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Conclusions: The Camino Verde community mobilisation intervention, as well as being effective in reducing dengue infections, was effective in reducing household use of and expenditure on insecticide anti-mosquito products.

Trial registration: (ISRCTN27581154).

Keywords: Dengue prevention, Personal protection costs, Insecticide anti-mosquito products

## Background

Since its re-emergence in the Americas, dengue has continued to spread in all its clinical forms, despite vector-control efforts on the part of health services from every country in the region, and health services in Latin America use considerable resources to treat cases of dengue fever [1].

In Mexico, the Specific Action Program for Dengue 2013–2018 (Programa de Acción Específico. Prevención y Control de Dengue 2013–2018) confirmed a protocol to identify dengue fever patients as potential carriers of the disease, and to register them in the National Epidemiological Surveillance System (Sistema Nacional de Vigilancia Epidemiológica) to locate cases in time and space. The programme includes guidelines for prevention and control measures to be carried out during visits by health workers to patients' homes and neighboring households, during which a larvicide, temephos, is placed in water containers, and the area surrounding each home is fumigated [2].

Studies in Latin America have estimated the direct and indirect costs of in- and out-patient dengue cases, workdays lost due to the disease, and disability- or quality-adjusted life years [3–7]. Authors have reported on the household costs of actions to prevent mosquito-borne infections in Asia and Africa [8–12]. However, we have not found any published report of a randomised controlled trial of dengue prevention that examined the impact of the trial intervention on household expenditures on prevention.w392(6l8TDp)1(at1(ven6,dy1(ven66Tmi)2(c226a54i)12(al)-57s04Tc5-1.226l)-57s0-57s04T57s0-57so

insecticides between groups of households according to characteristics potentially related to the use of these products: being covered by the healthcare services' temephos (Abate®) distribution programme; reporting at least one case of dengue illness in the previous year; and having evidence of recent dengue infection among children aged 3–9 years. We also examined expenditure on insecticides according to six household social vulnerability characteristics: socioeconomic region; area of residence; ethnicity; household type; education level of the household head; and employment status of the household head. We considered households to be more vulnerable if they were: located in the Costa Chica region; located in rural areas; inhabited by indigenous people; buildings with impermanent construction; headed by someone with a third-grade education or lower; or headed by someone unemployed.

### Extrapolation of expenditure figures

We extrapolated from expenditures reported by households in the sample in the baseline survey to estimate expenditure on insecticide anti-mosquito products by the whole population of Guerrero State's three coastal regions. We estimated the number of inhabited households per region by dividing the population of the region, from the census by the state average of 4.2 people per household [16]. We applied the proportion of households who reported spending on insecticides in the baseline sample to the estimated number of households in the regions, then calculated the mean total expenditure per region by multiplying by the reported monthly expenditure in the sample households who reported expenditure. To estimate annual expenditure in each region we multiplied the monthly figure by 12. The baseline survey was carried out between January and June 2010, and the reported monthly expenditure in these months would be expected to be relatively low as it is not the main season for mosquitoes. For a more conservative estimate, we multiplied the monthly expenditure by 6, on the assumption that there may be little or no expenditure for six months of the year.

### Analysis

Trained operators entered data, using EpiData software, with double data entry and validation to minimise keystroke errors. Analysis relied on the public domain software CIETmap [17, 18]. We calculated the mean and standard deviation (SD) for reported monthly household expenditure on insecticides and tested the significance of differences in expenditures between sub-groups using an unpaired t-test or the Kruskal-Wallis non-parametric test for sample difference when variances were different between the groups. We tested the significance of the associations between household reported insecticide use (yes or no) and self-reported dengue cases and serologically-defined dengue infection, using the Mantel-Haenszel procedure and reporting the Odds Ratio (OR) and cluster-adjusted 95% confidence intervals (95% CIca) [19, 20].

From the impact survey, we tested the significance of differences between intervention and control clusters in proportions of households reporting expenditure on insecticides, and in proportions of spending households, and ofideousbe5paclated9(significan)-12(camouen)-5D[oed25.30tio94(

Table 2 Average monthly household expenditure on insecticides in USD by social vulnerability characteristics in 2010 baseline survey

| Characteristic | n= | % of households using insecticides | Mean expenditure last month | SD | p= |
|---|---|---|---|---|---|
| Acapulco | 2189 | 51.5 | 5.1 | 4.8 | <0.0000001 |
| Costa Grande | 1618 | 40.5 | 4.2 | 3.9 | |
| Costa Chica | 1551 | 40.0 | 5.2 | 5.2 | |
| Rural | 2655 | 40.4 | 4.6 | 4.4 | <0.0000001 |
| Urban | 2703 | 48.7 | 5.1 | 4.9 | |
| Indigenous | 253 | 56.5 | 5.1 | 4.4 | 0.21 |
| *Mestizos* | 5092 | 43.7 | 4.9 | 4.7 | |
| Non-permanent house | 626 | 36.5 | 4.5 | 4.1 | 0.00002 |
| Semi-permanent house | 2104 | 41.6 | 4.7 | 4.8 | |
| Permanent house | 2610 | 49.2 | 5.0 | 4.7 | |
| Household head education: | | | | | |
| Less than 3rd grade | 1651 | 38.1 | 4.5 | 4.5 | <0.0000001 |
| 4th grade to high-school | 3156 | 46.4 | 4.9 | 4.7 | |
| Technical school or higher | 499 | 56.1 | 5.6 | 5.2 | |
| Household head unemployed | 776 | 40.3 | 4.6 | 4.9 | 0.00009 |
| Household head employed | 4570 | 45.0 | 4.9 | 4.6 | |

## Discussion

Our study shows that expenses for the purchase of products for personal protection against mosquitoes are an important proportion of monthly household incomes in Guerrero state**.** According to the 2012 National Household Income and Expenditure Survey, the average monthly income for Mexican households in the lowest income decile was USD171 [22]. The monthly expenditures on insecticide anti-mosquito products reported in our 2012 impact survey, of USD6.0 in intervention communities and USD6.83 in reference communities, represent 3.3% and 3.8% respectively of monthly income for people in this decile.

The findings from our study add to the existing literature on household expenditures on anti-mosquito products, as a means of protection against dengue and other mosquito-borne diseases. Mulla and colleagues estimated an expenditure between USD13.75 and USD86.13 on anti-mosquito products per household per year in four communities in Thailand, and reported that these expenses represented between 0.3% and 0.7% of the annual household income in Thailand [8]. A 2003 study in The Gambia reported that most (81%) of the recurring household expenditure for malaria protection was on insecticide anti-mosquito products rather than on bed nets [23]. Another 2003 survey in the Pondicherry region of Southern India reported that 99% of urban dwellers and 73% of rural dwellers used insecticide anti-mosquito products at some time in the year, and that annual expenditure on these products in urban areas was 0.63% of annual per capita income [9]. Similarly, a survey in Jaffna district, Sri Lanka, reported that 96% of respondents spent funds on products

Table 3 Proportion of households that purchased anti-mosquito products, and expenditure during the last month among those who purchased the products, in trial intervention and control sites surveyed in August–November 2012

| | Intervention clusters | Control clusters | Difference of proportions (95%Clca) |
|---|---|---|---|
| Surveyed households | 5349 | 5142 | |
| Proportion of households that purchased anti-mosquito products[a] | 47.8% (2530/5293) | 53.3% (2707/5079) | −0.05 (−0.1 to −0.01) |
| *Among households spending anything* | | | |
| Mean expenditure in the last month (USD) | 6.0 (SD 5.9) | 6.83 (SD 6.84) | |
| Proportion spending more than the mean of USD 6.43[b] | 30.4% (768/2530) | 36.7% (993/2707) | −0.06 (−0.12 to −0.01) |
| *Among all households* | | | |
| Mean expenditure in the last month (USD) | 2.86 (SD 5.12) | 3.65 (SD 6.04) | |
| Proportion spending more than the mean of USD 3.25[c] | 30.6% (1622/5293) | 37.5% (1906/5079) | −0.07 (−0.09 to −0.05) |

Cl t t-t t. t = −2.193, 88 p = 0.031
Cl t t-t t. t = −1.978, 88, p = 0.05
Cl t t-t t. t = −2.653, 88, p = 0.009

for personal protection against mosquitoes, mainly spirals, with monthly expenditure between USD0.70 and USD12.53 [10]. A survey in Orissa, India, reported use of anti-mosquito products by 99% of urban and 84% of rural households, with an average monthly expenditure of USD8.13 in urban areas and USD5.90 in rural areas [11]. In north-eastern Tanzania, a survey reported that households spent an average of USD0.18 on bed nets and their treatment each fortnight (47% of total prevention costs) and USD0.21 on insecticide anti-mosquito products (50% of the total) [12]. A 2012 survey of household incomes and expenditures in Mexico reported a household quarterly expenditure of USD21.83 (USD7.28 per month) on insecticide anti-mosquito products [22].

Table 4 summarises the monthly expenditure on anti-mosquito products reported by other authors in other countries. Using a Purchasing Power Parity conversion factor [24], the monthly expenditure estimates in our study fit within the range of expenditures previously reported.

In the baseline survey, we found an association between a self-reported case of dengue illness in the household and a greater likelihood of the household purchasing insecticide anti-mosquito products. We have to be cautious in interpreting this finding from a cross-sectional enquiry. It could be that the response of the health services to a case of dengue, which includes placing temephos into water containers in the index household and surrounding households, as well as fumigation of the area, encourages the residents to use more anti-mosquito products.

Our finding of more expenditure on insecticides with more education of the household head (see Table 2) runs