นิพนธ์ต้นฉบับ

Water consumption and distribution of dengue larvae in Pattani villages

อาแว ลือโมะ[1]
ดอน แม็คเนล[2]
เมตตา กูนิง[3]

Abstract:

Water consumption and distribution of dengue larvae in Pattani villages

Luemoh A, McNeil D, Kuning M.

Public Health Office, Muang, Pattani, 94000, Thailand

Department of Statistics, Macquarie University, Australia

Faculty of Science and Technology, Prince of Songkla University, Pattani Campus, Pattani, 94000, Thailand

Songkla Med J 2003; 21(3): 209-216

The water consumption characteristics and larval density of dengue haemorrhagic fever (DHF) vectors in DHF transmission and non-DHF transmission villages, as well as the relationship between these factors were investigated. We carried out a stratified cross-sectional survey during October and November 1998 in 160 households selected by randomized stratification from eight villages of Pattani province in southern Thailand. The villages were stratified by seaside or mountainside location, predominant religion of residents (Buddhist or Muslim), and transmission or non-transmission of dengue haemorrhagic fever. The mosquito larvae presence in containers used for storing drinking and washing water and the characteristics of these

---

[1]M.Sc (Research Methodology), Public Health Office, Muang, Pattani, 94000, Thailand
[2]Ph.D. (Statistics), Department of Statistics, Macquarie University, Australia
[3]M.Sc (Research Methodology), Faculty of Science and Technology, Prince of Songkla University, Pattani Campus, Pattani, 94000, Thailand
รับต้นฉบับวันที่ 13 กรกฎาคม 2544 รับลงตีพิมพ์วันที่ 24 มกราคม 2546

containers were measured. We used Mantel-Haenszel adjusted odds ratio and logistic regression to evaluate the factors determining DHF transmission in the village and the presence of larvae in the water containers. The larvae indices of dengue vectors were higher in the DHF transmission villages. There were strong associations between the water container characteristics, which varied between villages, and the presence of larvae. In particular, plastic containers were less likely to contain larvae.

Key words: *larvae of dengue vectors, dengue haemorrhagic fever, water consumption characteristics, Thailand*

บทคัดย่อ:

การศึกษาลักษณะการใช้น้ำของประชาชนและความชุกของลูกน้ำยุงลายในหมู่บ้านที่มีการแพร่ระบาดกับหมู่บ้านที่ไม่มีการแพร่ระบาดของโรคไข้เลือดออก และศึกษาความสัมพันธ์ของลักษณะการใช้น้ำของประชาชนและความชุกของลูกน้ำยุงลายที่มีผลต่อการแพร่ระบาดของโรคไข้เลือดออก ศึกษาแบบการวิจัยเชิงสำรวจแบบตัดขวาง ระหว่างเดือนตุลาคม - พฤศจิกายน 2541 ในหมู่บ้านซึ่งแบ่งตามลักษณะพื้นที่ทางภูมิศาสตร์ของจังหวัดปัตตานี เป็น 2 ลักษณะ คือ หมู่บ้านที่อยู่ใกล้ชายทะเล และหมู่บ้านที่อยู่ติดกับภูเขา โดยคัดเลือกพื้นที่ตัวแทนที่มีและไม่มีการแพร่ระบาดของไข้เลือดออกตามลักษณะหมู่บ้านไทยพุทธและไทยมุสลิม จำนวนทั้งสิ้น 8 หมู่บ้าน สุ่มแบบแบ่งชั้นภูมิ จำนวน 160 หลังคาเรือน ทำการนับจำนวนลูกน้ำยุงลายในภาชนะสำหรับน้ำดื่ม น้ำใช้ จำแนกตามประเภทของภาชนะ สถิติที่ใช้ คือ Mantel Haenszel Odds Ratios และการวิเคราะห์ถดถอยลอจิสติก จากการศึกษาพบว่า หมู่บ้านที่มีการแพร่ระบาดของโรคไข้เลือดออกมีค่าดัชนีความชุกของลูกน้ำยุงลายสูง ประเภทของภาชนะซึ่งผันแปรตามหมู่บ้านนั้นมีความสัมพันธ์กับความชุกของลูกน้ำยุงลาย โดยเฉพาะภาชนะประเภทพลาสติกมีความชุกของลูกน้ำยุงลายต่ำ

คำสำคัญ: *ลูกน้ำยุงลาย, ไข้เลือดออก, คุณลักษณะของน้ำดื่ม, ประเทศไทย*

Introduction

Dengue fever and dengue haemorrhagic fever (DHF) are caused by dengue viruses and transmitted exclusively from human to human by the bite of infected mosquitoes of the Aedes family.[1] DHF is one of the most rapidly expanding diseases in all regions in Thailand, and the most severe forms of the disease, DHF and Dengue Shock Syndrome (DSS), are leading causes of hospitalization and death among children. The epidemic pattern of DHF in Pattani province, located in the south of Thailand, has alternated by year from 1993 to 1997. The highest number of cases was recorded in 1995, particularly in the Pattani City, Khok Pho, and Nong Chik districts, with respective morbidity rates of 57.1, 34.5 and 31.7 per 100,000 population. In 1996, the number of cases was highest in Khok Pho, Panare and Pattani City, with respective morbidity rates of 11.4, 7.6 and 4.9 per 100,000 population. In 1997, the surveillance report of the Pattani Public Health Provincial Office revealed the highest incidence of DHF in September. The disease has spread to all districts in Pattani. Furthermore the DHF transmission always occurs in areas, for example Khok Pho and Pattani City, which have a mixed population of Buddhists and Muslims.[2]

From the above information it was felt of interest to determine why some areas in Pattani always have DHF transmission yearly while other areas do not. Furthermore, water consumption customs, which differ between Buddhist and Muslim people, may affect DHF transmission.

Thus, it was decided that water consumption characteristics and larval density of dengue vectors in both DHF transmission and non-DHF transmission villages should be thoroughly investigated, to gain a better understanding of the causes of DHF transmission among rural populations. The specific research objective was to investigate the determinants of the prevalence of larvae containing the dengue vector in household water containers, and in particular, whether specified properties of both the containers and the households were associated with the presence of these larvae. The main hypothesis tested was that water containers in DHF transmission villages have a higher prevalence of dengue vector-carrying larvae.

Materials and Methods

A stratified cross-sectional survey was used for this study. The instruments of data collection were based on the forms used for larvae identification by the Ministry of Public Health. The data were collected during October and November 1998 in Pattani province. Target villages were stratified by location (seaside or mountainside), by predominant religion (90% or more Buddhist or Muslim), and by DHF transmission status (at least one DHF case reported in the previous 5 years). Eight villages were thus selected, four from the coastal district of Panare and four from the mountainside district of Khok Pho, according to the sampling plan shown in Table 1.

From each of these villages, 20 households were selected randomly after consultation with local officials. In each household, all water containers were examined, and the unit of analysis was the individual water container. The variables in this study were as follows.

1. Outcome variable: presence of dengue vector larvae in a container.

2. Container-specific determinants: purpose (drinking, washing, other), lid presence or absence, material (clay/cement, plastic, other), location, and size.

3. Household-specific determinants: drinking water source, washing water source, frequency of renewal of water in containers.

4. Stratification variables: location (seaside or mountainside), DHF transmission status, religion (Islamic/Buddhist).

In the preliminary analysis, Pearson's chi-squared test and 95% confidence intervals for odds ratios and Mantel-Haenszel adjusted odds ratios were used to assess the associations between the outcome and the various determinants. For determinants with more than two categories, odds ratios were computed by comparing each category of the determinant with all other categories of that determinant combined.[3] In the statistical modeling, multiple logistic regression analysis was used for investigating the joint effects of the determinants on the outcome variable.[4] To allow for possible correlation between outcomes from different containers in the same household, the generalized estimating equation method[5] was used to fit the logistic model.

Table 1 Villages selected for study

Village	District	DHF transmission	Religion	Population	Households
Ban Klang	Panare	No	Muslim	609	106
Tha Nam	Panare	Yes	Muslim	725	97
Kor Krabu	Panare	No	Buddhist	279	83
Don	Panare	Yes	Buddhist	395	92
		Total for Panare district		**36,041**	**8,287**
Na Pradu Moo 7	Khok Pho	No	Muslim	916	147
Na Gae Moo 5	Khok Pho	Yes	Muslim	432	68
Na Pradu Moo 1	Khok Pho	No	Buddhist	1,412	286
Na Gae Moo 6	Khok Pho	Yes	Buddhist	687	150
		Total for Khok Pho district		**52,408**	**14,703**

Results

Of the standard indices of larvae of dengue vectors,[6] the House Index (HI) was 80.6%, the Container Index (CI) was 53.7%, the Breteau Index (BI) was 403 infected containers per 100 households, and the Stegomyia Index was 403.1 infected containers per 1,000 persons. The Breteau and Stegomyia indices for the DHF transmission villages were almost double those for the non-DHF transmission villages. The DHF transmission villages also had a greater proportion of containers with larvae than the non-DHF transmission villages (chi-squared=25.32, $p<0.05$). The results are shown in Table 2.

Table 3 shows the comparison between DHF transmission and non-DHF transmission villages with respect to household water source and renewal characteristics. There were statistically significant differences between water consumption characteristics in the DHF transmission villages and those in non-DHF transmission villages. These water consumption characteristics include drinking water source (chi-squared = 11.39, $p<0.05$) and washing water source (chi-squared = 8.03, $p<0.05$).

Table 2 Distribution of dengue vector indices by area

Area	Persons	Containers	Larvae Indices			
			House Index	Container Index	Breteau Index	Stegomyia Index
All areas	745	1,201	80.6	53.7	403	403.1
Non-DHF	382	514	78.8	45.3	291	609.9
DHF-Transmission	363	687	82.5	60.0	515	1,135.0
Muslim	315	599	0	52.5	393.8	759.0
Buddhist	330	602	81.2	54.8	412	1,000.0

Table 3 Associations for household-specific determinants and DHF transmission

Variable	Category	Transmission	Non-Transmission	Odds ratio (95% Confidence interval)
Drinking water source	Well	68	52	3.05 (1.42 - 6.57)
	Tap water	3	16	0.16 (0.04 - 0.56)
	Others	9	12	0.72 (0.28 - 1.81)
Washing water source*	Well	75	65	3.46 (1.19 - 10.0)
	Tap water	4	15	0.22 (0.07 - 0.72)
Drinking water renewal	Every day	32	32	1.00 (0.53 - 1.88)
	2 - 3 days	33	40	0.70 (0.38 - 1.31)
	4 - 6 days	5	4	1.27 (0.33 - 4.90)
	Others	10	4	2.71 (0.81 - 9.05)
Washing water renewal	Every day	28	28	1.00 (0.52 - 1.91)
	2 - 3 days	27	32	0.76 (0.40 - 1.45)
	4 - 6 days	17	15	1.17 (0.54 - 2.54)
	Others	8	5	1.67 (0.52 - 5.33)

* One household got its water from the river.

Table 4 shows the same comparison with respect to container characteristics. The prevalence of the dengue vector larvae among all containers in the sampled households was 53.7% (96% CI: 50.9-56.5%). Statistically significant determinants were type of use (chi-squared = 15.06, p<0.05) and having a lid (chi-squared = 3.98, p<0.05).

Table 5 shows the result of a logistic regression analysis in which the outcome was the presence or absence of larvae in an individual container. In this analysis, the container's location and type of use were combined to form a single variable with seven categories, and the container's material and lid presence/absence were similarly combined to form a single variable with five categories. Initially, all variables pertaining to both the container and the household were included in the model, and those failing to reach statistical significance at the 5% level were sequentially omitted using backward elimination. The result suggests that container type/location, material/lid, and DHF transmission status, were significantly associated with the prevalence of the dengue vector larvae in the containers.

Since containers located in the same household might be expected to give correlated outcomes, the logistic model was fitted using the generalized estimating equations method with an exchangeable correlation structure. The common correlation coefficient for containers within households was found to be 0.1665. The results are quite similar to those obtained assuming independence (Table 5a). The only noteworthy difference is that evidence of a district effect was found after fitting the model assuming independence between containers in the same household. For completeness, we have thus included region in the model, even though it fails to reach statistical significance.

Table 4 Associations for container-specific determinants and DHF transmission

Variable	Category	Transmission	Non-Transmission	Odds ratio (95% Confidence interval)
Larvae	Present	412	233	1.81 (1.43 - 2.78)
Container	Drinking	89	85	0.75 (0.54 - 1.04)
Type	Washing	215	200	0.71 (0.56 - 0.91)
	Other	284	165	1.49 (1.17 - 1.89)
	Unused	99	64	1.18 (0.84 - 1.66)
Lid	Yes	117	111	0.75 (0.56 - 0.99)
Material	Clay	184	147	0.91 (0.71 - 1.18)
	Cement	88	49	1.39 (0.96 - 2.08)
	Plastic	197	129	1.20 (0.93 - 1.55)
	Other	218	189	0.80 (0.63 - 1.02)
Place	Indoors	295	215	1.05 (0.83 - 1.32)
	Under eaves	260	193	1.01 (0.80 - 1.28)
	Outdoors	132	106	0.92 (0.69 - 1.22)
Size	< 50 litre	575	439	0.88 (0.64 - 1.21)
	51-100 litre	10	15	0.49 (0.22 - 1.10)
	100-150 litre	12	10	0.90 (0.38 - 2.09)
	151-200 litre	65	37	1.35 (0.88 - 2.05)
	> 200 litre	25	13	1.46 (0.74 - 2.87)

Table 5 Logistic regression model for dengue larvae risk (using GEE method)

Factor	P-value	Odds ratio	95% CI
Container type/location:	<0.001		
drinking/inside		(1.0)	
drinking/under eaves	0.392	0.406	0.051 - 3.207
drinking/outdoors	0.323	4.533	0.226 - 91.06
washing/inside	0.472	0.747	0.337 - 1.655
washing/under eaves & outdoors	0.623	1.218	0.556 - 2.668
other	0.002	4.099	1.715 - 9.796
unused	<0.001	8.327	3.204 - 21.64
Container material/lid:	<0.001		
plastic with lid		(1.0)	
plastic without lid	0.004	5.010	1.658 - 15.14
clay or cement with lid	<0.001	5.454	2.148 - 13.85
clay or cement without lid	<0.001	23.576	8.086 - 68.74
other	<0.001	8.584	2.740 - 2.983
DHF transmission	0.001	1.983	1.318 - 2.983
Seaside location	0.391	1.200	0.791 - 1.819

Table 5a Logistic regression model for dengue larvae risk (assuming independence)

Factor	P-value	Odds ratio	95% CI
Container type/location:	<0.001		
drinking/inside		(1.0)	
drinking/under eaves	0.380	0.373	0.041 - 3.367
drinking/outdoors	0.286	5.862	0.228 - 151.0
washing/inside	0.676	0.841	0.372 - 1.899
washing/under eaves & outdoors	0.516	1.304	0.586 - 2.904
other	<0.001	4.576	1.920 - 10.90
unused	<0.001	15.197	5.738 - 40.25
Container material/lid:	<0.001		
plastic with lid		(1.0)	
plastic without lid	0.002	5.973	1.889 - 18.89
clay or cement with lid	<0.001	6.381	2.380 - 17.11
clay or cement without lid	<0.001	25.45	8.305 - 77.99
other	<0.001	7.197	2.221 - 23.32
DHF transmission	<0.001	1.848	1.396 - 2.448
Seaside location	0.019	1.423	1.061 - 1.909

Discussion

The results support the research hypothesis that the dengue vector larvae are more prevalent in water used in villages with DHF transmission. The odds ratio for this association was found to be 1.98 (95% CI: 1.32-2.98). A strong association was also found between the container characteristics and the larvae prevalence. Plastic containers with lids had the lowest larvae prevalence. Compared to these containers, plastic containers without lids, and clay or cement containers with lids had approximately five times the odds (95% confidence intervals 1.66-15.14 and 2.15-13.85, respectively) of dengue vector larvae infestation. Among all types of containers, those made of clay or cement without lids had the highest prevalence of larvae in their water, with odds approximately 24 times higher (95% CI: 8.09-68.74) than that of plastic containers with lids.

The water usage type and the location of the container were also found to be predictors of larvae prevalence. Not surprisingly, water in containers used for drinking and washing were less likely to be contaminated with dengue vector larvae than those used for other purposes. There was some evidence that containers located outside the house had greater larvae contamination. This result is consistent with that obtained from Chareonsook et al. (1985),[7] who investigated the prevalence of Aedes mosquito larvae in three villages in Khon Khaen and reported that containers placed in the houses had fewer larvae than those outside the houses. However, a study by Kittyapong and Strickman (1993)[8] reported that containers placed inside houses had more larvae than those placed outdoors and under eaves or in the bathroom. This difference may be due to differences in the way of life and culture in each area.

For each location, the numbers of containers in the transmission villages was found to be not different from those in non-transmission villages. When compared to Muslim villages, the numbers of containers placed indoors and outdoors in Buddhist villages were higher, while those under eaves were lower. This difference may be due to the increased number of animal watering pans, which were coded as the "other" category in Muslim villages because many of the people there domesticate doves as a business. However, in Kok Krabur, Panare district, which is a Buddhist village and always lacks water in summer, the villagers prepared containers for storing water for washing.

The proportion of containers with larvae in drinking and washing water was lower than of those used for other purposes. The Division of General Communicable Control of Thailand[9] and Chareonsook et al.[7] (1985) reported higher proportions of containers with larvae for drinking and washing when compared with containers used for other purposes. It is interesting to note that most of the households in this study had cleaned the containers for drinking and washing regularly at intervals of one to three days. Moreover, most of the containers for drinking and washing having a low density of mosquito larvae were made of plastic (with or without lids) and were mostly found inside houses. These may have an important role in the distribution of mosquito larvae.

In general, people residing in all the study areas were at high risk of getting DHF infection because these larvae density indices were higher than the normal level of indices given by the WHO[6] in every category. Furthermore, the larvae indices in the transmission villages were higher than those in the non-transmission villages, having Breteau and Stegomyia indices increased almost by a factor of 2. This may be because the data were collected in the rainy season. The possibility of having water in the containers is high, therefore, giving a high probability of having larvae in the containers. This finding is supported by Dulyapaire and Wongskul (1990)[10], who studied the DHF vector density between the dry and rainy season in Narathiwat province. They found that the index of the dengue vector in the rainy season was higher than that in the dry season.

In addition, Sangtharathip (1997)[9] studied the determinants and correlation between larvae and adult indices, and incidence rates of DHF in Songkhla province. The study found that the House Index had the highest correlation (in communities, r = 0.82), following by the Container Index (in communities, r = 0.76) and the Stegomyia Index (in communities, r = 0.40). However, the Breteau Index and all adult indices showed negative correlations with the DHF case rate. From these findings, the water consumption characteristics related to the larvae indices should be associated with the DHF incidence rate.

Since the data on the frequency of cleaning the containers were collected as household information, this study could not analyze the frequency of cleaning of each container. In fact, cleaning of the containers was not done at the same time for every container, resulting in an imprecise relation between cleaning of the containers and having larvae in the container. This could either underestimate or overestimate the association.

The data for this study were only collected in the rainy season, so the results, especially larvae density indices, can be generalized only for the rainy season.

For future research, the comparison between water consumption behaviour of the residents and larvae density indices should be done both in summer and in the rainy season. Also the association between the life cycle of the larvae and the container characteristics, such as type of material, texture and water temperature in the container, should be explored.

Conclusion

The results of our study indicate that dengue vector larvae infestation in water containers in villages in Pattani province could be reduced by using plastic containers rather than clay or cement containers, and by using containers with lids.

References

1. Ramirez-Ronda CH. Dengue in the western hemisphere. In: Infect Dis Clin North Am 1994; 8: 107-125.
2. Pattani Public Health Province Office. A situation of dengue haemorrhagic fever in Pattani province 1997.
3. McNeil D. Graphing contingency tables. Special Issue for 30th Anniversary of Prince of Songkla University. Songklanakarin J Sci Technol 1998; 137-150.
4. Hosmer DW, Lemeshow S. Applied logistic regression. New York: Wiley, 1989.
5. Zeger S. Liang K. Longitudinal data analysis for discrete and continuous outcomes. Biometrics 1986; 42: 121-130.
6. Pant CP. Self LS. Vector ecology and bionomics: In: Thongcharoen P. ed. Monograph on dengue/dengue haemorrhagic fever. India: WHO, 23-30.
7. Chareonsook O, Setsaputra S, Singklang K, Yawa T, Purahung S, Suwankiri P. Prevalence of Aedes mosquito in big cement jars and rain water tanks. Commun Dis J 1985; 11: 247-263.
8. Kittyapong P. Strickman D. Distribution of container-inhabiting Aedes larvae (Diptera: Culicidae) at a dengue focus in Thailand. J Med Entomol 1993; 30: 601-605.
9. Sangtharathip S. Aedes mosquito of dengue vector. Dengue haemorrhagic fever, Department of Communicable Disease Control. Ministry of Public Health 437.4 38, 1997.
10. Dulyapaire Y, Wongskul P. Density of Aedes mosquito among villages around the Thai-Malaysian border in 1990. Commun Dis J 1990; 16: 27-32.