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Effect of Existing Practices on Reducing *Aedes aegypti* Pre-adults in Key Breeding Containers in Ho Chi Minh City, Vietnam

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Abstract. This study aimed to evaluate the effects of existing practices of residents in reducing pre-adult *Aedes aegypti* (L.) infestation and to assess the effect of dengue-related knowledge on the practices. A house-to-house survey was conducted in two areas with different socioeconomic status in Ho Chi Minh City between October and November 2007. Some residents in both the areas used covers on the productive containers such as the jars and plastic buckets (i.e., 58% and 81% in the two study areas), and it was effective in reducing *Ae. aegypti* infestation: odds ratio (OR) of 4.0 and 4.9 (95% confidence interval [CI]: 1.49–10.76 and 1.2–19.57, respectively) for the containers with inappropriate covers compared with those with appropriate covers in the two areas, respectively. Appropriate cover use was an effective practice; however, no beneficial role of the knowledge related to dengue in promoting the practice was identified.

INTRODUCTION

Dengue fever (DF) and subsequent potentially lethal shock and/or hemorrhage (DHF/DSS) are rapidly increasing public health problems in > 100 countries. There are an estimated 50–100 million dengue virus infections with 500,000 people being admitted to hospital.[1] Thus far, there is no promising vaccine for the prevention of dengue. To date, reduction in the population density of the vector mosquitoes, predominantly *Aedes aegypti*, has been the only treatment option for controlling the transmission of dengue virus in the human population.[2] The notorious dengue mosquito, namely, *Ae. aegypti*, exclusively feeds on human blood and deposits eggs in a variety of artificial water-holding containers in/around the premises. Vector control activities have mainly targeted the pre-adult *Ae. aegypti* (i.e., larvae or pupae) in their attempts to reduce the vector density, and it has been carried out with the use of biologic agents such as larvivous fish (e.g., *Poecilia reticulate*) and copepods (e.g., *Mesocyclops*), chemical agents such as larvicides (e.g., methoprene, temephos), and adoption of preventive practices by local residents (e.g., use of cover on water storage containers, exchange or clean water in containers, elimination of unnecessary containers).[3] Effective compliance of the residents is essential for the success of all these control methods.

Health education for dengue control has been effective in improving awareness regarding dengue[4–7]; however, the relationship between knowledge and practices and infestation of pre-adult *Ae. aegypti* is unclear. Most knowledge, attitude, and practice (KAP) studies of dengue were descriptive, and few have attempted to find determinants of dengue knowledge, preventive practices, and their effect on vector population with statistical significances.[8–10] To plan for effective dengue control programs, it is important to assess the potential maximal effect of preventive behaviors in reducing the mosquito density for important water-holding containers that generate most of *Ae. aegypti* pre-adults and the extent to which dengue-related knowledge can foster these behaviors. Rapid economic growth and urbanization in developing countries cause a gap in the living standard and socioeconomic status of residents between areas in the same city. Distribution and management of water-holding containers may be influenced by the lifestyle of people and the residential characteristics in each area. Therefore, the distribution of each container type, knowledge of dengue, practices of preventive measures, and their relationship should be confirmed in areas with different socioeconomic status even within the same city.

An entomologic survey and a questionnaire survey were conducted to evaluate the effect of the preventive practices in reducing pre-adult *Ae. aegypti* (i.e., larvae and pupae) infestation in important breeding containers in two areas with different socioeconomic status in Ho Chi Minh City. Furthermore, we examined the effect of dengue-related knowledge on preventive practices.

MATERIALS AND METHODS

Study area. Ho Chi Minh City has a tropical climate with two distinct seasons. The rainy season usually begins in May and ends in late November. The dry season lasts from December to April. Two study areas were selected among those with the highest dengue report and with different socioeconomic status in the No. 8 District in the city. The No. 8 District is 1 of the 19 urban districts in the city and is inhabited by local residents. The Tau Hu canal and the Doi canal that are natural branches of the Saigon River run through the No. 8 District. Almost all the residents in the first study area have uniform residential characteristics in the city. A block of 30–50 residential units was regularly separated by a paved road with a width of ~5–10 m, and these units were linked to a sewage system. Residents in this area used either a tap water system, private wells with pump, or the both as their water sources. On the other hand, most residents in the second study area reside in shanty huts (i.e., overcrowded premises with rusty tin roof), and these huts are built on damp ground along canals or drainages with inadequate sanitation provisions (i.e., sewage from most of these premises was dumped directly into the water). The tap system was installed in all the premises, and no well was used in this area. No premise in either of the study areas used rain or river water for drinking or other purposes. During the survey period, all of the 174 units in the first area (Area A) and 155 units in the second area (Area B) were visited. The two study areas were ~1 km away from each other. The four serotypes of dengue virus circulate in the city and can cause mild to severe manifestation of DF and DHF.[11,12]

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Study design. The survey was carried out between 22 October and 3 November 2007. Two teams comprising four field investigators conducted the survey. Each team included local leaders as guides. Before addressing the interview, informed consent was attained from the head of households or adult participants. The entomologic survey was conducted after the completion of the interview because the entomologic survey might have shown the presence of *Ae. aegypti* breeding sites to people in the premises. Individual visits were followed up at least three times in the event of closed buildings or absence of eligible respondents in the residential premises. Permission to conduct this survey was obtained from the head of the local public health office, the Pasteur Institute in the Ho Chi Minh City Review Board, and the University of Nagasaki at Tropical Medicine Institute Institutional Review Board. Informed consent was obtained from all adult participants and householders before the questionnaire was addressed.

Questionnaire survey. A questionnaire was designed to gather information regarding dengue-related knowledge and demographic status. Before starting the survey, validity of the questionnaire was confirmed by assessing reproducibility of respondent's answers to the same questions at different times and interviewers. The local health staff administered the questionnaire after training in a pilot area. The adult (> 17 years old) female head or the female spouse of the head of the household who was primarily involved in managing the household chores was intentionally interviewed. After obtaining information regarding the demographic status of the respondents, dengue-related knowledge was assessed by questions related to the disease symptoms, route of transmission, potential breeding places for the mosquitoes, and preventive measures for the prevention of diseases. Questions regarding the symptoms, transmission, breeding places, and preventive measures were open questions, and multiple responses were permitted by the respondents. Dengue-related knowledge (symptoms, transmission, mosquito breeding sites, and pre-adult control methods) was coded as 1 for respondents with knowledge and 0 for respondents without knowledge to calculate the knowledge scores. Question regarding preventive measures was addressed at the end of the interview. In addition to the questionnaire survey, socioeconomic status (i.e., ownership of premises belongings, water sources, and housing characteristics) were inspected with a check list.

Entomologic survey. An entomologic survey was conducted to determine the distribution and status of water-holding containers and to assess the presence of pre-adult (i.e., larvae and/or pupae) *Ae. aegypti*. The containers with one or more *Ae. aegypti* larvae and/or pupae were defined as pre-adult positive containers. The *Ae. aegypti* pupal count, rather than the larval count, would be a useful to obtain a more reasonable estimate of the number of adults because of the high survival rate of pupae[13] and the simplicity of identification of the emerged adult species. Recently, the pupal/demographic survey technique has been introduced, and its advantages have been reported.[14–16] Hence, the pupal count was applied to determine important container types in our study areas. All the water-holding containers both indoors and outdoors (including the porch and roof top) were inspected after obtaining the necessary permission from the occupants in the premises. Cover status and size (i.e., height in centimeters) was observed for all the water storage containers such as jars and plastic buckets. Broken or incomplete covers above which the water surface in the containers was visible were recorded as "inappropriately covered." Container categories were based on the former dengue mosquito survey conducted in Vietnam.[17,18] Small containers with a capacity of approximately < 5 L of water were upturned into a white plastic tray containing clean water to collect the pre-adult mosquitoes. Jars, concrete basins, and toilet concrete basins were collected with the quantitative sampling method that estimates the number of pre-adult mosquitoes in the containers.[19] All the collected pupae were kept in small plastic vials; they were subsequently transported to the laboratory. The number of pupae was counted, and the species (i.e., *Ae. aegypti* or others) was confirmed after the adult mosquitoes emerged. Although we did not count the number of larvae, the species was identified for containers with only larvae.

Statistical analysis. Analysis was performed to measure the effect of practices on the infestation of pre-adult *Ae. aegypti* in the premises depending on the study area (i.e., premises located in the underprivileged area or in the standard area). Further analysis was performed to identify the determinants of the container management practices based on logistic regression. Determinants that were found to be significantly associated ($P < 0.15$) with the practices in univariate analysis were selected for multivariate analysis, using forward procedures. In multivariate analysis, we tested statistically significant ($P < 0.05$) interactions between the determinants in the final model and the confounding variables. From the output of the model, adjusted odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated. The data were entered into the Microsoft Office Access 2003 program (Microsoft, Redmond, WA) and analyzed using Stata v 10.0 (Stata Corp, College Station, TX).

RESULTS

Among the 174 premises visited in Area A, 140 premises (80.5%) participated in the study. Among the 155 premises visited in Area B, 132 premises (85.2%) participated in the study. The remaining premises were closed, did not have eligible respondents, or refused to participate in the study. Among the 592 and 452 containers inspected in each area, respectively, flower vases, plastic buckets, and jars were most frequently distributed in both the areas, and these containers also occupied most of pre-adult positive containers (72% and 76% in Areas A and B, respectively). However, most of pupae were collected from jars or plastic buckets (58% and 81% in Area A and B, respectively; Table 1). We found only *Ae. aegypti* in water-holding containers throughout the survey period in our study areas.

Biologic and chemical agents to control pre-adult *Ae. aegypti* were not used by the residents in the study areas; however, some residents used covers on water storage containers such as jars and plastic buckets. No significant difference between the areas was observed in each status of practice on using covers on large (i.e., > 60-cm height) water storage containers such as jars and plastic buckets based on χ^2 analysis of numbers containers in each status of cover ($P = 0.19$; Table 2). Inappropriate cover on the containers increased the risk of the infestation with pre-adult *Ae. aegypti* compared with those with appropriate cover in the two areas (OR: 4.0; 95% CI: 1.49–10.76 in Area A; OR: 4.9, 95% CI: 1.21–19.57 in Area B). No application of cover in the area A significantly increased the risk of the infestation; however, no cover was not associated with significant risk of infestation in Area B (OR: 3.2; 95% CI: 1.36–7.51 in Area A; OR: 2.2; 95% CI: 0.67–6.92 in Area B).

TABLE 1
Number of water-holding containers and presence of pre-adult *Ae. aegypti* by container types in two neighborhoods, Ho Chi Minh City, Vietnam

Container types	Area A			Area B		
	No. of containers	No. of pre-adult positive containers	No. of pupae collected	No. of containers	No. of pre-adult positive containers	No. of pupae collected
Flower vase	167	44	28	205	15	6
Plastic bucket	194	39	80	129	23	71
Jar	103	44	105	62	25	92
Concrete basin	33	14	38	12	3	0
Ant trap	35	12	12	4	4	3
Plastic/metal water supply tank	7	1	0	20	4	15
Discard (artificial)	20	6	9	2	0	0
Toilet concrete basin	11	9	32	9	3	0
Metal drum	11	6	14	1	0	0
Tire	1	1	0	2	2	8
Plant saucer	4	1	0	0	—	—
Artificial pond	1	0	0	1	0	0
Water pool on the roof top	0	—	—	1	0	0
Well	1	0	0	0	—	—
Others	4	0	0	4	4	7
Total	592	177	318	452	83	202

Table 3 shows the demographic characteristics of 272 female respondents in the two study areas. Because we intentionally interviewed the female spouse of household head or adult women > 17 years old, the age of the questionnaire survey respondents ranged between 18 and 87 years, of which 73% were between 18 and 54 years of age. Overall, 8% of respondents had no educational history, 51% had primary level education (1–6 years), and the remainder were educated up to secondary or higher education (> 6 years). There were more respondents with lesser education ($P = 0.004$) and younger age groups ($P = 0.046$) from Area B than those in Area A.

Respondents in Area A had more knowledge related to dengue compared with those residing in Area B (Table 4). More respondents in Area A mentioned at least one appropriate dengue symptom (i.e., fever, rash, nausea/vomiting, head ache, muscular pain, bleeding, joint pain, and shock) compared with those residing in Area B ($P < 0.001$). There was no significant difference between the two areas with regard to the number of respondents who mentioned jars as a mosquito breeding site ($P < 0.77$); however, more respondents in Area A mentioned plastic buckets as breeding site compared with those in Area B ($P < 0.001$). More adult control measures such as bed nets and insecticide spray were mentioned as appropriate dengue control measures compared with pre-adult control measures such as elimination of discarded containers, change stored water frequently, and use of a cover on water storage containers in both areas. More residents in Area A mentioned cover on water storage containers as one of the useful dengue preventive measures ($P = 0.001$). Most respondents in the two areas recognized that dengue is transmitted by mosquito bite (i.e., 91% for the standard area and 88% for the underprivileged area), and the difference was not statistically significant between the two areas ($P = 0.34$).

In univariate analysis, knowledge of symptoms, acknowledgment of cover on containers as a control method, and age of respondents > 44 years old seemed to be important factors in the presence of a cover on jars in the premises ($P < 0.15$); however, they ware not statistically significant in multivariate analysis (Table 5). With regard to the presence of a cover on plastic buckets in the premises, we could not detect any significant relationships with the knowledge of dengue, the demographic status of respondents, and the location of premises in univariate analysis (Table 5).

DISCUSSION

Biological and chemical agents were not used to control pre-adult *Ae. aegypti* in our study areas at all; however, some residents used cover on jars and plastic buckets that were important breeding sites of *Ae. aegypti* in both the study areas with different socioeconomic status. Although the tap system or well was installed in all the premises in the study areas, the supply of water was limited and/or had insufficient numbers of faucets in most of the premises. Therefore, it is likely that they store water in jars and/or plastic buckets. Most of the jars and plastic buckets in the study areas were located indoor or in the eaves, because most premises in the areas were closely adjacent or connected. Thus, the distribution of these containers

TABLE 2
Impact of cover status on pre-adult *Ae. aegypti* infestation in water storage containers in two neighborhoods in Ho Chi Min City, Vietnam*

	Area A				Area B			
	N (%)	Percent with pre-adults	OR	95% CI	*N* (%)	Percent with pre-adults	OR	95% CI
Appropriately covered	88 (62.9)	25.0	1.0	Ref.	41 (51.9)	17.0	1.0	Ref.
Inappropriately covered	21 (15.0)	57.1	4.0	1.49–10.76	12 (15.2)	50.0	4.9	1.21–19.57
No cover	31 (22.1)	51.6	3.2	1.36–7.51	26 (32.9)	30.8	2.2	0.67–6.92
Total	140 (100)				79 (100)			

* Broken or incomplete covers above which we can see water surface in the containers were recorded as "inappropriately covered." A total of 219 large (> 60 cm of height) water storage containers (jars and plastic buckets) inspected in the entomologic survey were included.
OR = odds ratio; 95% CI = 95% confidence interval.

TABLE 3

Demographic characteristics of 272 female respondents of the questionnaire survey in two neighborhoods in Ho Chi Min City, Vietnam*

	Area A ($N = 140$) N (%)	Area B ($N = 132$) N (%)	Total ($N = 272$) N (%)	P
Age (years)				
18–39	45 (32)	47 (36)	92 (34)	
40–54	48 (34)	58 (44)	106 (39)	
> 54	47 (34)	27 (20)	74 (27)	0.046
Education (years)				
None	8 (6)	15 (11)	23 (8)	
1–6	62 (44)	76 (58)	138 (51)	
> 6	70 (50)	41 (31)	111 (41)	0.004
Total	140 (52)	132 (48)	272 (100)	

* P values are based on χ^2 analysis of number in each category.

was not influenced by rainfall and seasons. Furthermore, the occurrence of discarded containers kept outdoors, in which rainwater was filled, was rare for the same reason. Therefore, we considered jars and plastic buckets as sustained productive breeding containers at least in our study areas. Appropriate use of covers on these containers had a significant effect in reducing *Ae. aegypti* pre-adults infestation compared with the use of containers with inappropriate cover use. Inappropriate cover use increased the risk of the infestation in the containers in both the areas; however, we could not detect a significant increase in the risk for the containers with no cover in Area B. Although we did not investigate the frequency of water use, water might be filled in water storage containers and used frequently because of the daily outage of the water supply in Area B. The frequent use of the containers could explain the decreased use of cover for the convenience of people, and frequent use of water (i.e., exchanging water) might also cause less pre-adult infestation in these containers. Fishes in glass aquariums were frequently observed in the study areas; however, no fish were observed in water storage containers such as jars and plastic buckets. Water contained in jars and plastic buckets was usually stored for drinking or cleaning; therefore, people may be worried about water contamination caused by breeding fishes in these containers. Use of larvicide for drinking water was restricted by the Vietnamese government for concerns about safety.

Respondents in Area A had more knowledge related to dengue; however, the patterns of the preventive practice (i.e., using no cover, using broken/inappropriate cover, or using appropriate cover) was common in both areas. With regard to the presence of a cover on jars and plastic buckets in each premise, we could not detect significant relationships with the knowledge and demographic status of respondents and socioeconomic conditions of the premises. Concrete and direct answers regarding the knowledge of dengue, such as symptoms, transmission (i.e., mosquitoes acting as dengue vector), breeding site (i.e., jars or plastic buckets as mosquito breeding site), and methods used for preventing dengue (i.e., using cover on water storage containers as a useful dengue control method) were obtained from the interview; however, no significant relationship was detected with the aforementioned parameters of dengue-related knowledge. These results indicated that the knowledge may have no or slight effect on the preventive practice of the residents. The Health Belief Model (HBM) developed in the early 1950s has been one of the most widely used conceptual frameworks in health behavior change.[20] It is now believed that people will take action to prevent ill-health conditions if they regard themselves as susceptible, the conditions as serious, the action as beneficial, and when the barriers to taking the action outweigh its benefits.[21] Demographic status, socioeconomics, and knowledge are believed to have an indirect effect on behavior by influencing the perception of susceptibility, severity, benefits, and barriers. It is also reported that perceived barrier was the most powerful single predictor of the HBM dimensions across various studies of health behaviors.[22] A qualitative study indicated that barriers such as insufficient control agents, inadequate

TABLE 4

Knowledge of dengue symptoms, transmission of the disease, breeding site of pre-adult mosquitoes, and preventive measures of dengue in 272 female respondents in Ho Chi Min City, Vietnam*

	Area A ($N = 140$) [N (%)]	Area B ($N = 132$) [N (%)]	P
Symptoms			
Appropriate symptoms†	115 (82)	83 (63)	< 0.001
Transmission			
Appropriate routes‡	128 (91)	116 (88)	0.34
Breeding sites			
Jars	75 (54)	73 (55)	0.77
Flower vases	40 (29)	22 (17)	0.019
Concrete basins	24 (17)	14 (11)	0.12
Plastic buckets	19 (14)	2 (2)	< 0.001
Ant traps	13 (9)	4 (3)	0.033
Tires	5 (4)	2 (2)	0.28
Other sites§	35 (25)	11 (8)	< 0.001
Control measures of dengue			
Sleep in bed nets	71 (51)	42 (32)	0.002
Use insecticide spray	68 (49)	38 (29)	0.001
Eliminate discarded containers	31 (22)	21 (16)	0.19
Change stored water frequently	27 (19)	27 (20)	0.81
Cover on water storage containers	25 (18)	7 (5)	< 0.001
Keep fish in water storage containers	6 (4)	3 (3)	0.35
Use window screens	4 (3)	1 (1)	0.20
Put salt in ant traps	2 (1)	0 (0)	0.17

* P values are based on χ^2 analysis of number in each category.
† Included all appropriate dengue fever and/or dengue hemorrhage fever symptoms (i.e., fever, rash, nausea/vomiting, head ache, muscular pain, bleeding, joint pain, or shock).
‡ Included all appropriate answers that mentioned mosquiotes as dengue vector (i.e., mosquitoes, mosquiot bite, or *Ae. aegypti* bite during day time).
§ Included all other potential breeding sites of *Ae. aegypti* (i.e., metal drums, wells, toilet concrete basins, roof gutters, or discarded containers).

TABLE 5

Presence of cover on jars and plastic buckets in relation to knowledge of dengue, demographic status, and location of premises based on logistic regression analysis in two neighborhoods in Ho Chi Min City, Vietnam*

	Jars†					Plastic buckets‡				
	N	Percent premises with practice	Odd ratio	95% confidence interval	*P* value	*N*	Percent premises with practice	Odd ratio	95% confidence interval	*P* value
Knowledge of dengue										
Appropriate symptom										
No	33	51.2	1.0	Ref.		52	44.2	1.0	Ref.	
Yes	58	67.2	1.9	0.80–4.63	0.14	120	45.0	1.0	0.53–1.98	0.93
Mosquitoes as vector										
No	15	53.3	1.0	Ref.		19	57.9	1.0	Ref.	
Yes	76	63.2	1.5	0.49–4.58	0.48	153	43.1	0.6	0.21–1.44	0.23
Jars or plastic buckets as breeding site										
No	28	67.9	1.0	Ref.		158	44.3	1.0	Ref.	
Yes	63	58.7	0.7	0.26–1.72	0.41	14	50.0	1.3	0.42–3.75	0.68
Covers as a useful dengue control										
No	79	64.6	1.0	Ref.		153	43.8	1.0	Ref.	
Yes	12	41.7	0.4	0.11–1.35	0.14	19	52.6	1.4	0.54–3.70	0.47
Knowledge score§										
Low (0–2)	45	60.0	1.0	Ref.		36	44.4	1.0	Ref.	
High (3–4)	46	63.0	1.1	0.48–2.64	0.77	28	39.3	0.8	0.29–2.20	0.68
Demographic status										
Age (years)										
18–44	40	52.5	1.0	Ref.		82	43.9	1.0	Ref.	
> 44	51	68.6	2.0	0.83–4.66	0.12	90	45.6	1.1	0.58–1.95	0.83
Education (years)										
0–6	63	61.9	1.0	Ref.		102	44.1	1.0	Ref.	
> 6	28	60.7	1.0	0.38–2.37	0.91	70	45.7	1.1	0.57–1.96	0.84
Location of premises										
Area B	40	55.0	1.0	Ref.		69	50.7	1.0	Ref.	
Area A	51	66.7	1.6	0.69–3.83	0.26	103	40.8	0.7	0.36–1.23	0.20

* Premises with at least one jar or plastic bucket with any status of cover (i.e., appropriate and inappropriate cover) were considered as the premises with practice.
† Total of 51 premises in Area A and 40 premises in Area B with at least one jar were included in the analysis.
‡ Total of 103 premises in Area A and 69 premises in Area B with at least one plastic bucket were included in the analysis.
§ Dengue-related knowledge (i.e., symptoms, transmission, mosquito breeding sites, and pre-adult control method) was coded as 1 for respondents with knowledge and 0 for respondents without knowledge.

knowledge of control methods, and incompatibility of control practices with people's beliefs are strong determinants of sustained pre-adult *Ae. aegypti* control practices.[23] It is reported that local residents in dengue-endemic areas considered application of cover on frequently used water storage containers as impractical or regarded the covers as unnecessary for containers with non-potable water and did not pay attention to broken covers. In our study, perceived benefits of using cover for water storage containers as dengue mosquito control may be intermediated by the demographic status and individual knowledge of dengue; however, it may have a smaller and less consistent effect on changing these behaviors compared with the perceived barriers (e.g., inconvenience of cover use on water storage containers). Removing the barriers (e.g., distribution of new covers that are convenient for frequent use) may improve practices in individual households. However, we can not ignore the importance of multi-level programs that target not only individual households but also schools, work sites, and other organizations within a community. If mosquito breeding sites are eliminated in one household but not in neighbors, people in the clean house probably receive only limited protection against adult mosquito bite and/or dengue infection. To make matters worse, this result may end in losing trust of the effective behavior in the community. Hence, the behavior change is one area to target in social mobilization program.[10,24–26] Health education programs, in which target people and behaviors are identified rationally, probably become an important factor to change behaviors in the social mobilization program.[27] Awareness of dengue symptoms is vital to conduct appropriate treatment-seeking behavior against DHF among first-line care givers for children (i.e., usually mother and/or adult woman), and health education may be effective to foster early diagnosis and treatment of DHF in areas with relatively low level of dengue knowledge such as Area B in our study. However, our study suggested that we can not expect the desirable behavior change to reduce pre-adult *Ae. aegypti* density from mere transfer of knowledge related to dengue.

A negative association between respondent's knowledge of preventive measures and the number of unprotected containers in and around their premises has been reported.[8] In their analysis, significantly fewer unprotected containers in or around the houses was detected in respondents with knowledge of at least one preventive measure such as the use of larvicide, frequent changing of stored water, use of mosquito net, turning the containers upside down, or spraying of insecticide. However, their study did not distinguish each container type that has type-specific preventive measures (e.g., elimination of discarded containers, use cover on water storage containers, and changing the water in flower vases); thus, the relation between specific knowledge of preventive measures and the infestation by *Ae. aegypti* in each container type was not clear. In our study, we did not find any evidence that specific knowledge of dengue was associated with the adoption of preventive practices on key containers such as jars and plastic buckets by the residents. Further quantitative studies that include variables to measure attitude of people and barriers of practices are needed to examine the determinants of preventive practices in reducing *Ae. aegypti* infestation in key containers to achieve the expected behavioral change.

We conclude that the use of appropriate cover on water storage containers such as jars and plastic buckets is effective in reducing pre-adult *Ae. aegypti* infestation levels; however, we could not identify the association between knowledge of dengue and the preventive practice. It is highly possible that we can not expect the desirable behavior change and reduction of pre-adult *Ae. aegypti* density from mere transfer of knowledge related to dengue.

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REFERENCES

1. Halstead SB, Suaya JA, Shepard DS, 2007. The burden of dengue infection. *Lancet 369:* 1410–1411.
2. Farrar J, Focks D, Gubler D, Barrera R, Guzman MG, Simmons C, Kalayanarooj S, Lum L, McCall PJ, Lloyd L, Horstick O, Dayal-Drager R, Nathan MB, Kroeger A, 2007. Towards a global dengue research agenda. *Trop Med Int Health 12:* 695–699.
3. Morrison AC, Zielinski-Gutierrez E, Scott TW, Rosenberg R, 2008. Defining challenges and proposing solutions for control of the virus vector *Aedes aegypti. PLoS Med 5:* e68.
4. Vu SN, Kay BH, Nguyen TY, Ryan P, Bektas A, 2004. Community mobilization, behaviour change and biological control in the prevention and control of dengue fever in Viet Nam. *Dengue Bull 28:* 57–61.
5. Vu SN, Tran TT, Nguyen TA, Nguyen TH, 2003. The impact of health education on mother's knowledge, attitutde and practice (KAP) of dengue fever haemorrhagic fever. *Dengue Bull 27:* 174–180.
6. Winch PJ, Leontsini E, Rigau-Perez JG, Ruiz-Perez M, Clark GG, Gubler DJ, 2002. Community-based dengue prevention programs in Puerto Rico: impact on knowledge, behavior, and residential mosquito infestation. *Am J Trop Med Hyg 67:* 363–370.
7. Lloyd LS, Winch P, Ortega-Canto J, Kendall C, 1992. Results of a community-based *Aedes aegypti* control program in Merida, Yucatan, Mexico. *Am J Trop Med Hyg 46:* 635–642.
8. Koenraadt CJ, Tuiten W, Sithiprasasna R, Kijchalao U, Jones JW, Scott TW, 2006. Dengue knowledge and practices and their impact on *Aedes aegypti* populations in Kamphaeng Phet, Thailand. *Am J Trop Med Hyg 74:* 692–700.
9. Degallier N, Vilarinhos PT, de Carvalho MS, Knox MB, Caetano J Jr, 2000. People's knowledge and practice about dengue, its vectors, and control means in Brasilia (DF), Brazil: its relevance with entomological factors. *J Am Mosq Control Assoc 16:* 114–123.
10. Rosenbaum J, Nathan MB, Ragoonanansingh R, Rawlins S, Gayle C, Chadee DD, Lloyd LS, 1995. Community participation in dengue prevention and control: a survey of knowledge, attitudes, and practice in Trinidad and Tobago. *Am J Trop Med Hyg 53:* 111–117.
11. Ha DQ, Tien NT, Huong VT, Loan HT, Thang CM, 2000. Dengue epidemic in southern Vietnam, 1998. *Emerg Infect Dis 6:* 422–425.
12. Thai KT, Binh TQ, Giao PT, Phuong HL, Hung le Q, Van Nam N, Nga TT, Groen J, Nagelkerke N, de Vries PJ, 2005. Seroprevalence of dengue antibodies, annual incidence and risk factors among children in southern Vietnam. *Trop Med Int Health 10:* 379–386.
13. Focks DA, Haile DG, Daniels E, Mount GA, 1993. Dynamic life table model for *Aedes aegypti* (Diptera: Culicidae): simulation results and validation. *J Med Entomol 30:* 1018–1028.
14. Barrera R, Amador M, Clark GG, 2006. Use of the pupal survey technique for measuring *Aedes aegypti* (Diptera: Culicidae) productivity in Puerto Rico. *Am J Trop Med Hyg 74:* 290–302.
15. Hammond SN, Gordon AL, Lugo Edel C, Moreno G, Kuan GM, Lopez MM, Lopez JD, Delgado MA, Valle SI, Espinoza PM, Harris E, 2007. Characterization of *Aedes aegypti* (Diptera: Culcidae) production sites in urban Nicaragua. *J Med Entomol 44:* 851–860.
16. Lenhart AE, Castillo CE, Oviedo M, Villegas E, 2006. Use of the pupal/demographic-survey technique to identify the epidemiologically important types of containers producing *Aedes aegypti* (L.) in a dengue-endemic area of Venezuela. *Ann Trop Med Parasitol 100 (Suppl 3):* 53–59.
17. Tran VP, Vu SN, 1999. Key breeding site of dengue vectors in Hanoi, Vietnam, 1994–1997. *Dengue Bull 23:* 67–72.
18. Vu SN, Nguyen TY, Tran VP, Truong UN, Le QM, Le VL, Le TN, Bektas A, Briscombe A, Aaskov JG, Ryan PA, Kay BH, 2005. Elimination of dengue by community programs using Mesocyclops (Copepoda) against *Aedes aegypti* in central Vietnam. *Am J Trop Med Hyg 72:* 67–73.
19. Knox TB, Nguyen TY, Vu SN, Gatton ML, Kay BH, Ryan PA, 2007. Critical evaluation of quantitative sampling methods for *Aedes aegypti* (Diptera: Culicidae) immatures in water storage containers in Vietnam. *J Med Entomol 44:* 192–204.
20. Glanz K, Rimer BK, Lewis FM, 2002. *Health Behavior and Health Education*. San Francisco: Jossey-Bass.
21. Hochbaum GM, 1958. *Public Participation in Medical Screening Program: A Sociopsychological Study.* Washington, DC: Government Printing Office.
22. Janz NK, Becker MH, 1984. The Health belief model: a decade later. *Health Educ Q 11:* 1–47.
23. Phuanukoonnon S, Brough M, Bryan JH, 2006. Folk knowledge about dengue mosquitoes and contributions of health belief model in dengue control promotion in Northeast Thailand. *Acta Trop 99:* 6–14.
24. Gupta P, Kumar P, Aggarwal OP, 1998. Knowledge, attitude and practices related to dengue in rural and slum areas of Delhi after the dengue epidemic of 1996. *J Commun Dis 30:* 107–112.
25. Donalisio MR, Alves MJ, Visockas A, 2001. A survey of knowledge and attitudes in a population about dengue transmission–region of Campinas Sao Paulo, Brazil–1998. *Rev Soc Bras Med Trop 34:* 197–201.
26. Okanurak K, Sornmani S, Mas-ngammueng R, Sitaputra P, Krachangsang S, Limsomboon J, 1997. Treatment seeking behavior of DHF patients in Thailand. *Southeast Asian J Trop Med Public Health 28:* 351–358.
27. Will P, Lloyd L, 2004. *Planning Social Mobilization and Communication for Dengue Fever Prevention and Control.* Geneva: World Health Organization.