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A COMPARISON OF SURVEILLANCE SYSTEMS FOR THE DENGUE VECTOR *AEDES AEGYPTI* IN PORT OF SPAIN, TRINIDAD

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ABSTRACT. When the currently used larval surveillance system (visual inspection) for the dengue vector *Aedes aegypti* was compared with the surveillance for the presence of eggs by ovitrapping in Port of Spain, Trinidad, it was found that the latter (39.1%) was significantly more sensitive than the visual inspection system (10.1%). At the same time, the presence of the nuisance mosquito *Culex quinquefasciatus* was detected in 38.4% of the households. Both *Ae. aegypti* and *Cx. quinquefasciatus* showed preference for ovipositional attractants in ovitraps: hay infusion > yeast suspension > plain tap water. Although all the socioeconomic and geographic areas produced both mosquito species in 1996, upper middle class (UMC) areas (8.6–43.4%) produced more *Ae. aegypti* than did lower middle class (LMC) areas (7.8–38.8%), which produced more than working class (WC) areas (3.9–29.9%). For *Cx. quinquefasciatus*, the order of production was reversed with WC areas (50.1%) > LMC areas (30.0%) > UMC areas (26.0%). Change in vector surveillance strategies incorporating some ovitrapping and stratified sampling are recommended for Caribbean countries.

KEY WORDS Hay, yeast, enhanced ovitraps, socioeconomics, environmental sanitation.

INTRODUCTION

Accurate and reliable information regarding *Aedes aegypti* (L.) breeding habits, distribution, and dispersal is an essential prerequisite for the planning and execution of management strategies for the dengue vector (Wickramsuriya 1995[1]). Ministry of Health personnel as well as communities could use such data in campaigns to effectively eliminate the foci of mosquito production of this and other peridomestic mosquitoes.

The presently used system of mosquito surveillance employed throughout the Caribbean is based on a strategy designed for an eradication campaign requiring an examination of every household and treatment of all larval-positive habitats, whereas most Public Health Departments, recognizing the high level of *Ae. aegypti* endemicity, are operating in a mosquito control-mode type of intervention. Thus, house-to-house examinations are performed, providing indices such as the house (premises), container, and Breteau indices (World Health Organization 1972). In some countries 3–4 such labor-intensive cycles are performed per year, but the emerging data are rarely used for the purpose for which they were intended (S. C. Rawlins, personal observation 1996).

These inspections and necessary treatment of larval habitats are extremely labor-intensive, and with time, survey teams may become less meticulous in their search for breeding sites (Nathan 1993). The general failure of *Ae. aegypti* management programs following these mosquito surveillance practices has caused dengue and mosquito control authorities to stop and review the situation and ask hard questions such as: "How accurate are mosquito surveillance data?" "What price are we prepared to pay to obtain accurate information?" "What can we change to improve our surveillance tools?" The Pan American Health Organization (PAHO) has indicated that when *Ae. aegypti* population densities fall to low levels, the house-to-house inspection proves to be an even less efficient system of evaluation (PAHO 1994) than when densities are higher.

Ovitraps, first used by Fay and Perry (1965) for *Ae. aegypti* surveillance and then by Fay and Eliason (1966) have been assayed but not widely used in Trinidad for this purpose (Chadee 1989). The use of attractants as suggested by Reiter et al. (1991) could prove to be a sensitive tool for sample surveillance of *Ae. aegypti.*

The present study sets out to compare visual inspection for mosquito larvae in containers (i.e., the house index) by vector control (VC) officers of the Port of Spain (POS) City Department with the use of ovitraps equipped with chemical lures placed in selected premises for the detection of oviposition by gravid mosquitoes.

MATERIALS AND METHODS

Study area: These studies were performed in the city of Port of Spain, the capital of Trinidad and Tobago, which has a human population density of 4,235 persons/km^2, a total of about 250,000; the country as a whole has some 1.25 million inhabitants. The country experiences a dry season running from January to May when the mean monthly rainfall is 35 mm and temperature ranges from 22 to 32°C. In the remaining months of the year (June–December), a wet season occurs with a mean

[1] Wickramsuriya, T. 1995. An analysis of the statistics related to the control of *Aedes aegypti* in Barbados. Occasional paper. University of the West Indies, Bridgeton, Barbados.

monthly rainfall of 225 mm and temperatures from 25 to 34°C.

The city of Port of Spain consists of a wide diversity of socioeconomic areas, with working class (WC) areas with small, 1–2 bedroomed concrete and wooden structures, each occupied by 5–9 persons, lower middle class (LMC) areas of 2–3 bedroomed concrete houses with 5–7 residents per unit, and upper middle class (UMC) areas with 3–5 bedroomed concrete houses with 4–7 persons per home. The socioeconomic areas are well recognized and established divisions of the city and could be identified by external appearances.

In the dry and early wet seasons of 1996 when the present study was performed, there was no indication that 1996 would experience the highest prevalence of dengue ever recorded in the island of Trinidad. Approximately 4,000 cases were reported throughout the island, and case numbers for the city amounted to about 1,000, most of which occurred in the later part of the wet season, in the months of September to December.

The method for *Ae. aegypti* control normally used during the study period was source reduction and the addition of 1% temephos sand granules to any currently infested containers that could not be emptied. In areas where dengue transmission was known to be occurring, treatment both by thermal fogging and ultra-low volume sprays of malathion were added to the larvicidal programs.

The study: During the 7 weeks of the dry season and the following 18 weeks of the wet season of 1996, a trained VC inspector of POS City Public Health Department was accompanied by a technician from the Caribbean Epidemiology Centre, who placed ovitraps into each premise that was examined by the VC inspector. All the residences in each area were subjected to visual as well as ovitrapping surveillance. In the course of a period of 6 h of field work per day, about 20 residences were inspected per health worker team. The inspector surveyed each premise and noted and recorded the number of wet containers per premise and the number of these that were positive for mosquito larvae. A larval sample was taken back to the laboratory for identification. The ovitraps consisted of a darkened plastic 275-ml cup fitted with a strip of seed-germination paper lining for a substrate and supplied with either plain water, a brewer's yeast suspension in water at 1 g/20 ml allowed to stand for 7 days, or a hay infusion of dried grass steeped in water. The hay infusion was prepared by soaking dried coarse-leaved savannah grass (*Axonopus compressus*) in water at 1 kg/120 liters water for 7 days.

Ovitraps that had been placed adjacent to each other in quiet shaded areas outside of the homes were serviced 24 h after placement, and their biological contents transported to the laboratory for microscopic examination for mosquito larvae and the hatching of the eggs to larvae for identification of the species. The darkened plastic cups were brought to the laboratory and washed before reuse. Ten days later, the ovitraps were placed into these same premises to detect if there were any changes in oviposition figures compared to the first exposure, after the supposed intervention. Later, this follow-up trapping after 10 days was discontinued because it became clear that it was unnecessary. Larvicidal interventions were virtually absent because of the low positive rates of detection, and the 2nd (10-d) ovitrapping and surveillance inspection were proving to be just a repeat of the first assay.

Overall, in the dry season, studies were done in 7 clusters of residences each with about 20 premises per cluster, resulting in a total of about 140 households examined. In the wet season, 19 clusters each with about 20 residences per cluster, with a total of 380 homes, were surveyed.

Analysis: Because responses were percentages (proportions) rather than counts, the arcsin or angular transformation was used on the data prior to testing the hypothesis of no difference between the seasons (dry vs. wet), no difference between methods (house inspection vs. ovitrapping), and no season by method interaction.

The 2-factor interaction model

$$y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \epsilon_{ijk}$$

was used where τ_i and β_j are seasons and methods effects and $(\tau\beta)_{ij}$ is the seasons by method interaction and ϵ_{ijk} is a random error. The general linear model procedure was used for testing the hypothesis. All hypotheses were tested using a 5% level of significance (i.e., $\alpha = 0.5$). Data were analyzed using MINITAB, Version 7 (MINITAB Inc. 1994).

RESULTS

The percentage of premises found positive for mosquito larvae (house inspection) as well as the percentage of houses with positive ovitraps at day 1 and at day 10 are shown in Fig. 1. In the 7 areas surveyed in the dry season, positive findings of larvae in a household occurred only on 2 occasions, giving visual inspection an index of 2.76% premises positive (n = 7; 140 homes). At all other times inspection proved negative. Conversely, ovitrapping always proved positive for mosquito eggs, ranging from 12.5 to 47.6% with an average of 27.66% (n = 7; 140 homes) of residences at the first day of ovitrapping and 23.8–54.2%, with an average of 41.74%, positive 10 days later.

In the wet season, the differences were even more marked. Premise inspection often yielded negative results, and only gave between 0 and 33.3%, with an average of 10.0% (n = 19; 380 homes) premises with larval-positive containers. In contrast, there was a high occurrence of positive ovitraps with mean rates of 57.1% (n = 19; range 23.7–90.5%) (Fig. 1).

Mean prevalence of *Ae. aegypti* eggs was 39.1%

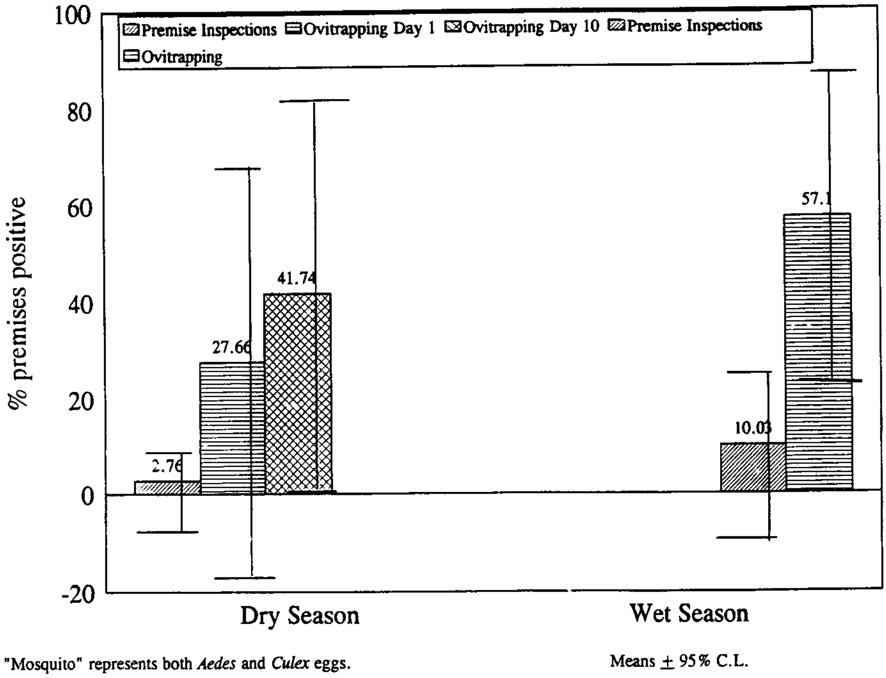


Fig 1. Ovitrapping versus premise inspection for mosquito surveillance.

(n = 19; range 14.3–66.7%), whereas that for *Cx. quinquefasciatus* Say eggs was 38.4% (n = 19; range 0–90.5%) (Fig. 2). In both the dry and wet seasons, statistically significant differences (F = 102.36; df 1,48; $P < 0.001$) existed between the positive rates by visual inspection and the rates obtained by oviposition in the enhanced ovitraps for *Ae. aegypti.*

Preference of ovipositional attractant: Based on the number of eggs oviposited per trap, *Ae. aegypti* was highly attracted to the hay infusion for ovipo-

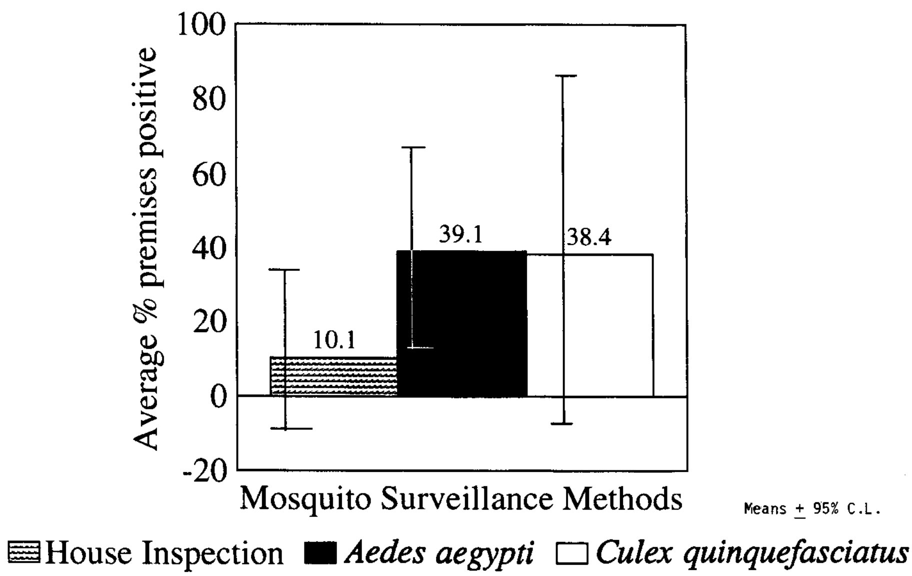


Fig 2. Ovitrapping versus premise inspection for mosquito surveillance, wet season.

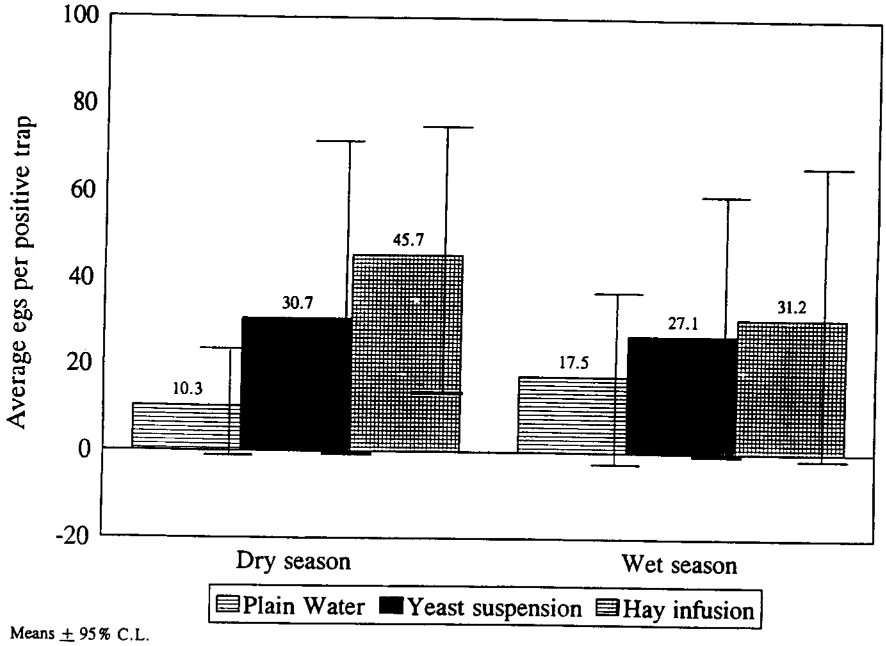


Fig 3. Comparison of *Aedes aegypti* oviposition given a choice of 3 media in ovitraps.

sition (45.7 eggs/trap), moderately attracted to the yeast suspension (30.7 eggs/trap), and attracted least by plain water (10.3 eggs/trap) in the dry season (Fig. 3). In the wet season, mean oviposition preferences were closer for these three attractants with hay infusion (31.2 eggs/trap) > yeast suspension (27.1 eggs/trap) > plain water (17.4 eggs/trap) ($F = 10.45$; df 2,69; $P < 0.001$). Data did not show any significant seasonal (wet vs. dry) difference in patterns of *Ae. aegypti* oviposition ($F = 0.36$; df 1,69; $P = 0.549$), nor was there any season by method interaction ($F = 1.39$; df 2,69; $P = 0.256$).

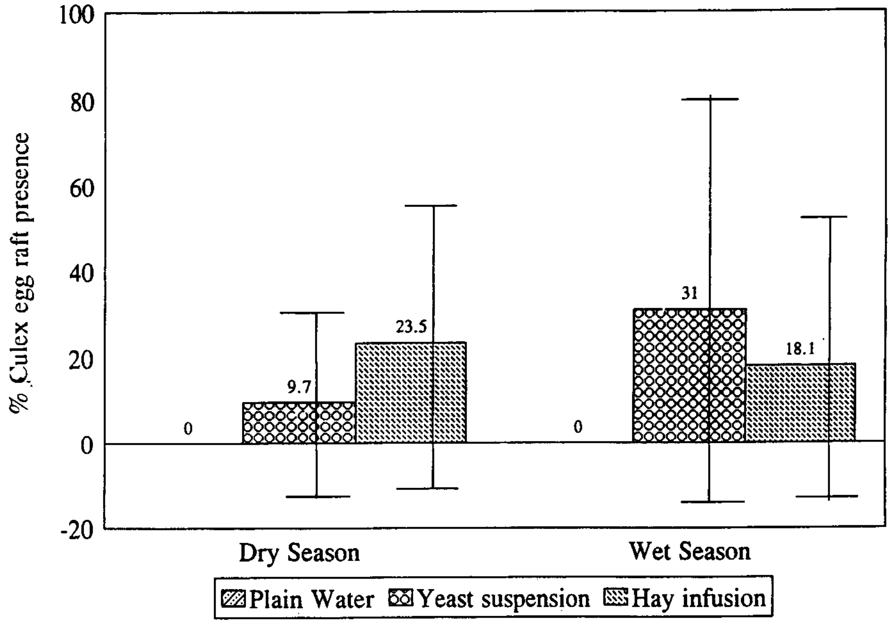
Culex quinquefasciatus showed a similar, although higher order of attraction to oviposit in the 2 enhanced oviposition sites in the dry season (Fig. 4). In terms of egg rafts deposited, the effectiveness of the traps was hay infusion traps > yeast suspensions traps > plain water traps. Plain water did not elicit any *Cx. quinquefasciatus* oviposition at all. No statistical difference was found between the positivity rates in traps enhanced with hay infusion or yeast suspensions, but the enhanced traps were significantly more attractive to both mosquito species than the plain water traps ($F = 8.70$; df = 2,72; $P < 0.001$). In the wet season, the plain water did not attract any *Culex* mosquitoes for oviposition, the yeast suspension was more effective with mean positivity of 31.0% (range 0–80.0%), and the mean positivity of the hay infusion traps was 18.1% (range 0–53.3%). No *Ae. albopictus* (Skuse) were detected throughout this study in POS.

When mosquito larval production (inspection) and oviposition were examined based on the socioeconomic levels of the neighborhoods, mosquito production was measurable in all 3 class areas (Fig. 5). In the wet season, all 3 socioeconomic neighborhoods were positive for *Ae. aegypti* and *Cx. quinquefasciatus* by inspection and enhanced ovitrapping. The percentage of premises positive by both ovitrapping and inspection were UMC areas (43.4%, 8.6%) > LMC areas (38.8%, 7.8%) > WC areas (29.9%, 3.9%) (Fig. 5). Conversely, percentage of premises with ovitraps positive for *Cx. quinquefasciatus* were WC areas (50.1%) > LMC areas (30.0%) > UMC areas (26.0%).

DISCUSSION

The most remarkable feature of these studies is the stark difference between the low level of larval positivity observed by VC inspection compared to high positivity rates for oviposition over both the wet and dry seasons, in all geographic locations of the city, and in all socioeconomic neighborhoods. Because most VC authorities throughout the region depend on inspection data to initiate any anti-*Aedes* intervention, it is clear that this system is deficient, given the high degree of detection of *Ae. aegypti* eggs by the enhanced ovitrapping system of Reiter et al. (1991) and the low level of larval detection by traditional and visual inspection.

Failure to identify breeding places despite overwhelming evidence of the presence of breeding only means that this mosquito uses a variety of locations for its oviposition, especially cryptic habitats that may escape routine examination. These habitats are increasingly important, especially when house indices drop to as low as 1% (POS Health



Means ± 95% C.L.

Fig 4. Comparison of *Culex quinquefasciatus* oviposition given a choice of 3 media in ovitraps.

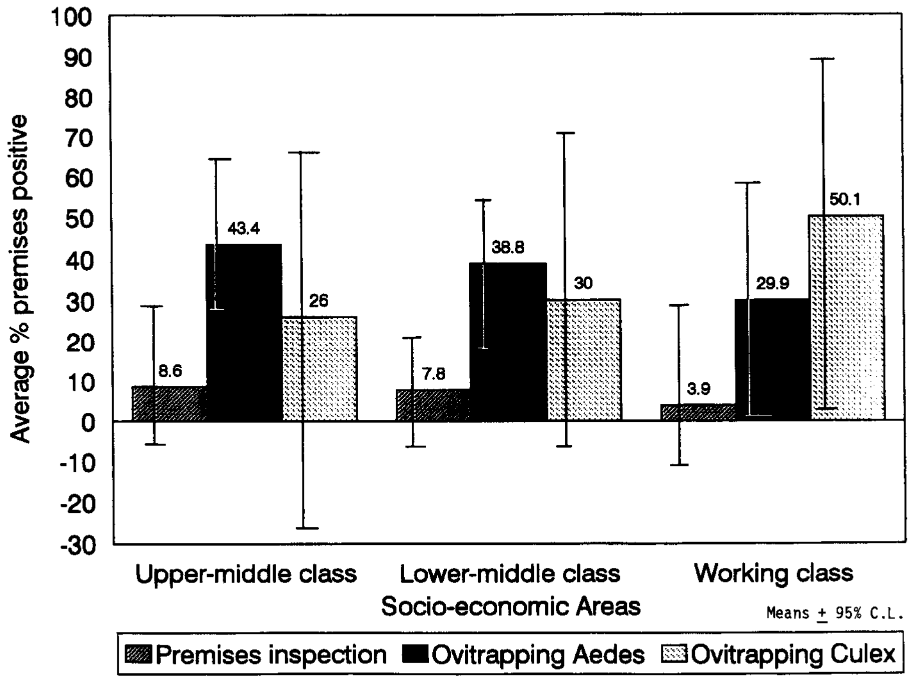


Fig 5. Comparison of surveillance methods by socioeconomic areas.

Department, personal communication, 1996). In such circumstances, other surveillance tools must be put in place, but they need to be highly sensitive, such as the ovitrapping device enhanced with hay infusion, or as we have modified it here by substituting a brewer's yeast suspension as an attractant.

The relatively higher levels of *Ae. aegypti* production in upper socioeconomic neighborhoods is interesting. The presence of a larger variety of appropriate containers for breeding (vases, flower pots with saucers) in these city communities whose residents have higher aesthetic values are contributory factors for the presence of *Ae. aegypti*. Conversely, in the relatively poor working class areas with less resources for aesthetics, with sewer and wastewater systems for oviposition, *Cx. quinquefasciatus* is more highly prevalent than elsewhere. Special but different sanitation messages will need to be developed for these varying communities to help mitigate their different mosquito production problems.

The high degree of *Cx. quinquefasciatus* oviposition in the ovitraps informs us of 2 things. First, a significant amount of *Cx. quinquefasciatus* breeding occurs in all the communities in Trinidad and Tobago, and intervention strategies must be applied for the control of this mosquito even though it is not an important disease vector. Rosenbaum et al. (1995) reported that communities in Trinidad and Tobago perceived this mosquito to be a major nuisance problem. Second, VC authorities will need to intervene in the control of this pest if any community confidence is to be built up to attempt effective management of *Ae. aegypti*. The public cannot distinguish between these 2 mosquito species by appearance, only by mosquito behavior and hematophagous periodicity.

All VC authorities will need to review the currently used mosquito surveillance techniques. It is clear that the current technique is not working well. Perhaps a surveillance system separate from attempts at instituting interventions may be more sensitive. Thus, a sampling exercise of visual inspection supported by ovitrap surveillance using a stratified or cluster sampling system recommended by PAHO (1994) would be more meaningful and practical. The current attempt to visit and inspect every home 3 times per year has become increasingly unworkable, given the reduced resources in most countries. In addition, in foci where the adult mosquito population is low, actual monitoring of the population could be measured by enhanced ovitrapping using either an infusion of hay or a yeast suspension.

Ovitrapping exercises twice per season could give vital information, useful for planning intense public health intervention by the VC authorities and to advise communities of changes in *Ae. aegypti* populations, if any are remarkable. Community knowledge from good surveillance information and community action against *Ae. aegypti* are the other essential components for dengue prevention.

The cost of ovitrapping occasioned by 2 visits to a community could be offset by the benefits of detecting the presence of *Ae. aegypti*. Low indices measured by inspection only give a false sense of security and cause VC authorities and communities to miss opportunities for meaningful intervention to prevent or reduce the transmission of dengue.

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