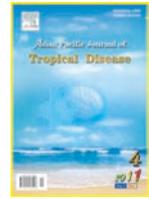




Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Disease

journal homepage: www.elsevier.com/locate/apjtd

Document heading doi:10.1016/S2222-1808(11)60063-7

Application of mosquito-proof water containers in the reduction of dengue mosquito population in a dengue endemic province of Vietnam

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ARTICLE INFO

Article history:

Received 15 September 2011
 Received in revised form 5 October 2011
 Accepted 28 October 2011
 Available online 28 December 2011

Keywords:

Mosquito-proof
 Water containers
 Reduction dengue mosquito
 Dengue
Aedes aegypti
Aedes larvae
 Rain collection
 Tank
 Jar
 Mosquito breeding sites
 Vietnam

ABSTRACT

Objective: To evaluate the application of dengue mosquito-proof water containers in the reduction of dengue mosquito population (both adult and larvae) and the acceptance and satisfaction of community in new containers usage. **Methods:** A community intervention was carried out from July–2008 to October–2009 in Dong Thanh commune, Can Giuoc district, Long An province, Vietnam. A cluster of 100 households that has a relative separate position from surrounding areas were supplied with mosquito-proof water containers, every household with two containers installed under the roof-gutters; and another cluster of households in another hamlet of the same commune used normal water containers. Evaluation of the changes in *Aedes aegypti* (*A. aegypti*) population and usage of new water containers were conducted quarterly. Assessment of the acceptance and satisfaction of community was done by the end of the project. **Results:** The number of larvae per concrete tank in the intervention area were lower than those in the control area in most survey rounds with statistic significance in the first, second and fourth surveys ($P < 0.05$). The number of larvae per new tank were lower than those per jars in the intervention site with statistic significance from the second to fifth surveys ($P < 0.01$, $P < 0.001$, $P < 0.01$ and $P < 0.05$ respectively). However, with the presence of old containers, vector indices did not change in the intervention area. More than 94 percent households kept their containers tightly covered with two nets and used their new containers by taps in all the survey rounds. Average of times of cleaning new water containers during three months were small, changing from 0.40 to 0.80 times. Number of old jars decreased regularly from means of 5.3 to 2.24 by survey rounds and the number in the fifth survey were statistically lower than in the second survey ($P < 0.001$). 100 percent households accepted the new containers and 96 percent households said they had ability to repair a broken nets/tapa or their materials. **Conclusions:** New containers prevented the development of *A. aegypti* mosquitos better than the same normal concrete containers and jars with statistic significance. Most households accepted, satisfied and used new containers in correct way and they could maintain new containers by themselves. However, the continuance of use of old water containers affected on the entomological indices.

1. Introduction

Vietnam is endemic for dengue, with morbidity per thousand changing from 0.3 in 2002 to 0.9 in 2006, and mortality per 100 thousand changing from 0.06 in 2002 to 0.08 in 2006[1]. Long An has been endemic with dengue with 2670 cases infected in 2004, mostly in Can Giuoc district[2].

For dengue control, there were studies about breeding sites of *Aedes* mosquito and their role in the transmission. Water containers were risk factor of mosquito larvae [effective rate (RR) 1.64; 95% confidence interval (CI) (1.02–2.62)][3]. In a study of dengue high-risk areas in Cambodia, *Aedes* pupae were found mostly from large concrete water storage jars (in 16 230 jars; with rate of 76.1% of all containers) or concrete water storage tanks (in 2819 tanks; with rate of 13.2% of all cotainers)[4]; Another study in Nha Trang City, Vietnam, containers discarded outdoors, wells, large plastic buckets, jars, and concrete toilet basins in the premises [adjusted odds ratios (aORs) = 63.3, 23.3, 22.5, 6.6, and 5.6, respectively] was significantly

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Foundation Project: This work was financially supported by WHO Special Programme for Research and Training in Tropical Diseases.

associated with repeated infestation (aOR = 6.1)[5]. Outdoor water containers were also found as the most productive vector breeding sites in a multicountry study in urban and periurban Asia[6]; Tires and canvas presented the highest positive rates for *Aedes aegypti* (*A. aegypti*), drains and other containers fixed to the buildings were highly predominant among positive containers; 32 to 76% of the positive containers in the 4 study strata. Public areas of apartment buildings and large non-residential premises presented the highest positive rates for *A. Aegypti*. Infestation levels were greater in residential areas with predominance of apartment buildings, where 76% of the breeding sites detected were containers fixed to the buildings[7]; *A. aegypti* were often found in water storage containers used by households without tap water supply[8].

Because there have been no vaccine applied, dengue control mostly depends on vector control especially larvae reduction due to high cost for adult mosquito control.

In recent year besides using of chemical agents such as abate[9], long-lasting insecticidal netting[10], or bioagents such as *Bacillus thuringiensis*[11], larvivorous fish[12], and mesocyclops or combination of many agents[13–16]. Other studies were conducted on improving the design of water containers. A long-term use of nylon net decreased female adult population density when both tanks and metal drums were covered[17], fine nets distributed to the farmers in southern Taiwan to cover their buckets reduced vector breeding sites[18].

The guidelines of dengue control of the World Health Organization suggest community to use mosquito-proof containers (Figure 1) supported by nets with small-size holes and taps[19].

It was the aim of this study to evaluate the changes in *A. aegypti* population (both adult and larvae) and to assess the acceptance and satisfaction of community towards the use of mosquito-proof water containers.

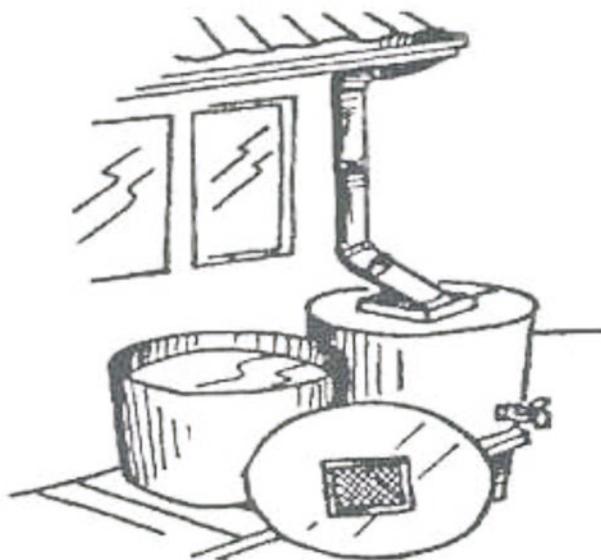


Figure 1. Picture of a container with net in guideline of WHO.

2. Materials and methods

2.1. Study design

This study was a community intervention project conducted in 2 hamlets in Long An province where dengue has been endemic. Trung hamlet served as intervention area and Nam hamlet as control. They have situated 500 meters apart to avoid mosquitoes from flying to the surrounding areas. The study was conducted over a period of 18 months.

2.2. Setting

Trung hamlet is located in Long An province, Can Giuoc district, Dong Thanh commune. The households in this hamlet are along the river banks and rice fields. They get their water sources mainly from rain and rivers during the rainy and dry seasons respectively. Hence, water tanks and jars were popular. This area has also a high incidence of dengue. There, every household was supplied with two new mosquito-proof water containers, and all old containers including jars and old tanks not covered by nets were supplied with insect-proof plastics as covers. Households in the control area used their normal rainwater containers without any support. The containers used in this study were concrete tanks which are favourite in South Vietnam. For long-term use, rust-proof metal nets were applied for this study. People used water by a tap installed on the container wall. Another tap at the bottom of the container will also be fixed in for easy routine cleaning (Figure 2).



Figure 2. Picture of a new container in this study.

2.3. Assessment/ sampling

Evaluation of changes in *A. aegypti* population (both adult and larvae) included comparison of the changes in *A. aegypti* indices between intervention and control areas; and changes in *A. aegypti* density between kinds of water

containers. Indices of HI (House Index: Percentage of houses or premises positive for *Aedes*), DI (Density Index: Average number of *Aedes* caught per house) were used for both larvae and adult; and BI (Breteau Index: Number of positive containers per 100 houses in a specific location), and CI (Container Index: Percentage of water-holding containers positive for *Aedes*) for larvae only. According to the guidelines of dengue surveillance by WHO^[19], the ideal sample size for assessment of *A. aegypti* is 100 households in case of large population. Due to budget limitation, the total

number of households included in the intervention area were only 100 households, hence the sample size for assessment in this study was suitable with 50 households. Households were chosen randomly along a linear transect through the community for each intervention and control areas, respectively^[19]. These surveillance were conducted every 3 months due to change of entomological indices by time and habit of householders about water usage. Entomologists used the standard techniques as described during the routine surveillance in Vietnam.

Table 1

Comparing number of mosquito larvae per water container (any kind) between intervention and control areas.

Survey rounds (SR)	Site	No. of houses investigated	No. of containers investigated	Average number of larvae per container
SR 0	Intervention	50	452	0.98
	Control	50	363	1.07
SR 1	Intervention	50	473	0.42*
	Control	50	408	0.35
SR 2	Intervention	50	472	0.61
	Control	50	462	0.48
SR 3	Intervention	50	437	1.56
	Control	50	485	1.12
SR 4	Intervention	50	462	0.66
	Control	50	455	1.45
SR 5	Intervention	50	518	0.25
	Control	50	451	0.61

*: $P < 0.05$, intervention sites compared with the control.

Table 2

Comparing number of *A. aegypti* larvae in tanks between the intervention and control areas.

Survey round (SR)	Site	Number of tanks Investigated	Average number of larvae per concrete tank	Mean rank
SR 1	Intervention	195	0.00	160.50*
	Control	128	0.07	164.29
SR 2	Intervention	166	0.00	159.00*
	Control	155	0.09	163.14
SR 3	Intervention	181	0.01	177.48
	Control	175	0.78	179.56
SR 4	Intervention	189	0.06	173.39*
	Control	164	0.27	181.16
SR 5	Intervention	187	0.00	170.50
	Control	154	0.07	171.61

*: $P < 0.05$, intervention sites compared with the control.

Table 3

Comparing number of *A. aegypti* larvae between jars and study tanks (new tank) in intervention area.

Survey round (SR)	Water container	Number of containers investigated	Average number of larvae	Mean rank
SR 1	New tank	100	0.00	182.00
	Jar	272	0.58	188.15
SR 2	New tank	100	0.00	188.00**
	Jar	296	0.89	202.05
SR 3	New tank	100	0.00	147.00***
	Jar	225	2.81	170.11
SR 4	New tank	100	0.00	165.00**
	Jar	247	0.46	177.64
SR 5	New tank	100	0.00	203.00*
	Jar	320	0.34	212.84

*: $P < 0.05$; **: $P < 0.01$; ***: $P < 0.001$. New tank group compared with jar group.

Table 4

State of usage of water containers by months and comparing the change of state of usage of water containers between the second and last survey.

State of usage of new water containers		Survey rounds (SR)							
		SR 2		SR 3		SR 4		SR 5	
		N	%	N	%	N	%	N	%
State of nets of new containers	Two tightly covered by net	50	100	50	100	47	94	48	96
	One tightly covered by net	0	0	0	0	3	6	2	4
Way of daily water usage of new containers	By taps	50	100	50	100	50	100	50	100
	Not by taps	0	0	0	0	0	0	0	0
Frequently uncover new containers when cleaning	Yes	23	67.6	8	47.1	15	68.2	12	50
	No	11	32.4	9	52.9	7	31.8	12	50
Times of cleaning new water containers between two surveys	Confident interval	0.68 ± 0.14		0.40 ± 0.18		0.59 ± 0.20		0.80 ± 0.16	
Number of old tanks used	Confident interval	1.40 ± 0.49		1.66 ± 0.53		1.18 ± 0.57		0.88 ± 0.29	
Number of jars	Confident interval	5.30 ± 1.06 ^{***}		4.42 ± 1.29		3.10 ± 0.86		2.24 ± 0.65 ^{***}	
Number of others	Confident interval	0.06 ± 0.06		0.22 ± 0.20		0.26 ± 0.24		0.08 ± 0.06	
Number of old containers have <i>Aedes</i> larvae	Confident interval	0.50 ± 0.20		0.73 ± 0.29		0.56 ± 0.29		0.38 ± 0.14	

N: Number; M–W test: Mann–Whitney test. ***: $P < 0.001$, SR2 compared with SR5.

Assessment of acceptance and satisfaction of community towards the use of new containers included quarterly assessment of the correctly maintenance of the provided containers, usage of other old containers; and interviewing the satisfaction and acceptance of the householders on new containers by the end of this study.

Data were collected and filled in entomological forms and structure questionnaire, described and analyzed by software of SPSS 11.5. Statistic test used were *Chi*-square, or *t*-test and Mann–Whitney tests.

3. Results

3.1 Changes in *Aedes aegypti* population

During 18 months from July 2008 to October 2009, comparison of number of mosquito larvae per water container (any kind) every three months between intervention and control area showed that, average numbers of larvae per container from Survey round 1 (SR 1) to SR 3 were higher in the intervention area, but they had no statistical significant difference except SR 1 ($P < 0.05$). On the contrary, in the surveys of SR 4 and SR 5, those numbers were lower in the intervention area with statistic significant difference in SR 4 ($P = 0.05$) (Table 1).

Without jars, statistic differences became clearer. After the intervention, the average number of larvae per concrete tanks (including old and new containers) in the intervention area were lower than those in the control area in most survey rounds ($P < 0.05$) (Table 2).

In the intervention area, since jars were still used, we compared the number of *A. aegypti* larvae between new containers and the jars there. Results showed that, numbers of *A. aegypti* larvae in jars were statistically higher than

those in study tanks. No mosquito larvae were found during the period of study in the new tanks. ($P < 0.01$ and $P < 0.001$, $P < 0.01$ and $P < 0.05$ respectively) (Table 3).

The differences of vector indices between intervention and control areas were also conducted and compared. With the presence of old containers, vector indices did not change by all survey rounds.

3.2. Acceptance and satisfaction of community towards the use of mosquito-proof water containers

Throughout the period of study, 94 to 100 percent of households kept their containers tightly covered by nets and no new containers were found uncovered. All households used the taps to get water instead of opening the nets in all survey rounds. The average number of times of cleaning new water containers between two survey rounds was less than 1 time and less than 68.2 percent with uncovering new containers when cleaning (Table 4).

Householders continued the usage of old containers, the average number of old containers by kinds did not decreased statistically between the second and the last survey except jars ($P < 0.001$). Likewise, the number of old containers had *Aedes* larvae decreased from SR 3 without statistical significance (Table 4).

4. Discussion

This study demonstrated that a mosquito proof container that was made of concrete materials with tightly fitted net and tap prevented the development of *A. aegypti* larvae and entry of adult mosquitoes in water tanks. This is an important measure especially in Vietnam where water sources are scarce and difficult and water containers are a must in every

household. The results of this study were variable because of the presence of old jars and tanks which are concurrently used along with the new water containers. However, it is noteworthy to say that when the new water containers were compared with jars in the intervention areas, the number of larvae were significantly lower in the new water container. It is therefore recommended that houses should minimize the use of jars. The results of this study was similar to that conducted in southern Taiwan[18].

Most households used the new containers in a correct way all throughout the period of the study because the new container requires low maintenance and cleaning thus, chances for adult mosquito escaping out of the new containers were small. Besides, most of them accepted new containers, and could be sustainable when compared to fish and mesocyclops that need support of collaborators.

However, this study also had some limitation. The sample size was so small, and householders continue to use old containers, which affected on the result.

New water containers with net strongly prevented the development of *A. aegypti* that had key breeding sites in Vietnam such as jars. They were accepted, used in correct way by most of householders, and could be a sustainable measure for dengue vector control.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgements

I would like to acknowledge WHO Special Programme for Research and Training in Tropical Diseases for financial support during research work.

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