

The unbearable lightness of technocratic efforts at dengue control

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Summary

OBJECTIVE To identify key elements that should provide an added value and assure sustainable effects of the deployment of technical tools for *Aedes aegypti* control.

METHODS An observational study was conducted between April 2001 and March 2002 in 30 blocks (1574 houses) in the central zone of Guantánamo city. A trial that combined two complementary technical interventions, the distribution of new ground level water tanks and the intensive use of insecticide, was nested in May 2001. Another 30 blocks (1535 houses) were selected as control area. We assessed community perceptions and household risk behaviour at baseline and after 9 months, and measured the trial's impact through entomological indices.

RESULTS Perceived self efficacy to solve *A. aegypti* infestation and prevent dengue was not modified. We found no changes in behaviour. In the study area the container indices decreased significantly from 0.7% before to 0.1% 1 month after the intervention. Six months later, they had increased to 2.7% and uncovered new water tanks constituted 75.9% of all breeding sites. Over the 9 months after the trial the average monthly house indices were similar in the study and control areas. A technical approach and lack of community involvement in the trial's implementation were the main causes of these short-lived results.

CONCLUSIONS Top-down deployment of technical tools without active involvement of the community has a temporary effect and does not lead to the behavioural changes necessary for sustainable *A. aegypti* control.

keywords *Aedes aegypti*, dengue, control tools, behavioural change, community participation, top-down intervention, Cuba

Introduction

Dengue and dengue haemorrhagic fever (DHF/DSS), the severe form of the disease, present a major and escalating global public health problem. More than 40% of the world's population (2.5 billion people) live in countries endemic for dengue and are at risk of infection. It was estimated that there are annually, 50 million cases of dengue fever (DF) worldwide and more than 500 000 cases of DHF/DSS requiring hospitalization (Guzman & Kouri 2003).

Prevention of DF/DHF essentially relies on control of the principal vector, *Aedes aegypti*, and on reduction of human-vector contact. There is no specific antiviral treatment and while a vaccine against the four dengue serotypes is currently under development, a licensed one is still several years away (Renganathan *et al.* 2003). Tools for

vector control (insecticides, biological agents, repellents and environmental management) are efficacious, but seem unsustainable due to their cost, lack of government investment or limited community involvement in their implementation (Gratz 1991). The ongoing search for new vector control tools has led to some promising efficacy results (Kroeger & Nathan 2006), but their effectiveness remains to be demonstrated.

Some countries, Cuba and Singapore in particular, have successfully controlled dengue with vertically managed programmes and systematic chemical elimination of *A. aegypti* larval habitats (Gubler & Clark 1996). Notwithstanding, human behaviour, influenced by social, cultural, economic and political factors (Townson *et al.* 2005), strongly determines the risk of dengue infection due to the close man-vector relationship. Therefore, promoting behavioural change through community interventions is

considered the more effective approach to *A. aegypti* control (Nathan & Knudsen 1991; Parks & Lloyd 2004). But this strategy is hampered by context-dependent complexities (Kroeger & Nathan 2006): maintaining the effects of community-based dengue prevention depends on the level of political commitment, on public health and routine vector control programme organization, on the degree of intersectoral coordination and on the approach taken towards community involvement (Parks & Lloyd 2004).

In 2001, an *Aedes* control trial in Guantanamo city, Cuba, combined two complementary technical interventions, the replacement of defective water tanks and intensive use of insecticides. While the residual effect of insecticides were short-lived (1–3 months), concomitant distribution of new water tanks were expected to have a more lasting impact on *A.* infestation levels. We evaluated the entomological impact up to 9 months after the intervention, determined the effects on the community's perception and risk behaviour and assessed the influence of the trial design and implementation process on these medium-term results.

Methods

Context

Guantanamo city is located at the western end of Cuba and has approximately 243 000 inhabitants. The average temperature oscillates between 30 and 32 °C and rainfall is concentrated in a short wet season from April to July. The municipality of Guantanamo, together with Santiago de Cuba and Havana, has the highest *A. aegypti* infestation levels in the country, with house indices reaching nearly 5% in September 2000. This can be attributed to a deficient water supply, the use of containers for water storage (many in poor conditions or without covers), deficient entomological surveillance, lack of adequate environmental management and limited context-dependent community involvement in vector control. Occasional dengue outbreaks were reported in this municipality in 1981 and 2003 (Kouri *et al.* 1989; Guzman *et al.* 2006).

The routine *A. aegypti* control programme is vertically organized, but some decentralized decision making is possible at the health area level, in accordance with local characteristics and the entomological situation. Standard control activities carried out by the programme's vector control workers comprise entomological surveillance, source reduction through periodic inspection of houses, larviciding (with temephos) of water-holding containers (including those used for domestic water storage), selective adulticiding (cipermetrin and clorpiriphos) when *A. aegypti* foci are detected, health education and enforcement of mosquito control legislation through the use of fines.

Study design and data collection

We conducted an observational study between April 2001 and March 2002. In the central zone of Guantanamo city, 30 blocks (totalling 1574 houses), where the highest *A. aegypti* infestation levels had been reported over the last 5 years were selected as study area. A trial that used technical interventions to control the vector was nested in this observational study in May 2001. Thirty blocks (1535 houses) were randomly selected as control in the same city zone.

The observational study

In April 2001, 200 houses were randomly selected in the study area to explore community perceptions and risk behaviours related to *A. aegypti* infestation. In each household an adult was interviewed with a semi structured questionnaire exploring the four dimensions of the Health Belief Model (susceptibility, seriousness, barriers perceived and self efficacy) (Soto *et al.* 2000) and the determinants of risk behaviour. An observation guide included the household behaviours concerning protection of artificial containers and covering of water storage containers. The perceptions of health workers and key decision makers from different sectors on the determinants of *A. aegypti* infestation and on the role of each social actor in vector control were explored through two group discussions with 27 participants (nearly all persons active in the various multisectorial groups) (Toledo Romani *et al.* 2007).

In February/March 2002, after the nested vector control trial described below, we revisited the study area to evaluate changes in the community's perceptions and in risk behaviours. We used the same tools as before in 200 other randomly selected households. In March 2002, all households where new tanks had been distributed were revisited to verify their presence and condition.

We studied the process of trial implementation by documental review of the project proposal, work plans, reports of capacity building, technical reports and routine economic reports of the vector control programme. Satisfaction of social actors (purposively selected among community-members and health providers) with the trial implementation and outcome was assessed using 25 in-depth interviews.

To appraise the overall influence of the trial at the household, community and organizational levels, a group was constituted of all 19 experts (in entomology, biology, epidemiology and clinical practice) of the provincial Ministry of Health team. The Expert Group received the collected evidence for preliminary individual perusal. The domains of influence to consider at each level were

suggested. Subsequently their findings and conclusions were presented and discussed in two plenary sessions until reaching a consensus.

Throughout the study period standard vector control activities were executed as described above and routine entomological data were collected in all houses of the study area by the provincial epidemiological surveillance and vector control units.

Nested trial

The entomological infestation of the important breeding sites and the conditions of the water storage containers were assessed in the 30 study blocks. Based on this information the technical intervention was determined and vector control workers were trained on technical issues.

During a community meeting convened by family doctors and community leaders, the objectives of the trial were explained to the population. Early May 2001, 2500 new 320-l plastic water storage tanks with a protective removable cover with click mechanism were distributed to all households of the trial blocks where defective tanks had been found. Within a week vector campaign workers visited these houses to remove old tanks and to briefly instruct every household on the need for permanent covering of the new ones. Subsequently, chemicals were applied for 1 month in the form of perifocal treatment (biweekly) with Solfac 10 WP (Cyfluthrin), indoor residual spraying (biweekly) with Responsar IC 12.5%, and spatial spraying (twice a week) with Solfac EW 0.50 (by portative sprayer) and Solfac UV (by thermal fogger) respectively.

Cross-sectional entomological follow-up was conducted 15 days and 1, 2, 3, 6 and 9 months after the intervention through house inspection as recommended by PAHO (1994). In the 30 control blocks routine vector control activities continued to be conducted as described in the section 'Context'. After the trial month, routine entomological surveillance proceeded similarly in the intervention and control areas and each house was visited by vector control workers every 11th day to search for breeding sites and destroy *Aedes foci*.

Data analysis

The items of the household questionnaire and of the observation guide were analysed quantitatively with spss 9.0 or qualitatively with N6 software. All dimensions of the Health Belief Model were dichotomised. We used the chi-squared test or Fisher exact test when indicated to determine statistical significance and calculated 95% confidence intervals for the differences in proportions. Qualitative information on the determinants of behav-

ours was coded and an overall thematic analysis provided the most frequent verbatim. The verbatim referred in italics coincide with the most frequent opinions.

In the study area, the absolute frequency of containers with *A. aegypti* immature stages (positive containers) and the container index (CI: number of containers with *A. aegypti* larvae/ number of wet containers inspected \times 100%) were calculated at the time intervals around the trial period specified above. Monthly house indices (HI: number of houses with *A. aegypti* larvae/ number of inspected houses \times 100%) were calculated for the years 2000 and 2001 in both study and control area.

The baseline data on health providers and decision makers' perceptions of determinants of *A. aegypti* infestation were analysed using the Structural Analysis method (Arcade *et al.* 1994). All factors identified were classified by the group of 19 experts as internal (under control of health services) or external (related to the environment and/or controlled by other multisectoral action). The mutual influence (I) and dependence (D) of all these factors was graded as very strong, strong, moderate, weak or very weak. The relationship between all factors (influence/dependence) was visualized using a perception graph or structural matrix. Each variable was visualized in the shape of a point identified by its sequential number. The establishment of four quadrants determined by the mean of influence (MI) and dependence (MD) permitted to place them in four frames:

- (1) North-west frame – determinant or 'influencer' variables, which are very influential and little dependent.
- (2) North-east frame – relay variables which are simultaneously very influential and very dependent, and by nature factors of instability since any action on them has consequences on the other variables in case certain conditions on other influential variables are met.
- (3) South-west frame – autonomous or excluded variables, which are both little influential and little dependent.
- (4) South-east frame – depending, or rather, result variables. These variables are simultaneously little influential and very dependent.

A content analysis of the documental review (Patton, 2001) was used by the authors who were not directly participating in the implementation of the nested trial, to rebuild the implementation process of the trial.

Multi criteria evaluation (Sigrid 2003) permitted analysis of the evidence, provided by the Expert Group, on the overall influence of the intervention at different levels (family, community and organizational level). An influence score of zero to three was assigned to each domain of influence (0: none; +/-: weak; +: moderate; ++: strong).

Ethical clearance

The study was approved by the ethical committee of the Institute of Tropical Medicine Pedro Kouri, Cuba, and by the national health authorities. During the meeting convened by family doctors and community leaders, the community's consent for the trial was obtained. Approval for the interviews was obtained at the start of the visit to each selected household.

Results*Changes in community perception and risk behaviour*

The proportion of households that perceived their susceptibility for dengue had significantly increased after the trial ($P < 0.01$), but perception of barriers related to vector control activities and appreciation of self efficacy to solve problems related with *Aedes* infestation was not modified (Table 1). Post-trial 79% still believed that the health system was solely responsible for *A. aegypti* control and only a minority identified community action as an important contribution.

We did not find any evidence for changes in risk behaviour following the trial (Table 2). 33.5% of the population still opposed vector control activities because 'chemicals could affect their health', 'abate gives a bad taste to water and fails to eliminate mosquito's eggs', 'visiting hours of control workers are inconvenient' or 'the work is of poor quality'. 13.5% of containers remained uncovered and 42.5% were incorrectly covered. The main reasons mentioned were 'it's a lot of work to uncover the container every time you need water' and 'we keep it uncovered during the day and put the lid on at night so that insects don't fall in'. By March 2002, 17.8% of the new water storage tanks distributed to 73.2% of households in May 2001 were reported 'lost'; 1% were 'broken'.

Table 1 Pre- and post-trial community perceptions of 200 households according to the four dimensions of the 'Health Belief Model'. Guantánamo study area, 2001–2002

Dimensions	Pre-trial		Post-trial		Difference		<i>P</i> -value
	<i>n</i>	%	<i>n</i>	%	%	95% CI	
Susceptibility perceived	180	90.0	193	96.5	6.5	1.6;11.3	0.02
Seriousness perceived	194	97.0	198	99.0	2.0	-0.7;4.7	0.28
Barriers perceived	176	88.0	180	90.0	2.0	-4.1;8.1	0.63
Self efficacy perceived	38	19.0	42	21.0	2.0	-5.8;9.8	0.70

Table 2 Pre- and post-trial risk behaviour at household level ($n = 200$). Guantánamo, study area, 2001–2002.

Risk behaviour in households	Pre-trial		Post-trial		Difference		<i>P</i> -value
	<i>n</i>	%	<i>n</i>	%	%	95% CI	
Non-acceptance of vector control activities	73	36.3	67	33.5	-0.3	-12.3;6.3	0.60
Unprotected artificial containers	43	21.5	36	18.0	-3.5	-11.3;4.3	0.45
Water storage containers							0.36
Uncovered	32	16.0	27	13.5	-2.5	-9.4;4.4	
Badly covered	93	46.5	85	42.5	-4.0	-13.7;5.7	
Well covered	74	37.0	88	44.0	7.0	-2.5;16.5	

Short and medium term impact of the trial

One month before the start of the trial, the Container Index (CI) in the study area was 0.7% and the main breeding sites (>70%) were low water storage tanks (Figure 1). Fifteen days after the last insecticide application, the trial area was *A. aegypti* free. However, the CI began to rise again one month post-intervention; the two containers then found positive were new tanks. After 9 months, the number of positive containers were three times as high as before. Distributed new water tanks with protective covers constituted 75.9% of all breeding sites.

Figure 2 shows the evolution of the monthly house indices (HI) in the study and control area in 2000 and 2001. Globally, HI seasonal fluctuations were similar in both areas, before as well as after the trial. In fact, its effect can hardly be discerned; both areas attained a comparable seasonal peak in the months following the trial.

Trial design and process of implementation

The design of the trial and the choice of control tools took into account technical criteria and entomological baseline data, which showed that low water tanks in poor condition were commonly infested with *A. aegypti* larvae and constituted the most important breeding sites. Still, other important determinants of *A. aegypti* infestation had been identified by health workers and decision makers of different sectors (Figure 3). Influential internal factors were related, among others, to difficulties at the organizational level (training and fluctuation of labour force, indiscipline at work). Neither these nor other external relevant factors, such as environmental management, had been addressed during the trial implementation. The community was not

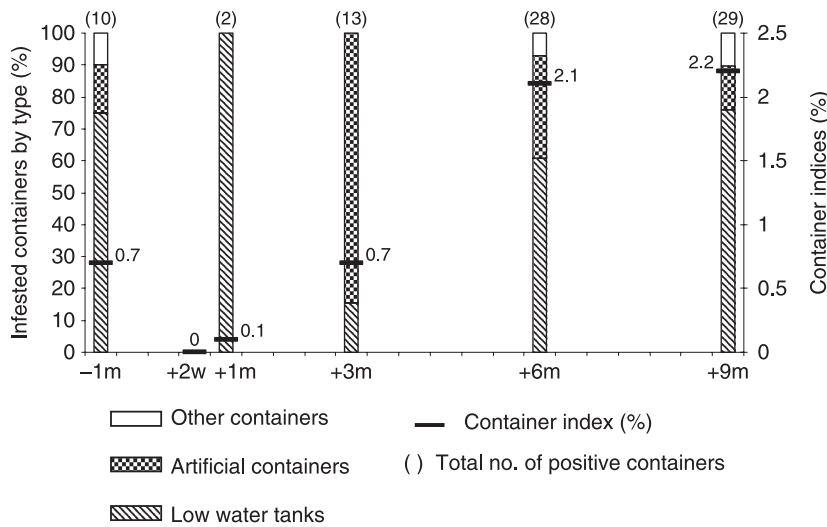


Figure 1 Infested containers by type (%) and container indices (%) before and up to 9 months after the trial. Guantanamo, study area, April 2001–February 2002.

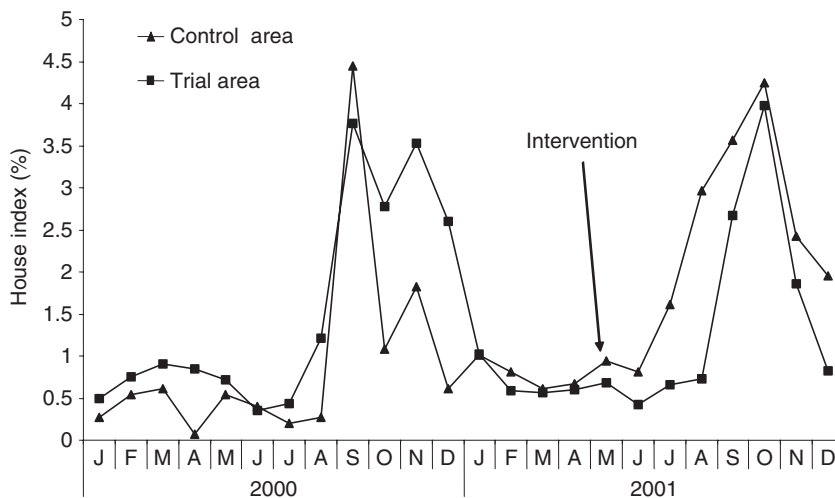


Figure 2 Average House Index (%) by month in the trial and control areas. Guantanamo 2000–2001.

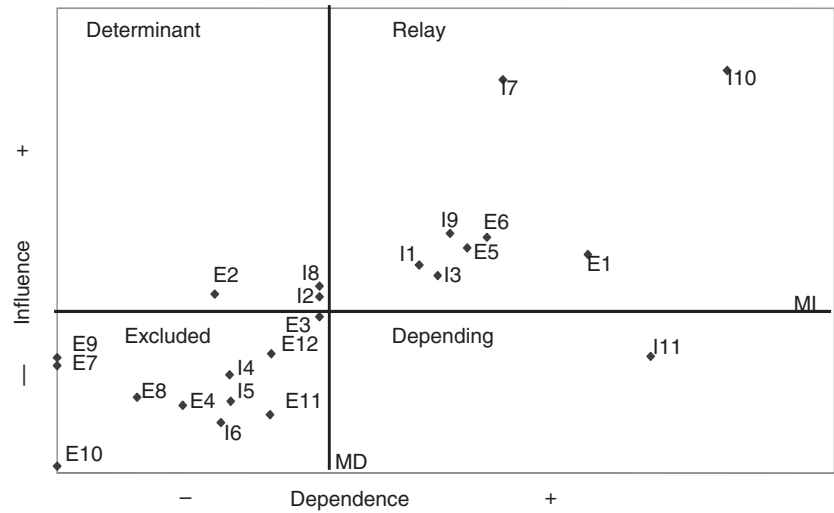
involved at all in the identification of problems or in the design of the intervention.

The following positions prevailed at the planning stage: the health sector considered itself to be in charge of vector control, local government authorities felt that they were responsible for environmental management and community organizations and mass media were seen as instruments for community mobilization. Communities were perceived to be producers of the conditions that allow *A. aegypti* to thrive and it was not considered that ‘communities themselves must be involved in environmental risk reduction’. According to these perceptions the roles and responsibilities of each actor in the trial were defined. Vector campaign workers carried out all *Aedes*

control activities and the local government and the community organizations participated in the substitution of the low water tanks. The community itself was a passive recipient during the whole implementation process.

Trial effect at household, community and organizational (vector control programme) level

After appraisal of the available evidence the group of 19 experts concluded that the trial mainly had an influence at the organizational level (Table 3). Capacity was built through pre-trial training, equipment was acquired and the job satisfaction of workers had increased. The impact at the community level was weak at best. The community had



Internal factors

- I1 . Training of field workers.
- I2 . Fluctuation of labour force.
- I3 . Ability to conduct health education activities.
- I4 . Role of family doctors and nurses.
- I5 . Integration with Primary Health Care services.
- I6 . Incentives for field workers.
- I7 . Quality of work of vector campaign workers.
- I8 . Indiscipline at work.
- I9 . Dispersion and seasonal fluctuation of vector.
- I10 . Timing of foci control activities.
- I11 . Organization of entomological surveillance system.

External factors

- E1 . Environmental management.
- E2 . Availability of insecticide.
- E3 . Quality of insecticide.
- E4 . Water supply for communities.
- E5 . Community participation.
- E6 . Availability of protected water storage containers.
- E7 . Political will.
- E8 . Availability of tools for entomological surveillance.
- E9 . Legislation and fines.
- E10 . Transportation.
- E11 . Equipment for insecticide spraying.
- E12 . Availability of entomological diagnostic tools.

Figure 3 Structural analysis of health workers' and decision makers' perceptions of determinants of *Aedes aegypti* infestation. Guantanamo, 2001.

Table 3 Expert assessment of the influence of the trial at organizational, community and household level. Guantanamo 2002

Levels	Domain of influence	Influence	Source of evidence
Organizational	Capacity building	++	Documental review
	Decrease of financial cost	+/-	Routine economic information
Community	Satisfaction	++	In-depth interviews
	Capacity building	+/-	Documental review
	Community involvement	+/-	Documental review
Household	Environmental changes	+/-	Monitoring of changes
	Satisfaction of felt needs	+/-	Semi-structured questionnaires
	Behavioural changes	0	Direct observation
	(Peri)domestic environmental changes	+	Direct observations

O, none; +/-, weak; +, moderate; ++, strong.

not been actively involved and no local capacities for future vector control activities were developed. The trial did not result in any appreciable environmental change. Beyond the substitution of defective water containers there were no

(peri) domestic environmental effects. Since substitution of tanks was not perceived as a priority by the people, satisfaction of felt needs at the household level was low. The influence on behaviour was nil.

Discussion

This study confirms in an area with relatively low entomological indices previously observed short-lived effect of the use of insecticides on *A. aegypti* infestation (Gubler & Clark 1996; Castle *et al.* 1999; Spiegel *et al.* 2005). The main finding, however, is that (concomitant) top-down substitution of defective water storage containers – however, efficacious from a technocratic *a priori* point of view – does not ensure a sustained impact on entomological indices without an accompanying strategy for achieving behavioural change.

Reports from various countries indicate that vertical *A. aegypti* control activities are not sustainable (Nathan & Knudsen 1991; Winch *et al.* 1992; Rosenbaum *et al.* 1995) and that isolated vector control initiatives do not promote behavioural change (Castle *et al.* 1999; Parks & Lloyd 2004). Kay and Vu (2005) suggested that sustained chemical control efforts coupled with active community participation in source reduction and environmental management are probably the most effective venue to prevent dengue epidemics. Our findings corroborate the importance of behavioural changes and the need to actively implicate the community in the design and implementation of strategies to control *A. aegypti*. More generally, Shediac-Rizkallah and Bone (1998) and recently Pluye *et al.* (2005) have identified key project design and implementation factors that influence the sustainability of health interventions. They comprise the availability of sufficient financial and human resources, the pre-implementation negotiation process, the appropriation of the project, and the perception of effectiveness. These are precisely the factors that we used to appraise the process of design and implementation of the trial in Guantanamo and to explain its effects.

As for negotiation, from the perspective of the vector control programme, the strategy and the objectives of the trial were discussed during the planning phase with all partners involved. The activities were incorporated into the provincial vector control programme's plan of action and resources were set aside for institutional capacity building and for the distribution of new water tanks in the community. According to health workers and decision makers, the intervention also had an important impact at the organizational level.

However, the picture is quite different from the community and household perspective. Grass root actors were not invited to a joint analysis of needs and search for solutions, and none of available resources were allocated to build local capacities for the promotion of behavioural change. This could explain why so many new tanks were 'lost' or 'broken', while it would be expected that they are a direct benefit to the communities. Winch *et al.* (1992),

Bermejo and Bekui (1993) and Rosenbaum *et al.* (1995) have shown that technical interventions limit the perceived self efficacy of the community and reinforce the belief that the government is responsible for the vector control.

According to Bracht *et al.* (1994), also supported by Shediac-Rizkallah and Bone (1998), the perception of effectiveness by all partners involved in a control effort is an important determinant of its success and sustainability. The control programme workers in the present trial were quite aware of the short term effect of the intensive use of insecticides as well as of the community's perception of nuisance and intrusions associated with routine vector control programme activities. On the other hand, the community did not feel that the control programme became more efficacious or that the tanks prevented *Aedes* infestation. As Jackson *et al.* (1994) have demonstrated in an experiment on cardiovascular disease prevention, it is necessary to invest time and resources to train local actors to eliminate 'perceived barriers' and to guarantee continuity of programme activities.

We also need to take into account that vector control programmes do not function in a vacuum and to consider the larger political, economic and social environment. The Cuban government has demonstrated strong political commitment to health development despite the limited financial resources available to the country and the economical blockade imposed by US (Kuntz 1994; DeVos 2005). The present trial, as well as other pilot initiatives in the country (Sanchez *et al.* 2005; Spiegel *et al.* 2007; Toledo Romani *et al.* 2007) received all necessary financial and human support from the government, which has also been remarkably successful in dengue prevention (Gubler & Clark 1996). Global changes in dengue epidemiology and local environmental threats nevertheless constitute increasing challenges for *Aedes* control.

Community participation is being increasingly hailed as the only way forward to achieve sustainable dengue prevention and *A. aegypti* control (Parks *et al.* 2004; Kroeger *et al.* 1995). This study unequivocally demonstrates the need for community involvement. Notwithstanding, effective intersectoral coordination that guarantees, among others, reliable minimal water supply and adequate waste management, seems equally essential (Sanchez *et al.* 2005; Toledo Romani *et al.* 2007). Strengthening the delivery of essential public services while deploying specific vector control tools could leverage the much needed behavioural change at individual level. How to harmonize meso-level action with micro-level technological innovation and how to embed this in community centered strategies remain largely unanswered questions, even at pilot project level. How to scale up such pilot

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strategies – if successful – given the limited resources of governments in endemic regions is still another question. While awaiting answers, purely technocratic initiatives towards *A. aegypti* control that do not actively involve the community ought to be discouraged.

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