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# Study on key *Aedes* spp breeding containers in dengue outbreak localities in Cheras district, Kuala Lumpur

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**Abstract**
The elimination of most productive breeding sites for *Aedes* spp has been applied worldwide in order to keep vector density below a critical threshold. Key-breeding container plays important roles in determining the most suitable and effective methods for vector control. This study was conducted to identify the key-breeding container of *Aedes* spp. larvae as a baseline data for Cheras District and to suggest suitable *Aedes* prevention and control steps based on Integrated Vector Management strategies. An entomological survey was done in 20 Dengue outbreak localities in Cheras district, Kuala Lumpur, in 2016 involving all types of properties. The location of breeding was determined by indoor or outdoor, and type of mosquito species was identified. Descriptive statistics and chi-square analysis were done to identify differences in breeding containers by type of property (Low-rise vs High-rise). Statistical significance was set at *P-value* less 0.05. All the study sites were 100% positive for *Aedes* breeding. For all study sites, entomology indices showed a high risk of *Aedes* index (15%), medium risk for breeding index (55%) and medium risk for container index (70%). Of 546 potential breeding containers included in the survey, 11.7% were positive, indoor (2.6%) and outdoor (9.2%). The most common type of container was plastic container (30%) and there is no significant difference of indoor and outdoor breeding by high-rise and low rise, *p-value*= 0.0613. Artificial containers are key breeding habitats in dengue outbreaks. Therefore, community mobilisation towards eliminating human made containers, either indoor or outdoor, is vital for dengue control program.

**Keywords:** Dengue, key breeding container, integrated vector management, *Aedes*

## 1. Introduction
Dengue is one of the main and fast emerging tropical mosquito-borne diseases that spread throughout tropical and sub-tropical regions of the world. Dengue virus (DENV) causes more human morbidity and mortality than any other arboviral disease. A 2012 study estimated that 3.9 billion people in 128 countries were at risk of infection with dengue viruses [1]. Dengue virus belongs to the family *Flaviviridae* and has four serotypes. The virus is transmitted to humans by the bites from infected *Aedes* mosquitoes. In the absence of dengue vaccine and drugs to cure the disease, vector control is the only option available to prevent outbreaks of dengue.

Dengue fever is predominant with an incremental annual incidence rate of 392.96 per 100,000 populations since 2016 [2]. In Malaysia, dengue has become one of the major health problems, with an alarming rising trend in dengue outbreaks every year. Vector control activity in Malaysia mostly focuses on chemical control, source reduction activities to eliminate sources of *Aedes* breeding, and community mobilisation [3, 4]. In Kuala Lumpur, similar incremental pattern was observed as incidence rates were rising every year. In 2016, Kuala Lumpur recorded 8,664 dengue cases and 1,262 dengue outbreaks [5]. Within the city, Cheras district contributed 20% of dengue cases and 24% of dengue outbreaks. Moreover, Cheras district had shown rising trends in both dengue cases (160% increase) and outbreaks (590% increase) compared to the previous year, 2015.

The reoccurrence of dengue outbreak due to ineffective methods of vector control as it were conducted after the occurrence of dengue transmission at the affected locality and re-emerge of the vector after space spraying activities [6].

Current practice primarily focuses on adulticiding rather than larvaciding [7]. Most importantly, there are abundant of water containers that allows *Aedes* breeding even during adverse weather months of the year; and consistently serves as the primary producers of *Ae*. *Aegypti*. These habitats are referred as "Key Containers" which are region specific for *Aedes* breeding. *Aedes* mosquitoes such as *Aedes aegypti*, normally prefers artificial containers as their breeding sites. Many of the classic key breeding containers for *Aedes aegypti* are artificially flooded sites used to store water, which can produce large numbers of pupae even when rainfall is low [8]. Examples of domestic water storage which serve as breeding containers for *Aedes aegypti* are 50-200 litres capacity jars [9], water tanks [10], rainwater tank [11] and water drums [12]. Other breeding sites of *Aedes aegypti* are flower pots and vases [13], manhole service pits [14], roof gutters [15], buckets [16] and tyres [17]. A previous study by de Freitas and de Oliveira [18] suggested that the elimination of the most productive breeding sites for the primary dengue vector should be broadly adopted worldwide to keep the vector population density below a critical threshold. Tsuzuki [19] also reported that one approach in the eradication of larvae is to focus on key breeding containers of the primary vector which has proven to reduce the proliferation of *Aedes aegypti* larvae. In fact, the elimination of key artificial container breeding sites has been regarded as one of the best approaches for the prevention and control of dengue [20]. Furthermore, vector control activities would be more efficient by giving high priority to the container with the highest percentage of larvae/pupae [21].

In order to enhance prevention and vector control activities, there is a crucial need to identify key breeding containers in Dengue outbreak. Vector control should emphasize on source reduction rather than chemical control. Elimination of key artificial container could be one of the best approaches for the prevention and control of dengue [20].

To our current knowledge, there is no study that has been carried out to identify the key breeding containers at outbreak localities in Kuala Lumpur. Therefore, accentuation towards eliminating and eradication of key breeding containers by community and vector control activity have not been necessarily highlighted. This may lead to less efficient and effectiveness of vector control activities as high priority has not been given to the container with the highest density of *Aedes* larvae.

This study was aimed to identify key breeding containers in dengue outbreak localities in Cheras district and to suggest suitable steps in controlling dengue at particular outbreak localities. This study would provide baseline data of main breeding containers at dengue outbreaks localities in Cheras district as a reference for further vector control activities and community engagements. Knowing the key breeding containers for these areas is the logical first step towards identifying more effective and efficient dengue prevention efforts.

## 2. Materials and Methods

### 2.1 Study Sites

The Cheras district health office consists of two sub-districts: Bandar Tun Razak and Cheras. This was a cross-sectional study that included a total of 20 dengue outbreak localities from this two sub-districts and involving outbreaks from January to December 2016. These 20 localities were randomly selected from all outbreaks that reported a minimum of three dengue cases as shown in Table 1.

**Table 1**: List of selected dengue outbreak localities in Cheras district, Kuala Lumpur.

| Study sites | Sub-district | Number of cases | Period of outbreak |
|---|---|---|---|
| Desa Tasik Polis A | Bandar Tun Razak | 6 | Feb – March (39 days) |
| Desa Tasik Polis B | Bandar Tun Razak | 7 | March – April (23 days) |
| PPR Desa Tun Razak | Bandar Tun Razak | 6 | March – April (44 days) |
| PPR Sri Alam B | Cheras | 6 | January (21 days) |
| Tasek Height Apartment | Bandar Tun Razak | 17 | July – August (50 days) |
| Taman Jaya A | Bandar Tun Razak | 4 | Jan – Feb (31 days) |
| Kg Cheras Baru C | Bandar Tun Razak | 3 | June – July (24 days) |
| Ketumbar Height Condo | Cheras | 7 | Jan – Feb (47 days) |
| Taman Cheras | Cheras | 6 | March (30 days) |
| Flat Sri Penara | Bandar Tun Razak | 24 | Jan – April (105 days) |
| Cendana Apartment | Bandar Tun Razak | 5 | August – Sept (34 days) |
| Pangsapuri Permai | Bandar Tun Razak | 6 | Sept – Oct (36 days) |
| Flat Sri Kota | Bandar Tun Razak | 9 | Jan – Feb (50 days) |
| Taman Connaught | Bandar Tun Razak | 3 | March (18 days) |
| Kem Sg Besi (Jln Labuan) | Bandar Tun Razak | 39 | August – Dec (125 days) |
| Lumayan Apartment | Bandar Tun Razak | 6 | Nov -Dec (33 days) |
| PPR Pinggiran Bukit Jalil | Bandar Tun Razak | 9 | March (28 days) |
| Cheria Height Apartment | Cheras | 3 | October (23 days) |
| Desa Tun Razak Apartment | Bandar Tun Razak | 11 | Nov – Dec (43 days) |
| Angkasa Condominium | Bandar Tun Razak | 6 | June – July (41 days) |

### 2.2 Entomological Survey

The entomological survey was carried out at the 20 selected outbreak localities during the duration of each outbreak (second to the third week of outbreak period) in Cheras district by the state entomology team and the Cheras district vector control team. A sampling of larvae was conducted around 50 to 100-metre radius from the case index. A sampling of larvae was done by using a dipper and placed in labelled bottles. Type of breeding containers and potential breeding containers (water-holding container that are suitable for *Aedes* breeding) were recorded. Samples were transported to the laboratory of the Vector Control Unit, Health

Department of Kuala Lumpur for larvae identification. Larvae collected from the field were identified using a light microscope to determine the species. The identification was referred to the Pictorial Key for Identification of Mosquito by Leopoldo M. Rueda [22]. All larvae collected were identified but only *Aedes* spp larvae were included for this study. Three larval indices: House Index (HI), Container Index (CI) and Breteau Index (BI) were worked out as stated in WHO guidelines. Container preference of *Aedes* spp larval breeding was also calculated using breeding preference ratio [23]. The parameters below were used to obtain the entomology indices for all the surveyed localities:

***Aedes* Index (AI)**: percentage of houses infested with larvae and/or pupae

$$HI = \frac{\text{Number of positive houses}}{\text{Number of houses inspected}} \times 100\ \%$$

**Container index (CI):** percentage of water-holding containers infested with larvae or pupae

$$CI = \frac{\text{Number of positive containers}}{\text{Number of containers inspected}} \times 100\ \%$$

**Breteau index (BI):** number of positive containers per 100 houses inspected

$$BI = \frac{\text{Number of positive containers}}{\text{Number of houses inspected}} \times 100 \text{ houses}$$

### 2.3 Data Analysis

Data were analyzed using EpiInfo®. Descriptive statistics were carried out to observe the entomological indices and risk characterization by localities, types of breeding containers and further stratified by *Aedes* species. The Breeding preference ratio (BPR) was calculated to assess the container preference of *Aedes.* The *Chi-square* statistics was done to identify differences in breeding containers (indoor vs outdoor) by types of property (low-rise vs high-rise). Statistical significance was set at *p-value* <0.05.

## 3. Results

All the dengue outbreak localities surveyed were positive (100%) for *Aedes;* consisting of indoor and outdoor breeding. Out of 20 sites, the minimum (min) HI=0%, maximum (max) HI= 13.33%, while the min BI=0% and max BI=13 and min CI=3.57% and max CI=19.05%. Detailed entomology indices are as shown in Table 2.

**Table 2:** Entomology indices from entomology surveys at studied sites in Cheras district, Kuala Lumpur

| Study sites | House Index (%) | Breteau Index | Container Index (%) |
|---|---|---|---|
| Desa Tasik Polis A | 13.33 | 13 | 12 |
| Desa Tasik Polis B | 6.67 | 7 | 13.33 |
| PPR Desa Tun Razak | 0 | 0 | 14.29 |
| PPR Sri Alam B | 0 | 0 | 16 |
| Tasek Height Apartment | 6.25 | 6 | 4.55 |
| Taman Jaya A | 9.09 | 9 | 10 |
| Kg Cheras Baru C | 11.11 | 11 | 9.38 |
| Ketumbar Height Condo | 0 | 0 | 13.33 |
| Taman Cheras | 0 | 0 | 19.04 |
| Flat Sri Penara | 0 | 0 | 11.43 |
| Cendana Apartment | 0 | 0 | 3.57 |
| Pangsapuri Permai | 0 | 0 | 10.53 |
| Flat Sri Kota | 4.76 | 5 | 11.43 |
| Taman Connaught | 0 | 0 | 19.05 |
| Kem Sg Besi (Jln Labuan) | 11.11 | 11 | 16 |
| Lumayan Apartment | 9.09 | 9 | 9.09 |
| PPR Pinggiran Bukit Jalil | 8.33 | 8 | 12.5 |
| Cheria Height Apartment | 7.69 | 8 | 7.69 |
| Desa Tun Razak Apartment | 8.33 | 8 | 10.81 |
| Angkasa Condominium | 0 | 0 | 5.56 |

From the results of entomological indices, three outbreak localities were identified with high HI and at high risk of transmitting dengue. A total of 70% of studied localities had a moderate risk of transmission based on CI, 55% recorded BI value between 5-50 and none of the studied outbreak localities showed BI value >50 (Table 3). This risk categorization represents a persistent high risk of transmission status in the studied localities despite a few cycles of implementing vector control for the outbreak.

**Table 3:** Risk categorization of studied sites according to entomological indices [24]

| Index type | Category | No of localities (n = 20) | % |
|---|---|---|---|
| House index (HI) | <1 | 9 | 45 |
| | 1-10 | 8 | 40 |
| | >10 | 3 | 15 |
| Container index (CI) | <10 | 6 | 30 |
| | 10-30 | 14 | 70 |
| | >30 | - | - |
| Breteau index (BI) | <5 | 9 | 45 |
| | 5-50 | 11 | 55 |
| | >50 | - | - |

A total of 546 containers, both indoors and outdoors, were identified as potential breeding sites or water-holding containers. Among the containers, 64 (11.7%) were found to be positive breeding sites for *Aedes* mosquitoes. The most common containers with *Aedes* breeding were plastic containers (30%), pails (16%), vase pedestals (11%) and toilet pumps (8%) (Figure 1). Vase pedestals had the highest BPR followed by plastic containers, toilet pumps, water flow and tyres (Table 4).

From the larvae species identification, the result showed 77% (49/64) of the breeding containers were positive for *Aedes albopictus* and 23% (15/64) for *Aedes aegypti* (Figure 2). Further analysis for indoor positive containers showed that pail [50% (7/14)] was the most common indoor container for breeding *Aedes* followed by toilet pump [36% (5/14)], platting [7% (1/14)], watertub [7% (1/14) and polystyrene [7% (1/14)]. Analysis of outdoor positive containers revealed that the three main breeding containers for *Aedes* mosquitoes were plastic containers [38% (19/50)], vase pedestal [14% (7/50)] and cement floor [8% (4/50)]. For distribution of species at indoor and outdoor containers, all 50 outdoor positive containers were *Aedes albopictus* while all 14 indoor positive containers were *Aedes aegypti*. No mixed species were found in all positive containers. The results also concluded that all positive containers (indoor and outdoor) were artificial or man-made containers and none were natural containers. All positive breeding containers were further categorized into six main breeding sites: toilets and kitchen area (indoor breeding sites); no man's land, illegal dumping area, landscape and vegetation areas, and building structure (outdoor breeding sites). The results showed that illegal dumping contributed to the highest positive breeding for *Aedes* spp at 28% (18/64) followed by landscape at 19% (12/64) and toilet at 17%(11/64) (Figure 3). *Chi*-square analysis showed no significant difference between positive breeding containers found in high-rise buildings (> 5 stories) and low-rise buildings (< 5stories) for indoor or outdoor breeding ($X^2$ = 3.5001, *p-value* = 0.0613) (Table 5).

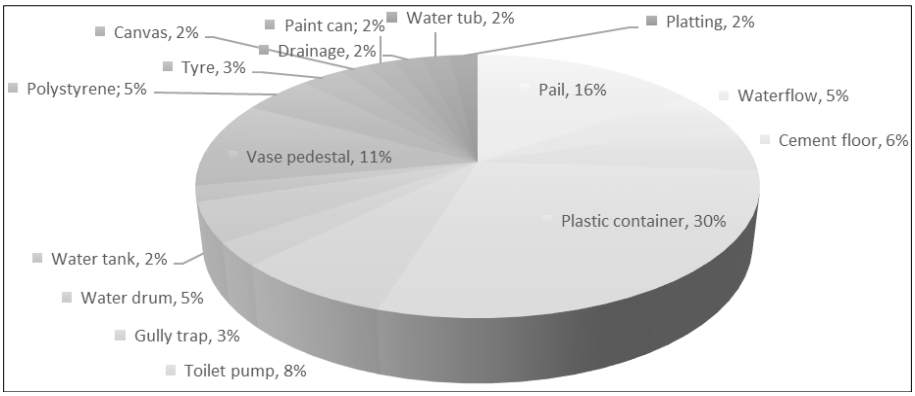


**Fig 1:** Type of breeding container with positive *Aedes* larvae (Indoor and Outdoor)

**Table 4**: Breeding preference ratio (BPR) based on type of containers

| Container type | Number of containers with water | | | | Breeding preference ratio (BPR) (Y/X) |
|---|---|---|---|---|---|
| | No. of container inspected (n) | Percentage (X%) | No. of container with *Aedes* larvae (n) | Percentage (Y%) | |
| Pail | 78 | 14.29 | 10 | 15.62 | 1.09 |
| Water flow | 20 | 3.66 | 3 | 4.69 | 1.28 |
| Cement floor | 34 | 6.23 | 4 | 6.25 | 1.00 |
| Plastic container | 89 | 16.3 | 19 | 29.69 | 1.64 |
| Toilet pump | 32 | 5.86 | 5 | 7.81 | 1.33 |
| Gully trap | 26 | 4.76 | 2 | 3.13 | 0.66 |
| Water drum | 45 | 8.24 | 3 | 6.67 | 0.81 |
| Water tank | 35 | 6.41 | 1 | 1.56 | 0.24 |
| Vase pedestal | 36 | 6.59 | 7 | 10.94 | 1.67 |
| Polystyrene | 64 | 11.72 | 3 | 4.69 | 0.40 |
| Tyre | 14 | 2.56 | 2 | 3.13 | 1.22 |
| Canvas | 10 | 1.83 | 1 | 1.56 | 0.85 |
| Pain can | 21 | 3.85 | 1 | 1.56 | 0.41 |
| Drainage | 15 | 2.75 | 1 | 1.56 | 0.57 |
| Water tub | 13 | 2.38 | 1 | 1.56 | 0.66 |
| Platting | 14 | 2.56 | 1 | 1.56 | 0.61 |

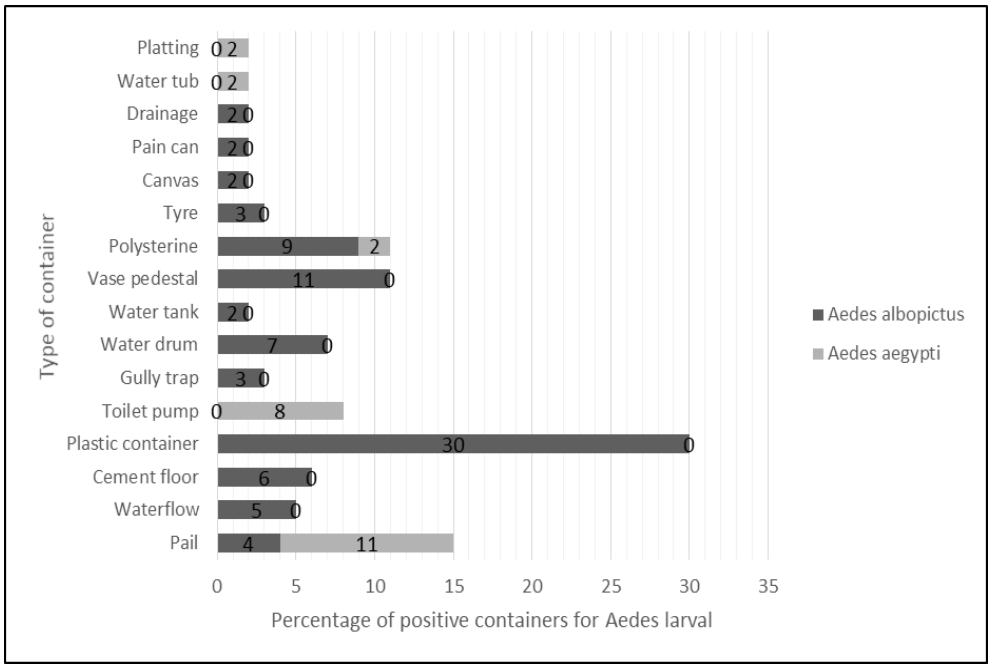


**Fig 2:** Types of breeding containers of *Aedes aegypti* and *Aedes albopictus*

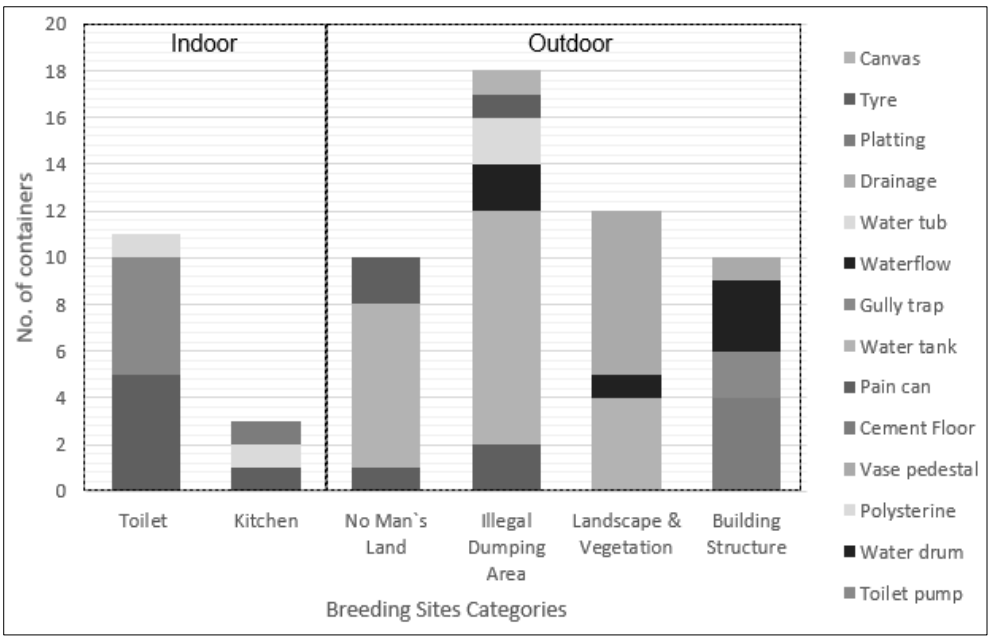


**Fig 3:** Types of breeding containers based on breeding sites categories

**Table 5:** Distribution of positive *Aedes* spp breeding containers

| Study sites | No of positive *Aedes* spp breeding containers identified, n=64 | |
|---|---|---|
| | Indoor | Outdoor |
| High-rise (> 5 stories) | 8 | 15 |
| Low-rise (< 5 stories and landed houses) | 6 | 35 |

($X^2$ = 3.5001, *P-value* = 0.0613)

## 4. Discussion

The results indicated most of the key breeding containers found at dengue outbreak localities in Cheras district were artificial or man-made containers. These findings concurred with previous studies that *Aedes* spp larvae, especially *Aedes albopictus*, were detected in a wide range of artificial containers [25-27]. These key-breeding containers were found in both outdoors and indoors at the outbreak localities. The main key-breeding containers, based on common breeding containers found and BPR, were plastic containers and toilet pumps. This finding concurred with the study done by Rohani *et al*. which showed that plastic containers were the most preferred breeding containers for both *Aedes aegypti* and *Aedes albopictus* in Malaysia [28]. We also found other key-

breeding containers included vase pedestal, pail, water flow and tyres and these findings corroborated with other studies in Malaysia where *Aedes* mosquitoes preferred all those key-breeding containers whether in urban, suburban or rural habitats [24, 27, 32]. Previous studies stated that the immature stages of *Aedes* were almost entirely restricted to artificial water containers, such as plastic containers, tyres, potted-plant bases, rain water tanks, gutters and sump pits [29-32]. All these are man-made receptacles that can be eradicated or eliminated by community involvement and other related agencies.

This identification of key indoor containers can facilitate the crafting of mosquito control messages specific to each type of container. Previous studies have regarded this strategy as best practice in the prevention and control of dengue in the Americas [33] and Australia [15]. Data from our study, therefore, can also be used to formulate specific messages pertaining to plastic container, toilet pump, pail, vase pedestal, all of which showed the greatest proportions positive for *Aedes* larvae. As a monitoring and evaluation measure, performing a follow up survey to check for an improvement in the larval indices may help determine the effectiveness of the messages given.

For outdoor breeding, our observation showed that all *Aedes* spp breeding containers were artificial and could be found mostly at illegal dumping areas followed by landscape and vegetation areas, 'no man`s land' and building structures. A previous local study in Bandar Baru Bangi also stated that *Aedes* breeding sites were found in the area deemed no 'man`s land', illegal dumping area, plants and flower nurseries [34]. One of the suggested methods to overcome illegal dumping and landscape/vegetation issue is by empowering community-based environmental management; this is an important element in Integrated Vector Management (IVM) strategy. The involvement of the community and other agencies to manage environmental problems, such as illegal dumping, breeding at vegetation water-holding containers and littering in residential areas [35]. The most productive types of breeding sites should be removed, destroyed or altered to prevent further breeding. Enforcement and monitoring by municipal councils can be strengthened by identifying illegal dumping areas and 'no man`s land' with information provided by the community and vector control team. To improve the management of vegetation in residential areas, especially management of water holding containers, proper education on *Aedes* control and prevention should be given to the respective vegetation owners.

Our study also concluded that one of the main categories of outdoor breeding sites was building structures comprising cement flooring, water flow, gully trap and drainage. These findings correlates with the study done in Malaysia showing that *Aedes* larva was mainly found in gutters, flat roof surfaces, floor finishes, gully traps, cracked slab, trench, drainage, piping, and outlets of high-rise buildings [36]. Moreover, the local study also reported that drainage systems with stagnant water serve as a good artificial breeding site for *Aedes* spp [37]. Therefore, there is a need for scheduled maintenance and regular cleaning by the residential management body and community focusing on building structures that had been identified as *Aedes* breeding sites. This study also emphasizes the importance of microelements in building design towards free *Aedes* breeding sites, and the need to strengthen the implementation of the *Aedes* Control Guideline in Construction Sites 2015 [38].

Our findings showed that there was no significant difference between high-rise building (defined as more than 5 stories) and low-rise building (defined as less than 5storeies and landed properties) for indoor and outdoor breeding. This indicates that the source reduction activity for *Aedes* control should consider wider coverage involving all levels of the building and common areas on the ground level and surrounding areas as these areas contribute positive *Aedes* breedings. A previous study reported on the vertical distribution of *Aedes* mosquitoes using ovitraps in multiple storey buildings in Selangor and Kuala Lumpur also showed *Aedes* breeding could be found at any level of the buildings [39]. This finding also supported by a local study on the vertical distribution of *Aedes* at apartments in Kuala Lumpur that indicated positive breeding for *Aedes* could be found from the first floor to thirteen floor of the apartment [40].

To strengthen the preventive and control of dengue, World Health Organization (WHO) recommended the approach of IVM as one of the main strategies. IVM is defined as rational decision-making process to optimize the use of the resources for vector control [41]. This IVM strategy includes the elements of advocacy, social mobilization and legislation, collaborative with the health sector, integrated approach, evidence-based decision making and capacity building.

From our results, the elements of IVM which are advocacy and social mobilisation can be applied in order to change community behaviour and practices towards dengue prevention and control activities. The idea of changing behaviour gradually to sustain dengue prevention is very important and the model of HICDARM and behaviour adoption can be implemented (Table 5) [42]. Since these findings identified the key behaviour of the community that contributed to indoor *Aedes* spp breeding, efforts should be focussed on prevention behaviour in the kitchen and toilet areas of their homes.

**Table 6**: Hicdarm and Behaviour Adoption

| **HICDARM and Behaviour Adoption** | |
|---|---|
| First, we hear,<br>Then we become,<br>And later | Hear about new behaviour |
| | Informed about it |
| | Convinced that is worthwhile |
| In time we make the,<br>And later we take,<br>We next await,<br>And if all is well, we | Decision to do something about our conviction |
| | Action on the new behaviour |
| | Reconfirmation our action was a good one |
| | Maintain the behaviour |

In this study, there are few limitations that need to be highlighted. First, this was a descriptive study only focusing on dengue outbreaks in one district. Hence, this study does not represent the entire urban locality of Kuala Lumpur. However, it has a relatively high risk of dengue outbreaks, and we believe this study serves as an appropriate site for studying vector-related risk factors, namely, breeding containers. Therefore, further study is recommended to obtain better coverage of dengue outbreaks in all districts of Kuala Lumpur.

The study concluded that a dengue surveillance tool should not only monitor the local dengue vector distribution but also provide objective information for the community to take appropriate action against dengue vectors. Thus, providing and identifying the most preferable breeding sites in certain dengue localities is important to mobilise prevention and control activities, especially by the community.

## 5. Conclusion

In conclusion, our study covering a wide area of an urban district in Kuala Lumpur has provided further data on the substantial role played by human-made habitats as a barrier to controlling *Aedes* dengue outbreaks. This preventable risk requires integrated source reduction activity by identifying key breeding containers for dengue control. Evaluation of IVM implementation efficacy in dengue outbreaks in Cheras District is also needed to ensure sustainability of prevention and control activities.

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## 7. References

1. Brady OJ, Gething PW, Bhatt S, Messina JP, Brownstein JS, Hoen AG *et al*. Refining the global spatial limits of dengue virus transmission by evidence-based consensus. PLoS neglected tropical diseases. 2012; 6(8):e1760.
2. Kesihatan PI. Petunjuk Kesihatan Putrajaya, Malaysia: Kementerian Kesihatan Malaysia, 2017.
3. Kumarasamy V. Dengue fever in Malaysia: Time for review. Med J Malaysia. 2006; 61(1):1-3.
4. Tham A. Issue and challenges in *Aedes* surveillance and control workshop proceeding behavior intervention in dengue control of Malaysia Centre of Drug Malaysia. Universiti Sains Malaysia and Institute of Health Promotion, Ministry of Health, Malaysia. 2000, 15-23.
5. eDengue Versi 2 [Internet], 2016. [cited 10 January 2017]. Available from: http://edenguev2.moh.gov.my/.
6. Erlanger T, Keiser J, Utzinger J. Effect of dengue vector control interventions on entomological parameters in developing countries: A systematic review and meta-analysis. Medical and veterinary entomology. 2008; 22(3):203-21.
7. Rohani A, Ismail S, Malinda M, Anuar I, Mazlan IM, Maszaitun MS *et al*. *Aedes* larval population dynamics and risk for dengue epidemics in Malaysia. 2011.
8. Tun-Lin W, Kay BH, Barnes A. Understanding Productivity, A Key to *Aedes aegypti* Surveillance. The American Journal of Tropical Medicine and Hygiene. 1995; 53(6):595-601. doi: doi:https://doi.org/10.4269/ajtmh.1995.53.595.
9. Knox TB, Nguyen YT, Vu NS, Kay BH, Ryan PA. Quantitative relationships between immature and emergent adult *Aedes aegypti* (Diptera: Culicidae) populations in water storage container habitats. J Med Entomol. 2010; 47(5):748-58.
10. Kay BH, Nam VS, Tien TV, Yen NT, Phong TV, Diep VT *et al*. Control of *Aedes* vectors of dengue in three provinces of Vietnam by use of Mesocyclops (Copepoda) and community-based methods validated by entomologic, clinical, and serological surveillance. Am J Trop Med Hyg. 2002; 66(1):40-8.
11. Hanna JN, Ritchie SA, Merritt AD, van den Hurk AF, Phillips DA, Serafin IL *et al*. Two contiguous outbreaks of dengue type 2 in north Queensland. Med J Aust. 1998; 168(5):221-5.
12. Chadee DD. Key premises, a guide to *Aedes aegypti* (Diptera: Culicidae) surveillance and control. Bull Entomol Res. 2004; 94(3):201-7.
13. Focks DA, Chadee DD. Pupal survey: an epidemiologically significant surveillance method for *Aedes aegypti*: An example using data from Trinidad. Am J Trop Med Hyg. 1997; 56(2):159-67.
14. Kay BH, Lyons SA, Holt JS, Holynska M, Russell BM. Point source inoculation of mesocyclops (Copepoda: Cyclopidae) gives widespread control of *Ochlerotatus* and *Aedes* (Diptera: Culicidae) immatures in service manholes and pits in north Queensland, Australia. J Med Entomol. 2002; 39(3):469-74.
15. Montgomery BL, Ritchie SA. Roof gutters: a key container for *Aedes aegypti* and *Ochlerotatus notoscriptus* (Diptera: Culicidae) in Australia. The American Journal of Tropical Medicine and Hygiene. 2002; 67(3):244-6.
16. Ritchie SA, Long SA, McCaffrey N, Key C, Lonergan G, Williams CR. A biodegradable lethal ovitrap for control of container-breeding *Aedes*. Journal of the American Mosquito Control Association. 2008; 24(1):47-53.
17. Stoler J, Brodine SK, Bromfield S, Weeks JR, Scarlett H. Exploring the relationships between dengue fever knowledge and *Aedes aegypti* breeding in St. Catherine Parish, Jamaica: a pilot of enhanced low-cost surveillance. Res Rep Trop Med. 2011; 2:93-103.
18. Maciel-de-Freitas R, Lourenço-de-Oliveira R. Does targeting key-containers effectively reduce *Aedes aegypti* population density? Le ciblage des conteneurs clés réduit-il efficacement la densité de la population *d'Aedes aegypti*? Tropical Medicine & International Health. 2011; 16(8):965-73. doi: 10.1111/j.1365-3156.2011.02797.x.
19. Tsuzuki A, Duoc VT, Higa Y, Yen NT, Takagi M. Effect of Peridomestic Environments on Repeated Infestation by Preadult *Aedes aegypti* in Urban Premises in Nha Trang City, Vietnam. The American Journal of Tropical Medicine and Hygiene. 2009; 81(4):645-50. doi: doi:https://doi.org/10.4269/ajtmh.2009.08-0175.
20. Lloyd LS. Best practices for dengue prevention and control in the Americas. 2003.
21. Medronho RA, Macrini L, Novellino DM, Lagrotta MTF, Câmara VM, Pedreira CE. *Aedes aegypti* Immature

Forms Distribution According to Type of Breeding Site. The American Journal of Tropical Medicine and Hygiene. 2009; 80(3):401-4.
doi: doi:https://doi.org/10.4269/ajtmh.2009.80.401.
22. Rueda LM. Pictorial keys for the identification of mosquitoes (Diptera: Culicidae) associated with dengue virus transmission. Walter Reed Army Inst of Research Washington Dc Department of Entomology, 2004.
23. Kumar RR, Kamal S, Patnaik S, Sharma R. Breeding habitats and larval indices of *Aedes aegypti* (L) in residential areas of Rajahmundry town, Andhra Pradesh. The Journal of communicable diseases. 2002; 34(1):50-8.
24. Vijayakumar K, Kumar TS, Nujum ZT, Umarul F, Kuriakose A. A study on container breeding mosquitoes with special reference to *Aedes* (Stegomyia) *aegypti* and *Aedes albopictus* in Thiruvananthapuram district, India. Journal of vector borne diseases. 2014; 51(1):27.
25. Chen C, Lee H, Stella-Wong S, Lau K, Sofian-Azirun M. Container survey of mosquito breeding sites in a university campus in Kuala Lumpur, Malaysia. 2009.
26. Thavara U, Tawatsin A, Chansang C, Kong-ngamsuk W, Paosriwong S, Boon-Long J *et al*. Larval occurrence, oviposition behavior and biting activity of potential mosquito vectors of dengue on Samui Island, Thailand. J Vector Ecol. 2001; 26(2):172-80.
27. Preechaporn W, Jaroensutasinee M, Jaroensutasinee K. The Larval Ecology of *Aedes aegypti* and *Ae. albopictus* in Three Topographical Areas of Southern Thailand, 2006.
28. Rohani A, Aidil Azahary AR, Malinda M, Zurainee MN, Rozilawati H, Wan Najdah WM *et al*. Eco-virological survey of *Aedes* mosquito larvae in selected dengue outbreak areas in Malaysia. J Vector Borne Dis. 2014; 51(4):327-32.
29. Christophers S. *Aedes aegypti* (L.) the yellow fever mosquito: its life history, bionomics and structure. *Aëdes aegypti* (L) the Yellow Fever Mosquito: its Life History, Bionomics and Structure, 1960.
30. Barker-Hudson P, Jones R, Kay BH. Categorization of domestic breeding habitats of *Aedes aegypti* (Diptera: Culicidae) in Northern Queensland, Australia. Journal of medical entomology. 1988; 25(3):178-82.
31. Kay B, Ryan P, Russell B, Holt J, Lyons S, Foley P. The importance of subterranean mosquito habitat to arbovirus vector control strategies in north Queensland, Australia. Journal of medical entomology. 2000; 37(6):846-53.
32. Montgomery BL, Ritchie SA. Roof gutters: a key container for *Aedes aegypti* and *Ochlerotatus notoscriptus* (Diptera: Culicidae) in Australia. Am J Trop Med Hyg. 2002; 67(3):244-6.
33. David MR, Lourenço-de-Oliveira R, Freitas RMd. Container productivity, daily survival rates and dispersal of *Aedes aegypti* mosquitoes in a high income dengue epidemic neighbourhood of Rio de Janeiro: presumed influence of differential urban structure on mosquito biology. Memórias do Instituto Oswaldo Cruz. 2009; 104(6):927-32.
34. Meftahuddin T, Anisah AB, A MF. Outbreak of Dengue in Bandar Baru Bangi. Malaysian Journal of Public Health Medicine. 2004; 4(1):22-8.
35. Sommerfeld J, Kroeger A. Eco-bio-social research on dengue in Asia: A multicountry study on ecosystem and community-based approaches for the control of dengue vectors in urban and peri-urban Asia. Pathogens and global health. 2012; 106(8):428-35.
36. Zainon N, Rahim FAM, Roslan D, Samat AHA. Prevention of *Aedes* Breeding Habitats for Urban High-Rise Building in Malaysia. Planning Malaysia Journal. 2016; 14(5).
37. Chen C, Benjamin S, Saranum MM, Chiang Y, Lee H, Nazni W *et al*. Dengue vector surveillance in urban residential and settlement areas in Selangor, Malaysia. Tropical biomedicine. 2005; 22(1):39-43.
38. Malaysia MOH. Garis Panduan Pengawalan Nyamuk Aedes di Tapak-Tapak Binaan. Putrajaya, Malaysia: Ministry of Health Malaysia, 2015, 13.
39. Lau K, Chen C, Lee H, Izzul A, Asri-Isa M, Zulfadli M *et al*. Vertical distribution of *Aedes* mosquitoes in multiple storey buildings in Selangor and Kuala Lumpur, Malaysia. Tropical biomedicine. 2013; 30(1):36-45.
40. Roslan MA, Shafie A, Ngui R, Lim YAL, Sulaiman WYW. Vertical infestation of the dengue vectors *Aedes aegypti* and *Aedes albopictus* in apartments in Kuala Lumpur, Malaysia. Journal of the American Mosquito Control Association. 2013; 29(4):328-36.
41. Organization WH. Global strategic framework for integrated vector management. 2004.
42. Organization WH. UNICEF. Communication for behavioural impact (COMBI): A toolkit for behavioural and social communication in outbreak response. 2012.