Rico	Barrera, 2017	To compare chikungunya virus incidence in *Ae. aegypti* in areas with and without AGO control traps to test the hypothesis that the presence of control traps limited local outbreaks of chikungunya virus infection.	NRCT
24	Puerto Rico	Barrera, 2018	To test if integrated vector control using a combination of source reduction, larviciding, and Autocidal Gravid Ovitraps (AGO traps) applied to at least 80% of houses in an area with a 150 m radius significantly reduced the density of *Ae. aegypti* around a pre-selected house in its centre.	NRCT
25	Puerto Rico	Juarbe-Rey, 2018	To examine the process and outcomes of a risk communication initiative to increase Zika virus awareness and health-enhancing behaviours among low-income housing residents.	Pre-post (before-after) study
26	Puerto Rico	Barrera, 2019	To investigate the control *Ae. aegypti* and Zika virus transmission in Caguas City, Puerto Rico during the 2016 epidemic using integrated vector management. To determine if female adult *Ae. aegypti* density in the city could be brought down to a steady 2–3 per trap per week at this geographic scale.	CRT

Type of intervention (s)	Outcome (s)	Main results
Ovitrap (CDC-AGO trap).	The density of *Ae. aegypti* mosquito	There were significant reductions in the captures of female *Ae. aegypti* (53–70%) in the intervention area.
Usage of autocidal gravid ovitraps and source reduction management.	The density of *Ae. aegypti* female mosquitoes	Mosquito density in the former reference area (the new intervention area) decreased 79%, and mosquito density in the new reference areas was 88% greater than in the intervention areas.
Usage of AGO traps.	Incidence of chikungunya virus infection and mosquito density	Lower incidence of chikungunya virus infection in the intervention compared with the control group occurred in the context of tenfold lower mosquito densities in the intervention areas with AGO traps.
Usage of AGO traps.	Female *Ae. aegypti* density, viral RNA of dengue virus and chikungunya virus in mosquitoes	The density of *Ae. aegypti* females were 10.5 times lower in the two areas with AGO control traps. Ten times more chikungunya virus-positive pools were identified in the control areas than in intervention areas. We found a significant linear relationship between the number of positive pools and both densities of *Ae. aegypti* and vector index. Temporal and spatial patterns of positive chikungunya virus pools suggested limited virus circulation in intervention areas.
The intervention consisted of eliminating, cleaning, or modifying containers, applying larvicide (Altosid Pro-G), and placing three AGO traps in the backyards of houses.	*Ae. aegypti* density	Overall, pre-treatment mosquito densities in the inner (0–50 m; 15,6 mosquitoes/trap/week), intermediate (50–100 m; 18,1), and outer rings (100–150 m; 15,6) were reduced after treatment to 2.8, 4.1, and 4.3 in the inner, middle, and outer rings, respectively. Density at the target house in the intervention area changed from 27.7 mosquitoes/trap/week before to 2.1 after intervention (92.4% reduction). After treating the original control area (cross-over), density changed from 22.4 to 3.5 (84.3% reduction).
Health education campaign focussing on community mobilisation.	KAP	Findings from baseline and follow-up data demonstrated significant positive changes in participants' recognition of personal and community responsibility for preventing Zika virus infection, increased knowledge of prevention strategies, and enhanced engagement in preventive behaviours for mosquito control.
Integrated vector management: community awareness and education, source reduction, larviciding, and mass-trapping with autocidal gravid ovitraps.	Adult female ***Ae. aegypti*** mosquitoes, vector index and maximum likelihood minimum infection rates	Out of 12.081 mosquito pools, there were one dengue virus, seven chikungunya virus, and 49 Zika virus-positive pools from October 2016 to March 2017. Afterwards, we found only one positive pool of dengue virus in July 2017. Mosquito density significantly changed ($P < 0.001$) from 8.0 ± 0.1 females per trap per week before the intervention to 2.1 ± 0.04 after the percentage of buildings treated with traps was 60% and to 1.4 ± 0.04 when coverage was above 80%.

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	Country	Author, year	Objective (s)	Study design
27	Puerto Rico	Sharp, 2019	To estimate the prevalence of chikungunya virus infection in communities with and without AGO traps and evaluate their effect on reducing chikungunya virus transmission.	NRCT
28	Puerto Rico	Harris, 2021	To evaluate if control of *Ae. aegypti* could be achieved by repeated (weekly and biweekly) micro-droplet application of Bti AM65-52 pushed high into the air using vehicle-mounted air-blast spraying equipment, allowing the larvicide to be distributed by the wind across neighbourhoods and into a range of larval sources.	NRCT
29	Trinidad	Chadee, 2005	To examine the impact of routine vector control operations during the 1998 outbreak of dengue fever and dengue haemorrhagic fever in Trinidad, West Indies.	Record-surveillance
30	Trinidad	Chadee, 2009	To test the efficacy of a new approach to the control of *Ae. aegypti,* which aims to reduce populations during periods of the anticipated rapid increase in population density, as predicted by dengue early warning systems.	NRCT
31	15 islands of the English-speaking Caribbean	Nathan, 2004	To describe an initiative on community mobilisation and organisational change implemented through the Caribbean Cooperation in Health/ Government of Italy integrated vector control project.	Pre-post (before-after) study

Note:
*Portuguese
** Spanish
CRT: Cluster Randomised Trial
NRCT: Non-randomised control trail
Ha: Hectare
HHs: Households
KAP: Knowledge, Attitude and Practices
Bti: *Bacillus thuringiensis var israeliensis*
PPM: One part per million, equivalent to one gram of active ingredient in 1 million millilitres of water.

Type of intervention (s)	Outcome (s)	Main results
Usage of autocidal gravid ovitraps traps.	Chikungunya virus seropositivity	An estimated 26.1% (with autocidal gravid ovitraps) and 43.8% (without traps) of residents had been infected with the chikungunya virus (adjusted prevalence ratios = 0.50, 95% CI: 0.37–0.91). The monthly number of chikungunya virus-infected mosquitos and symptomatic residents were diminished in communities with traps compared to those without traps.
Bti was applied at a rate of 500 g/ha using vehicle-mounted aqueous wide-area larvicide spray applications.	The population of adult female *Ae. Aegypti*, deposition of Bti droplets in open spaces, and building coverage	Bti spray was successfully deposited into jars in an array of open and covered locations, as confirmed by larval bioassays. After the fourth weekly spraying, differences in autocidal gravid ovitrap densities were observed between the intervention and control group resulting in 62% ($P = 0.0001$) and 28% ($P < 0.0001$) reductions in adult female *Ae. aegypti* numbers.
House inspection, treat water-holding containers with temephos. All houses of suspected /dengue cases were treated with temephos (all water-holding containers), and walls of houses intra-domiciliary treated with fenthion insecticide. In addition, 100 houses were spaced-sprayed using malathion insecticide applied by thermal foggers.	Breteau index, and incidence of dengue fever and dengue haemorrhagic fever	The Breteau index was >10 for 75% of the dengue haemorrhagic fever cases indicating a high vector activity. The Breteau indices in all these counties remained in excess of five throughout the year, thus maintaining the risk of dengue transmission. These results suggest that vector control operations failed to achieve the desired target of reducing mosquito densities to below the disease transmission threshold or possibly a Breteau index of five.
Houses were inspected and focally treated with insecticides temephos.	Breteau index, container index, house index, and pupae/person index	Following focal treatment during April (2-3 weeks before the onset of the rainy season), the *Ae. aegypti* population declined significantly ($P>0.01$) from a Breteau index of 19.0 to a minimum of 6.0 and a pupae/person index of 1.23 to a minimum of 0.35 in May, while in the untreated town of St. Joseph, the Breteau index steadily increased from 23 to 38. The pupae/person index rose from 0.96 to 2.00 in August.
Health education campaign focusing on community mobilisation.	KAP and entomological indices	The most significant change resulting from this project was how national vector control teams approached and worked together with communities and other stakeholders to resolve issues of mutual concern. There was a shift away from a 'top-down' approach to one of dialogue, negotiation and partnership to resolve environmental sanitation and vector control problems. Although KAPs were favourably altered and entomological indices were reduced in most project communities, the magnitude of these changes was modest and unlikely to be significant.

S5 Table Characteristics of studies identified in the Latin America and Caribbean region about *Ae. aegypti* and *Ae. albopictus* prevention and control interventions

	Country	Author, year	Objective (s)	Study design	Type of intervention (s)	Outcome (s)	Main results
1	Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Ecuador, Paraguay and Peru, Eastern and Southern Caribbean (Multi-country intervention study)	USAID report, n.d.	To improve institutional capacity building and infrastructure strengthening in countries where Zika Airs Project (ZAP) was implemented between 2016-2019	NRCT	The intervention was implemented across the region of Latin America and the Caribbean and consisted of three pillars: (i) entomological monitoring and surveillance through larvae/pupae surveys and several mosquito collection methods, including Prokopack aspirators, Gravid *Ae.* Traps, and Biogent sentinel traps for adult collection, ovitraps for egg collection, and manual collection for larvae. (ii) vector control activities included larviciding with Bti and indoor residual spraying. (iii) environmental management through household visits and cleaning up areas around homes to eliminate places where mosquitoes can breed, and educating householders on common breeding sites.	Removal of mosquito breeding sites, behaviour change of community and entomological indices such as container index	In general, the performed interventions led to a reduction of all forms of *Ae.* mosquitoes. ZAP provided extensive institutional capacity building and infrastructure strengthening to support robust routine entomological monitoring in collaboration with Ministries of Health and local stakeholders. ZAP initiated the development, delivery, and/or refurbishment of insectaries and laboratories and the Mosquito Control Research Unit. ZAP also built local capacity to conduct insecticide susceptibility tests to guide vector control decisions and equipped country governments to carry forward policies, protocols, and decision-making that rely on reliable, accurate, and real-time data, ensuring they are better able to prepare for future outbreaks.

Chapter 3

Table 1. Action plan to improve the performance of the health system of Curaçao

Actions to improve prevention and control strategies concerning VBDs	**Responsible**
Assign three health professionals with VBDs, management, and public health experience to coordinate actions related to the prevention and control of VBDs.	The management team of the MoHEN
Institute a multidisciplinary team (MDT) including an entomologist, epidemiologist, communication expert, certified vector inspector, sociologists, surveillance systems specialist, laboratory representative (e.g., microbiologist), policymaker, environmental specialist, and if possible, PhD students that have been working in this field. Note: The three assigned health professionals are responsible for documenting, disseminating information, and coordinating team-related activities. They are members and representatives of the MDT.	The three assigned health professionals
Evaluate, adjust and promote laws/policies regarding infectious diseases and vector control (e.g., the existent Integrated Management Strategy for Dengue Prevention and Control in Curaçao, 2012).	The MDT and the Policy Department
Make a protocol for the usage of biological and chemical control measures, including related safety procedures.	The entomologist, certified vector inspector, environmental specialist, and policymaker
Evaluate and provide recommendations to improve the working procedure related to housing inspections (e.g., create teams, VCU field workers under the supervision of certified vector inspectors responsible for specific neighbourhoods/ geo zones).	The MDT
Actions to enhance capacity building	
Make job descriptions for the health system workforce that works in the field of prevention and control of VBDs. Note: HR recruit future health professionals based on developed job descriptions.	Human Resources (HR) and the representatives of the MDT
Seek ways to acquire funds to organise training for the workforce in different aspects (e.g., entomology, surveillance, RC, geographic information system (GIS), equipment calibration, pesticide safety).	The representatives of the MDT
Make use of local published data to make decisions and use the research skills of PhD students to perform the necessary research, for example, in the field of social sciences and entomology.	The MDT
Perform insecticide resistance and entomological research (e.g., determine the house index container index, breteau index, and pupal index).	The entomologist and the VCU
Seek funding to create a basic entomological laboratory to perform basic entomological research.	The representatives of the MDT
Actions to enhance communication and intra- and intersectoral collaboration	
Seek ways to connect both governmental organisations and NGOs that are needed for prevention and vector control, e.g., Selikor (waste management), Caribbean Research and Management of Biodiversity (CARMABI), Ministry of Traffic, Transport and Urban Planning and Ministry of Social Development, Work and Welfare, Ministry of Education, Science, Culture and Sport, and laboratories. Note: The representatives of the MDT, the management specialist, the sociologist, and the policymaker are responsible for documenting agreements between organisations to enhance accountability and transparency.	The representatives of the MDT, management specialist, sociologist, and policymaker

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Actions to reform the health system	
Examine and determine the organisational culture of the health system.	Management specialist, sociologist, policymaker, and HR
Make a plan to improve the management and culture style of the health system. Provide recommendations to reinforce the organisational structure of the MoHEN.	Management specialist, sociologist, policymaker, and HR
Evaluate the motivation, job satisfaction, and abilities of the workforce of the health system.	HR

Table S1. Characteristics of the study participants

	Focus Group Discussion with Professionals (*n* = 30)			
	Number of participants	**Age range**	**Gender[a]**	**Expertise (s)**
1	9	25-61	5F/4M	Vector control, surveillance of vector and breeding sites
2	6	26-40	2F/4M	Vector control, surveillance of vector and breeding sites
3	3	47-70	2F/1M	Previous ministers of health
4	5	57-64	1F/4M	Epidemiology, vector control, policy, surveillance of cases, vector and breeding sites, microbiology, laboratory techniques, and procedures, entomology, microbiology
5	7	36-63	4F/3M	Vector control, surveillance of vector and breeding sites
	Expert Interviews (*n* = 11)			
	Name[c]	**Age**	**Gender**	**Profession (s)**
1	Sarah	59	F	Epidemiologist
2	John	59	M	Previous head of the sector of health/ epidemiologist/ general practitioner
3	Elsa	52	F	Entomologist/ policymaker/ registered restricted pest controler
4	Ana	63	F	Coordinator of the VCU[b]
5	Peter	62	M	Coordinator of the VCU
6	Stephan	57	M	Policy-maker/ general practitioner/ previous director of the sector of health
7	Glen	66	M	Previous minister of health/ general practitioner
8	Sol	69	F	Geriatrician
9	Audrey	NA	F	Laboratory technician
10	Twin	81	F	Alternative medicine practitioner
11	Sandro	66	M	General practitioner

Additional notes:
-The majority of the interviewed health professionals worked for the MoHEN during the period of data collection of this study. Except for the following participants; (i) previous ministers of health who worked from 10-10-2010 to 29-09-2012 (DD-MM-YYYY), (Glen) 31-12-2012 to 30-11-2015, 30-11-2015 to 23-12-2016, (ii) a previous deputy who worked in 2002, (iii) the geriatrician who worked from 2007 to 2015, and (iv) the microbiologist who worked from 2008 to 2016.
- The first FGD with health professionals was held in January 2019, and the last one took place in October 2019.
- The first interview with an expert was held in January 2019, and the last one took place in December 2020.
[a] Gender: F= Female, and M=Male.
[b]VCU=Vector Control Unit
[c] Fictional names were used to protect the identity of the study participants.

Table S2. Characteristics of the collected documents

	Type of document	Amount	Department (s)
1	Legislation, policy, protocols	4	Policy Department
2	Plans (e.g., project, business, surveillance, communication plan)	13	Director of the health sector, Policy Department, ERU
3	Health promotion materials	14	Department of communication
4	Evaluation reports	4	External medical entomologists, Court of Audit Curaçao
5	Minutes of meetings	5	Director of the health sector, Policy Department, ERU, VCU
6	Budget of MoHEN	2	Policy Department
7	Surveillance reports	8	ERU, VCU
	Total	**50**	

Text S1. Topic guide: FGD with the Vector Control Unit

Topic guide: Understanding the preparedness and performance of the health system, and risk communication in the face of chikungunya and Zika virus infection epidemics

Group: Vector control inspectors

FGD number : .... Moderator : ....
Date : .... Note-taker : ....

Introduce yourself to the participants:
Thank you very much for agreeing to participate in this group discussion. My name is Vaitiare Jansen. I am a doctoral student at the University of Groningen.

- ✓ ***Explain the general purpose of the study***: The general purpose of the study is to understand risk communication and the performance of the health system from your point of view in order to provide the health system with content specific advice to strengthen risk communication efforts and sustainability of risk management.
- ✓ ***Estimated time***: Approximately 1 ½ hour
- ✓ ***Right to participate and withdraw from the study:*** Involvement in this study is entirely voluntary. You are free to withdraw from the study at any time. You are free to skip any questions that you would prefer not to answer during the discussion.
- ✓ ***Use of tape recorder***: To be able to keep a more accurate record of our discussion, I am proposing to use a tape recorder, if you do not mind. Do you mind if I use a tape recorder? *(observe whether people agrees)*
- ✓ ***Plan to protect the identity of the participants:*** The information that we will discuss here today will remain anonymous. Your names will be removed from the data, and no one will be able to link your name with what is said. No one apart from the research team will have access to the data. This data will be published and shared with the scientific community, but your name will not appear in any of the publications.
- ✓ ***Basic principles:***
    1. Respecting opinions from others is important.
    2. There are no right and wrong answers. We value each idea, opinion and experience.
    3. One person speaks at a time.
    4. Ask if there is any question.
- ✓ Do you have any questions?
- ✓ ***Consent:*** Do you agree to take part in this discussion?
- ✓ The moderator turns on the digital recorder and starts the discussion

Introduction

- ✓ As an introduction, let us go around so that you can introduce yourselves and tell us your name, age and what type of work you do.

Let us start our discussion by talking about chikungunya and Zika. Curaçao has witnessed the chikungunya virus infection outbreak in 2014-2015 and, more recently, the Zika virus infection outbreak in 2016. As inspectors of the Vector Control Unit of the GMN, you worked closely with the community in order to reduce cases of chikungunya and Zika virus infection.

1. ***What do you think about the job of a vector control inspector?***

Probe for:

a. What are the good things?
b. What can be better?
c. Do you think that the job of a vector control inspector is important?
d. Why?

Topic 1: Preparedness of the health system

1. ***What does preparing for an outbreak of diseases transmitted by mosquitoes mean to you?***
2. ***How prepared was the health system for chikungunya?***

   Probe for:

   a. In what way did they prepared?
   b. What about the vector control unit?
   c. Ask for the following factors *(enough workforce and materials)* if they are not mentioned.
3. ***How prepared was the health system for Zika?***

   Probe for:

   a. In what way did they prepared?
   b. What about the vector control unit?
   c. Ask for the following factors *(enough workforce and materials)* if they are not mentioned.
4. ***What can be done to improve the readiness of the health system?***

Probe for:

a. Why?
b. What can be done to improve the readiness of the vector control unit?

Topic 2: Performance of the health system

1. ***What is the role of the vector control unit in the health system?***

   Probe for:

   a. Which departments work closely with the department of vector control?
   b. How is the collaboration between the departments?

2. ***Could you describe your experiences during the chikungunya epidemic as vector control inspectors?***
   Probe for:
   a. What went well?
   b. What can be improved?
3. ***Could you describe your experiences during the Zika epidemic as vector control inspectors?***
   Probe for:
   a. What went well?
   b. What can be improved?

We heard in the community that many people thought that the government did anything.

1. ***Why do people think like this?***
   Probe for:
   a. Which challenges do you face during your work?
   b. Ask for the following *factors (trust issues, limited resources, immigrants, unplanned urbanisation, and work-related insecurities)* if they are not mentioned.

Now that we spoke about the challenges that you faced or that you are facing during your work.

4. ***I would like to know how do these challenges affect your day-to-day work?***
5. ***What lessons did the vector control unit learn from these epidemics?***
   Probe for:
   a. What has been done with the lessons learned?
6. ***What could be done to improve the performance of the vector control unit?***
   Probe for:
   a. Why?
   b. Who can provide the vector control unit with the needed help?

Topic 3: Risk communication

We heard that the vector control inspectors were also responsible for the provision of information to the community.

1. ***What type of information was or is shared with the community?***
   Probe for:
   a. Ask for the following type of information *(preventive measures, the transmission of disease, and treatment)* if they are not mentioned.
2. ***Do you think that the information you provided helped to change the behaviour of people?***

3. ***Which challenges do vector control inspectors face when they are providing information to the community?***
   Probe for:
   a. Ask for the following factors *(language barriers, lack of self-confidence, information materials, time, and community interest)* if they are not mentioned.
4. ***What can be done to improve communication between the vector control inspectors and the community?***

Closing question

1. ***Imagine, this year, we have another disease transmitted by mosquitoes. Do you think we are prepared to deal with it?***
   Probe for:
   a. What can be done?

We are now reaching the end of the discussion. Does anyone have any further comments to add before we conclude this group discussion? I want to thank you all very much for your participation in this discussion; your experiences and opinions are valuable to assist in improving risk communication and risk management in Curaçao.

Text S2. Topic guide FGD with health professionals

Topic guide: Understanding the preparedness and performance of the health system, and risk communication in the face of dengue, chikungunya and Zika virus infection epidemics

Group: Health professionals

FGD number : .... **Moderator** : ....
Date : .... **Note-taker** : ....

Introduce yourself to the participants:
Thank you very much for agreeing to participate in this group discussion. My name is Vaitiare Jansen. I am a doctoral student at the University of Groningen.

- ✓ ***Explain the general purpose of the study***: The general purpose of the study is to understand risk communication and the performance of the health system from your point of view, in order to provide the health system with content specific advice to strengthen risk communication efforts and sustainability of risk management.
- ✓ ***Estimated time***: Approximately 1 ½ hour
- ✓ ***Right to participate and withdraw from the study:*** Involvement in this study is entirely voluntary. You are free to withdraw from the study at any time. You are free to skip any questions that you would prefer not to answer during the discussion.
- ✓ ***Use of tape recorder***: To be able to keep a more accurate record of our discussion, I am proposing to use a tape recorder, if you do not mind. Do you mind if I use a tape recorder? *(observe whether people agrees)*
- ✓ ***Plan to protect the identity of the participants:*** The information that we will discuss here today will remain anonymous. Your names will be removed from the data, and no one will be able to link your name with what is said. No one apart from the research team will have access to the data. This data will be published and shared with the scientific community, but your name will not appear in any of the publications.
- ✓ ***Basic principles:***
  1. Respecting opinions from others is important.
  2. There are no right and wrong answers. We value each idea, opinion and experience.
  3. One person speaks at a time.
  4. Ask if there is any question.
- ✓ Do you have any questions?
- ✓ ***Consent:*** Do you agree to take part in this discussion?
- ✓ The moderator turns on the digital recorder and starts the discussion

Introduction

- ✓ As an introduction, let us go around so that you can introduce yourselves and tell us your name, age and what type of work you do.

Let us start our discussion by talking about chikungunya and Zika. Curaçao has witnessed the chikungunya virus infection outbreak in 2014-2015 and, more recently, the Zika virus infection outbreak in 2016. Dengue epidemics occur cyclically. As health professionals of the GMN, you worked closely with the community to reduce the risk for dengue, chikungunya and Zika virus infection.

1. ***What does preparing for an outbreak of diseases transmitted by mosquitoes mean to you?***
2. ***How prepared was the health system for dengue?***
   Probe for:
   a. How prepared was the health system for chikungunya?
   b. Which department (s) were less prepared, and why?
   c. How prepared was the health system for Zika?
3. ***What can be done to improve the readiness of the health system?***
   Probe for:
   a. Why?

Topic 1: Governance

1. ***How was the health system organised during the epidemic of dengue in 2010?***
   Probe for:
   a. Which departments were responsible for the surveillance of cases, vector, communication, prevention and control?
   b. Which ministries/departments/institutions were involved and needed to work together?
2. ***How was the health system organised during the epidemic of chikungunya in 2014-2015?***
   Probe for:
   a. What were the changes *(e.g., assigned new head of department, laws, protocols, strategies for prevention and control of the vector?)*
   b. How was the health system organised during the epidemic of Zika in 2016?
   c. What were the changes?
   d. Did the collaboration between ministries/departments/institutions improve or deteriorate in the last ten years?
   e. Currently, how is the collaboration between departments?
   f. What do you think about the organisational structure of the ministry of health (MoH)?

3. ***What were the challenges of the MoH during the epidemics of dengue and chikungunya?***
   Probe for:
   a. What were the challenges with regards to the development, implementation and reinforcement of laws/protocols?
   b. What were the challenges with regards to the surveillance of cases and the vector?
   c. What were the challenges concerning the prevention and control of the vector?
   d. What were the challenges concerning risk communication?
4. ***What were the challenges of the MoH during the epidemic of Zika?***
5. ***Which laws or protocols did you use for public health issues, surveillance of cases, surveillance of vector, prevention and control of the vector?***
   Probe for:
   a. There is a basic law on infection disease *(Bestrijding van besmettelijk ziekten, p.b.1921, no.66).* Is this law still useful?
   b. What are the benefits and disadvantages of this law or the protocols that you used?
   c. What about laws concerning public health and prenatal Zika infection?
6. ***What are the lessons learned?***
   Probe for:
   a. What have you done with these lessons?
   b. What is needed to improve surveillance of cases, vector, prevention and vector control?

Topic 2: Financing system

1. ***Describe the healthcare financing system?***
   Probe for:
   a. Which stakeholders *(e.g., hospital, general practitioners, specialists, laboratories)* are involved?
   b. What are the benefits and gaps in this healthcare financing system?
2. ***How was the public health sector financing system organised during the dengue epidemic?***
   Probe for:
   a. Which ministries/departments/institutions were involved?
   b. What are the benefits and gaps in this public health financing system?
   c. What were the major changes during the chikungunya and Zika epidemics in the context of financing?

3. ***Which services related to prevention and vector control are free for the community?***
   Probe for:
   a. Which services are not free?
   b. Why?
4. ***What can be done to improve the public health sector financing system to ensure prevention and vector control sustainability?***

Topic 3: Health information system

1. ***What type of data (e.g., cases of VBDs, the vector etc.) has been collected by which department in the last ten years?***
   Probe for:
   a. How was the data collected?
   b. How was the data stored?
   c. What was the aim of the data collection?
   d. How reliable was the collected data?
2. ***How was the data analysed?***
   Probe for:
   a. By whom?
   b. What were the strengths and gaps in the collected data?
3. ***Has the data been published or shared?***
   Probe for:
   a. By whom?
   b. To whom *(e.g., community, public health system)*?
   c. Was the information shared on time?
   d. What are the strengths and gaps in data sharing?
4. ***How was the risk communication regarding VBDs organised?***
   Probe for:
   a. How was the risk communication regarding dengue communicated to the community?
   b. How was the risk communication regarding chikungunya and Zika communicated to the community?
   c. How was the risk communication regarding VBDs communicated within the health system?
   d. What were the strengths and gaps in risk communication strategies?
   e. What can be done to improve risk communication?
5. ***How was the surveillance system of cases of VBDs organised?***

Probe for:
   a. Which surveillance methods, software and strategies were used during the dengue, chikungunya and Zika epidemics?
   b. Which department was responsible for the surveillance of cases?
   c. Which departments and institutions needed to collaborate?

   d. How was the collaboration?
   e. Was the collaboration documented in law or protocol?
   f. What can be done to improve the surveillance system of cases?
6. ***How was the surveillance system of the vector organised?***
   Probe for:
   a. Which surveillance methods, software and strategies were used during the dengue, chikungunya and Zika epidemics?
   b. Which department was responsible for the surveillance of the vector?
   c. Which departments and institutions needed to collaborate?
   d. How was the collaboration?
   e. Was the collaboration documented in law or protocol?
   f. What can be done to improve the surveillance system of the vector?

Topic 4: Workforce

1. ***How qualified are the workforce of the health system? Explain why?***
   Probe for:
   a. Is it enough?
   b. Are the job descriptions clear?
   c. What are the strengths and gaps in the workforce of the VCU?
   d. What are the strengths and gaps in the workforce of the department of epidemiology and research?
   e. What are the strengths and gaps in the workforce of the department of communication?
   f. What are the strengths and gaps in the workforce of the policy department?
2. ***How satisfied were you with your job during the epidemics?***
   Probe for:
   a. Were you motivated?
   b. Which factors were associated with a reduction in motivation and satisfaction?
3. ***Which stakeholders (e.g., general practitioners, hospital, laboratories, department of communication, epidemiology and research, THZ, Selikor, DOW, PR, Policy) are essential for prevention and vector control?***
   Probe for:
   a. *Why?*
4. ***What can be done to improve the performance of the workforce?***

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Topic 5: Service delivery

1. ***Which interventions were conducted by the public health system during the epidemic of dengue?***
   Probe for:
   a. Which interventions (related or not related to the community) were conducted during the epidemics of chikungunya and Zika, and by whom?
   b. What are the strengths and gaps in these interventions?
   c. What can be done to improve these interventions?
2. ***What can be done to ensure the sustainability of these interventions?***
3. ***Which resources were needed to perform these interventions?***
   Probe for:
   a. Which resources were used for prevention and vector control?
   b. Which biological methods for vector control (all stages) were used?
   c. Which chemical methods for vector control were used?
   d. Which other methods were used?
   e. Were the resources available during the epidemics? Why?
   f. Which measures were taken to protect the workforce during fieldwork?
   g. Are these interventions documented?
4. **How effective were the performed interventions?**
   Probe for:
   a. Were the performed interventions sufficient? Why?
   b. Have the interventions been evaluated?
   c. Why?

Topic 6: Medical products and technology

1. ***Which laboratories worked with the MoH during the epidemics of dengue, chikungunya and Zika?***
   Probe for:
   a. What were their tasks?
   b. What were the challenges?
   c. How was the collaboration?
   d. Was this collaboration documented in a protocol?
2. ***Which diagnostic tests were performed to test for dengue, chikungunya and Zika?***
   Probe for:
   a. Other diseases transmitted by mosquitos were also tested?
   b. Did the laboratories take "cross-reactivity" also into account?
   c. Did the laboratories perform a "confirmatory test *(virus neutralisation test)*"?
   d. Is a protocol concerning testing for VBDs for the general practitioners available?
   e. Explain the content of this protocol?
   f. What are the strengths and gaps of this protocol?

3. ***What were the challenges concerning access to medication to reduce the symptoms of mentioned VBDs?***

Closing question

1. ***Imagine, this year, we have another disease transmitted by mosquitoes. Do you think we are prepared to deal with it?***
   Probe for:
   a. What can be done?

We are now reaching the end of the discussion. Does anyone have any further comments to add before we conclude this group discussion? I want to thank you all very much for your participation in this discussion; your experiences and opinions are valuable to assist in improving risk communication and risk management in Curaçao.

Text S3. Topic guide: Interview with general practitioners and geriatrician

Topic guide for interviews: Understanding the preparedness and performance of the health system, and risk communication in the face of dengue, chikungunya and Zika virus infection epidemics

IDI number: ....
Date: ....
Interviewer: ....

Introduce yourself to the participants: Thank you very much for agreeing to participate in this research. My name is Vaitiare Mulderij-Jansen. I am a doctoral student at the University of Groningen.

- ✓ ***Explain the general purpose of the study***: The general purpose of the study is to understand risk communication and behaviour of individuals concerning the prevention and control of chikungunya, dengue, and Zika, from your point of view. Your perceptions, opinions and experiences can help us provide the government with content specific advice to strengthen risk communication efforts, the sustainability of risk management and enhance the health-seeking behaviour of people living in Curaçao.
- ✓ ***Estimated time***: Approximately 1 hour
- ✓ ***Right to participate and withdraw from the study:*** Involvement in this study is entirely voluntary. You are free to withdraw from the study at any time. You are free to skip any questions that you would prefer not to answer during the interview.
- ✓ ***Use of tape recorder***: To be able to keep a more accurate record of the interview, I am proposing to use a tape recorder, if you do not mind. Do you mind if I use a tape recorder? *(observe whether people agrees)*
- ✓ ***Plan to protect the identity of the participants:*** The information that we will discuss here today will remain anonymous. Your name will be removed from the data, and no one will be able to link your name with what is said. No one apart from the research team will have access to the data. This data will be published and shared with the scientific community, but your name will not appear in any of the publications.
- ✓ ***Basic principles:***
    1. There are no right and wrong answers. I value each idea, opinion and experience.
    2. Ask if there is any question.
- ✓ Do you have any questions?
- ✓ ***Consent:*** Sign the “informed consent” form.
- ✓ The interviewer turns on the digital recorder and starts with the interview.

Introduction

- ✓ As an introduction, can you introduce yourself, tell me your name, age, and whether you are currently working, and what type of work you do.

Let us start the interview by talking about chikungunya, dengue, and Zika. The majority of individuals living in Curaçao witnessed the dengue outbreak in 2010, the chikungunya outbreak in 2014-2015 and more recently, the Zika outbreak in 2016.

1. ***What do you know about dengue?***
   Probe for:
   a. Ask for the following types of information *(e.g. transmission routes, prevention measures, the link between these diseases, symptoms, treatment)* if they are not mentioned.
2. ***What do you know about chikungunya and Zika?***
   Probe for:
   a. Ask for the following types of information *(e.g. transmission routes, prevention measures, the link between these diseases, symptoms, treatment)* if they are not mentioned.
3. ***According to you, what are the reasons/causes of these outbreaks in Curaçao?***
   Probe for:
   a. What makes Curaçao susceptible to these diseases?
4. ***How did you obtain or receive information about these diseases?***

Topic 1: Preparedness

1. ***How prepared was the health system for dengue?***
   Probe for:
   a. How prepared was the health system for chikungunya and Zika?
   b. Did the level of preparedness of the health system influence the preparedness of the general practitioners?
   c. Explain how?
2. ***What can be done to improve the preparedness of the health system?***

Topic 2: Performance of the health system

1. ***What was your role during the epidemics of dengue, chikungunya and Zika?***
   Probe for:
   a. What were your challenges during the dengue epidemic *(e.g., communication problems with patients or other general practitioners, lack of information, protocol)*?
   b. What were your challenges during the epidemic of chikungunya?
   c. And Zika?

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3. ***How was the collaboration between general practitioners and the MoH during these epidemics?***
   Probe for:
   a. What went well, and what can be improved?
   b. What can be done to improve the collaboration between the MoH and the general practitioners?
4. ***How was the collaboration between general practitioners and laboratories during these epidemics?***
   Probe for:
   a. What went well, and what can be improved?
   b. What can be done to improve the collaboration between general practitioners and laboratories?

Topic 3: Communication

1. ***How was the communication concerning dengue between general practitioners and the association of general practitioners?***
   Probe for:
   a. Did you receive the information on time?
   b. Was the information sufficient and clear?
   c. Which type of information did you miss?
2. ***How was the communication concerning chikungunya and Zika between general practitioners and the association of general practitioners?***
   Probe for:
   a. Did you receive information on time?
   b. Was the information sufficient and clear?
   c. Which type of information did you miss?
3. ***What can be done to improve the communication between general practitioners and the association of general practitioners?***
   Probe for:
   a. How do you want to receive information?
   b. When do you want to receive information?
   c. Which type of information do you want to receive?
4. ***What do you think about the communication strategies performed by the MoH during the last three epidemics?***
   Probe for:
   a. What went well, and what can be improved?
   b. Was the communication strategies effective and efficient? Why?
   c. What can be done to improve the communication strategies of the MoH?

Topic 4: Prevention and control of VBDs

1. ***Who is responsible for prevention and vector control?***
   Probe for:
   a. Ask for the following individuals/groups/institutions *(e.g., community, government)* if they are not mentioned.
   b. Why?
2. ***According to you, which factor did obstruct the prevention and control strategies of the Moh?***
   Probe for:
   a. Ask for the following factors *(e.g., financing, lack of workforce, materials, law, the collaboration between stakeholders)* if they are not mentioned.
3. What can be done to improve the health-seeking behaviour of the community?
4. What can be done to improve the collaboration between the MoH and the community?

Closing question

1. ***Imagine, this year, we have another disease transmitted by mosquitoes. Do you think we are prepared to deal with it?***
   Probe for:
   a. What can be done?

We are now reaching the end of the interview. Do you have any further comments to add before we conclude? Thank you very much for your participation in this interview; your experiences and opinions are valuable to assist in improving risk communication and risk management in Curaçao.

Text S4. Topic guide: Interview with alternative medicine practitioners

Topic guide for interviews: Understanding the preparedness and performance of the health system, and risk communication in the face of dengue, chikungunya and Zika virus infection epidemics

IDI number: ....

Date: ....

Interviewer: ....

Introduce yourself to the participants: Thank you very much for agreeing to participate in this research. My name is Vaitiare Mulderij-Jansen. I am a doctoral student at the University of Groningen.

- ✓ ***Explain the general purpose of the study***: The general purpose of the study is to understand the risk communication and behaviour of individuals concerning the prevention and control of chikungunya, dengue, and Zika, from your point of view. Your perceptions, opinions and experiences can help us provide the government with content specific advice to strengthen risk communication efforts, the sustainability of risk management and enhance the health-seeking behaviour of people living in Curaçao.
- ✓ ***Estimated time***: Approximately 1 hour
- ✓ ***Right to participate and withdraw from the study:*** Involvement in this study is entirely voluntary. You are free to withdraw from the study at any time. You are free to skip any questions that you would prefer not to answer during the interview.
- ✓ ***Use of tape recorder***: To be able to keep a more accurate record of the interview, I am proposing to use a tape recorder, if you do not mind. Do you mind if I use a tape recorder? *(observe whether people agrees)*
- ✓ ***Plan to protect the identity of the participants:*** The information that we will discuss here today will remain anonymous. Your name will be removed from the data, and no one will be able to link your name with what is said. No one apart from the research team will have access to the data. This data will be published and shared with the scientific community, but your name will not appear in any of the publications.
- ✓ ***Basic principles:***
  1. There are no right and wrong answers. I value each idea, opinion and experience.
  2. Ask if there is any question.
- ✓ Do you have any questions?
- ✓ ***Consent:*** Sign the "informed consent" form.
- ✓ The interviewer turns on the digital recorder and starts with the interview.

Introduction

✓ As an introduction, can you introduce yourself, tell me your name, age, and whether you are currently working, and what type of work you do.

Let us start the interview by talking about chikungunya, dengue, and Zika. The majority of individuals living in Curaçao witnessed the dengue outbreak in 2010, the chikungunya outbreak in 2014-2015 and more recently, the Zika outbreak in 2016.

1. ***What do you know about dengue?***
   Probe for:
   a. Ask for the following types of information *(e.g. transmission routes, prevention measures, the link between these diseases, symptoms, treatment)* if they are not mentioned.
2. ***What do you know about chikungunya and Zika?***
   Probe for:
   a. Ask for the following types of information *(e.g. transmission routes, prevention measures, the link between these diseases, symptoms, treatment)* if they are not mentioned.
3. ***According to you, what are the reasons/causes of these outbreaks in Curaçao?***
   Probe for:
   a. What makes Curaçao susceptible to these diseases?
4. ***How did you obtain or receive information about these diseases***

Topic 1: Risk perception

1. ***Who are at risk for chikungunya?***
   Probe for:
   a. Who can be more at risk for chikungunya? *Ask for waste management officials or employees of the VCU if they are not mentioned.* Why?
   b. Who can be less at risk for chikungunya? Why?
   c. And in the case of dengue? Why?
   d. And in the case of Zika? Why?
2. ***What kind of people do you think is more at risk for complications in the case of chikungunya?***
   Probe for:
   a. Why?
   b. And in the case of dengue? Why?
   c. And in the case of Zika? Why?
3. ***Do you consider yourself at risk for one of these diseases, and why or why not?***

4. ***Which of these diseases do you consider as more severe or more threatening to your health?***
   Probe for:
   a. Explain why or why not?
1. ***What were/are the personal consequences of you having chikungunya?***
   Probe for:
   a. What are the social, economic, physical and psychological consequences?
2. ***What were/are the personal consequences of you having Zika?***
   Probe for:
   a. What are the social consequences, economic, physical, and psychological consequences?
3. ***What were/are the personal consequences of you having dengue?***
   Probe for:
   a. What are the social, economic, physical, and psychological consequences?
4. Which of these consequences affected the choices you made or the actions you took to protect yourself during the outbreaks?
   Probe for:
   a. Which actions did you perform *(e.g. personal and household protection and mosquito breeding sites control)*?
   b. Why?
   c. Do these consequences still affect your present choices or actions for protection?
   d. Furthermore, what do you do currently for protection and prevention?

Topic 2: Risk communication

1. ***What did you hear from the government (official information) about chikungunya?***
   Probe for:
   a. What about Zika?
   b. What about dengue?
   c. Which channels were used? *(e.g. vector control inspectors, Facebook, the website of the G&Gz, folder, App etc.)*
2. ***Which impact did the official information had on you?***
   Probe for:
   a. In what way or not?
   b. What did you do with the received official information?
   c. Did you use it to educate others, and why not?
3. ***What do you think about the information that you received from the government?***
   Probe for:
   a. Was the information on time, clear, useful?
   b. Why or why not?

4. ***Do you trust the information that the government provides? Explain why or why not.***
   Probe for:
   a. In the case of distrust, how do you deal with this?
   b. Which sources other than the government do you trust?
   c. How do you ensure the authenticity of the information?
5. ***After the outbreaks, did you receive or continue to receive official information to prevent these outbreaks in the future?***
   Probe for:
   a. According to you, is this positive or negative? Why or why not?
   b. Does this influence your (preventive) behaviour?
   c. According to you, what are the factors that obstruct the risk communication of the government concerning these diseases?
6. ***What can be done to improve risk communication*?**
   Probe for:
   a. What would be the best way to provide you with information about these diseases?
   b. Via which channels? Why?
   c. What would you like to know?
   d. When do you want to receive information?

Topic 3: Health-seeking behaviour, prevention and control measures

1. ***When prevention and control measures need to be conducted, who all are responsible?***
   Probe for:
   a. Ask for the following individuals/group/institution *(e.g. the participant itself, infected individuals, not infected individuals, the community, and the government)* if they are not mentioned.
   b. Why or why not are they responsible for prevention and control measures?
2. ***Which barriers do you encounter in protecting yourself against dengue, chikungunya and Zika?***
   Probe for:
   a. Ask for the following factor *(e.g. lack of practical information, financial factors, availability and accessibility of preventive tools)* if they are not mentioned.
   b. What external factors *(e.g. illegal dumping sites, inadequate waste management)* obstruct you in preventing and controlling these diseases?
   c. In what way do they obstruct your actions?

3. ***According to you, what are the factors that obstruct the government to prevent and control these diseases?***
   Probe for:
   a. Ask for the following factors *(e.g. financing, lack of workforce, lack of educated workforce, lack of collaboration between the community and the government)* if they are not mentioned.

I also heard that people do not perform preventive and control measures to combat these diseases because of different factors, for example, mentality.

4. ***Could you explain what people may mean by this statement?***
5. ***Which other factors obstruct prevention and control measures?***
6. ***What can be done to improve the collaboration between the community and the government in preventing and controlling these diseases?***

Closing question

1. ***Imagine, this year, we have another disease transmitted by mosquitoes. Do you think we are prepared to deal with it?***
   Probe for:
   a. What can be done?

We are now reaching the end of the interview. Do you have any further comments to add before we conclude? Thank you very much for your participation in this interview; your experiences and opinions are valuable in improving risk communication and risk management in Curaçao.

Text S5. Topic guide: Interview with a laboratory technician

Topic guide for interviews: Understanding the preparedness and performance of the health system in the face of dengue, chikungunya and Zika virus infection epidemics

IDI number: ....

Date: ....

Interviewer: ....

Introduce yourself to the participants: Thank you very much for agreeing to participate in this research. My name is Vaitiare Mulderij-Jansen. I am a doctoral student at the University of Groningen.

- ✓ ***Explain the general purpose of the study***: The general purpose of the study is to understand the risk communication and behaviour of individuals concerning the prevention and control of chikungunya, dengue, and Zika, from your point of view. Your perceptions, opinions and experiences can help us provide the government with content specific advice to strengthen risk communication efforts, the sustainability of risk management and enhance the health-seeking behaviour of people living in Curaçao.
- ✓ ***Estimated time***: Approximately 1 hour
- ✓ ***Right to participate and withdraw from the study:*** Involvement in this study is entirely voluntary. You are free to withdraw from the study at any time. You are free to skip any questions that you would prefer not to answer during the interview.
- ✓ ***Use of tape recorder***: To be able to keep a more accurate record of the interview, I am proposing to use a tape recorder, if you do not mind. Do you mind if I use a tape recorder? *(observe whether people agrees)*
- ✓ ***Plan to protect the identity of the participants:*** The information that we will discuss here today will remain anonymous. Your name will be removed from the data, and no one will be able to link your name with what is said. No one apart from the research team will have access to the data. This data will be published and shared with the scientific community, but your name will not appear in any of the publications.
- ✓ ***Basic principles:***
  1. There are no right and wrong answers. I value each idea, opinion and experience.
  2. Ask if there is any question.
- ✓ Do you have any questions?
- ✓ ***Consent:*** Sign the “informed consent” form.
- ✓ The interviewer turns on the digital recorder and starts with the interview.

A

Introduction

- ✓ As an introduction, can you introduce yourself, tell me your name, age, and whether you are currently working, and what type of work you do.

Let us start the interview by talking about chikungunya, dengue, and Zika. The majority of individuals living in Curaçao witnessed the dengue outbreak in 2010, the chikungunya outbreak in 2014-2015 and more recently, the Zika outbreak in 2016.

1. ***What do you know about dengue?***
   Probe for:
   a. Ask for the following types of information *(e.g. transmission routes, prevention measures, the link between these diseases, symptoms, treatment)* if they are not mentioned.
2. ***What do you know about chikungunya and Zika?***
   Probe for:
   a. Ask for the following types of information *(e.g. transmission routes, prevention measures, the link between these diseases, symptoms, treatment)* if they are not mentioned.
3. ***According to you, what are the reasons/causes of these outbreaks in Curaçao?***
   Probe for:
   a. What makes Curaçao susceptible to these diseases?
4. ***How did you obtain or receive information about these diseases***

Topic 1: Preparedness and Performance

1. ***What was the role of ADC during the epidemics of dengue, chikungunya and Zika?***
   Probe for:
   a. With which departments/institutions did ADC collaborate?
   b. What do you think about the collaboration between the MoH and ADC?
   c. What are the agreements between ADC and MoH?
   d. Are the agreements between ADC and the MoH documented?
   e. What can be done to improve the collaboration between these stakeholders?
2. ***How prepared was ADC for the chikungunya epidemic?***
   Probe for:
   a. What about the epidemic of Zika and dengue?
   b. What went well, and what can be improved?
3. ***According to you, was the MoH prepared for the chikungunya and Zika epidemics?***
   Probe for:
   a. Why?
   b. What went well, and what can be improved?
   c. What about the dengue epidemics?

4. ***Which type of test were conducted to test for dengue, chikungunya and Zika?***
   Probe for:
   a. Did the ADC test for other diseases transmitted by mosquitoes?
   b. Did the ADC take cross-reactivity between dengue and Zika into account?
   c. Did the ADC perform a confirmatory test (virus neutralisation test)?
   d. What can you tell me about the sensitivity and specificity of the tests?
5. ***How was the financing system of the tests related to public health issues organised?***
   Probe for:
   a. What are the strengths and gaps in this financing system?
6. ***Which measures did ADC take to ensure the quality of the tests?***
7. ***Do you work according to a protocol?***
   Probe for:
   a. What is the content of the protocol?
8. ***What were the challenges that ADC faced during the last three epidemics of VBDs?***
9. ***What can be done to improve the preparedness of the ADC in the context of VBDs?***
   Probe for:
   a. What can be done to improve the performance of the ADC?

Topic 3: Communication

1. ***What do you think about the communication between the Moh and ADC?***
   Probe for:
   a. What do you think about the communication within ADC?
   b. What are the gaps in the communication strategy?
   c. What can be done to improve the communication between the MoH and the ADC?
   d. What do you want to know about VBDs?
   e. When do you want to receive information about VBDs?
   f. How do you want to receive information about VBDs?

Closing question

1. ***Imagine, this year, we have another disease transmitted by mosquitoes. Do you think that ADC is prepared to deal with it?***
   Probe for:
   a. What can be done?

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We are now reaching the end of the interview. Do you have any further comments to add before we conclude? Thank you very much for your participation in this interview; your experiences and opinions are valuable to assist in improving risk communication and risk management in Curaçao.

Text S6. Topic guide: FGD with previous ministers of health
Topic guide: Understanding the preparedness and performance of the health system, and risk communication in the face of chikungunya and Zika virus infection epidemics

Group: previous ministers of health

FGD number : .... Moderator: ....
Date : .... Note-taker : ....

Introduce yourself to the participants:
Thank you very much for agreeing to participate in this group discussion. My name is Vaitiare Jansen. I am a doctoral student at the University of Groningen.

- ✓ ***Explain the study's general purpose***: I did various group discussions, interviews with locals, specific groups in our community, and health professionals at different levels to gather information about risk communication, the preparedness, and performance of the health system of Curaçao. Now it's your turn, as previous ministers of health, to tell me your experience with each of these epidemics. The general purpose of the study is to understand risk communication, the preparedness, and performance of the health system from your point of view in order to provide the health system with content specific advice to strengthen risk communication efforts and sustainability of risk management
- ✓ ***Estimated time***: Approximately 1 ½ hour
- ✓ ***Right to participate and withdraw from the study:*** Involvement in this study is entirely voluntary. You are free to withdraw from the study at any time. You are free to skip any questions that you would prefer not to answer during the discussion.
- ✓ ***Use of tape recorder***: To be able to keep a more accurate record of our discussion, I am proposing to use a tape recorder, if you do not mind. Do you mind if I use a tape recorder? *(observe whether people agrees)*
- ✓ ***Plan to protect the identity of the participants:*** The information that we will discuss here today will remain anonymous. Your names will be removed from the data, and no one will be able to link your name with what is said. No one apart from the research team will have access to the data. This data will be published and shared with the scientific community, but your name will not appear in any of the publications.
- ✓ ***Basic principles:***
    1. Respecting opinions from others is important.
    2. There are no right and wrong answers. We value each idea, opinion and experience.
    3. One person speaks at a time.

4. Ask if there is any question.

- ✓ Do you have any questions?
- ✓ ***Consent:*** Do you agree to take part in this discussion?
- ✓ The moderator turns on the digital recorder and starts the discussion

Introduction

- ✓ As an introduction, let us go around so that you can introduce yourselves and tell us your name, age and what type of work you do.

Let us start our discussion by talking about dengue, chikungunya and Zika. Curaçao witnessed the dengue virus infection outbreak in 2010, the chikungunya virus infection outbreak in 2014-2015 and more recently, the Zika virus infection outbreak in 2016. As previous health ministers, you worked closely with the ministry of health (MoH) to reduce the mentioned diseases' risk.

1. ***What do you know about dengue?***
   Probe for:
   a. What do you know about chikungunya and Zika?
   b. From which channels of information did you receive information about these diseases?
2. ***As minister of health, how important was the prevention and control of these diseases for you and the MoH?***
   Probe for:
   a.
   b. What was your role?
   c. What actions did you perform to prevent and control these diseases?
   d. What challenges did you face?
   e. How important are the diseases for the current MoH?

Topic 1: Preparedness

1. ***What does preparing for an outbreak of diseases transmitted by mosquitoes mean to you?***
2. ***How prepared was the health system for dengue?***
   Probe for:
   a. How prepared was the health system for chikungunya?
   b. And Zika?
   c. What went well, and what needs to be improved?
3. ***What can be done to improve the readiness of the health system?***
   Probe for:
   a. Why?

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Topic 2: Governance

1. ***How was the health system organised during the epidemic of dengue in 2010?***
   Probe for:
   a. Which departments were responsible for the prevention and control of this disease?
   b. Which ministries/departments/institutions were involved and needed to work together?
   c. How was your collaboration with these ministries/departments/institutions?
   d. What went well, and what needs to be improved?
2. ***How was the health system organised during the epidemic of chikungunya in 2014-2015?***
   Probe for:
   a. What were the changes *(e.g., assigned new head of department, laws, protocols, strategies for prevention and control of the vector?)*
   b. How was the health system organised during the epidemic of Zika in 2016?
   c. Did the collaboration between ministries/departments/institutions improve or deteriorate in the last ten years?
   d. What can you tell me about the current performance of the MoH in the context of diseases transmitted by mosquitoes?
   e. Compared to your working period, what has improved and what has deteriorated?
   f. Why?
3. ***What do you think about the organisational structure of the MoH?***
   Probe for:
   a. What are the strengths and gaps in the organisational structure of the MoH?
   b. What can be done to improve the organisational structure of the MoH?
4. ***What were the challenges of the MoH during the epidemic of dengue?***
   Probe for:
   a. What about challenges related to communication, prevention and control strategies?
   b. What were the challenges of the MoH during the epidemic of chikungunya and Zika?

I want to talk about the infrastructure of Curaçao. Infrastructure plays an essential role in prevention and vector control. For example, there are some neighbourhoods built in a dam *(e.g., Koralspecht).* During the rainy season, these neighbourhoods have many problems with floods. Water retention leads to a higher mosquitoes density. There are more issues *(e.g., The mangroves in the city of Curaçao)* that also impact these diseases prevention and control.

5. ***Are you aware of these problems?***
6. ***What is your role in dealing with problems related to infrastructure and health care?***
   Probe for:
   a. What are the challenges?
   b. What can be done to improve the collaboration between the ministries of the government?
7. ***Which laws did you use to deal with the prevention and control of diseases transmitted by mosquitoes?***
   Tip: The basic law on infection disease (Bestrijding van besmettelijk ziekten, p.b.1921, no.66)
   Probe for:
   a. What are the strengths and gaps in these laws?
   b. The MoH made a law for public health. What is the reason that the law is not being used?
8. ***What are the lessons learned?***
   Probe for:
   a. What have you done with these lessons?

Topic 3: Financing system

1. ***How is the financing system of the health system organised?***
   Probe for:
   a. What do you think about this system?
   b. What are the strengths and gaps in the system?
   c. What can be done to improve the financing system of public health care?

Topic 4: The sustainability of interventions

1. ***What can be done to improve the sustainability of interventions related to diseases transmitted by mosquitoes?***
   Probe for:
   a. What is needed to improve the performance of the health system?
   b. Which issue has more priority?
   c. What can be done to reach this goal?
   d. What can you do to help the MoH to improve its preparedness and performance to deal with future outbreaks of diseases transmitted by mosquitoes?

Closing question

1. ***Imagine, this year, we have another disease transmitted by mosquitoes. Do you think we are prepared to deal with it?***
   Probe for:
   a. What can be done?

We are now reaching the end of the discussion. Does anyone have any further comments to add before we conclude this group discussion? I want to thank you all very much for your participation in this discussion; your experiences and opinions are valuable to assist in improving risk communication and risk management in Curaçao.

Table S3. Coding list

Code category	Code	
	Inductive	**Deductive**
Leadership/Governance	Law Negative image Positive image Priority The visibility of the governmental departments Power Impact of 2010 (autonomy of Curacao) Copy-paste the health system of the Netherlands Consulting agency Functional illiteracy	Governmental structure Protocol concerning VBDs Guidance Collaboration Accountability Lawmakers Programs Division of tasks Decision making
Financing system	Economize Priority	Budget for prevention Budget for care Health insurance
Medical products and technologies	Collaboration Budget Coordination	Laboratories Equipment
Health information system	Communication to the GP's	Surveillance system cases Surveillance system vector Risk communication Communication flowchart Share information Digitial system Communication channels
Workforce	Respect Accountability Security during working hours Materials needed Retirement Negligence Research team Risk communication team Vector control team Promotion	Education/training Collaboration between departments/ institution Motivation Guidance Collaboration between co-workers Job description
Service delivery	Vector control strategies	Availability
Trust	Corruption Bureaucracy	
Prevention	Budget Prevention strategies Impact Future risk of other infectious diseases Sewage system Culex Aedes Cesspool	Larvacide Bti Personal protection against mosquitoes
Evaluation	Evaluation efforts	

Code category	Code	
	Inductive	**Deductive**
Recommendation	Collaboration Consistency Share information within and outside the health system Fines Follow up report (after the epidemic) Enhance communication to the general practitioners Use social platforms Adaptation of law with regards to the infrastructure of Curaçao	Capacity building Governmental structure Proactive approach Environmental police officers Improve waste management Improve employee accountability

Table S4. List of mosquito species of Curaçao

	Species	Host	Status	Reported	Pathogens
1.	*Anopheles pseudopunctipennis*	Mammals	Native	Van der Kuyp, 1949	Malaria parasites
2.	*Aedes aegypti*	Human	Native	Van der Kuyp, 1949	Dengue, Zika, chikungunya virus, Dirofilaria immitis
3.	*Aedes taeniorhynchus*	Mammals, birds, reptiles	Native	Van der Kuyp, 1949	Eastern equine encephalitis virus (EEE), Venezuelan equine encephalitis virus (VEE), Dirofilaria immitis
4.	*Haemagogus chrysochlorus*	Mammals	Native	Van der Kuyp, 1949	-
5.	*Psorophora confinnis*	Mammals	Native	Van der Kuyp, 1949	VEE virus
6.	*Culex maracayensis*	-	Native	Van der Kuyp, 1949	-
7.	*Culex nigripalpus*	Mammals, birds, reptiles, batrachians	Native	Van der Kuyp, 1949	Saint Louis encephalitis virus (SLE), EEE virus
8.	*Culex quinquefasciatus*	Mammals, birds	Native	Van der Kuyp, 1949	West Nile virus (WN), Dirofilaria immitis, Lymphatic filariasis
9.	*Culex erraticus*	Mammals, birds, reptiles	Native	Van der Kuyp, 1949	EEE, VEE virus
10.	*Deinocerites magnus*	Mammals, birds, reptiles	Native	Van der Kuyp, 1949	-
11.	*Wyeomyia celaenocephala*	Mammals	Native	Van der Kuyp, 1949	-

Adapted from Surveillance and control of vector species in Curaçao (West Indies): Situation analysis an needs assessment, by Francis Schaffner and Marieta Braks, 2016. Adapted with permission.

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Table S5. The workforce during the epidemics in comparison with the required workforce to perform prevention and control strategies with regards to VBDs

Departments	The estimated workforce (The business plan of the MoHEN)	The available workforce during the epidemics of VBDs
Epidemiology and Research	1 head of the department 2 medical doctors specialised in epidemiology 1 social scientist 1 economist specialised in health care 1 statistician 1 medical expert in environmental science 2 employees to support the management of the department	1 medical doctor/ epidemiologist *(head of the department)* 2 health professionals specialised in epidemiology and public health
Total FTE	9	3
VCU	1 head of the department 15 vector inspectors 1 secretary	2 coordinators 20 fieldworkers 3 vector inspectors 1 secretary 1 administrative assistant
Total FTE	17	23
Communication	4 communication experts	2 communication experts 1 head of the department
Total FTE	4	3
Policy Department	1 head of the department 1 lawyer 2 researchers 8 policy officers (4 for health care, 3 for public health, and 1 for veterinary public health)	1 head of the department 1 medical doctor 1 statistician 1 health scientist 1 health promoter
Total FTE	12	5

Adapted from Curaçao: Business plan, Ministry of Health, Environment and Nature (p. 80-98), by MoHEN, 2011. Adapted with permission.

Chapter 4

S1 Table. Characteristics of the study participants of the FGDs and IDIs

	# participants	# Female	Age range
FGDs (n=7)			
Residents from the Netherlands	8	6	61-71
Local youth	4	2	19-24
Koraalspecht	10	10	55-97
Seru Fortuna	9	8	18-70
Rooi Santu	8	4	51-80
Souax	7	4	34-72
Interviewers of the survey	4	3	64-67
IDIs (n=20)			
Participants infected with the CHIKV	20	12	36-87
Family members	5	2	-

Adapted from: Elsinga J, van der Veen HT, Gerstenbluth I, Burgerhof JGM, Dijkstra A, Grobusch MP, et al. Community participation in mosquito breeding site control: an interdisciplinary mixed methods study in Curacao. Parasit Vectors. 2017;10(1):434.

S2 Table. Coding list for FGDs and IDIs

Family codes	Codes
Channel of information Preferred channels of information	Television Newspaper Radio Family Friends Colleagues Conventional medicine practitioners Alternative medicine practitioners Flyers Social media Internet *(e.g. websites, google)* International media Schools Community centres Government *(e.g. minister)* Public Health Department (G&Gz previously called GGD)
The user of the channel of information	Younger generation The older generation
Risk perception	Susceptibility of dengue virus infection The severity of dengue virus infection Susceptibility of chikungunya virus infection The severity of chikungunya virus infection The feeling of fear
Transmission routes	Water Unhygienic conditions Air Bite of an infected mosquitoes Contact with an infected individual
Symptoms	Headache Muscle pain Joint swelling Rash
Preventive measures	Spraying insecticides Plagatox Larvicide *(e.g. Abate)* Repellent The disposal of tires and bottles Removal of stagnant water breeding sites Cleaning of yards Wearing long-sleeved clothing Nets Eating healthy Vitamins Good immune system
Treatment options	Painkillers *(e.g. paracetamol)* Drink liquid Alcolado Glacial Vitamines Coconut oil Mango leaves Papaya leaves Shilling oil Prednisone
Trust in the channel of information	Sources trusted Source not trusted Negative Positive Information was late Unclear information

S3 Table. Socio-demographic characteristics of the survey participants

	Total (N=339)	N (%)
Age		
18-50	164	48.4
≥51	175	51.6
Gender		
Female	247	72.9
Male	92	27.1
Education		
Illiterate and primary school	80	23.6
Secondary school	128	37.8
Intermediate vocational school	84	24.8
Higher vocational education	47	13.9
Occupation [a]		
Unemployed/student/housewife/ volunteer	63	18.6
Paid job (manual)	144	42.6
Paid job (not manual)	67	19.8
Retired	64	18.9
Income [b,c,]		
0-999 ANG/ month	35	10.5
1000-2499 ANG/ month	136	41.0
2500-4999 ANG/ month	118	35.5
≥5000 ANG/ month	43	13.0

[a] Total is 338
[b] Total is 332
[c] Antillean Guilders, 1 ANG= 0.54 USA dollars and 0.47 EUR
Adapted from: Elsinga J, van der Veen HT, Gerstenbluth I, Burgerhof JGM, Dijkstra A, Grobusch MP, et al. Community participation in mosquito breeding site control: an interdisciplinary mixed methods study in Curacao. Parasit Vectors. 2017;10(1):434.

S4 Table. Selected comparisons between socio-demographic characteristics and the use of social media and the internet to seek information regarding chikungunya

Age vs Social media	**Users n (%)**	**Total number of subjects**	***p*-value**
18-50 years	30 (18.4)	163	< 0.001^
≥ 51 years	10 (5.7)	174	
Age vs Internet	**Users n (%)**	**Total number of subjects**	***p*-value**
18-50 years	40 (24.5)	163	< 0.001^
≥ 51 years	12 (6.9)	174	
Gender vs Social media	**Users n (%)**	**Total number of subjects**	***p*-value**
Male	6 (6.6)	91	0.07^
Female	34 (13.8)	246	
Gender vs Internet	**Users n (%)**	**Total number of subjects**	***p*-value**
Male	7 (7.7)	91	0.02^
Female	45 (18.3)	246	
Education vs Social media	**Users n (%)**	**Total number of subjects**	***p*-value**
Illiterate and primary school	4 (5.0)	80	0.05^
Secondary school	19 (15.0)	127	
Intermediate vocational school	8 (9.6)	83	
Higher vocational education	9 (19.1)	47	
Education vs Internet	**Users n (%)**	**Total number of subjects**	***p*-value**
Illiterate and primary school	4 (5.0)	80	0.01^
Secondary school	21 (16.5)	127	
Intermediate vocational school	15 (18.1)	83	
Higher vocational education	12 (25.5)	47	
Occupation vs Social media	**Users n (%)**	**Total number of subjects**	***p*-value**
Unemployed	4 (6.3)	63	< 0.001^
Paid job (manual)	17 (11.9)	143	
Paid job (not manual)	17 (25.4)	67	
Retired	2 (3.1)	64	
Occupation vs Internet	**Users n (%)**	**Total number of subjects**	***p*-value**
Unemployed	7 (11.1)	63	< 0.01^
Paid job (manual)	25 (17.5)	143	
Paid job (not manual)	17 (25.4)	67	
Retired	3 (4.7)	64	
Income (ANG/*month*)[1] **vs Social media**	**Users n (%)**	**Total number of subjects**	***p*-value**
0 - 999	3 (8.6)	35	0.09*
1000 – 2499	10 (7.4)	135	
2500 – 4999	16 (13.6)	118	
≥5000	9 (20.9)	43	
Income (ANG/*month*)[1] **vs Internet**	**Users n (%)**	**Total number of subjects**	***p*-value**
0 – 999	3 (8.6)	35	0.16^
1000 – 2499	16 (11.9)	135	
2500 – 4999	21 (17.8)	118	
≥5000	10 (23.3)	43	

[1]Antillean Guilders, 1 ANG= 0.54 USA dollars and 0.47 EUR
*Fisher-Freeman-Halton exact test, ^ Chi-square test

S5 Table. Univariate analysis of socio-demographic characteristics associated with the use of social media to seek information regarding chikungunya

	Use of social media				
Variables	**Users n (%)**	**Total number of subjects**	**Crude OR**	**95% CI for exp b**	***p*-value**
Age *(years)*[3]	40 (11.9)	337	0.95	0.93 – 0.98	0.00*
Gender[3]					
Male	6 (6.6)	91	1	-	-
Female	34 (13.8)	246	2.27	0.92 – 5.61	0.01*
Education[3]					0.07*
Illiterate and primary school	4 (5.0)	80	1	-	
Secondary school	19 (15.0)	127	3.34	1.09 – 10.22	0.03*
Intermediate vocational school	8 (9.6)	83	2.03	0.58 – 7.02	0.26
Higher vocational education	9 (19.1)	47	4.50	1.30 – 15.56	0.02*
Occupation[1,3]					< 0.001*
Unemployed	4 (6.3)	63	1	-	
Paid job (manual)	17 (11.9)	143	1.99	0.64 – 6.17	0.23
Paid job (not manual)	17 (25.4)	67	5.01	1.58 – 15.88	0.01*
Retired	2 (3.1)	64	0.48	0.08 – 2.70	0.40
Income *(ANG/month)*[2,4]					0.09*
0 - 999	3 (8.6)	35	1	-	
1000 – 2499	10 (7.4)	135	0.85	0.22 – 3.28	0.82
2500 – 4999	16 (13.6)	118	1.67	0.46 – 6.11	0.44
≥5000	9 (20.9)	43	2.82	0.70 – 11.37	0.14

[1]The variable unemployed includes student, housewife and volunteer
[2]Antillean Guilders, 1 ANG= 0.54 USA dollars and 0.47 EUR
[3]For two participants the data regarding social media usage was missing. These two participants were excluded from the data analysis (n=337).
[4]For eight participants the data regarding social media usage was missing. These eight participants were excluded from the data analysis (n=331).
*Significance was determined at an alpha level of 0.10.

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S6 Table. Multivariate analysis of socio-demographic characteristics associated with the use of social media to seek information regarding chikungunya

Use of social media			
Variables	**OR**	**95% CI for exp b**	***p*-value***
Age *(years)*	0.96	0.93 – 0.99	0.02*
Gender *(Female)*	2.54	0.93 – 6.97	0.07
Education			0.52
Illiterate and primary school	1	-	-
Secondary school	1.33	0.38 – 4.67	0.65
Intermediate vocational school	0.66	0.16 – 2.80	0.58
Higher vocational education	0.83	0.18 – 3.84	0.82
Occupation[1]			0.16
Unemployed	1	-	-
Paid job (manual)	2.68	0.72 – 9.98	0.14
Paid job (not manual)	4.82	1.17 – 19.85	0.03*
Retired	1.81	0.23 – 14.57	0.57
Income *(ANG/month)*[2]			0.66
0 - 999	1	-	-
1000 – 2499	0.59	0.14 – 2.49	0.47
2500 – 4999	0.89	0.21 – 3.84	0.87
≥5000	1.15	0.23 – 5.83	0.86

[1]The variable unemployed includes student, housewife and volunteer
[2]Antillean Guilders, 1 ANG= 0.54 USA dollars and 0.47 EUR
*Significance was determined at an alpha level of 0.05.
Note: Nagelkerke R^2=0.181 (18.1%), Omnibus *(p=0.00),* and Hosmer and Lemeshow *(p=0.31)* show a good fit of the model.

S7 Table. Preventive measures reported in the FGDs and IDIs

Coils *(a type of insecticide)*	*"what is it again? That spiral. What is the name again? Plagatox. Plagatox."* Female, accountant, age not documented, IDI.
Larvicide	*"Yes, you can do it yourself, because you can get Abate here."* Male, retired, 68 years, IDI.
Environmental management	" Making sure that there is no stagnant water in the area." Female, art historian and History teacher, age not documented, IDI.
Insecticide	"Aerosol." Male, Loader Operator, age not documented, IDI.
Environmental management	"Eliminate empty pots, tires or bottles from your yard." Male, retired, 68 years, IDI.
Clothing that minimises skin exposure and repellent	*"Prevention? Yes eh, wrap yourself up.. eh? Space clothing, yes space clothing. Anyway use long sleeves, and use eh.. that thing against insects."* Male, general practitioner, age not documented, IDI.
Vitamins and herbs	Interviewer: *"Okay, how can people protect themselves against chikungunya?"* Female 1: *"Drink herbs and eh... Vitamin C."* FGD 5, Koraal Specht
Healthy food	Interviewer: *"But what do you think that people could do to protect themselves against chikungunya?* Male 1: *"To protect themselves?"* Interviewer: *"Hmm."* Male 1: *"Do not leave anything in your garden that can hold water. Plants and things like that, look good! Also, they (people) need to eat well in order to maintain a stable resistance."* FGD 3, Souax

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Chapter 5

Table 1. The characteristics and descriptives of the participants of the in-depth interviews, divided by low/middle SES and high SES groups

Living in	***Gender***	***Profession***
Low/middle SES	Female	Manager community center
Low/middle SES	Female	Housewife
Low/middle SES	Male	Volunteer community center
Low/middle SES	Female	Kindergarten teacher
Low/middle SES	Female	Cleaning
Low/middle SES	Male	Concierge
Low/middle SES	Female	Assistant at pre-school
Low/middle SES	Female	Employee at daycare
Low/middle SES	Male	Entrepreneur in social consultancy
Low/middle SES Mean age: 39.7 years Range age: 21-66 Female n=6 Male n=3		

Note: Participant information. "Living in" is defined as living in a high or low/middle SES area, SES = Social Economic Status.

High SES	Male	Manager sales&marketing company
High SES	Female	Artist and art-teacher
High SES	Female	Beauty therapist
High SES	Male	Retired director company
High SES	Female	Businessman in a technical company
High SES	Female	No profession
High SES	Female	Osteopath
High SES	Female	Teacher
High SES	Male	Photographer
High SES Mean age: 52.6 years Range age: 32-65 Female n= 6 Male n= 3		

Note: Participant information. "Living in" is defined as living in a high or low/middle SES area, SES = Social Economic Status.

Interview guide

Opening questions:

1. Did you or anyone in your environment got infected with dengue, chikungunya, and Zika?

Key questions:

2. How do you think communication, in general, has been about the epidemics?
   2a.- What do you think this is due to?
   2b.- Has communication during one epidemic been specifically better or worse than the other?
3. Where do you get your information about the epidemics?
4. Do you think you know enough about prevention methods for Zika, dengue, and chikungunya?
5. Do you think you know enough about the health risks of Zika, dengue, and Chikungunya?
   5a.- If not, do you understand what these diseases entail?
6. Where or with whom does the main responsibility lie regarding communicating risks and information on the epidemics?
7. How did you experience the epidemics?
   7a.- What did you think about possible infection with Zika, dengue or chikungunya?
8. Have you ever heard of dengue, Zika, or chikungunya before the epidemic in question occurred in Curaçao?
9. Were these epidemics a topic of conversation in your area at the time of occurrence? (2010-2017)
10. What do you think of the role of the media in communicating about the epidemics?
    10a.- Has the media influenced your perception of these epidemics?
11. What do you think of the role of social and cultural groups (e.g., friends, neighbors, family) in communicating about the epidemics?
    11a.- Have your friends/neighbors/family influenced your perception of these epidemics?
12. What do you think of the role of the government in communicating about the epidemics?
    12a.- Has the government influenced your perception of these epidemics?
13. Are there any other sources of information that have played a role for you in communicating about the epidemics?
    13a.- Has this influenced your perception of the epidemics?
14. How did you respond to the epidemics (e.g., risk-reducing behavior)?
15. To what extent do you trust the information you receive?

16. What information source do you trust?
    16a.- What information sources do you trust less or not?
17. What would you like to see different in risk communication?

Closing questions

18. Are you confident that in the future, the epidemics will be controlled better in Curaçao?
19. Are there any other things that you wish to say that I might not have asked?

Table 2. Overview of the Pan American Health Organization (PAHO) and the World Health Organization (WHO) epidemiological reports

Epidemic	Event	Source
Dengue		
Augustus / September 2010	Dengue outbreak Curaçao	Epidemiology and Research Unit, Ministry of Health Environment and Nature of Curaçao
September 8, 2010	Health alert: rainy season expect	PAHO/WHO
April 2011	End Dengue outbreak Curaçao	Epidemiology and Research Unit, Ministry of Health Environment and Nature of Curaçao
Chikungunya		
2011	Warning chikungunya is expected to travel to the Americas	PAHO/WHO
December 2013	-Epidemiological alert chikungunya -First case Sint-Maarten -Advise to start preparedness and response chikungunya	PAHO/WHO
June / July 2014	First outbreaks chikungunya Curaçao	Epidemiology and Research Unit, Ministry of Health Environment and Nature of Curaçao
August 29, 2014	-Continued epidemiological alert chikungunya	PAHO/WHO
March 2015	End chikungunya epidemic	Epidemiology and Research Unit, Ministry of Health Environment and Nature of Curaçao
Zika		
May 7, 2015	Epidemiological alert Zika	PAHO/WHO
October 17, 2015	First confirmed cases Americas	PAHO/WHO
January 2016	Start Zika epidemic Curaçao	Epidemiology and Research Unit, Ministry of Health Environment and Nature of Curaçao
February 17, 2016	Confirmed cases Aruba and Bonaire	PAHO/WHO
October 2016	Peak Zika epidemic Curaçao	Epidemiology and Research Unit, Ministry of Health Environment and Nature of Curaçao
April 2017	End Zika epidemic Curaçao	Epidemiology and Research Unit, Ministry of Health Environment and Nature of Curaçao

Information obtained from:
PAHO. Dengue: Epidemiological alerts and updates [Internet]. Washington, D.C; 2019 [cited 2019 October 10]. Available from: https://www.paho.org/hq/index.php?option=com_topics&view=rdmore&cid=2217&item=dengue&type=alerts&Itemid=40734&lang=en
PAHO. Chikungunya: Epidemiological alerts and updates [Internet]. Washington, D.C.; 2019 [cited 2019 October 10]. Available from: https://www.paho.org/hq/index.php?option=com_topics&view=rdmore&cid=5855&item=chikungunya&type=alerts&Itemid=40931&lang=en
PAHO. Zika virus infection [Internet]. Washington, D.C.; 2019 [cited 2019 October 10]. Available from: https://www.paho.org/hq/index.php?option=com_content&view=article&id=11585:zika-virus-infection&Itemid=41688&lang=en
Personal communication with Gerstenbluth (2018)

Table 3. Overview of the articles used in the content analysis.

Newspaper	Headline	Date (M-D-Y)	Topic
Amigoe			
1.	Research shows a risk of chronic chikungunya	4-22-17	chikungunya
2.	Minister did not respond to draft report chikungunya	11-23-16	chikungunya
3.	More than 25.000 days of occupational disability from chikungunya	11-11-16	chikungunya
4.	"Report ARC has its limitations." New chikungunya report by Swiss expert almost ready	11-11-16	chikungunya
5.	Minister did not respond to draft report Chikungunya	11-3-16	chikungunya
6.	Efficiency Report Court of Audit: Ministry understaffed and too late to combat Chikungunya	11-2-16	chikungunya
7.	Alex "Don Quixote" Roose fights pollution	6-26-15	chikungunya
8.	Agreement on international health regulation during Health Care Conference	6-4-15	chikungunya
9.	Court of Auditors will examine chikungunya control	2-5-15	chikungunya
10.	The peak of chikungunya appears to have been reached	12-20-14	chikungunya
11.	Chikungunya in the States "The whole of society is responsible."	12-18-14	chikungunya
12.	A special telephone number for mosquito control cleaning action	12-17-14	chikungunya
13.	RIVM warns against chikungunya	12-16-14	chikungunya
14.	Parliament meeting is canceled again Franco: "This cannot be justified."	12-12-14	chikungunya
15.	Hospital (Sehos) staff shortage due to chikungunya	12-12-14	chikungunya
16.	Mosquito control 2.1 million guilders for major cleaning action	12-5-14	chikungunya
17.	MAN and PAR want emergency meeting on chikungunya	11-27-14	chikungunya
18.	At least 8000 chikungunya infections	11-21-14	chikungunya
19.	Intensiving the chikungunya approach	11-18-14	chikungunya
20.	Chikungunya count at 817 Looking for an alternative and natural treatment and control	11-14-14	chikungunya
21.	MAN ask questions on chikungunya	11-11-14	chikungunya
22.	Three additional sprayers ordered	11-8-14	chikungunya
23.	New spraying round of mosquito pesticide	10-23-14	chikungunya
24.	Fight against chikungunya continues	10-28-14	chikungunya
25.	Chikungunya is spreading like wildfire	10-13-14	chikungunya
26.	Spray actions with pesticites against dengue and chikungunya	9-22-14	chikungunya

Newspaper	Headline	Date (M-D-Y)	Topic
27.	Ilness still on Curaçao "Be aware of chikungunya"	9-2-14	chikungunya
28.	FOL wants an approach to the mosquito plague	8-19-14	chikungunya
29.	Pesticide in neighborhoods against Chikungunya	8-8-14	chikungunya
30.	9 chikungunya cases on Curaçao	1-8-14	chikungunya
31.	"No confirmed case of chikungunya in Curaçao"	7-10-14	chikungunya
32.	Curaçao health workers informed Two cases of chikungunya infections on French Saint Martin	12-11-13	chikungunya
33.	Fight against mosquitoes after rainfall	10-8-16	dengue
34.	Measures to control mosquitoes in Otrobanda	4-3-14	dengue
35.	Mosquito nuisance in reef area due to stagnant water	3-19-14	dengue
36.	Downward trend continues Fewer cases of dengue	1-11-13	dengue
37.	Integral plan for dengue control	8-8-12	dengue
38.	Miscommunication Council of Ministers Dengue employees falsely fired	7-29-11	dengue
39.	Information campaign “Health First” launched	2-26-11	dengue
40.	Conventional dengue control not very effective	2-2-11	dengue
41.	“As long as the rain continues, the risk of dengue is higher.”	2-2-11	dengue
42.	One death 2010 record year of dengue infections	1-7-11	dengue
43.	“Number of dengue cases is increasing”	1-5-11	dengue
44.	Not much to do against complaints stagnant water	12-7-10	dengue
45.	Government establishes dengue team	11-6-10	dengue
46.	47 cases in August One death from dengue	9-23-10	dengue
47.	Sporadically still Zika on Curaçao	11-2-17	Zika
48.	Zika-specialists US on Curaçao	8-16-17	Zika
49.	GMN cautious about genetically engineered mosquitoes	7-28-17	Zika
50.	More inspectors for tackling the mosquito problem	6-30-17	Zika
51.	PAHO: Chance of a new Zika wave	6-27-17	Zika
52.	Money for Zika research	2-28-17	Zika
53.	TV-program on Zika ADC Prevention is better than cure	1-5-17	Zika
54.	Disagreement about the allowance for Zika tests	12-16-16	Zika
55.	100 positive Zika-cases weekly	12-13-16	Zika

Newspaper	Headline	Date (M-D-Y)	Topic
56.	A baby develops glaucoma from Zika	12-1-16	Zika
57.	Association between Zika and male fertility	11-21-16	Zika
58.	This year 15 patients so far. A large number of cases of Guillain-Barré	11-16-16	Zika
59.	Information booklet mosquito diseases	11-5-16	Zika
60.	'Mayaro-mug' is indeed on Curaçao	11-1-16	Zika
61.	About 800 Zika cases on Curaçao	10-31-16	Zika
62.	Mysterious virus possibly different Zika mutation	10-28-16	Zika
63.	Prevention mosquitos after rainfall	10-8-16	Zika
64.	Prepared to control mosquito breeding sites	9-28-16	Zika
65.	Considering Zika Women no sex for six months as well	9-7-16	Zika
66.	Researchers clone Zika virus	8-26-16	Zika
67.	162 positive Zika tests	7-19-16	Zika
68.	208 confirmed Zika cases "WHO advises not feasible in Curaçao."	6-1-16	Zika
69.	No new Zika numbers	5-3-16	Zika
70.	Relationship with Zika and microcephaly confirmed	4-14-17	Zika
71.	"Zika is a mild disease." 73 confirmed Zika cases	3-31-16	Zika
72.	Women of the army are returning home due to Zika	3-21-16	Zika
73.	ADC: Testing back on track "Visitors well informed about Zika."	2-29-16	Zika
74.	"Zika forum message loud and clear."	2-22-16	Zika
75.	'No political shenanigans in Zika approach.'	2-19-16	Zika
76.	Former commissioner Selikor wants to clean the island	2-17-16	Zika
77.	Motion for the free use of landfill rejected	2-16-16	Zika
78.	Minister Victorina: "Only spray against Zika in urgent cases."	2-16-16	Zika
79.	No new entomologist	2-16-16	Zika
80.	"No pregnant women among infected people." 35 Zika cases in Curaçao	2-15-16	Zika
81.	Number of infections now at 15 ADC is working on a new Zika test	2-12-16	Zika
82.	Still unclarity about policy PAHO: Fighting Zika requires explicit support from the highest political level	2-10-16	Zika
83.	Member of Parliament Melvin Cijntje about Zika: "The biggest polluter is the government."	2-5-16	Zika

Newspaper	Headline	Date (M-D-Y)	Topic
84.	Izzy Gerstenbluth: “Structural approach to Zika is compromised by treatment of complaints.”	2-4-16	Zika
85.	Zika travel advice for Curaçao as well	2-3-16	Zika
86.	Four zika cases on Curaçao	2-2-16	Zika
87.	MFK: “No concrete plan against Zika.”	2-2-16	Zika
88.	“Zika vaccine not on the market within a year.”	2-1-16	Zika
89.	Rhuggenaath: Zika little impact on tourism	2-1-16	Zika
90.	Minister Victorina on Zika: “We should not exaggerate.”	1-29-16	Zika
91.	First local Zika virus infection detected	1-28-16	Zika
92.	The opposition is ringing the alarm about Zika	1-26-16	Zika
93.	Pregnant women can reschedule Flexible approach travel organizations considering Zika virus	1-23-16	Zika
94.	The suspected link between Zika and Guillain-Barré is growing stronger	1-23-16	Zika
95.	First Zika case on Curaçao	1-20-16	Zika
96.	A new entomologist in the fight against Zika	1-12-16	Zika
97.	Zika prevention Incoming ships controlled more intensively	12-17-15	Zika
98.	One in three houses has a mosquito breeding site	12-15-15	Zika
99.	Members of parliament ask questions about Zika	12-11-15	Zika
100.	Zika control in full swing Fine of 500 guilders for not cleaning breeding sites	12-1-15	Zika
101.	No official cases yet “There is no awareness of Zika”	11-19-15	Zika
102.	Concerns about Zika “We have to be alert.”	11-4-15	Zika
103.	Increasement of waste big problem in Otrobanda ‘Too little attention for Zika virus’	9-17-15	Zika
104.	The government must prepare for Zika virus	7-8-15	Zika
105.	A new form of chikungunya on the way	5-6-15	Zika
106.	“Extra checks on inbound flights.” GGD also alert for Zika	11-7-15	Zika
Extra			
1.	Experts warn about another wave of Zika	6-26-17	Zika
2.	Many reactions of victims of the plague of mosquito at the Rif	5-9-17	Zika
3.	GGD started to spray insecticide against mosquito in Otrobanda	5-10-17	Zika

Newspaper	Headline	Date (M-D-Y)	Topic
4.	The platform wants to see a structural solution to solve the problem with mosquito	5-16-17	Zika
5.	The impact of Zika will cost billions of dollars	6-8-17	Zika
6.	More than 100 positive test of Zika each week	12-14-16	Zika
7.	1.23 guilders to give information about Zika. It is too cheap	11-23-16	Zika
8.	There is an indication of when a new epidemic will start	11-12-16	Zika
9.	Different general practitioners gave their opinion	10-31-16	Zika
10.	According to Dr. Izzy Gerstenbluth, data of general practitioners and laboratories are important for GGD to detect possible cases of Zika.	10-29-16	Zika
11.	Ministery of health, environment, and nature informs that…	10-11-16	Zika
12.	Gisette Seferina: it is the niece of chikungunya	9-24-16	Zika
13.	Dr. Gerstenbluth believes that…	7-30-16	Zika
14.	Scientists expect…	7-15-16	Zika
15.	Scientists will test if the Zika virus can treat brain cancer.	5-26-17	Zika
16.	Authorities follow cases of babies with a small head due to Zika	5-9-17	Zika
17.	The first case of microcephaly due to Zika in the Caribbean	1-21-17	Zika
18.	The number of test for Zika will reduce dramatically	12-14-16	Zika
19.	General practitioners will not test for Zika anymore	12-13-16	Zika
20.	A baby of a mother develops microcephaly due to Zika after birth	11-25-16	Zika
21.	Ennia with a folder about Zika; it contains many prevention tips, and it is in different languages.	11-21-16	Zika
22.	The amount of Zika cases exploded in Curaçao in the last few days.	11-18-16	Zika
23.	The amount of cases of Zika has been raised.	11-11-16	Zika
24.	Male infected with Zika died in Puerto Rico	11-4-16	Zika
25.	According to Dr. Izzy Gerstenbluth… No baby was born with microcephaly due to Zika this year… Pregnant people need to take care more than ever	10-31-16	Zika
26.	According to epidemiologist Dr. Izzy Gerstenbluth… the majority of individuals infected with Zika are not aware of their infection. 820 confirmed cases this year, but it can be more…	10-29-16	Zika
27.	First baby with microcephaly due to Zika in Puerto Rico	10-29-16	Zika

Newspaper	Headline	Date (M-D-Y)	Topic
28.	Zika caused mild symptoms only among children	10-1-16	Zika
29.	Insecticide helped to combat Zika in Miami	9-20-16	Zika
30.	At the moment that Zika has been detected… WHO advises not to have sex without protection for six months.	9-9-16	Zika
31.	Parks in Orlando distributed repellent due to the threat of Zika	8-30-16	Zika
32.	Another discovery concerning the effects of Zika… Babies with a normal head can develop microcephaly after birth	8-26-16	Zika
33.	CTB expects that the "hype" of Zika is becoming less… Zika caused significant damage to the tourism industry this year	8-26-16	Zika
34.	Florida receives more money to fight Zika	8-24-16	Zika
35.	The search for a vaccine against Zika is increasing	8-19-16	Zika
36.	Puerto Rico needs to start with a health promotion campaign concerning Zika	8-12-16	Zika
37.	US Virgin Islands increase efforts to fight Zika	8-3-16	Zika
38.	Blood donation canceled due to Zika	7-29-16	Zika
40.	Zika has been detected in a woman that took care of a person infected with Zika	7-19-16	Zika
41.	Milos Raonic does not want to perform during the Olympics to avoid Zika	7-16-16	Zika
42.	Advance medical investigations will start in Curaçao	4-13-17	Zika
43.	325 cases registered… 9 pregnant women under surveillance due to possible effects of Zika in Curaçao	9-10-16	Zika
44.	Experts are preoccupied with the phenomenon …The amount of cases of Guillain Barre has doubled in our region after Zika	9-6-16	Zika
45.	We will test people… new vaccine that blocks the Zika virus works among apes	8-6-16	Zika
46.	Dr. Gerstenbluth believes that… there are not many insights about the contamination of Zika	7-30-16	Zika
47.	Bad news announced… Aedes Egypti is not the only mosquito that spread Zika	7-28-16	Zika
48.	Additional investigation is being performed… first possible death associated with Zika announced in Grenada	7-12-16	Zika
49.	Scientists indicate… Zika will be active for three more years because it will kill itself.	7-15-16	Zika

Table 4. Coding list for newspapers, expert interviews, and visual materials.

Information
- Number of deaths
- Number of infections
- Transmission
- Symptoms
- Tests
- Mention new disease first time (Zika, dengue, chikungunya)

Prevention methods

Government
- Negative
- Positive
- Too late
- Questioning each other
- Unpreparedness

Limited untrained staff

Global warning

Indifference

Locals
- Blame for not cleaning
- Urge to act
- Participatory initiatives

Tourism

Economy
- A threat to public health

Long impacts

Research

Efficient approach
- Inefficient approach
- Lack of coordination between institutions

Cooperation

Lack of structure

Distrust

Pollution

Table 5. Coding list for In-depth interviews with locals.

Had Zika/dengue/chikungunya
- Self
- Family/friends

Quality communication

Information source
- Tv
- Newspaper
- Radio
- Family / Friends
- Doctor
- Flyers
- Social media
- Internet
- International media
- Schools
- Community centers

Quality information

Prevention methods

Health risks knowledge
- Know enough
- Do not know
- Transmission
- Symptoms

Responsibility

Perception risk
- Perceived susceptibility
- Perceived severity

Afraid infection Zika dengue chikungunya

Role media

Role government

Role social groups

Risk-reducing behavior
- Indifference

Trust information

Sources trusted

Sources not trusted

Suggestions improvements

Unclear information
- Inaccurate information
- Believing wrong information

Heuristics
- Previous experience with VBDs

Chapter 6
Table S1. Overview of the study participants.

Number	Pseudonym	Sex	Type of sector
1	Elena	Female	Tourism industry
2	Anne	Female	Tourism industry
3	Gerard	Male	Tourism industry
4	William	Male	Tourism Industry
5	Aryan	Male	Tourism industry
6	Samuel	Male	Tourism industry
7	Evan	Male	Tourism Industry
8	Julian	Male	Tourism industry
9	Carlos	Male	Tourism industry
10	Liam	Male	Tourism official
11	Hannah	Female	Tourism official
12	Max	Male	Tourism official
13	Jacob	Male	Public health official
14	Sara	Female	Public health official
15	Tim	Male	Waste management official
16	Lucy	Female	Waste management official
17	Mark	Male	Recycling company
18	Miguel	Male	Recycling company
19	Sophia	Female	Private company
20	Daniel	Male	NGO
21	Mason	Male	NGO
22	Ethan	Male	NGO
23	Mia	Female	NGO
24	Anthony	Male	NGO
25	Bella	Female	NGO
26	Leo	Male	NGO
27	Linda	Female	NGO (Amigu di Tera)
28	John	Male	NGO (Amigu di Tera)

Interview Guide for Tourism Industry

Sustainable tourism questions

1. What are the challenges of being a famous destination?
   Probe: environmental problem; social problem; infrastructure problem
2. What potential do you see in Curacao tourism?
   Probe: any potential tourism destination?
3. Have you heard about sustainable tourism?
   Probe: concept; realization; action
4. If yes, what kind of practices that you think you can do to achieve sustainable tourism?
5. What contribution can you give to achieve sustainable tourism?
   Probe: training; publication; awareness;

Waste management questions

The common problem that comes from tourism is usually related to waste, and on a small island like Curacao, waste becomes a bigger problem since the island has limited space to accommodate a huge amount of waste.

1. How does waste management work in Curacao?
   Probe: recycling; waste storage; separation technique; waste disposal; waste collection frequency; price
2. How much waste do you generate a day?
   Probe: type of waste, the composition of waste
3. Have you done anything to avoid any waste?
   Probe: Waste avoidance and reuse
4. What are the challenges in waste management?
   Probe: technical or capacity challenges?
5. What do you think is the negative effect of bad waste management?
   Probe: who's or what is going to be affected? In which way?
6. Who do you think is responsible for waste management in Curacao?
   Probe: what institution? Why are they responsible?

MBDs questions

In the past few decades, Curacao has been hit by several epidemic mosquito-borne diseases such as chikungunya, dengue, or zika.

1. Have you or your family ever got sick from diseases caused by the mosquito?
   Probe: What kind of diseases; How was the treatment?
2. Have you ever received or participated in training from the ministry of health about mosquito-borne diseases?
3. Probe: if yes, when? How extensive is the training?
4. Have you done something to minimise the transfer of MBDs?
   Probe: prevention actions;

5. What contribution that your institution can do to minimise the MBDs?
   Probe: direct contribution or indirect contribution

Closing questions

1. What aspects are still needed to improve on waste management in Curacao?
2. What is your ideal waste management?
3. How do you see the tourism industry in Curacao for the next 20 years?

Interview Guide for Health Institution

Opening Questions

1. Can you tell me a bit about this institution?
   Probe: When it was founded? Why was it funded? What kind of programs?

MBDs questions

In the past few decades, Curacao has been hit by several epidemic mosquito-borne diseases such as chikungunya, dengue, or zika.

1. Can you tell me about the current situation of MBDs in Curacao?
   Probe: What are the diseases that still occur? How often do you get MBDs patients?
2. What caused the MBDs in Curacao?
   Probe: How did it spread? What is the infection rate?
3. Have you or your family ever got sick from diseases caused by the mosquito?
   Probe: What kind of diseases; How was the treatment?
4. Have you ever gave training about mosquito-borne diseases?
   Probe: if yes, when? How extensive is the training?
5. Have you done something to minimise the transfer of MBDs?
   Probe: prevention actions;
6. What contribution that your institution can do to minimise the MBDs?
   Probe: direct contribution or indirect contribution
7. What are the other effects of MBDs other than health-related?
   Probe: economic effect; tourism effect

Waste management questions

Waste management plays an important role in minimising the spread of MBDs.

1. Do you see any relationship between waste management and the spread of MBDs?
   Probe: does it directly related?
2. What do you know about waste management in Curacao?
   Probe: recycling; waste storage; separation technique; waste disposal; waste collection frequency; price
3. Have you noticed any challenges in waste management?
   Probe: financial; personnel; techniques; infrastructure
4. What do you think is the negative effect of bad waste management?
   Probe: environmental effect; social effect;
5. Who do you think is responsible for waste management in Curacao?
   Probe: institution; government; resident

Sustainable tourism questions

If we look at the bigger picture, proper waste management is an important aspect of tourism, namely sustainable tourism.

1. Have you ever done any project related to tourism??
2. **Probe**: concept; realization; action
3. Have you ever heard about the concept of sustainable tourism?
4. **Probe:** concept; realization; action
5. If yes, what kind of practices that you think you can do to achieve sustainable tourism?
6. Will tourism brings your institution any good?
7. **Probe:** economic aspect; less waste

Closing questions

1. What are the actions needed to prevent the further spread of MBDs?
2. What aspects are still needed to improve on waste management in Curacao?
3. What is your ideal waste management?
4. How do you see Curacao tourism for the next 20 years?

Interview Guide for Waste Institution

Opening Questions

1. Can you tell me a bit about this institution?
   Probe: When it was founded? Why was it funded? What kind of programs?

Waste management questions

1. How does waste management work in Curacao?
   Probe: recycling; waste storage; separation technique; waste disposal; waste collection frequency; price
2. How much waste do you generate a day?
   Probe: type of waste, the composition of waste
3. Have you done anything to avoid any waste?
   Probe: Waste avoidance and reuse
4. What are the challenges in waste management?
   Probe: financial; personnel; techniques; infrastructure
5. What do you think is the negative effect of bad waste management?
   Probe: environmental effect; social effect;
6. Who do you think is responsible for waste management in Curacao?
   Probe: institution; government; resident
7. Have you done any training for resident related waste management?

MBDs questions

In the past few decades, Curacao has been hit by several epidemic mosquito-borne diseases such as chikungunya, dengue, or Zika.

1. Have you or your family ever got sick from diseases caused by the mosquito?
   Probe: What kind of diseases; How was the treatment?
2. Have you ever received or participated in training from the ministry of health about mosquito-borne diseases?
   Probe: if yes, when? How extensive is the training?
3. Have you done something to minimise the transfer of MBDs?
   Probe: prevention actions;
4. What contribution that your institution can do to minimise the MBDs?
   Probe: direct contribution or indirect contribution

Sustainable tourism questions

If we look at the bigger picture, proper waste management is an important aspect of tourism, namely sustainable tourism.

1. Have you ever done any project related to tourism??
   Probe: concept; realization; action
2. Have you ever heard about the concept of sustainable tourism?
   Probe: concept; realization; action

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3. If yes, what kind of practices that you think you can do to achieve sustainable tourism?
4. Will tourism brings your institution any good?
   Probe: economic aspect; less waste

Closing questions

1. What aspects are still needed to improve on waste management in Curacao?
2. What is your ideal waste management?
3. How do you see Curacao tourism for the next 20 years?

Table S2. Codebook

First level code	Second level	Third level
Personal information		
Waste management	Solid waste management practices	Separation and recycle
		Reuse
		Upcycle
		Less packaging
		Biodegradable goods
		Landfill
	Challenges	Mentality
		Economic situation
		Education
		Government role
		Facilities
		Imported goods
		Partnership and network
		Priority and continuity
	Opportunities for waste management	Separation and recycle
		Waste to energy
		Import banned
		Plastic banned
		Bottle deposit
		New organisation
		Circular economy
		Integrated campaign
	Stakeholders and responsibility	Government
		Corporates
		Local
		Selikor
		NGO
		Recycling companies
MBDs	Current situation	Causes
		Attention
		Treatment
	Prevention	Campaign
		Site cleaning
	Mitigation	Inspection
		Spraying
	Awareness	Local
		Government Institution
		Tourism institution
		Tourist
	Impact	Tourism
		General health

First level code	Second level	Third level
Sustainable tourism	Tourism impact	Environmental degradation
		Economic development
		Culture loss
		Waste generated
		Carrying capacity
		Sustainable initiatives
	Perception	Tourism future
		Global warming

Chapter 7
Text S1 Topic guide FGD
Group: Community

FGD number: .... **Moderator: ....**
Date: .... **Note-taker: ....**

Introduce yourself to the participants:
Thank you very much for accepting to participate in this group discussion. My name is Vaitiare Jansen. I am a doctoral student at the University of Groningen.

- ✓ ***Explain the general purpose of the study***: The general purpose of the study is to understand the performance of the health system, risk communication and behaviour of individuals from the point of view of the community in order to provide the health system with content-specific advice to strengthen risk communication efforts and sustainability of risk management.
- ✓ ***Estimated time***: Approximately 1 ½ hour
- ✓ ***Right to participate and withdraw from the study:*** Involvement in this study is voluntary. You are free to withdraw from the study at any time. You are free to skip any questions you prefer not to answer during the discussion.
- ✓ ***Use of tape recorder***: To keep a more accurate record of our discussion, I propose using a tape recorder, if you do not mind. Do you mind if I use a tape recorder? *(observe whether people agree)*
- ✓ ***Plan to protect the identity of the participants:*** The information that we will discuss here today will remain anonymous. Your names will be removed from the data, and no one will be able to link your name with what is said. No one apart from the research team will have access to the data. This data will be published and shared with the scientific community, but your name will not appear in any of the publications.
- ✓ ***Basic principles:***
  1. Respecting the opinions of others is essential.
  2. There are no right and wrong answers. We value each idea, opinion and experience.
  3. One person speaks at a time.
  4. Ask if there is any question.
- ✓ Do you have any questions?
- ✓ ***Consent:*** Do you agree to take part in this discussion?
- ✓ The moderator turns on the digital recorder and starts the discussion

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Introduction

- ✓ As an introduction, let us go around so that you can introduce yourselves and tell us your name, age, whether you are currently working, and what type of work you do.

Let us start our discussion by talking about chikungunya and Zika. Most individuals living in Curaçao have witnessed the chikungunya infection outbreak in 2014-2015 and, more recently, the Zika infection outbreak in 2016. I heard that information about chikungunya and Zika was shared by different information channels.

1. What do people know about chikungunya?
   Probe for:
   a. Ask for the following types of information *(transmission routes and prevention measures)* if they are not mentioned.
   b. Where do people obtain information about chikungunya?
2. What do people know about Zika?
   Probe for:
   a. Ask for the following types of information *(transmission routes and prevention measures)* if they are not mentioned.
   b. Where do people obtain information about Zika?

1: Risk perception

1. What kind of people is at risk for chikungunya?
   Probe for:
   a. Who can be more at risk for chikungunya?
   b. Who can be less at risk for chikungunya?
2. What are the consequences of having chikungunya?
   Probe for:
   a. What are the social consequences?
   b. What are the economic consequences?
   c. What are the physical consequences?
   d. What are the emotional consequences?
3. What kind of people is at risk for Zika?
   Probe for:
   a. Who can be more at risk for Zika?
   b. Who can be less at risk for Zika?
   c. What are the consequences of having Zika?

2: Risk communication

1. What did you hear from the government about chikungunya and Zika?
   Probe for:
   a. Which channels were used? *(e.g. vector control inspectors, Facebook, the website of the G&Gz, folder, App etc.)*

2. What do you think about the information that you received from the government?
   Probe for:
   a. Was the information on time?
   b. Was the information clear?
3. What do people around you do with the information they receive from the government?
   Probe for:
   a. Why?
   b. Was it easy to accept?
4. What would be the best way to provide your community with information about chikungunya and Zika?
   Probe for:
   a. Via which channels? Why?
   b. What would they like to know?
   c. When do they want to receive information?

Topic 3: Performance of the health system

1. What did the health institution do during the chikungunya epidemic?
   Probe for:
   a. Ask for the following institutions *(G&Gz, especially for the vector control unit, hospital and health insurances)* if they are not mentioned.
   b. What went well?
   c. What can be improved?
2. What did the health institutions do during the Zika epidemic?
   Probe for:
   a. Ask for the following institutions *(G&Gz, especially for the vector control unit, hospital and health insurances)* if they are not mentioned.
   b. What went well?
   c. What can be improved?
3. How did the health professionals react during the chikungunya epidemic?
   Probe for:
   a. Ask for the following health professionals *(GP, alternative medicine practitioner, vector control inspectors)* if they are not mentioned.
   b. What was their behaviour?
   c. What was their reaction during the Zika epidemic?
4. What are the challenges the government faces when dealing with chikungunya and Zika?
   Probe for:
   a. Aks if the following factors *(trust issues, limited resources, immigrants, and unplanned urbanisation)* if not mentioned.
   b. Why?

Topic 4: Health care utilisation

1. Many people suffer from chikungunya. What were the symptoms?
   Probe for:
   a. And what about Zika?
2. Which medication (s) did they use for chikungunya?
   Probe for:
   a. Why?
   b. Which medication did they use for Zika?
   c. Why?
3. Whom did they consult for help?
   Probe for:
   a. Ask for the following caregivers *(e.g. partner, parent, friend, religious leader, community worker, general practitioner or alternative medicine practitioner)* if they are not mentioned.
   b. Why? *(e.g. in the case of the GP, for sickness certification)*.
4. During the chikungunya and Zika epidemic, what difficulties did people have in obtaining healthcare?
   Probe for:
   a. Medication costs – consultation and medicine costs
   b. Availability of medicines
   c. Waiting time before consultations
   d. Operating hours (e.g. GP availability during the evening and weekend)
   e. The attitude of health professionals
   f. Alternative medicine practitioners

Topic 5: Health-seeking behaviour and preventive measures

1. When prevention needs to be conducted, who all are responsible?
   Probe for:
   a. Ask for the following individuals/groups/institution *(infected individuals, not infected individuals, the community, and the government)* if they are not mentioned.
   b. Why are they responsible for prevention?
2. What problems do people have in protecting themselves against chikungunya and Zika?
   Probe for:
   a. Ask for the following factor *(lack of practical information, poverty and availability of preventive tools)* if they are not mentioned.

We also heard that people do not perform preventive measures because of their mentality.

1. Could you explain what people mean by this statement?
2. What can be done to improve the community and government collaboration in the context of prevention?

Closing question

1. Imagine next year. We have another disease transmitted by mosquitoes. Do you think we are prepared to deal with it?
   Probe for:
   a. What can be done?

We are now reaching the end of the discussion. I want to thank you all very much for your participation in this discussion, your experiences and opinions are valuable to assist in improving risk communication and risk management in Curaçao. Does anyone have any further comments to add before we conclude this group discussion?

Text S2 Topic guide IDI

IDI number: ....
Date: ....
Interviewer: ....

Introduce yourself to the participants: Thank you very much for accepting to participate in this research. My name is Vaitiare Mulderij-Jansen. I am a doctoral student at the University of Groningen.

- ✓ ***Explain the general purpose of the study***: The general purpose of the study is to understand the risk communication and behaviour of individuals concerning the prevention and control of chikungunya, dengue, and Zika, from your point of view. Your perceptions, opinions and experiences can help us provide the government with content-specific advice to strengthen risk communication efforts, the sustainability of risk management and enhance the health-seeking behaviour of people living in Curaçao.
- ✓ ***Estimated time***: Approximately 1 hour
- ✓ ***Right to participate and withdraw from the study:*** Involvement in this study is voluntary. You are free to withdraw from the study at any time. You are free to skip any questions you prefer not to answer during the interview.
- ✓ ***Use of tape recorder***: To keep a more accurate interview record, I propose using a tape recorder, if you do not mind. Do you mind if I use a tape recorder? *(observe whether people agree)*
- ✓ ***Plan to protect the identity of the participants:*** The information that we will discuss here today will remain anonymous. Your name will be removed from the data, and no one will be able to link your name with what is said. No one apart from the research team will have access to the data. This data will be published and shared with the scientific community, but your name will not appear in any of the publications.
- ✓ ***Basic principles:***
  1. There are no right and wrong answers. I value each idea, opinion and experience.
  2. Ask if there is any question.
- ✓ Do you have any questions?
- ✓ ***Consent:*** Sign the “informed consent” form.
- ✓ The interviewer turns on the digital recorder and starts with the interview.

Introduction

- ✓ As an introduction, can you introduce yourself? Please tell me your name, age, neighbourhood, whether you are currently working, and what type of work you do.

Let us start the interview by talking about chikungunya, dengue, and Zika. Most individuals living in Curaçao witnessed the dengue outbreak in 2010, the chikungunya outbreak in 2014-2015 and the Zika outbreak in 2016.

1. What do you know about chikungunya?
   Probe for:
   a. Ask for the following types of information *(e.g. transmission routes, prevention measures, the link between these diseases, symptoms, treatment)* if they are not mentioned.
2. What do you know about dengue?
   Probe for:
   a. Ask for the following types of information *(e.g. transmission routes, prevention measures, the link between these diseases, symptoms, treatment)* if they are not mentioned.
3. What do you know about Zika?
   Probe for:
   a. Ask for the following types of information *(e.g. transmission routes, prevention measures, the link between these diseases, symptoms, treatment)* if they are not mentioned.
4. According to you, what are the reasons/causes of these outbreaks in Curaçao?
   Probe for:
   a. What makes Curaçao susceptible to these diseases?
   b. How did you obtain or receive information about these diseases?

Infodemic: *Link inaccurate information with the source of information.*

1: Risk perception

1. Who are at risk for chikungunya?
   Probe for:
   a. Who can be more at risk for chikungunya? *Ask for waste management officials or employees of the VCU if they are not mentioned*. Why?
   b. Who can be less at risk for chikungunya? Why?
   c. And in the case of dengue? Why?
   d. And in the case of Zika? Why?
2. What kind of people do you think are more at risk for complications in the case of chikungunya?
   Probe for:
   a. Why?
   b. And in the case of dengue? Why?
   c. And in the case of Zika? Why?

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3. Do you consider yourself at risk for one of these diseases, and why or why not?
4. Which diseases do you consider more severe or threatening to your health?
   Probe for:
   a. Explain why or why not.
5. What can influence your feeling of being at risk?
   Probe for:
   a. Time? Is there a change over time?
   b. Does media attention has an influence?
   c. Does the recovery rate have an influence?
6. Which impact did the community, family, or friend have on your feeling of being at risk?
   Probe for:
   a. In what way or not?
   b. Has this impact affected your behaviour in some way?
7. What were/are the personal consequences of you having chikungunya? Or What can be the personal consequences of having chikungunya?
   Probe for:
   a. What are the social, economic, physical and psychological consequences?
   b. What can be the consequences for the family of those who had chikungunya?
8. What were/are the personal consequences of your having Zika? Or What can be the personal consequences of having Zika?
   Probe for:
   a. What are the social consequences, economic, physical, and psychological consequences?
   b. What can be the consequences for the family of those who had Zika?
9. What were/are the personal consequences of your having dengue? Or What can be the personal consequences of having dengue?
   Probe for:
   a. What are the social, economic, physical, and psychological consequences?
   b. What can be the consequences for the family of those who had dengue?
10. Which of these consequences affected the choices you made or the actions you took to protect yourself during the outbreaks?
    Probe for:
    a. Which actions did you perform *(e.g. personal and household protection and mosquito breeding sites control)*?
    b. Why?
    c. Do these consequences still affect your present choices or actions for protection?
    d. Furthermore, what do you do currently for protection and prevention?

2: Risk communication

Definition of risk communication: *Risk communication refers to the exchange of real-time information, including advice and opinions between experts and individuals facing threats to their health, economic or social well-being.*

1. What did you hear from the government (official information) about chikungunya?

   Probe for:
   a. What about Zika?
   b. What about dengue?
   c. Which channels were used? *(e.g. vector control inspectors, Facebook, the website of the G&Gz, folder, App etc.)*
2. Which impact did the official information have on you?

   Probe for:
   c. In what way or not?
   d. What did you do with the received official information?
   e. Did you use it to educate others, and why not?
3. What do you think about the information that you received from the government?

   Probe for:
   a. Was the information on time, clear, and useful?
   b. Why or why not?
4. Do you trust the information that the government provides? Explain why or why not.

   Probe for:
   a. In the case of distrust, how do you deal with this?
   b. Which sources other than the government do you trust?
   c. How do you ensure the authenticity of the information?
5. After the outbreaks, did you receive or continue to receive official information to prevent these outbreaks in the future?

   Probe for:
   a. According to you, is this positive or negative? Why or why not?
   b. Does this influence your (preventive) behaviour?
   c. According to you, what are the factors that obstruct the risk communication of the government concerning these diseases?
6. What can be done to improve risk communication?

   Probe for:
   a. What would be the best way to provide you with information about these diseases?
   b. Via which channels? Why?
   c. What would you like to know?
   d. When do you want to receive the information?

Topic 3: Health-seeking behaviour, prevention and control measures
Definition of prevention: *The action of stopping something, in this case, infection of dengue, Zika, and chikungunya from happening.*
Definition of control measures: *Actions and/or activities that are taken to prevent, eliminate or reduce the occurrence of infection of dengue, Zika, and chikungunya.*

1. When prevention and control measures need to be conducted, who all are responsible?
   Probe for:
   a. Ask for the following individuals/group/institution *(e.g. the participant itself, infected individuals, not infected individuals, the community, and the government)* if they are not mentioned.
   b. Why or why not are they responsible for prevention and control measures?
2. Which barriers do you encounter in protecting yourself against dengue, chikungunya and Zika?
   Probe for:
   a. Ask for the following factor *(e.g. lack of practical information, financial factors, availability and accessibility of preventive tools)* if they are not mentioned.
   b. Which external factors (e.g. illegal dumping sites, inadequate waste management) obstruct you in preventing and controlling these diseases?
   c. In what way do they obstruct your actions?
3. According to you, what factors obstruct the government from preventing and controlling these diseases?
   Probe for:
   a. Ask for the following factors *(e.g. financing, lack of workforce, lack of educated workforce, lack of collaboration between the community and the government)* if they are not mentioned.

I also heard that people do not perform preventive and control measures to combat these diseases because of different factors, for example, mentality.

4. Could you explain what people may mean by this statement?
5. Which other factors obstruct prevention and control measures?
6. What can be done to improve the collaboration between the community and the government in preventing and controlling these diseases?

Closing question

1. Imagine, next year, we have another disease transmitted by mosquitoes. Do you think we are prepared to deal with it?
   Probe for:
   a. What can be done?

We are now reaching the end of the interview. I want to thank you for your participation; your experiences and opinions are valuable to assist in improving risk communication and risk management in Curaçao. Do you have any further comments to add before we conclude this interview?

Table S1. Coding List

Themes (n=5)	**Categories (n=12)**	**Codes (n=75)**
Perceived threat	Perceived susceptibility Perceived severity Knowledge about ABIDs Cues to action Trust	Elderly/children/women/people with chronic diseases are more at risk Same risk for everyone No threat to human life No risk for men Rainy season Work environment The environment around the house Aetiology Symptoms of Zika Symptoms of dengue Symptoms of Chik Knowledge about mosquitoes Consequences of ABIDs Knowledge about breeding sites Channels of information Social pressure Lack of information Misinformation Influence of religion Internal cues to action Health education at school Communication between people Risk communication of the health system Trust in the health system Trust in the media channels Trust in the community Trust in science Trust in God
Barriers	Perceived barriers Perceived benefits	Perceived benefits of actions Lack of education regarding prevention/control No access to the health system Poverty No consequences for inappropriate behaviour Mentality of people Time to invest in prevention/control actions Resources Infrastructure of neighbourhoods Priority to prevent/control ABIDs Connection with the environment Mosquito control is challenging Do not like repellents Collaboration between the health system and community Actions of others Effectiveness of control measures Negative impact of insecticide
Self-efficacy	Self-efficacy	People do not like to read/ educate themselves Lack of practical information Misinformation
Internal and external locus of control	Internal locus of control External locus of control	God will protect me The health system will protect me I am responsible for my protection The community is responsible for my protection Prevention/control of ABIDs is the task of all

Themes (n=5)	Categories (n=12)	Codes (n=75)
Health-seeking behaviour	HSB Recommendations	Usage of vitamines Usage of herbs Usage of repellents Screens at doors/windows Usage of long sleeves Usage of insecticide Usage of larvicide Usage of biological control measures Removing mosquito breedings sites Other ways to protect against mosquitoes Reasons to not protect against mosquitoes Social control Interventions to clean the environment Regulations Research Improve respect for authorities Improve collaboration between the health system and the community Recommendations to motivate HSB Health education at schools Consequences for wrongdoing Recommendations to improve risk communication Improve trust in the health system

Nederlandse samenvatting

Dengue, chikungunya en Zika zijn virusinfecties, die door *Aedes*-muggen (voornamelijk *Aedes aegypti*) overgedragen worden op mensen. Deze arbovirussen veroorzaakten uitbraken in verschillende landen die tot Afrika, Amerika, Azië, het Caribisch gebied en de Stille Oceaan behoren. Recentelijk zijn de virusinfecties te weten dengue en chikungunya gerapporteerd in Europa, wat de uitbreiding van deze virussen naar nieuwe en onverwachte geografische gebieden aan het licht heeft gebracht. Ondanks alle aanbevelingen van de Wereldgezondheidsorganisatie (WHO), Pan American Health Organization (PAHO), de Caribbean Public Health Agency (CARPHA) en de nieuwe strategieën voor de bestrijding van muggen die ontwikkeld zijn, worstelen landen/eilanden nog steeds met het voorkomen en beheersen van de door *Aedes* overgedragen infectieziekten. Curaçao, een land autonoom onderdeel in het Koninkrijk der Nederlanden, had ook moeite om de recente uitbraken van *Aedes* overgedragen virusinfecties, waaronder dengue (2010), chikungunya (2014-2015) en Zika (2016), onder controle te brengen. Het is daarom noodzakelijk om te begrijpen waarom gezondheidsstelsels en volksgezondheidsinstellingen, die verantwoordelijk zijn voor muggenbestrijding, er niet in slagen om effectieve muggenbestrijdingsinterventies te ontwerpen en te implementeren.

Om de moeilijkheden bij de bestrijding van - door *Aedes* overgedragen - infectieziekten te overwinnen, moeten eerst de uitdagingen met betrekking tot de bestrijding van *Aedes* op macroniveau (gezondheidssysteem), mesoniveau (gemeenschap) en microniveau (individuen) van dat specifiek land worden bepaald. Daarom is het algemeen doel van dit proefschrift om de context en concepten te onderzoeken die het gezondheidssysteem, gemeenschap en individuele preventie- en controle-interventies/gedrag vormen met betrekking tot *Aedes* overgedragen infectieziekten in Curaçao. We hebben verschillende onderzoekmethodologieën gecombineerd (kwalitatief en kwantitatief) en disciplines (bijvoorbeeld epidemiologie, entomologie, microbiologie, sociale wetenschappen en milieuwetenschappen) om het bovengenoemd doel te behalen. Daarnaast werden verschillende theoretische kaders en concepten gebruikt om de ingewikkelde relatie tussen macro-, meso- en microniveau te begrijpen. De gegevensverzameling voor elke studie werd verdeeld in twee of meer rondes om de vragenlijsten aan te scherpen en de verzamelde gegevens te valideren. Dit traject vergroot de geloofwaardigheid en validiteit van de onderzoeksresultaten.

Het **2de hoofdstuk** van dit proefschrift is een scoping review die tot doel heeft bewijs te synthetiseren met betrekking tot de effectiviteit van *Aedes aegypti* en *Aedes albopictus* preventie en controle-interventies uitgevoerd in Latijns-Amerika en het Caribisch gebied (2000-2021). De scoping review is gebaseerd op de methodologie van het Joanna Briggs Institute. De databases MEDLINE (via PubMed en Web of Science), Cochrane Library, Scopus, EMBASE en ScienceDirect werden gebruikt om artikelen te zoeken. Grijze literatuur werd doorzocht op websites van overheidsinstanties en organisaties die niet verbonden zijn aan de overheid. In totaal zijn 122 publicaties in de review opgenomen. De meeste onderzoeken waren gericht op dengue-virusinfectie en *Aedes aegypti*. Entomologische gegevens werden vooral gebruikt om de effectiviteit van de interventie te bepalen. Een geïntegreerde bestrijdingsinterventie was in beide regio's de meest gebruikte strategie. Biologische controlemaatregelen, milieubeheer en gezondheidsvoorlichtingscampagnes gefocust op gemeenschapsparticipatie leverden duurzamere resultaten op dan een interventie waarbij alleen een chemische controlemaatregel werd gebruikt. Volgens de scoping review lijkt een geïntegreerd vectorbeheer programma gericht op participatie van de gemeenschap de meest effectieve benadering te zijn om door *Aedes* overgedragen infectieziekten te verminderen. Het behouden van het effect van deze aanpak blijft een uitdaging, omdat er verschillende aspecten zijn zoals onvoldoende financiële steun, middelen, personeel, intersectorale samenwerking en wetgeving die de processen binnen overheidsinstellingen verstoren.

Het **2de hoofdstuk** geeft een breder perspectief op *Aedes*-bestrijdingsinterventies en hun barrières in het Latijns-Amerika en het Caribisch gebied. In het **3de hoofdstuk** verkleinen we de context en richtten we ons op de prestaties van het gezondheidssysteem van Curaçao. De studie gepresenteerd in het **3de hoofdstuk** heeft tot doel de prestaties van het gezondheidssysteem van het Nederlands Caribische eiland Curaçao met betrekking tot de preventie en bestrijding van *Aedes* overgedragen infectieziekten in het laatste decennium te onderzoeken door gebruik te maken van het WHO-raamwerk “WHO health system building blocks framework“(macroniveau). Van november 2018 tot december 2020 is op Curaçao een kwalitatief onderzoek uitgevoerd, waarbij inhoudsanalyse van documenten (n = 50), vijf groepsdiscussies (n = 30), interviews met experts (n = 11) en 15 observatie sessies zijn uitgevoerd. De gegevens van deze studie benadrukten de uitdagingen (bijvoorbeeld, onvoldoende toezicht, coördinatie, leiderschapsvaardigheden, structuur en communicatie) waarmee de afdelingen van het gezondheidssysteem van Curaçao te maken kreeg tijdens de laatste drie epidemieën van *Aedes* overgedragen infectieziekten (2010-2020). Bovendien werd er weinig samenwerking tussen overheidsinstellingen en particulier organisaties (bijvoorbeeld, laboratoria) en onvoldoende capaciteitsopbouw om vaardigheden te verbeteren (bijvoorbeeld, entomologische, surveillancevaardigheden) waargenomen. We hebben ook waargenomen hoe knelpunten in één bouwsteen van het raamwerk andere bouwstenen negatief beïnvloedden (bijvoorbeeld, onvoldoende leiderschap/bestuur belemmerde de prestaties van het personeel). De informatie gepresenteerd in het **2de en de 3de hoofdstuk** van dit proefschrift geeft aan dat de meeste landen/eilanden in de Latijns-Amerika en het Caribisch gebied kampen met dezelfde uitdagingen met betrekking tot de preventie en de bestrijding van *Aedes* overgedragen infectieziekten.

In het **4de en 5de hoofdstuk** focussen we op risicocommunicatie en concepten die risico perceptie beïnvloeden. De studie, in hoofdstuk 4, heeft tot doel risicocommunicatie met betrekking tot *Aedes* overgedragen infectieziekten te onderzoeken om zo de risicocommunicatiestrategieën op Curaçao te versterken. In 2015 is op Curaçao een "mixed-method" studie uitgevoerd met groepsdiscussies (n = 7), interviews (n = 20) en een gestructureerde vragenlijst (n = 339). Het onderzoek is opgezet op basis van het "Health Belief Model" en de "Theory of Planned Behaviour". Daarnaast werden de "Social Amplification of Risk Framework" (SARF) en de theorie van culturele schema's gebruikt om de effecten van de sociale context op risico perceptie te begrijpen. Het onderzoek richt zich zowel op het macro- als op het mesoniveau en hun mogelijke invloed op het microniveau (individuele risicoperceptie). Onze resultaten suggereren dat televisie, radio en kranten de belangrijkste informatiekanalen waren over dengue en chikungunya. Bovendien gaven individuen ook aan informatie te ontvangen via sociale media, internet en familie/vrienden. Interessant is, dat het gebruik van internet om informatie te verkrijgen afnam met de leeftijd, terwijl vrouwen vaker internet gebruikten dan mannen. Een belangrijke uitkomst was, dat de risicoperceptie jegens chikungunya aan het begin van de uitbraak was afgezwakt. Dit kan te wijten zijn aan het (vermeende) gebrek aan risicocommunicatie vóór de epidemie. Diezelfde risicoperceptie werd later tijdens de uitbraak versterkt door de toegenomen blootstelling aan informatie. Onze resultaten toonden ook aan, dat de culturele schema's van individuen mogelijk aanwijzingen zijn voor actie, die het preventieve gedrag van individuen in gang heeft gezet. Ook toonden de resultaten van ons onderzoek aan, dat mensen in de war raakten, wanneer hun realiteit (voorbeeld: kruiden genezen of verminderen de symptomen van de chikungunya virusinfectie niet) niet paste in hun cultureel schema (voorbeeld: kruiden genezen ziekten).

Op basis van het bewijsmateriaal, gepresenteerd in het **4de hoofdstuk**, hebben we de studie ontworpen die in het **5de hoofdstuk** besproken wordt. De studie in het **5de hoofdstuk** is uitgebreider in haar analyses door de inhoud van de krant te analyseren en de percepties van mensen te vergelijken met de percepties van experts. In 2018 is een kwalitatief onderzoek bevattende interviews met lokale mensen en experts/overheidsfunctionarissen en een inhoudsanalyse van kranten en ander beeldmateriaal (folders, posters, etc.) uitgevoerd om de ervaringen en processen met betrekking tot risicocommunicatie en risicoperceptie van mensen te onderzoeken. De studie is ontworpen op basis van de SARF en concepten zoals heuristiek, eerdere ervaring met *Aedes* overgedragen infectieziekten en vertrouwen. Onze resultaten toonden aan, dat risicocommunicatiestrategieën werden belemmerd door een gebrek aan overheidsstructuur, organisatie en communicatie. Uit de inhoudsanalyse bleek, dat het merendeel van de krantenartikelen negatieve berichtgeving over de overheid bevatten. Verder laat dit onderzoek zien hoe vertrouwen en heuristieken de risicopercepties van mensen afzwakken of versterken en mogelijk het preventieve gedrag van mensen positief of negatief beïnvloeden. Ons onderzoek naar risicocommunicatie (hoofdstukken 4 en 5) benadrukten de complexiteit van het beoordelen, communiceren en beheren van risico's. Veel componenten kruisen elkaar vanuit vele perspectieven. We ontdekten, dat er meerdere factoren zijn waaronder (i) de hoeveelheid informatie, (ii) vertrouwen in de informatiebron, (iii) ervaring met een vergelijkbare ziekte, (iv) culturele schema's en (v) heuristieken, die bepalen hoe mensen omgaan met risico's en informatie.

Het **6de hoofdstuk** richt zich op het huidige afvalbeheer, de invloed van de toeristenindustrie op het afvalbeheer en de mogelijke implicaties van het afvalbeheer op muggenbestrijding op Curaçao. Afvalbeheer speelt een essentiële rol bij de bestrijding van muggen, want het kan de vicieuze cirkel van broedplaatsen voor muggen, de muggen en de ziektes die overdraagbaar zijn door muggen doorbreken door kunstmatige waterhoudende containers te verminderen. Een mix van kwalitatieve gegevensverzamelingsmethoden, namelijk “transect-walks” (n=10), semigestructureerde interviews (n=26) en observaties (n=12), werden uitgevoerd (maart-april 2019 en augustus 2020). Om het probleem beter in kaart te brengen hebben we in februari 2021 illegale stortplaatsen gedocumenteerd met behulp van een geografisch informatiesysteem. De resultaten van deze studie benadrukten, dat sociale (gebrek aan gemeenschapsbewustzijn en betrokkenheid bij afvalbeheer), economische (armoede), ecologische (illegale dumping) en overheidsfactoren (gebrek aan handhaving van regelgeving en intersectorale samenwerking) het afvalbeheer belemmeren. Hoewel er initiatieven zijn om recyclingdiensten en biologisch afbreekbare voorzieningen te gebruiken, komt de meeste afval die door de toeristenindustrie en de gemeenschap wordt gegenereerd, op de vuilstort terecht. Het onbehandelde afval, die zich op illegale stortplaatsen of terreinen van de bevolking of de stortplaats bevindt, kan de beschikbaarheid van broedplaatsen voor muggen vergroten, waardoor de kans op *Aedes* overgedragen infectieziekten uitbraken mogelijk toeneemt.

Het laatste hoofdstuk van dit proefschrift richt zich op de contexten en concepten, die het gedrag van individuen met betrekking tot preventie en controle van *Aedes* overgedragen infectieziekten op Curaçao beïnvloedt **(7de hoofdstuk).** De studie is opgezet op basis van het Health Belief Model. Van april 2019 tot september 2020 is een kwalitatief onderzoek opgesteld, waarbij zeven (n = 54) groepsdiscussies en vijfentwintig interviews uitgevoerd zijn met individuen die op Curaçao leven. In deze studie werden lage media-aandacht (externe cue to action) en beperkte ervaring met de symptomen van *Aedes* overgedragen infectieziekten (interne cue to action) in verband gebracht met een laag waargenomen risicoperceptie voor de genoemde ziekten. De lage waargenomen risicoperceptie was gekoppeld aan verminderde motivatie en actie om *Aedes* overgedragen infectieziekten te voorkomen en te beheersen. Onze resultaten geven ook aan, dat de waargenomen barrières opwegen tegen de waargenomen voordelen van *Aedes* overgedragen infectieziekten preventie en controle-interventies, waardoor preventief gedrag wordt belemmerd. Onze bevindingen geven ook aan, dat aan de ene kant onvoldoende kennis de zelfeffectiviteit van mensen belemmert om een actie te ondernemen. Aan de andere kant bevordert het hebben van goede kennis het preventief gedrag niet. Ook ontdekten we dat onze deelnemers geloofden, dat ze verantwoordelijk zijn voor het voorkomen van genoemde ziekten (interne locus of control), maar tegelijkertijd aangaven dat hun succes afhangt van de inspanningen van de gemeenschap en het gezondheidssysteem (externe locus of control).

Op basis van de informatie gepresenteerd in de hoofdstukken 4, 5, 6 en 7 kunnen we concluderen, dat de gemeenschap de overheid/gezondheidszorg van Curaçao niet vertrouwt. Het wanbeheer van eerdere epidemieën, negatieve berichtgeving in de media, onopgeloste problemen met illegale stortplaatsen en de overheid die haar beloften niet nakomt, zijn de factoren die mogelijk wantrouwen vergroten. In ons onderzoek speelde de factor vertrouwen een belangrijke rol bij gedragsverandering. Er moet aandacht worden besteed aan deze bevindingen om de deelname van de gemeenschap aan de bestrijding van muggen te verbeteren. Anders zal het gezondheidssysteem *Aedes* overgedragen infectieziekten niet kunnen beheersen, omdat wantrouwen niet leidt tot gedragsverandering van de gemeenschap en het individu.

De belangrijkste bevindingen van de hoofdstukken 2 tot en met 7 zijn samengevat en een opsommende discussie over de resultaten is gepresenteerd in het **8ste hoofdstuk**. Het **8ste hoofdstuk** bevat ook toekomstperspectieven op basis van de resultaten die zijn verkregen en besproken worden in dit proefschrift.

Conclusies

Alle studies die in dit proefschrift worden gepresenteerd (hoofdstuk 2-7) bieden de lezers de informatie om de uitdagingen van *Aedes* controle op Curaçao holistisch te begrijpen. Onze resultaten benadrukken de relevantie van risicocommunicatie, culturele schema's, en heuristieken in ziektebestrijding. Deze informatie is nuttig voor beleidsmakers en anderen, die zich bezighouden met het voorkomen en bestrijden van *Aedes* overgedragen infectieziekten. Daarnaast kunnen onze bevindingen en adviezen een bijdrage leveren aan het vormgeven van context-specifieke interventies om muggen te bestrijden op Curaçao. De *Aedes* overgedragen infectieziekten epidemieën benadrukken de noodzaak voor een verandering in de benadering van muggenbestrijding. Een geïntegreerd vectorbeheer programma gericht op de participatie van de gemeenschap in muggenbestrijding kan helpen om toekomstige epidemieën van *Aedes* overgedragen infectieziekten te voorkomen en te beheersen. Met het oog hierop is er een urgente noodzaak om de barrières van het gezondheidssysteem aan te pakken. Want deze barrières zullen risicocommunicatie, paraatheid en prestatie van gezondheidssystemen blijven belemmeren.

Resúmen

Dengue, chikunguña i Zika ta vírùsnan ku sangura *(Aedes,* spesialmente *Aedes aegypti)* ta transmití pa hende. E arbovírùsnan akí a okashoná diferente brote na vários pais ku ta pertenesé na Afrika, Amérika, Asia, den Caribe i pasífiko. Resientemente a dokumentá infekshon ku dengue i chikunguña na Oropa. Esaki ta indiká ku e vírùsnan menshoná a plama i a yega na paisnan nobo i na un kontinente ku nos no tabata spera. Apesar di tur e rekomendashonnan presentá pa e organisashon mundial di salú (WHO), Pan American Health Organization (PAHO), Caribbean Public Health Agency (CARPHA), i tur e strategianan nobo desaroyá pa kombatí sangura, ainda tur pais/isla ta lucha pa prevení i kontrolá malesanan infeksioso ku sangura *Aedes* ta transmití. Kòrsou, un isla den Reino Hulandes, a lucha hopi pa kombatí e último brotenan di malesanan infeksioso ku sangura *Aedes* ta transmití, dengue (2010), chikunguña (2014-2015) i Zika (2016). Pa e motibu akí ta nesesario pa komprondé dikon e sistema di salubridat i organisashonnan responsabel pa kombatí sangura no ta logra desaroyá i implementá intervenshonnan efektivo.

Pa vense e opstákulonan, mester deskubrí i dokumentá e bareranan relatá na maneho di sangura na tres nivel, makro (sistema di salubridat), meso (komunidat) i mikro (persona individual). Ta p'esei e meta prinsipal di e tésis akí ta pa determiná e kontekstonan i konseptonan ku ta forma/influensiá e sistema di salubridat, komunidat i persona individual su akshonnan pa kombatí malesanan infeksioso di e sangura *Aedes* na Kòrsou, un isla den desaroyo. Nos a kombiná i hasi uso di diferente metodologia (kualitativo i kuantitativo) i disiplinanan (epidemiologia, entomologia, mikrobiologia, siensia sosial i ambiental) pa por alkansá e meta di e tésis akí. Ademas nos a hasi uso di vários modèlnan teorétiko pa por investigá e nivelnan menshoná. Pa kada estudio sientífiko nos a kolektá informashon den dos òf mas buèlta. Esaki a yuda pa adaptá i mehorá e kuestionarionan, verifiká resultadonan i subi kredibilidat di e investigashon.

E di **dos kapítulo** di e tésis akí ta un "scoping review"(= revishon di alkanse) ku tin komo meta pa resumí e evidensia relatá na e efektividat di intervenshonnan pa prevení i kombatí *Aedes aegypti* i *Aedes albopictus* den Latinoamérika i Caribe (2000-2021). E "scoping review" ta basá riba e metodologia di Joanna Briggs Institute. Komo fuente di informashon pa buska artíkulonan sientífiko nos a usa MEDLINE (via PubMed i Web of Science), Cochrane Library, Scopus, EMBASE i ScienceDirect. A buska otro tipo di literatura riba wèpsait di organisashonnan di gobièrnu i privá. A inkorporá un total di 122 publikashon den e "scoping review". Mayoria di e estudionan ta dirigí riba dengue i *Aedes aegypti*. A usa informashon entomológiko, den mayoria kaso, pa determiná efektividat di e intervenshon. Un intervenshon ku ta konsistí di diferente strategia ta e intervenshon ku uso mas frekuente den Latinoamérika i Caribe. Strategia biológiko, ambiental i kampaña di edukashon dirigí riba partisipashon di komunidat a demostrá resultadonan mas duradero i efektivo kompará ku un strategia ku ta solamente apliká un produkto kímiko. Segun e “scoping review’’ un intervenshon ku ta konsistí di diferente strategia ta un bon solushon pa kontrolá malesanan infeksioso ku sangura *Aedes* ta transmití. Tambe e intervenshon mester inkorporá partisipashon di e komunidat pa e efekto ta duradero. Mantené e efekto di e strategia menshoná ta keda un desafio, debí ku tin diferente aspekto manera poko rekurso finansiero , humano, material, kolaborashon entre gobièrnu i sektor privá i lei/maneho pa guia prevenshon i kontròl di sangura.

E di **dos kapítulo** ta basá riba un konteksto mas amplio (Latinoamérika i Caribe) i ta ofresé informashon tokante intervenshonnan apliká pa kombatí dos sangura di e espesie *Aedes* i e opstákulonan relatá na e intervenshonnan den e regionnan menshoná. Den e di **tres kapítulo** nos ta redusí e konteksto i ta dirigí nos mes riba e sistema di salubridat di Kòrsou. E estudio presentá den **kapítulo tres** tin komo meta pa investigá e aktuashon di e sistema di salubridat di Kòrsou pa ku e prevenshon i kontròl di malesanan ku sangura ta transmití, den e último dies añanan usando e modelo teorétiko ku yama “WHO health system building blocks framework“. For di novèmber 2018 te ku desèmber 2020 nos a investigá e tópiko menshoná. Nos a diseñá un estudio kualitativo, na kua nos a apliká análisis di kontenido di dokumentonan (n = 50), sinku grupo di enfoke (n = 30), entrevista ku ekspertonan (n = 11) i diessinku momento di opservashon. E resultadonan di e estudio ta indiká e opstákulonan (insufisiente supervishon, koordinashon, liderazgo, struktura i komunikashon) ku e departamentonan di e sistema di salubridat a eksperensiá durante e último tres epidemianan di malesanan infeksioso ku sangura *Aedes* ta transmití (2010-2020). Ademas nos a opservá ku e kooperashon entre organisashonnan di gobièrnu i organisashonnan privá/semi privá (laboratorio) i kapasidat pa desaroyá abilidat relatá na entomologia i monitoreo ta limitá. Tambe nos a deskubrí ku opstákulonan den un piedra di konstrukshon di e modelo teorétiko ta afektá un otro piedra di konstrukshon. Por ehèmpel, insufisiente liderazgo ta opstruí e prestashon di e personal ku ta traha pa e sistema di salubridat. E informashon presentá den e di **dos i di tres kapítulo** di e tésis akí ta indiká ku paisnan den Latinoamérika i Caribe ta eksperensiá e mesun opstákulonan ku ta stroba prevenshon i kontròl di malesanan ku sangura ta transmití.

Den e di **kuater i di sinku kapítulo** nos a enfoká riba komunikashon di riesgo i e konseptonan ku ta afektá persepshon di riesgo. E estudio presentá den kapítulo 4 tin komo meta pa investigá komunikashon di riesgo relatá na malesanan ku sangura ta transmití (*Aedes*) pa por mehorá strategianan di komunikashon na Kòrsou. E estudio a kuminsá na aña 2015. E estudio ta un kombinashon di dos metodologia (kualitativo i kuantitativo), ku a apliká grupo di enfoke (n = 7), entrevista (n=20) i enkuesta (n=339). E investigashon ta basá riba dos modelo teorétiko, “Health Belief Model” i “Theory of Planned Behaviour”. Ademas nos a usa un otro modelo teorétiko ku yama “Social Amplification of Risk Framework” (SARF) i e teoria “Cultural schema” (skemanan kultural) pa por investigá e efektonan di e kontekto sosial riba persepshon di riesgo. E investigashon ta enfoká riba e nivel makro i meso i nan efekto riba e nivel mikro (persepshon di riesgo di un persona). E resultadonan ta sugerí ku televishon, radio i korantnan ta e fuentenan di informashon mas usá relashoná ku dengue i chikunguña. Tambe e partisipantenan na e investigashon a indiká ku nan sa usa medionan sosial, internèt i famia/konosínan pa por risibí informashon. Nos a deskubrí ku uso di Internèt pa risibí informashon ta baha ora ku edat di un persona ta subi. Tambe nos a mira ku e sekso femenino ta hasi mas uso di internet pa risibí informashon ku un persona ku ta pertenesé na e sekso maskulino. Un resultado ku sigur ta importante pa menshoná ta ku e persepshon di riesgo pa ku chikunguña, na kuminsamentu di e epidemia ta leve. E posibel motibu pa ku esaki ta ku ta e komunikashon di riesgo promé ku e epidemia di chikunguña ta limitá. E mesun persepshon di riesgo pa ku chikunguña a bira fuerte na momentu ku un grupo grandi di hende den e komunidat ta sufri di e malesa i ku a duna hopi informashon. Nos resultadonan tambe ta indiká ku skemanan kultural di un persona por influensiá su komportashon. Ku otro palabra skemanan kultural por stimulá akshon. Tambe nos resultadonan ta sugerí ku, na momentu ku e realidat di un situashon no ta konforme ku e skemanan kultural, e persona ta eksperensiá e sintimentu di konfushon. Por ehèmpel, uso di yerba pa kura un malesa ta un skema kultural ku a pasa di generashon pa generashon. Pero na momentu ku e personanan infektá ku chikunguña,ku a usa yerba pa kura e malesa, a realisá ku e yerba no ta yuda nan, nan a eksperensiá e sintimentu di konfushon. Nan no tabata sa mas kiko nan mester a hasi.

Pa por profundisá mas riba e tópiko presentá den **kapítulo kuater** nos a diseñá un estudio nobo ku nos ta presentá den **kapítulo sinku**. Den 2018 nos a diseñá i apliká un estudio kualitativo. Nos a entrevistá ekspertonan ku ta traha den e sistema di salubridat i den sektor privá. Tambe nos a analisá kontenido di korantnan i otro formanan di komunikashon manera foyeto, poster etc. pa por komprondé kon nan a komuniká riesgo pa ku dengue, chikunguña i zika i ki efekto esaki tabatin riba persepshon di riesgo. E estudio ta basá riba e modelo teorétiko SARF i konseptonan manera “heuristiek” (shortcut mental ku hende ta usa pa por solushoná un problema den un tempu kòrtiku), eksperensia ku malesanan ku sangura ta transmití i e grado di konfia un medio di komunikashon. Nos resultadonan ta indiká ku a opstruí strategianan di komunikashon di riesgo pa motibu di poko struktura, organisashon i komunikashon den e sistema di salubridat i gobièrnu. For di e análisis di kontenido nos a deskubrí ku mayoria di e artíkulonan di korant ta presentá e sistema di salubridat i gobièrnu den un forma negativo. Ademas e investigashon akí ta sugerí ku e grado di konfiansa i “heuristiek” ta reforsá òf baha e persepshon di riesgo di nos partisipantenan. Esaki por tin un efekto positivo òf negativo riba e komportashon di un persona. Nos estudionan, enfoká riba komunikashon di riesgo **(kapítulo kuater i sinku),** ta pone énfasis riba e punto di bista ku komunikashon di riesgo ta un proseso kompleho, debí ku tin diferente komponente ku ta intervení ku otro. Bo por tin un bon strategia pa komuniká riesgo pero tin diferente komponente ku por opstruí e efekto di e strategia. Faktornan manera, (i) kantidat di informashon, (ii) grado di konfiansa den un medio di komunikashon, (iii) eksperensia ku un malesa komparabel, (iv) skemanan kultural, i (v) shortcut mental ku hende ta usa pa por determiná kon e ta atendé ku riesgo i e informashon risibí.

Den **kapítulo seis** nos ta enfoká riba e maneho di shushi, e influensia di e sektor di turismo riba maneho di shushi i e posibel efekto di e maneho di shushi riba e strategia pa kontrolá sangura na Kòrsou. Maneho di shushi ta hunga un ròl hopi importante den e strategia pa kombatí sangura, debí ku e por kibra e sírkulo visioso di foko di sangura, sangura i e malesanan ku sangura ta transmití. Un bon maneho di shushi por redusí e fokonan ku sangura por brui i asina redusí e kantidat di sangura. Pa e estudio akí nos a hasi uso di diferente método kualitativo pa kolektá informashon, manera "transect-walks" (n = 10), entrevista (n = 26) i momentunan di opservashon (n = 12). Tur esaki a tuma lugá den mart- aprel 2019 i ougùstùs 2020. Ademas nos a dokumentá lugánan di tira shushi ilegal na Kòrsou usando un sistema di informashon geográfiko. E resultadonan di e estudio akí ta indiká ku faktornan sosial (insufisiente konosementu i partisipashon di komunidat den maneho di shushi), ekonómiko (pobresa), ekológiko (shushi ilegal den naturalesa), i relatá na gobernashon (poko kolaborashon entre ministerionan i sektor privá, falta di lei i kontròl) ta stroba maneho di shushi na Kòrsou. Apesar di e inisiativa pa resiklá i usa produktonan biológiko, te ainda mayoria di e shushi ku komunidat i e sektor di turismo ta produsí, ta yega na e lèntfel. Shushi no prosesá na e lugánan di tira shushi ilegal, riba tereno di komunidat i lèntfel ta fuentenan potensial ku sangura por usa pa brui. Ku otro palabra, tin basta fuente ku sangura por usa rònt Kòrsou, kual ta subi e kantidat di sangura ku por transmití malesanan manera dengue i Zika. Esaki ta subi e riesgo pa eksperensiá otro epidemianan di malesanan ku sangura ta transmití (*Aedes*).

E último kapítulo di e tésis akí ta enfoká riba e kontekstonan i konseptonan ku por influensiá komportashon di un persona pa preventí i kontrolá malesanan ku sangura ta transmití (*Aedes*) **(kapítulo shete)**. E estudio ta basá riba e modelo teorétiko ku yama "Health Belief Model". For di aprel 2019 te ku sèptèmber 2020 nos a apliká un investigashon kualitativo, ku shete grupo di enfoke (n = 54) i entrevista (n = 25) ku hende lokal. Den e estudio akí nos a deskubrí ku persepshon di riesgo ta leve na momentu ku medionan di komunikashon no duna hopi atenshon na un problema: den e kaso akí ta malesanan ku sangura ta transmití i un persona no a eksperensia e síntomanan di e malesa. A konektá e persepshon di riesgo leve na poko motivashon i akshon pa prevení i kontrolá malesanan ku sangura ta transmití. Tambe nos resultadonan ta indiká ku e bareranan relatá na prevenshon i kontròl di sangura i malesanan ku sangura ta transmití tin mas influensia riba komportashon di nos partisipantenan ku e bentahanan menshoná. Esaki tin un efekto negativo riba e komportashon di nos partisipantenan. Ademas nos a bin komprondé ku poko konosementu por afektá un persona su abilidat pa ehersé un akshon, den e kaso akí apliká strategianan pa kombatí sangura òf protehá su mes kontra piká di sangura. Pero tambe nos a deskubrí ku e echo ku tin sufisiente konosementu no ta garantia ku un persona ta ehersé akshonnan pa protehá su mes kontra di un malesa. Nos partisipantenan a indiká ku nan ta responsabel pa protehá nan mes kontra malesanan transmití pa sangura pero nan ta na altura tambe ku nan éksito pa logra esaki ta dependé riba e akshonnan di komunidat i e sistema di salubridat.

Basá riba e informashonnan presentá den e **kapítulonan kuater, sinku, seis i shete** nos por konkluí ku e komunidat no tin konfiansa den gobièrnu/sistema di salubridat di Kòrsou. E persepshon ta ku no a manehá e epidemianan anterior bon, e informashon negativo di medionan di komunikashon pa ku gobièrnu/ sistema di salubridat, problemanan ku lugánan di tira shushi ilegal i e sintimentu di desapunto (gobièrnu no ta kumpli ku su promesanan) ta faktornan ku ta reforsá e deskonfiansa ku e komunidat tin pa ku gobièrnu/sistema di salubridat. Den nos investigashon konfiansa ta un komponente ku ta hunga un ròl hopi importante den kambio di komportashon. Mester pone mas atenshon na e komponente akí pa asina por mehorá partisipashon di komunidat den e maneho pa kombatí sangura.

Nos a resumí e resultadonan di mas importante den **kapítulo ocho.** Den kapítulo ocho ta menshoná tambe puntonan di diskushon/atenshon i perspektiva pa den futuro.

Konklushon

Tur e estudionan presentá den e tésis akí **(kapítulo dos te ku shete)** ta ofresé e lesadó informashon pa por komprondé e retonan pa ku kontròl di sangura (*Aedes*) na Kòrsou holístikamente. Nos resultadonan ta indiká e relevansia di komunikashon di riesgo, skemanan kultural, i “heuristiek” den prevenshon i kontròl di malesanan. E informashon akí ta importante i kreadónan di maneho, ku ta traha den e área di prevenshon i kontròl di sangura por uzé. Ademas e resultadonan i rekomendashonnan lo por aportá na desaroyo di strategianan pa kombatí sangura na Kòrsou. E epidemianan ku Kòrsou a eksperensiá den pasado ta pone énfasis riba e importansia pa kambia e maneho pa kontrolá sangura. Un programa ku ta inkorporá diferente strategia i ku ta enfoká riba partisipashon di komunidat den prevenshon i kontròl di sangura por ta e solushon pa prevení i kombatí futuro epidemianan di malesanan ku sangura ta transmití. Ku bista riba esaki nos ta enfatisá ku ta nesesario pa tene kuenta i solushoná e bareranan ku e sistema di salubridat di Kòrsou ta eksperensiá. Pasobra e bareranan akí lo sigui stroba komunikashon di riesgo, preparashon i prestashon di e sistema di salubridat.

List of publications

Mulderij-Jansen, V., Elsinga, J., Gerstenbluth, I., Duits, A., Tami, A., & Bailey, A. (2020). Understanding risk communication for prevention and control of vector-borne diseases: A mixed-method study in Curaçao. PLoS neglected tropical diseases, 14(4), e0008136. https://doi.org/10.1371/journal.pntd.0008136

van Goudoever, M. J. F., **Mulderij-Jansen, V. I. C**., Duits, A. J., Tami, A., Gerstenbluth, I. I., & Bailey, A. (2021). The Impact of Health Risk Communication: A Study on the Dengue, Chikungunya, and Zika Epidemics in Curaçao, Analysed by the Social Amplification of Risk Framework (SARF). Qualitative *Health Research*. https://doi.org/10.1177/10497323211007815

Mulderij-Jansen, V., Gerstenbluth, I., Duits, A., Tami, A., & Bailey, A. (2021). Evaluating and strengthening the health system of Curaçao to improve its performance for future outbreaks of vector-borne diseases. Parasites & vectors, 14(1), 500. https://doi.org/10.1186/s13071- 021-05011-x

Mulderij-Jansen, V., Pundir, P., Grillet, M.E., Lakiang, T., Gerstenbluth, I., Duits, A., Tami, A., & Bailey, A. (2022). Effectiveness of *Aedes*-borne infectious disease control in Latin America and the Caribbean region: A scoping review. PLoS ONE, 17(11), e0277038. https://doi.org/10.1371/journal.pone.0277038

Under review

Mulderij-Jansen, V., Gerstenbluth, I., Duits, A., Tami, A., & Bailey, A. (2023). Contexts motivating protective behaviours related to *Aedes*-borne infectious diseases in Curaçao. BMC Public Health.

List of conference presentations

Understanding risk communication, health system preparedness and performance during the last three epidemics of *Aedes*-borne infection diseases. Presentation at the International Health Regulation Conference 2019, June 3rd-7th, Willemstad, Curaçao.

The importance of risk communication for the control of vector-borne diseases. Presentation at the 6th Microbes in Health & Disease Science day 2019, November 12th, Groningen, the Netherlands.

Evaluating and Strengthening the Health System of Curaçao to Improve its Performance for Future Outbreaks. Poster presentation at the Dutch Caribbean Research Week 2021, June 14th – 18th. (Online)

Understanding risk communication for prevention and control of vector-borne diseases. Poster presentation at the 44th Annual Conference of the Society for Caribbean Studies 2021, July 6th – 10th. (Online)

Preparedness and performance of the health system of Curaçao during the last three epidemics of *Aedes*-borne infection diseases. Presentation at the Klinische Conferentie NASKHO 2022, May 4th, Willemstad, Curaçao.

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Curriculum vitae

Vaitiare Isaudrey Cerila was born on July 7th 1992, in Willemstad, Curaçao. In 2010, she finished secondary school at Peter Stuyvesant College. In September 2010, she started studying Nutrition and Dietetics at HAN University of Applied Science. She obtained her Bachelor of Science (BSc) degree in September 2014. Afterwards, she started with the research master Nutrition and Health at Wageningen University of Research (WUR). For her first master thesis, she researched the association between coffee consumption and cardiometabolic disease in dutch older men (The Zutphen Elderly Study). For her second master thesis, she performed a trend analysis for the Ministry of Health in Curaçao to determine the trend of underweight and overweight among children (Baseline Study Overweight Cohort 2004). After finishing her master's theses, she obtained her Master of Science (MSc) degree in October 2016. From August 2016 to January 2018, she worked as a clinical dietitian at the Antillean Adventist Hospital. In January 2018, she started as a PhD candidate at the University Medical Center Groningen (UMCG), Department of Medical Microbiology and Infection Prevention, under Prof. dr. A.W. Alex Friedrich, Prof. dr. Ashley Duits, Prof. dr. Ajay Bailey, dr. Adriana Tami and medical doctor/epidemiologist drs. Izzy Gerstenbluth. During her PhD journey, she researched health system performance and preparedness, risk communication, social amplification of risk, and concepts influencing preventive behaviour in the context of *Aedes*- borne diseases. Almost all her research has been submitted/ published in peer-reviewed international (QI) journals. Besides, she participated in international conferences such as the 44th Annual Society for Caribbean Studies Conference. In 2020, she helped the Department of Epidemiology and Research of the Ministry of the health of Curaçao during the second COVID-19 wave. Currently, she is working on two projects: (i) a risk communication roadmap in collaboration with the Communication Department of the Government of Curaçao, and (ii) a policy for the Ministry of the health, Environment, and Nature to reorganise mosquito control in Curaçao. In 2022, she worked as a clinical dietitian at the Gelre Ziekenhuizen. In April 2023, she will start a new position as a post-doctoral researcher at the UMCG. Her Post-doc research focuses on the decision-making processes of general practitioners and patients regarding antibiotic prescriptions for respiratory infections in the Netherlands and Germany.