Effect of water supply system installation on distribution of water storage containers and abundance of *Aedes aegypti* immatures in urban premises of Ho Chi Minh City, Viet Nam

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Abstract

To assess the effect of installation of a water supply system on the distribution of water storage containers and abundance of *Aedes aegypti* immatures, we conducted two successive entomological surveys in October 2007 and July 2008 in an urban neighbourhood of Ho Chi Minh City, Viet Nam. In all, 850 water-holding containers, including plastic buckets, water jars, concrete basins, flower vases, ant-traps, outdoor discards, used tyres and plant saucers were observed in 122 premises. Of these, 44 premises already had a water supply system installed at the time of the first survey (i.e. control premises). In the remaining 78 premises, a water supply system was installed 3–6 months before the second survey (i.e. intervention premises). There was a drastic reduction in the number of water storage containers, except concrete basins, between the first and second surveys. We also observed that the distribution of water storage containers in the control and intervention premises was similar. This was probably because the construction of a water supply system before the second survey increased the reliability of the system not only for the residents in intervention premises but also in the control premises (i.e. increased water pressure in the water supply system). The number of plastic buckets and water jars was reduced in the second survey; however, these containers were still an important source of *Ae. aegypti* pupae. For effective control of dengue infection, it is necessary to conduct entomological monitoring considering the seasonal changes in vector abundance and dengue transmission threshold after installing a water supply system.

Keywords: Dengue; *Aedes aegypti*; Viet Nam; water supply, vector control.

Introduction

Dengue fever and the associated lethal shock and/or haemorrhage are rapidly growing public health problems in over 100 countries of the world, and particularly in South-East Asia, North and South America, and the Western Pacific islands. It has been estimated that about 50×10^6 cases of dengue viral infection, including 50×10^4 cases of dengue

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fever with shock and/or haemorrhage, occur worldwide annually.[1] An effective vaccine against dengue has not yet been developed.[2] To date, the only option for controlling dengue virus transmission in human population is by reducing the population density of *Aedes aegypti*—the mosquito primarily responsible for causing dengue—which exclusively feeds on human blood and deposits eggs in a variety of artificial water storage containers in and around residential premises.

An increase in the density and geographical distribution of *Ae. aegypti* is known to be widely influenced by unprecedented global population growth and unplanned urbanization, which has resulted in substandard housing and inadequate water supply and waste management systems. These conditions increase the number and prevalence of water storage containers that may become the breeding sites for pre-adult *Ae. aegypti*.[3] However, the effect of installing a water supply system in dengue endemic areas as a measure to reduce the number of potential breeding sites and abundance of *Ae. aegypti* pre-adults (i.e. larvae and/or pupae) have been evaluated in only a few studies. In order to identify the effect of installation of a water supply system on the distribution of water storage containers and abundance of *Ae. aegypti* breeding, we conducted two successive entomological surveys in an urban neighbourhood in Ho Chi Minh City in Viet Nam.

Materials and methods

Entomological surveys were conducted in October 2007 (first survey) and July 2008 (second survey) in an urban neighbourhood in District No. 8 of Ho Chi Minh City. The city has a tropical climate with distinct wet and dry seasons. The rainy season usually begins in May and ends in late November; the dry season lasts from December to April. The surveys were conducted to determine the distribution of water storage containers and prevalence of *Ae. aegypti* breeding before and after the installation of a water supply system in the study area. The detailed study methods and characteristics of our study area (referred to as area A in the previous study) have been described previously.[4] Containers with more than one *Ae. aegypti* larva and/or pupa were defined as "positive containers". We believed that it was reasonable to obtain the *Ae. aegypti* pupal count, rather than the larval count, to estimate the number of adults because of the high survival rate of pupae[5] and the ease of identification of emerged adult species. All water storage containers situated both indoors and outdoors (including porches and rooftops) were inspected. All the pupae were collected in small plastic vials and subsequently transported to the laboratory. The number of pupae was counted, and the species of the mosquitoes (i.e. *Ae. aegypti* or others) was confirmed after emergence.

The mosquito density was evaluated in terms of the house index (HI): percentage of houses with containers positive for *Ae. aegypti* larvae or pupae; container index (CI): percentage of water storage containers positive for *Ae. aegypti* larvae and pupae; Breteau index (BI): number of containers positive for *Ae. aegypti* larvae and pupae per 100 houses; and pupae per person (PPP): number of *Ae. aegypti* pupae per person (i.e. average number of pupae among the number of residents). The data were entered into the Microsoft Office Access 2003 program (Microsoft Corporation, USA) and analysed using Stata™ v 10.0 (Stata Corporation, USA). The average number of containers per premise was expressed as mean (SD). Statistical analysis was performed using the *t* test. Significance was determined at the 5% level.

Results

Among the 174 residential premises in the study area, 122 (70.1%) were inspected both in the first and the second surveys. When we conducted the first survey, 78 (55.7%) premises did not have a water supply system (intervention premises) and private pump-wells were the main source of water. In the other 44 (44.3%) premises, the water supply system had already been installed (control premises). A water supply system was installed by the Ho Chi Minh City water supply service in 78 premises 3–6 months before the second survey. In comparison with the larval density indexes (CI, HI, BI, and PPP) obtained during the first survey, all, except PPP, were reduced during the second survey in the 78 intervention premises; however, these indices were similarly reduced in the 44 control premises (Table 1).

In all, 850 water-holding containers, including plastic buckets, water jars, concrete basins, flower vases, ant traps, outdoor discards, used tyres and plant saucers, were observed in the 122 premises (Table 2). Almost all the water storage containers, such as plastic buckets, water jars and concrete basins, were located indoors or under eaves; outdoor water-holding containers (e.g. used tyres, plant saucers and outdoor discards) were few in number because most of the surveyed urban residential premises were located adjacent to each other or were connected, leaving little or no outdoor space. Water-storage containers (i.e. plastic buckets, water jars and concrete basins) accounted for 53.8% of the total water-holding containers. There was a drastic reduction in the number of plastic buckets and water jars between the first and second surveys in both the intervention and control premises; however, the number of concrete basins did not change between the survey periods. The above-mentioned water storage containers accounted for the majority of positive containers in the first (55.3% in the intervention premises and 63.7% in the control premises) and second surveys (68.0% in the intervention premises and 86.7% in the control premises). However, the number of positive containers in the second survey was less than that in the first survey. The water

Table 1: Pre-adult *Ae. aegypti* indices of 122 premises before and after water supply installation in Ho Chi Minh City, Viet Nam*

	1st survey (before)		2nd survey (after)	
	Intervention (n = 78)	Control (n = 44)	Intervention (n = 78)	Control (n = 44)
Container index (CI)	28.4%	30.6%	21.4%	14.3%
House index (HI)	53.9%	56.8%	37.2%	29.5%
Breteau index (BI)	120.5	125.0	64.1	34.1
Pupae per person	0.37	0.45	0.46	0.40

* The first and second surveys were conducted in October 2007 and July 2008, respectively, in an urban neighbourhood in District No. 8 of Ho Chi Minh City. A water supply system was installed in the 78 premises 3–6 months before the second survey (i.e. intervention premises), whereas the system had been already installed in 44 premises when the first survey was conducted (i.e. control premises).

Table 2: Number of water-holding containers and presence of pre-adult *Ae. aegypti* in 122 premises before and after water supply installation in Ho Chi Minh City, Viet Nam

Container types	1st survey (before)						2nd survey (after)					
	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 (%)	
Intervention (n = 78)												
Plastic buckets	111	(33.5)	21	(22.3)	34	(24.3)	32	(13.7)	9	(18.9)	41	(23.2)
Water jars	61	(18.4)	21	(22.3)	49	(35.0)	46	(19.7)	19	(38.0)	103	(58.2)
Concrete basins*	20	(6.0)	10	(10.6)	18	(12.9)	20	(8.5)	6	(12.0)	7	(4.0)
Others‡	139	(42.0)	42	(44.7)	39	(27.9)	136	(58.1)	16	(32.0)	26	(14.7)
Total	331	(100)	94	(100)	140	(100)	234	(100)	50	(100)	177	(100)
Control (n = 44)												
Plastic buckets	61	(33.9)	14	(25.5)	3	(2.8)	27	(25.7)	1	(6.7)	25	(26.6)
Water jars	29	(16.1)	12	(21.8)	39	(36.8)	16	(15.2)	3	(20.0)	0	(0)
Concrete basins*	17	(9.4)	9	(16.4)	52	(49.1)	17	(16.2)	9	(60.0)	62	(66.0)
Others‡	73	(40.6)	20	(36.3)	12	(11.3)	45	(42.9)	2	(13.3)	7	(7.4)
Total	180	(100)	55	(100)	106	(100)	105	(100)	15	(100)	94	(100)

* Built-in concrete basins in kitchens, gardens and bathrooms were included.
‡ Others included flower vases, ant-traps, outdoor discards, used tyres and plant saucers.

storage containers responsible for most of the pupal population in the intervention premises were 72.1% and 85.3% in the first and second survey, respectively; and in control premises were 88.0% and 92.6% in the first and second survey, respectively.

Although the number of plastic buckets and water jars per premises during the second survey had drastically decreased compared with the first survey (plastic buckets: $P<0.001$ and $P<0.001$ in the intervention and control premises, respectively; water jars: $P=0.05$ and $P<0.05$ in the intervention and control premises, respectively), no significant difference was observed between the intervention and control premises (Table 3). We found only *Ae. aegypti* pupae in the water-holding containers throughout the survey period in our study area.

Discussion

Our results indicated that installation of a water supply system in residential premises may lead to a reduction in the number of different water storage containers, such as plastic buckets and water jars, within a short period. However, other factors such as the

Table 3: Average number of plastic buckets and water jars in premises before and after water supply installation, Ho Chi Minh City, Viet Nam*

	1st survey (before)			2nd survey (after)		
	Intervention (mean (SD))	Control (mean (SD))	P	Intervention (mean (SD))	Control (mean (SD))	P
Plastic buckets	1.94 (1.18)	1.74 (1.34)	0.5	0.56 (0.68)	0.69 (0.83)	0.2
Water jars	2.03 (1.35)	2.23 (1.09)	0.6	1.33 (1.37)	1.08 (1.38)	0.6

*Average number of containers in the premises that owned plastic buckets and water jars in the first survey was calculated (i.e. 57 and 35 of the intervention and control premises, respectively, had plastic buckets; 30 and 13 of the intervention and control premises, respectively, had water jars).

reliability of the supply system may have a greater impact on reducing the number of water-holding containers. In the 78 premises that had private pump-wells before the water system was installed, water was intermittently pumped up from the wells and stored in plastic buckets, water jars and concrete basins. After the installation of the water supply system, residents could directly use the water from taps, thereby avoiding the need to store water. Hence, the number of water storage containers, except for concrete basins, in the study area reduced within a short period. We also observed that the distribution of the water storage containers in the control premises was similar to their distribution in the intervention premises and the number of water storage containers had drastically reduced in the second survey. This may be because of the construction of a water supply system 3–6 months before the second survey, which increased the reliability of the system not only for the residents in the intervention premises but also for those in the control premises (i.e. increased water pressure in a water supply system and less frequent suspension of water supply).

The first survey may have also resulted in a change in the water storage habits of the residents (i.e. people recognized *Ae. aegypti* breeding sites in their premises during the house-to-house entomological survey). Although we do not know about the seasonal changes in the water-storing behaviour of residents, almost all the water storage containers in which water was stored artificially were located indoors or under eaves in our study area, and seasonal changes in the number of water storage containers might not be influenced by rainfall. The number of concrete basins before and after water supply system installation did not change because they were fixed structures in the houses (i.e. built-in type).

The number of plastic buckets and water jars was reduced in the second survey; however, these containers were still an important source of *Ae. aegypti* pupae. A high mean temperature promotes the growth of *Ae. aegypti*.[6] Different weather conditions between the first and second surveys might be the primary reason for the difference in *Ae. aegypti* abundance. Furthermore, after installation of the water supply system, the less frequently used water-storage containers and the resultant standstill water in them may have also favoured larval breeding (i.e. fewer chance of water exchange and more nutrition in the water). Thus, more pupae may have been produced from fewer numbers of plastic buckets and water jars.

It was not clear why some residents stored water in jars and plastic buckets even after the water supply system had been installed; we speculate that this could be because residents felt using water from the well was economical (i.e. no extra cost incurred, except for the electricity used by the motor pump), or because they were still doubtful about an assured water supply system given the fact that the system had been newly installed in the area.

It is difficult to immediately change the attitude/habits of residents; in the meantime, water storage containers such as plastic buckets, water jars and concrete basins may become important breeding sites for *Ae. aegypti*. To effectively control dengue infection, it is necessary to conduct entomological monitoring considering the seasonal changes in vector abundance and dengue transmission threshold[7] even after installation of a water supply system. We believe that a follow-up survey in the succeeding year and/or a survey spanning more residential areas would be helpful in reaching a definitive conclusion.

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