

The control of *Aedes aegypti* for water access in households: Case studies towards a school-based education programme through the use of net covers

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Abstract

We report the progress made so far towards developing a school-based education programme for controlling *Aedes aegypti* oviposition in household flowerpots through the use of a net cover (evidengue®) to seal off the flowerpot saucer. A core feature of this programme is the association of evidengue® delivery with a basic package of oral and written information on dengue in classrooms. The flowerpot saucer is one of the most common type of water-bearing containers positive for the larvae of *Ae. aegypti* in the south-eastern region of Brazil. We present the results of a preliminary laboratory efficacy evaluation of evidengue® and of an inter-group, experimental, exploratory trial in which the evidengue® delivery was associated with educational information by means of a lecture and/or a leaflet in a school situated in a dengue-endemic area. The results are encouraging in both cases: (i) evidengue® has shown to be an efficacious tool to prevent ovipositing female access to flowerpot saucers in the laboratory; and (ii) despite the small numbers of students involved in the trial, one of the experimental groups yielded 85.7% of evidengue®-user households among those students whose households had flowerpot saucers. Use of evidengue® was maintained for at least 60 days, the period of data collection.

Keywords: *Aedes aegypti*; dengue prevention; flowerpot saucer; evidengue®, correctness of use; health education; school-based programme.

Introduction

Indoor plant growing is a valued and prevalent habit in Brazil, and it is rare to find a home in urban and suburban areas of the country's south-eastern region (states

of São Paulo, Rio de Janeiro, Espírito Santo and Minas Gerais) without a plant flowerpot and its associated saucer to collect water under it. Household surveys have frequently identified the flowerpot saucer as one of the most common water-bearing containers

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positive for the larvae of *Aedes aegypti* in this region.^[1,2]

Mosquito-proof net covers have been evaluated as physical barriers to prevent ovipositing *Ae. aegypti* access to water storage containers,^[3,4,5] buckets of rainwater^[6] and flowerpot saucers.^[7] Among a variety of sanitation measures for dengue prevention,^[8] net covers constitute a basic method to control oviposition and hence prevent the development of this mosquito vector in water-bearing containers.^[9] The implementation of their use as prevention tools in households of dengue-endemic areas, however, is far from simple. Not only must the efficacy of a candidate cover be previously demonstrated in laboratory and field trials, but also an efficient scheme of educational information on dengue must be associated with its distribution in order to stimulate residents to: (i) use it collectively and extensively; (ii) use it correctly; and (iii) maintain its use over a long period of time. Correct use of this device is an essential skill for its implementation.^[7]

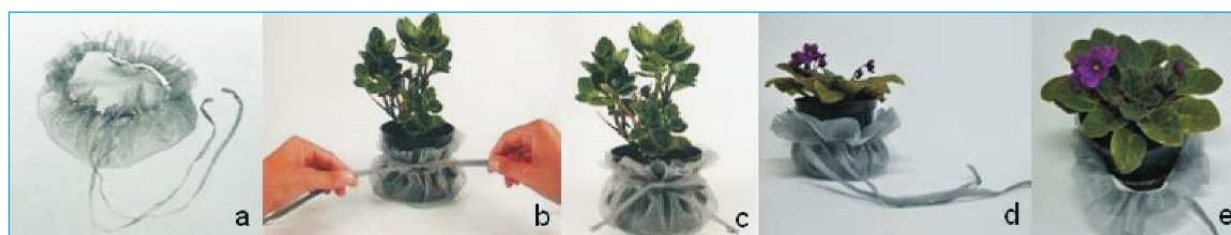
The present paper describes the progress made so far towards developing a school-based health education programme for controlling *Ae. aegypti* oviposition in household flowerpot saucers through the use of a net cover (evidengue®) designed to seal off the

same. Highlights include: (i) main features of evidengue®; (ii) an account of preliminary laboratory efficacy evaluations of the cover; and (iii) an experimental, exploratory field trial in a dengue-endemic area in Brazil. The trial aimed at quantifying students' households as users of evidengue® after associating its delivery with a basic package of oral and/or written information about the disease in a classroom. Lastly, we discuss the educational nature of the programme and its efficacy as a complement to vector control initiatives at the household level.

Evidengue® – the net cover

Evidengue® is a circular mosquito-proof net cover, manufactured with a polyester resin mesh equal to or smaller than 2 mm x 1 mm (Figure 1a). Its upper structure has a frill along the aperture brim, where a strap of the same material and a rubber band are embedded. The strap allows the user to adjust tightly the cover to the flowerpot wall, whereas the rubber band helps to keep the brim fastened. When used correctly, evidengue® seals off the saucer completely without leaving gaps for access of ovipositing *Ae. aegypti* (Figure 1b). Evidengue®*, then, can be characterized as a sealing cover for flowerpot saucers.

Figure: (a) Evidengue® cover; (b) flowerpot saucer being sealed up with the cover; (c) correct use; (d) partially-correct; (e) incorrect use



* A prototype of the cover was registered as a utility model at the Brazilian National Institute for Industrial Property in 2003. This prototype is now being used at the Oswaldo Cruz Foundation in the state of Minas Gerais as an experimental model of a research line dedicated to simultaneous development of tools and educational programmes for protecting household water containers.



Preliminary laboratory evaluations

A full account of a preliminary efficacy evaluation of evidengue® was published elsewhere.^[7] In short, two black plastic flowerpot saucers, each containing 220 ml of unchlorinated water, were individually wrapped in the cover and placed with their respective pots in two entomological cages (A and B), one in each cage. One identical set of a flowerpot and a saucer, with the same amount of unchlorinated water, was placed without evidengue® in a third cage (C). Twenty gravid female *Ae. aegypti*, bred in the laboratory's insectary, were placed into each cage four days after receiving a blood meal from an anaesthetized mouse. Upon the opening of the cages, no female was found inside the evidengues®. In cage C, there were eggs on the portion of the pot wall immediately above the saucer's waterline.

Another laboratory evaluation (unpublished data) was performed with five identical sets of a flowerpot and a saucer. This time, in addition to replicating the previous procedure with a greater number of saucers, we also evaluated evidengue®'s preventive efficacy under conditions of skilled and unskilled use. Four identical black plastic flowerpot saucers 11 cm in diameter, each containing 200 ml of unchlorinated water, were individually wrapped with the evidengue® and placed with their respective pots in four (A to D) entomological cages (40 cmx40 cmx40 cm), one in each cage.

In cages A and B, the strap of the aperture brim was fastened tightly; in cages C and D, the strap-fitting left gaps between the brim and the pot wall that could allow ovipositing females

access to the saucers. In cage C, although the aperture brim was fastened to the pot wall by the rubber band, the strap did not form a tight knot to seal completely the cover to the vessel; in cage D, the strap was completely loose. Such an arrangement allowed to compare evidengue® efficacy under three conditions of use in the laboratory: correct use (tightly-fastened strap) in cages A and B (Figure 1c); partially-correct use (strap without tight knot) in cage C (Figure 1d); and incorrect use (loose strap) in cage D (Figure 1e). A control set of flowerpot and saucer with the same amount of unchlorinated water was placed without the evidengue® in the fifth cage (E) and, as before, 20 gravid female *Ae. aegypti* were released into each cage four days after receiving a blood meal from an anaesthetized mouse. Eggs were not counted.

The results of this evaluation can be summarized as follows: no female was found inside the evidengues® in cages A and B; one female was found in the saucer of cage C, and ten in the saucer of cage D; in cage E (control), four females were found in the saucer. All other females were found dispersed either on the plant leaves, on the pot soil or on the bottom of the cages, except for cages A and D, where four and one females, respectively, were found on the external surface of evidengue®.

Taken together, the results of both evaluations showed that evidengue® is 100% effective to prevent ovipositing *Ae. aegypti* access to flowerpot saucers. Yet, the second evaluation showed that the preventive efficacy of the cover depends not only on design and structure factors, but also on the correctness of its use. Further investigations are needed to better quantify oviposition and to evaluate denier and texture factors.



Exploratory field trial

An exploratory field trial was conducted as part of a Masters dissertation^[10] which sought to determine the domicile use of evidengue[®] by students, after associating its delivery with a package of educational information about the disease in a classroom. The focus of the study was on three modalities of association of evidengue[®] delivery with oral (lecture) and/or written (leaflet) information on dengue.

Design of field trial

The trial was carried out in four classes (three 9th grade and one 8th grade) of a public school in the Venda Nova district in the city of Belo Horizonte, Minas Gerais. The students' households were distributed across a large low-income peri-urban dengue-endemic region. A recent household survey had shown that the flowerpot saucer is the second most frequent breeding site for *Ae. aegypti* in the study area.^[11] The sampling comprised 115 students regularly attending classes. Their average age was 16.2 years. Prior to the study, ethical clearance and informed consent were obtained.

The programme comprised three components: lecture on dengue (LD), delivery of evidengues[®] (EV) and delivery of an information leaflet (LF) regarding sealing of water-bearing containers. The components were differentially associated in classes 1, 2 and 3 (hereafter called experimental groups), whereas the fourth class was considered the control group. The modalities of association were as follows: Group 1: LD+EV+LF; Group 2: LD+EV; Group 3: EV+LF; Group 4: LD. The modality of association assigned to each group was defined by the drawing of lots. The lecture instructor (see below) was not informed of the outcome of the draw.

Lecture on dengue

The 20-minute lecture was given once to each group, during regular school hours and in the students' own classrooms. The instructor (second author) had no link whatsoever with the school. The lecture content comprised six topics: (i) concept of dengue; (ii) symptoms of the disease; (iii) forms of clinical manifestation; (iv) transmission; (v) life cycle of *Ae. aegypti*; and (vi) prevention. Short texts (maximum 94 characters) and pictures on these topics were projected onto a screen using the following multimedia: (i) 35 powerpoint slides; (ii) five segments of a professional video about the vector;^[12] and (iii) a 70-second black-and-white domestic video in which the instructor demonstrated the correct placement of evidengue[®] on a violet flowerpot. The texts and pictures related to the cover were part of the topic of prevention. There was no practice of evidengue[®] placement. All of the instructor's lines referred to the texts and images showed on the screen, and most of the times the strict function performed by him was of pointing out or complementing relevant aspects of the visual information. No instruction was given about any other measure to control *Ae. aegypti* oviposition in household flowerpots. After the lecture, the students returned to their school routine. There was no questionnaire or discussion on the lecture topics.

The instructor's performance was registered by four independent observers, according to a proper direct observation data collection system. The instructor's five behaviour categories were recorded: (i) follow orally the script (say the lines of a script: see below); (ii) point out using a laser pointer (manipulate the device so as to make it project a red light on the screen); (iii) look at the group (make eye contact and/or head movement either from the screen, the keyboard or the instructor's



script towards one or more students); (iv) call attention (single out some aspect shown on screen using one of the following verbs: notice, see, observe, look); and (v) change the slide (handle the computer mouse or keyboard and substitute the slide projected on the screen). The four observers were previously trained to record these categories. Records were entered in two distinct paper-and-pencil observation forms. Two of the observers, working independently, recorded those speech lines which identified the instructor's compliance with a pre-established sequence of topics for each slide according to a printed script of the lecture topics, slide by slide. The same pair of observers recorded the time the instructor spent on each slide. The other pair, also working independently, recorded the frequency of the other categories.

Delivery of evidengues®

Four evidengues® were delivered to each student of the experimental groups, irrespective of the number of flowerpots that their households could have. The evidengues® were numbered in series, which allowed their identification during data collection. To increase the use likelihood, evidengues® were delivered in three sizes: two small (aperture diameter of about 18 cm), one medium (35 cm), one large (45 cm). These sizes encompass the majority of flowerpot saucers found in Brazilian homes. In groups 1 and 2, evidengues® were delivered at the end of the lecture; in group 3 (not submitted to LD component), delivery was made at the end of a regular class after the lecture was given to the other groups. Group 4 was not informed as to where to get the evidengue®. In the event of a question in this sense, the instructor plainly replied that the cover was on test and therefore not available.

Delivery of the leaflet

The leaflet (15 cm x 21 cm, four colours) stressed the importance of sealing up household water containers. In its upper half, a three-line text heading enunciated: "It is dangerous to leave pots uncovered. To prevent dengue, it is necessary to seal up. It is not enough just to cover water-bearing containers." Underneath, three photos exemplified situations of uncovered containers, partially (incorrectly) covered, and correctly sealed. In the lower half, a photo of an empty evidengue®, sided by a secondary text ("Evidengue® seals up flowerpot saucers completely"), presented the cover to students. Underneath, three photos exemplified the situations of containers uncovered, partially covered and correctly sealed in three household flowerpots wrapped with evidengue®.

Data collection

Evidengue® use was verified by direct observation in the students' households. Use was defined as the observation of a flowerpot wrapped with an evidengue®. Only flowerpots wrapped with the cover were registered, and observation of at least one cover in use (that is, irrespective of the number of covers provided in the classroom) was enough to consider the household as an evidengue® user. Residents were not questioned about who in the household was responsible for placing the cover(s), or about any other behaviour related to its use.

Verifications were done by a trained male health worker and an assistant researcher (the researcher acted as independent observer in 30% of households). Both of them had fieldwork experience. Two series of verification visits were conducted: the first one started



five days after classroom intervention and lasted for three weeks; the second started 60 days after intervention and lasted for two weeks. Each household was visited once in each series. Evidengue® use was registered on a standardized paper-and-pencil form. Upon introducing himself, the health worker informed the resident that the home had been chosen among the addresses of the students registered in the school office and that he would check household interventions regarding dengue prevention. Knowledge, attitudes and other practices relating to vector control were not surveyed.

Results

The main outcome measure was the number of evidengue® user households among those households that had flowerpot saucers. Of the 115 households that made up the sample, 98 were visited in the first verification and 46 (46.9%) of them had flowerpot(s) with saucer (of those which were not visited, 13 had incorrect addresses and four were empty).

In the second verification, 94 households were visited and 44 (46.8%) of them had flowerpot(s) with saucer (four other were empty in addition to the 17 not previously visited). The Table shows, for each group, the number of students who received evidengues®, the number of households in which at least one flowerpot with saucer was verified, and the number of evidengue® user households in both verifications. It can be seen that the number of user households is higher in groups 1 and 3 (modalities LD + LF + EV and EV + LF, respectively) in which there was delivery of leaflet. In the second verification, the number of user households increased in all three experimental groups, reaching 85.7% (12 out of 14) of those households with saucer in group 1. None of the households discontinued the use of the cover between verifications, which means a period of maintenance of use of 60 days or more. The great majority of flowerpots with saucer (82.7%) was observed on verandas (average 6.4 per household). Overall, the education programme resulted in 34.8% evidengue® user households in the first verification (16 out of 46 households

Table: Number of students who received evidengues®, number of households with saucer, and number of user households in each group in two verifications of cover use

Group	Students with evidengue®	1st verification		2nd verification	
		Households with saucers	User households	Households with saucer	User households
1 (LD+EV+LF)	30	10	5	14	12
2 (LD+EV)	33	13	4	13	8
3 (EV+LF)	34	15	7	11	9
4 (LD)	–	8	–	6	–
Total	97	46	16 (34.8%)	44	29 (65.9%)

LD = lecture on dengue

EV = delivery of evidengues®

LF = delivery of the leaflet



with saucer) and 65.9% in the second (29 out of 44 households with saucer). Data collected on correct use were not reliable and were discarded. Nonetheless, some level of incorrect use (5% to 10% in the three experimental groups) may be assumed.

The data on the instructor's performance resulted in indexes of agreement between the observers (number of agreed-upon records divided by the sum of agreements and disagreements) of above 90% in the three modalities of association of the LD component. Therefore, such indexes do not indicate a trend in the instructor's performance toward any of the groups submitted to these modalities.

Discussion

Despite the small numbers of students involved in each group, the results of this exploratory trial reflect the potential of the education programme in stimulating the use of a net cover for flowerpot saucers in households of students. Evidengue® use was verified in varied proportions in all three experimental groups irrespective of the modality of association of the components of the programme. Moreover, all early user households maintained the cover in use for a period of 60 days at least. Additional research is obviously needed to clarify the specific influence of each modality of association of the components of the programme. The results of groups 1 and 3 suggest that the leaflet may have differentially influenced the use of evidengue®; however, replication of the current modalities of the association in larger samples is required. The maintenance of use for periods longer than the 60-day inter-verification interval utilized in this study also needs further investigation.

The results refer to user households of evidengue® and do not constitute, as is obvious, entomological indicators for the evaluation of oviposition control in the whole set of flowerpot saucers that a house might have. Rather, results indicate merely the occurrence, in students' households, of a behaviour class suitable and specific to this control through the use of evidengue®. A post-hoc analysis of the behaviours constituting this class would include the receipt of the cover by the student in school, the transportation, the handling, the wrapping of a flowerpot saucer with it, and the exposure (or re-exposure) of the container together with the vase in a place susceptible to the presence of *Ae. aegypti*. Although one cannot identify objectively the agent(s) of all behaviours of such a sequence, it is logically plausible to infer that at least part of them may be attributed to the student. We could not find prior school-based dengue control research addressing students' mediation, at the household level, through the use of a net cover. The lack of prior studies explains why our exploratory field trial contained two information components, given that we could not anticipate the probability of obtaining a successful outcome with any one or the other.

A relevant aspect in the evaluation of the present results concerns the matching of the sizes of evidengues® delivered in the classroom to the sizes of the existing flowerpot saucers in households. The study did not measure a baseline by means of which this matching could have been made. In such a circumstance, it is highly likely that a number of user households express some size incompatibility between the covers delivered to students and the flowerpot saucers in their homes, to the extent that inadequate sizes of evidengue® reduced opportunities of use which otherwise would have materialized.



Other limitations of the study were the short time-span of the trial, which did not allow a greater number of verifications and, therefore, was insufficient to see any change, positive or negative, in the trends of evidengue[®] use; and the relatively small number of households with flowerpot saucers in all experimental groups, which precluded a statistical assessment of the effects of the different modalities of association or comparisons between these trends. Moreover, the possibility exists that the previous visit had contributed to the enhancement of evidengue[®] use in the second verification, a limitation that the experimental procedure could not overcome.

General discussion

Although the need for health education for behavioural research is widely acknowledged,^[8,13] current research practices on dengue prevention have been inadequate in producing educational programmes capable of fostering effective preventive behaviours at the level of the household.^[14,15] Net covers are probably the most efficacious way to prevent access of female *Ae. aegypti* to the interior of water-bearing domestic containers, and evidengue[®] seems to be a convenient method to control vector oviposition in flowerpot saucers. A variety of educational programmes have sought to establish dengue prevention behaviours among residents of endemic areas of the disease.^[13,16] Although aimed at residents in their homes, some of these programmes are implemented in schools.

It is assumed that educational interventions in schools can somehow influence the behaviour of residents, using the student as mediator.^[16] However, notwithstanding the presumed cost-effectiveness of such a strategy,^[17] behavioural research data

on health education are insufficient to empirically support this conjecture. In fact, at the present stage of behavioural research on dengue prevention, the pursuit of educational procedures that are able to establish, through school, a minimum of preventive behaviours at the level of the household, is an area fit for detailed empirical investigations. It is in this context of relative absence of data that evidengue[®] has been used at the Oswaldo Cruz Foundation as an experimental model of a research line conjointly dedicated to the development of tools and school-based education programmes for protecting household water containers.

In Brazil and other dengue-endemic countries, most residents are passive participants in vector control initiatives. The simple argument we make in this paper is that a school-based programme can better educate students to actively co-participate in those initiatives by offering them a domestic tool for vector control rather than merely advising them to undertake preventive measures. The data set we presently have is, of course, too incipient to draw any conclusion about the efficaciousness of such a programme, but building on the research results in the domain of behaviour modification for injury prevention,^[18] it is reasonable to argue that if a resident (student or other) behaves in ways that effectively avoid a threatening consequence, such as when he/she makes a correct use of a net cover for vector control, there may be an increased probability that such behaviour will in turn induce other preventive behaviours in the household. Our next study will test the possibility that the use of evidengue[®] in flowerpot saucers might be an opportunity for the generalization of the net cover use to other kinds of water-bearing containers, including larger tanks that are productive for *Ae. aegypti* pupae.^[19] Also, maintenance of use will be investigated for longer periods.



One critical aspect to be assessed is the stability of evidengue® at a height of the flowerpot which is far enough from the saucer to prevent possible lowering of the net which would enable *Ae. aegypti* to oviposition in puddles formed by water coming out through the mesh. On another front, field investigations of the correctness of use will be a crucial aspect for the evaluation of the efficacy of evidengue®. The importance of correct net cover use can be illustrated by a study that evaluated the efficacy of an insecticide-treated cover for large water storage containers in Cambodia.^[3] Albeit a follow-up of this study found a great proportion of containers to be duly protected by the cover, 16.5% of them were still infested, an outcome that puts into question the efficacy with which residents were using the tool to seal off the container.

Evidengue® can be produced in a variety of colours and manufactured with ornamental fastenings. This may encourage residents to use them in verandas and gardens as well as inside their homes. Polyester nets are highly durable and resistant to moisture and temperature changes. This could increase their protection factor. They could be reasonably priced if manufactured in large numbers (we are presently paying to our evidengue® manufacturer the equivalent of US\$ 1 for each cover) and may be widely commercialized and distributed through gardening shops and supermarkets.

We intend to keep developing the programme outlined in this paper with simultaneous further laboratory and field tests of evidengue®. The development of an efficacious education programme takes time and the evidengue® efficacy itself depends, to a large degree, on understanding

the behavioural processes that result in its adoption and use. Looking at the matter of efficaciousness in a different perspective, one might go so far as to presume, as one reviewer of this manuscript did, that perhaps evidengue® should be insecticide-treated. This view, however, does not diminish the need to investigate the efficacy of this and other vector control tools in behavioural terms. Perhaps training methods should be used, but it seems clear that this is an area of research in health education and health behaviour domains that needs more attention.

It is curious that health education programmes are generally provident and categorical when addressing the need to use seat-belts in vehicles, condoms in sexual relations, special clothing in risk tasks and other individual and collective safety devices in ordinary circumstances of prevention. Interestingly enough, despite the weak evidence that educational information is able to convert itself into behaviours for vector control of dengue in households,^[14,15] one does not see the same providence and determination to recommend the use of preventive tools when it comes to the safe use of domestic water containers by residents of endemic areas of the disease.

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