

Short Report: Can Daytime Use of Bed Nets Not Treated with Insecticide Reduce the Risk of Dengue Hemorrhagic Fever Among Children in Vietnam?

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Abstract. The purpose of this study was to investigate the prevalence of bed net use and elucidate the effect of daytime bed net use on preventing dengue hemorrhagic fever (DHF) among children in Vietnam. We conducted a population-based cross-sectional survey and a matched case-control study in Khanh Hoa Province where not only some pre-schoolchildren but also some school children, who take a nap during lunch break prior to returning to school, used bed nets during the day. Among 36,901 children 2–10 years of age, most used untreated bed nets during the night (98.3%) compared with 8.4% during the day. The results of the case-control study, which defined 151 cases who were hospitalized with DHF in the provincial hospitals and 604 age-matched neighborhood controls, did not support our hypothesis that children using untreated bed nets during the day are less likely to be hospitalized with DHF (adjusted odds ratio = 0.56, 95% confidence interval = 0.23–1.39).

Dengue hemorrhagic fever (DHF), a life-threatening syndrome caused by any one of four dengue virus (DENV) infections, is a rapidly increasing public health problem in the tropical and subtropical regions of the world.¹ The pathogenesis of DHF has been hypothesized to involve a complex interaction of several factors including the host immune response, virus virulence, and host genetic background.^{2,3} However, antibody-dependent enhancement caused by secondary heterologous DENV infections is widely accepted as a principal risk factor for DHF, except in infants who acquire maternal dengue antibodies.⁴ Dengue infection is highly endemic in the urban/peri-urban areas of Vietnam, and all four serotypes of DENV (DEN-1 to DEN-4) have been identified.⁵ The breeding sites of dengue vector mosquitoes (i.e., *Aedes aegypti*) are located in and around households and may include indoor water jars, basins, and vases.^{6–9} Because such containers are often indispensable, it is difficult to limit their use.⁹ As a result, household residents are highly susceptible to *Ae. aegypti* bites and subsequent dengue infection.

Insecticide-treated bed nets, promoted for malaria control in the rural areas of Vietnam,¹⁰ are usually not used in urban/peri-urban areas, where malaria is not endemic. However, residents of urban/peri-urban areas commonly use untreated bed nets (not treated with insecticides) for protection against *Culex* mosquitoes and other nuisance insects during the night. If daytime bed net use for children could decrease the frequency of *Ae. aegypti* bites, the incidence of dengue may be reduced. To investigate the prevalence of bed net use and elucidate the effect of daytime bed net use on preventing DHF among children, we conducted a population-based cross-sectional study and a matched case-control study in Khanh Hoa Province in central Vietnam.

The province has a hot-dry season from May through October and a cool-wet season from November through April. Although the province includes suburban communes surrounded by rice fields, most residents in the province live in urban communes. The study area covered 33 communes

in this province. A population-based cross-sectional survey was conducted in July 2006 to collect information on the demography and socioeconomic statuses of all residents. The detailed study methods and the characteristics of this population have been described.¹¹ The study was reviewed and approved by the Institutional Review Board of the National Institute of Hygiene and Epidemiology, Hanoi, Vietnam, and the Institutional Review Board of the Institute of Tropical Medicine, Nagasaki University, Nagasaki, Japan.

All houses were geo-referenced using a handheld global positioning system unit with a resolution of 2–5 meters. We obtained admission records of two principal hospitals (provincial-level hospitals) in Khanh Hoa Province that provide medical care exclusively to patients with severe illnesses such as DHF. Patients with DHF were diagnosed by well-experienced local clinicians as part of routine procedures in the hospitals; diagnosis was based on the World Health Organization classification criteria.¹² Hospital records during the 16-month period preceding the census and population census data were linked by using the individual's name, sex, age, contact person, and address.

Among the identification-confirmed DHF patients, children 2–10 years (24–119 months) of age at the time of the interview were included in our case-control study. For each patient, four age-matched neighbor controls (the first- to fourth-nearest age-matched neighbors living in different households) were selected from the study population by using the census database and data from a geographic information system (ArcGIS version 9.3; Environmental Systems Research Institute, Redlands, CA). Information on child bed net practices was collected during household interviews with mothers. To evaluate the effect of daytime bed net use on DHF, we performed a case-control analysis by using a conditional logistic-regression model.

A total of 52,671 children 2–10 years of age were enumerated in the census. Among these children, we excluded 4,028 preschool children (2–5 years of age) who attended kindergarten, 2,304 school age children (6–10 years of age) who had not attended primary school, and 9,438 for whom we had no information on bed net use or other socioeconomic variables. Thus, we included 36,901 children (70.1%) in the analysis. Almost all mothers of the children mentioned that their children used

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bed nets during the previous night of the household interview (36,259 of 36,901, 98.3%). However, few mothers of the children mentioned that their children used bed nets during the day on the previous day of the interview (3,107 of 36,901, 8.4%). Because insecticide treatment of bed nets and long-lasting insecticide-treated bed-nets were not available, all bed nets in the study area were not treated with insecticide.

We identified 251 patients 2–10 years of age who were hospitalized with DHF from our study area within the 16-month period preceding the census. Among these patients, we obtained matched census data for 212 (47.6%). Among the matched 212 DHF patients, we included 151 (71.2%) patients in the case-control study except the minorities (i.e., attending kindergarten among preschool children and not attending primary school among school age children) and patients without complete information about bed net use or other variables. Among the 151 DHF patients and 604 age-matched neighbor controls, the mean age of persons in each group was 7.0 years. Children (cases and controls) had similar demographic and bed net use patterns (Table 1). Compared with controls, cases were more likely to be males, were more likely to be members of a household with middle/high income levels, were less likely to use a bed net during the day, and were more likely to use a bed net at night. The results of crude and multivariate analyses showed no evidence of a lower hospitalization rate among the children who used bed nets during the day (odds ratio [OR] = 0.57, 95% confidence interval [CI] = 0.23–1.39, adjusted OR [AOR] = 0.56, 95% CI = 0.23–1.39) (Table 2). Although nighttime bed net use, sex, and the educational level of the mothers did not increase or decrease the risk of hospitalization for DHF, children from high-income households were at increased risk for DHF (OR = 2.04, 95% CI = 1.02–4.08, AOR = 2.17, 95% CI = 1.06–4.43).

Our results do not support our hypothesis that children who used untreated bed nets during the day were less likely to be hospitalized with DHF. This observation may have occurred because daytime sleep for children is restricted to a short period. Although primary school children (6–10 years of age) in Khanh Hoa Province usually return to their houses during lunch break, their daytime sleep is usually restricted to less

TABLE 1
Demographic and bed net use characteristics among children 2–10 years of age, Nha Trang, Vietnam, July 2006

| Characteristic | Cases (n = 151) | | Controls (n = 604) | |
|--------------------------------|-----------------|--------|--------------------|--------|
| | No. | (%) | No. | (%) |
| Sex | | | | |
| Male | 91 | (60.3) | 326 | (54.0) |
| Female | 60 | (39.7) | 278 | (46.0) |
| Household income level* | | | | |
| Low | 14 | (9.3) | 93 | (15.4) |
| Middle | 92 | (60.9) | 353 | (58.4) |
| High | 45 | (29.8) | 158 | (26.2) |
| Maternal education (years) | | | | |
| No schooling history (0) | 3 | (2.0) | 9 | (1.5) |
| Primary/middle education (1–9) | 125 | (82.8) | 497 | (82.3) |
| Higher education (> 9) | 23 | (15.2) | 98 | (16.2) |
| Daytime bed net use | | | | |
| No | 143 | (94.7) | 557 | (92.2) |
| Yes | 8 | (5.3) | 47 | (7.8) |
| Nighttime bed net use | | | | |
| No | 1 | (0.7) | 14 | (2.3) |
| Yes | 150 | (99.3) | 590 | (97.7) |

* Household income level was estimated based on household ownership of 15 main durable assets by using principal component analysis.

TABLE 2

Risk of hospitalization for dengue hemorrhagic fever associated with demographic and bed net use characteristics among children 2–10 years of age, Nha Trang, Vietnam, July 2006*

| Characteristic | Odds ratio (95% CI) | |
|--------------------------------|---------------------|-------------------|
| | Crude | Adjusted |
| Sex | | |
| Male | Referent | Referent |
| Female | 0.78 (0.54–1.11) | 0.81 (0.56–1.17) |
| Household income level | | |
| Low | Referent | Referent |
| Middle | 1.78 (0.96–3.29) | 1.81 (0.97–3.37) |
| High | 2.04 (1.02–4.08) | 2.17 (1.06–4.43) |
| Maternal education (years) | | |
| No schooling history (0) | Referent | Referent |
| Primary/middle education (1–9) | 0.76 (0.21–2.82) | 0.75 (0.20–2.87) |
| Higher education (> 9) | 0.70 (0.18–2.79) | 0.67 (0.16–2.77) |
| Daytime bed net use | | |
| No | Referent | Referent |
| Yes | 0.57 (0.23–1.39) | 0.56 (0.23–1.39) |
| Nighttime bed net use | | |
| No | Referent | Referent |
| Yes | 4.61 (0.54–39.44) | 4.29 (0.51–35.90) |

* CI = confidence interval.

than 2–3 hours around noon (11:00 AM–2:00 PM). The risk of dengue infection during this period might be already minimal because *Ae. aegypti* activity is typically lowest in the hotter midday period and therefore protection gained would be minimal. Preschool children (2–5 years of age) sleep longer during the day than primary school children. However, the duration of bed net use may still be short, and/or children may not be protected by bed nets because they do not use the bed net continuously.

The observation that residents of high-income households experienced an increased risk of DHF was intriguing. It is reported that malnutrition blunts the severity of second dengue infection by possibly reducing immune activities.¹³ Although the relationship between the household income-level and nutritional status of children is not clear in our study, children from higher-income households may have better nutritional status that increase the severity of secondary dengue infection compared with malnourished children who may be more likely to belong to low-income households.

Children who used bed nets during the day might have shown differences in age and area of residence. These differences could cause variations in the frequency of dengue transmission because of differences in their behavior, vector density, and virus circulation. To take into account potential variations in risk by age and area of residence, we used age-matched controls from the adjacent neighborhood in our case-control analysis. Also, there is no risk of introducing interviewer bias because DHF cases were detected by clinicians in the hospitals and the census interviews were conducted independently by the local health staff. To minimize recall bias, the current status of bed net use was recorded during household interviews. This use reflected practices one day prior to the household interview. Another potential source of bias is a reverse-causality bias; i.e., the mothers of children who had DHF may have started using bed nets during the day for their children. Although we cannot completely exclude the possibility of this bias, its effect may be insignificant because of the absence of health education/promotional programs for using bed nets for dengue prevention. Host genetic factors are probably

important for the manifestation of DHF among the children.¹⁴ However, these are independent risk factors for DHF among children.

Our study indicated that routine use of untreated bed nets during the day may have little or no effect on reducing the risk of DHF among children at least in our study area. This study is the first study known to evaluate the effect of untreated bed nets use on reducing the risk of DHF.

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