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A community empowerment strategy embedded in a routine dengue vector control programme: a cluster randomised controlled trial

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ABSTRACT

The non-sustainability of vertically organised dengue vector control programmes led to pleas for changing the emphasis towards community-based strategies. We conducted a cluster randomised controlled trial with 16 intervention and 16 control clusters to test the effectiveness of a community empowerment strategy intertwined with the routine dengue vector control programme in La Lisa, Havana City, Cuba. The intervention included four components on top of routine control: organisation and management; entomological risk surveillance; capacity building; and community work for vector control. In the control clusters, routine activities continued without interference. The community participation score increased from 1.4 to 3.4. Good knowledge of breeding sites increased by 52.8% and 27.5% in the intervention and control clusters, respectively. There were no changes in adequate *Aedes aegypti* control practices at household level in the control clusters, but in the intervention clusters adequacy increased by 36.2%. At baseline, the Breteau indices (BI) were approximately 0.1 and were comparable; they fluctuated over time but became different with the launch of the community-based dengue control activities in the intervention clusters. Over the intervention period, the BI remained 53% (95% CI 22–92%) lower in these clusters than in the control clusters. The empowerment strategy increased community involvement and added effectiveness to routine *A. aegypti* control.

1. Introduction

Owing to rapid massive urbanisation, defective water supplies, global travel and environmental changes, dengue is the most common and fastest spreading arboviral disease worldwide.[1] More than two-fifths of the world's population live in areas potentially at risk for dengue, and the estimated number of dengue fever and complicated dengue cases has reached 50 million and 500 000 per year, respectively.[2] The main vector transmitting the virus is the *Aedes aegypti* mosquito. In the absence of a vaccine, control of the vector is the only effective prevention measure.[3]

The non-sustainability of vertically organised and insecticide-based *A. aegypti* control programmes led to pleas for changing the emphasis towards community-based source reduction strategies.[4] Various pilot projects have more or less successfully implemented participatory approaches to dengue vector control, but most were small scale, with a short follow-up period and did not allow for comparison with control areas.[5]

In Cuba, some long-term controlled studies carried out in Santiago and Havana city demonstrated the effectiveness of a strategy aimed at building partnerships between the community, primary healthcare staff and

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governmental intersectoral bodies.[6,7] The project in Santiago provided evidence on how transformation and integration of a routine vertical programme, coupled with community capacity building and organisation, can lead to sustainable and cost-effective dengue control.[6,8–11] The small-scale, long-term study carried out in Havana City showed that applying popular education theories aimed at empowerment[12] allows communities to make their own decisions for dengue vector control through existing community-level government structures.[7,13–15]

A participatory strategy based on these two pilot studies was designed and replicated on a larger scale. We carried out a cluster randomised controlled trial to test its effectiveness.

2. Methods

2.1. Study area

This research was carried out in La Lisa Municipality, West Havana, Cuba. The extension of the municipality is 37.5 km^2 and it has 130 969 inhabitants. The population is concentrated in residential areas with urban characteristics and in the periphery the territory is semiurban to rural. The mean annual temperature is 26 °C; May–October is generally hot and rainy, whereas November–April is characterised by lower ambient temperatures and precipitation.

Dengue is non-endemic in Cuba[16] but the municipality was affected by the dengue outbreaks that have occurred in Havana City since 1981.[17,18] The most productive *A. aegypti* breeding sites are ground-level water tanks and small, man-made containers inside or close to houses.[19] *Aedes albopictus* infestation is low and confined to semi-urban areas, where it predominantly breeds in the same containers.[20,21] Among the seven 'Consejos Populares' (CP) (an intermediate government structure between the municipal level and the 'circumscription', the lowest level of local government that covers approximately 1000 inhabitants), three CPs (Versalles Coronela, Alturas de la Lisa and Balcón Arimao) were selected to implement the strategy.[22] These CPs had the highest risk for dengue transmission, an urban layout and virtual absence of *A. albopictus*.[21]

2.2. Study design

A cluster randomised controlled trial was conducted. In October 2004, 32 circumscriptions were selected in the three CPs. The circumscriptions were randomly allocated to 16 intervention and 16 control clusters. The intervention, which ended in December 2007, is outlined below. In short, a participatory strategy, rooted in empowerment and popular education theories,[12] was added as a horizontal component to the existing vector control programme. In the control clusters, the routine vector control programme continued to be carried out without interference. The sample size was calculated as proposed by Hayes and Bennett.[23] We aimed to detect a 50% reduction in the Breteau index (BI), with a power of 80% and an α error of 0.05 and assumed a coefficient of variation of 0.25 for the clusters' BIs.

2.2.1. Routine vector control activities in intervention and control clusters

Following national policy, standard *A. aegypti* control actions comprised entomological surveillance, source reduction through periodic house inspection (in cycles of 11 days), application of larvicides (temephos) in water containers, use of adulticides (pyrethroids) when *A. aegypti* foci were detected, health education and enforcing mosquito control legislation through the use of fines.

2.2.2. Intervention

The participatory strategy, fully described elsewhere,[24] basically consists of four components: setting up of organisation and management structures; entomological risk surveillance; capacity building at grass-root and intermediate level; and community work for vector control. These components were defined independently from each other but their introduction was simultaneous and interactive. The strategy was adapted from earlier experiences[6,7] to the context of La Lisa Municipality after formative research.[22]

In October 2004, a management group, composed of researchers from the Institute of Tropical Medicine 'Pedro Kouri' (IPK) (Havana City, Cuba), municipal health authorities and community leaders, was created. This group ensured co-ordination of the implementation process. Responsibilities were defined and the members organised themselves in three teams, one for each CP. Between January and June 2005, members of the management group were trained in conventional and participatory research and in strategic planning with community participation.

From July 2005 onward, the set up of routine *A. aegypti* surveillance was modified in the intervention clusters. Fixed vector control workers were assigned to each cluster to optimise the relationship between the vector control programme and the communities. These technicians also liaised with community authorities to inform on the principal breeding sites.

In January 2006, a community working group (CWG) with 5 to 10 members (formal and informal leaders, public health workers from the vector control programme, family doctors and nurses) was created in each of the 16 intervention clusters. These groups received continuous training. The capacity-building process was rooted in popular education theories,[12] which implied using participatory learning methods to ensure dialogue among equals, experience-based learning, collective contribution to knowledge building, and a dialectic relationship between theory and practice.

Subsequently, the CWG initiated the community work for dengue vector control. The activities were organised as a cycle of sequential phases developed at circumscription level: conducting participatory need assessment of needs; mapping of environmental and domiciliary risks and associated behaviours; elaborating action plans; developing local communication strategies; implementing activities; and conducting participatory evaluation. The inhabitants of the circumscription were actively involved in the whole process.

Implementation of the action plans for *A. aegypti* control elaborated by the CWGs started in September 2006. These action plans varied between clusters but generally included cleaning public areas, identification of environmental and domiciliary risks together with vector control workers, and activities for communication and social mobilisation. In all clusters, CWGs encouraged inhabitants to participate in all planned activities. Members of the CWGs visited the houses in their communities, surveying backyards and water storage containers, offering options to protect or eliminate the containers, and conducting follow-up visits to reinforce the messages delivered.

2.3. Data collection

2.3.1. Participation

Assessment of community participation in the intervention clusters relied on participant observation and document analysis by the CWGs and by the management group. In October 2004, the management group assessed the pre-intervention level of participation in dengue control activities at municipal level. In April 2007, a workshop was held to discuss and reach a consensus on the level of participation attained in the intervention clusters. Participation was assessed by members of the CWGs together with the management group using Rifkin's framework,[25] assigning a score (1 = none, 2 = weak, 3 = fair, 4 = good and 5 = excellent) to each of the framework's dimensions: needs assessment; leadership; organisation; resource mobilisation; and management.

2.3.2. Knowledge, perception and behaviour

In November 2004 and April 2007, trained local health volunteers carried out a survey to assess knowledge, risk perception and practices regarding dengue. Heads (or, if absent, another adult resident) of 780 and 800 households, respectively, which were randomly selected in the intervention and control clusters, were interviewed.

Good knowledge of dengue symptoms was defined as the respondent mentioning fever and at least one of the following symptoms: headache; nausea/vomiting; muscular pain; and rash or bleeding. Good knowledge of *A. aegypti* breeding sites was defined as referring to any container with clean water and good knowledge of preventive measures as mentioning at least three of the following: adding temephos to water storage containers; covering other useful containers; eliminating useless containers; and using insecticide. Risk perception was assessed on the basis of two questions and was considered present when the respondent expressed that he could possibly contract dengue fever and that dengue infection can be fatal. Preventive practices of the respondents were observed and classified as adequate if they had covered all water storage containers, had backyards without useless containers and had protected the useful ones.

2.3.3. Entomological outcome

Routine entomological surveillance data collected by the vector control programme between January 2004 and December 2007 were used. The data combine the observations of the technicians that periodically inspect all houses and the peridomestic environment for the presence of immature mosquito stages in man-made and natural containers, and those of the quality control inspectors who revisit a systematic sample of 33% of the premises. The collected larvae and pupae are identified at the Municipal Hygiene and Epidemiology Unit and the *A. aegypti* foci are reported to the surveillance system. From these records, information was extracted on the number of houses inspected in all study clusters in each inspection cycle and on the number of containers with *A. aegypti* larvae.

2.4. Data analysis

STATA V.10 (StataCorp LP, College Station, TX, USA) and SPSS V.15 (SPSS Inc., Chicago, IL, USA) were used for the analyses. To obtain a measure of participation, the score attained in the intervention clusters for the different dimensions of community participation by CP was averaged. Spider diagrams were constructed to present the scores attained before and after the intervention. Percentages of households with good dengue-related knowledge, risk perception and practices (and 95% CIs) were calculated for the intervention and control clusters. Generalised estimating equation (GEE) models were constructed to estimate the effect of the intervention.[26] This model takes into account the nature of the data (repeated measures in each cluster) and allows an estimate of the period effect (before/after the start of the intervention), the group effect (intervention/control cluster) and the effect of the intervention by fitting a period × group interaction.

The monthly BI (number of positive containers per 100 houses) for each cluster and, for descriptive purposes, the mean BI for the intervention and control clusters before (January 2004–December 2005) and after (January 2006–December 2007) the start of the intervention were calculated. A semiparametric mixed model[27] was applied to capture the form of the evolution of the monthly differences of *A. aegypti* larval densities in the intervention and control clusters. The influence of the intervention on the BI was further evaluated by fitting a GEE model as above.

2.5. Ethical considerations

Individual informed consent was obtained from all interviewed household members. Confidentiality was ensured. Ethical aspects associated with participation were considered, in particular avoiding the creation of false expectations in the population and guaranteeing collective planning and shared decision-making.[15]

3. Results

All clusters received the intended strategy, completed the study and were included in the analysis. Baseline sociodemographic characteristics were similar between the intervention and control clusters (Table 1). The majority of residents had a piped water supply inside the house and received water every 2 days. All residents systematically stored water, usually in ground-level tanks and small containers inside the houses.

Table 1
Household characteristics in the intervention and control clusters, November 2004, La Lisa Municipality, Havana City, Cuba

Characteristic	Intervention clusters	Control clusters
No. of randomly sampled households	389[a]	390
No. (%) of households by 'Consejos Populares'		
Alturas de la Lisa	148 (38.0)	145 (37.2)
Balcón Arimao	118 (30.3)	122 (31.3)
Versalles Coronela	123 (31.6)	123 (31.5)
No. of inhabitants per household (mean ± SD)	4.90 ± 1.83	5.01 ± 2.02
Type of housing [n (%)]		
House	295 (75.8)	289 (74.1)
Apartment	57 (14.7)	75 (19.2)
Room	37 (9.5)	26 (6.7)
Water provision point [n (%)]		
Inside the house	278 (71.5)	275 (70.5)
Outside the house	96 (24.7)	103 (26.4)
Communal well or water truck	15 (3.9)	12 (3.1)
Frequency of water distribution [n (%)]		
Every day	31 (8.0)	51 (13.1)
Alternate days	358 (92.0)	334 (85.6)
Every 3 days or more	0	4 (1.0)
Irregular	0	1 (0.3)
No. of water storage containers per household (mean ± SD)		
Cistern	0.24 ± 0.48	0.29 ± 0.49
Elevated tank	0.99 ± 1.32	0.97 ± 1.35
Ground-level tank	1.60 ± 1.90	1.40 ± 1.57
Other small water storage containers	6.47 ± 11.19	5.21 ± 7.33

[a] One household provided incomplete information and was excluded from the analysis.

3.1. Participation

Figure 1 summarises the changes in community participation in the intervention clusters in the three selected CPs. Improvements on all dimensions of Rifkin's framework were observed in all CPs. The mean scores, over all dimensions, were 1.4 at baseline and 3.4 at the end of the intervention. The highest mean score (4.2) was attained in Balcón Arimao.

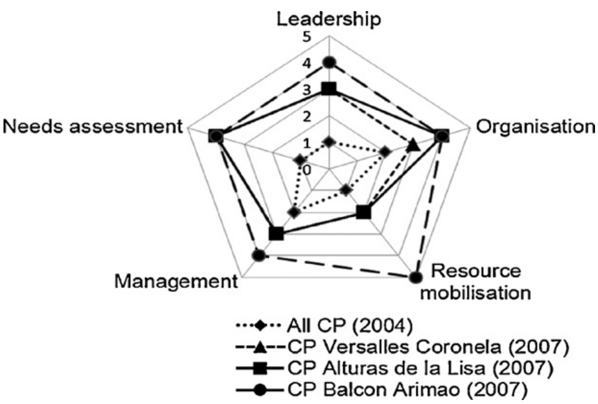

Figure 1. Change over time in community participation in the intervention clusters by 'Consejos Populares' (CP) in La Lisa Municipality, Havana City, Cuba, 2004–2007.

3.2. Knowledge, perception and behaviour

There were no significant differential changes in the high pre-intervention levels of knowledge of dengue symptoms and prevention measures in the intervention and control clusters (Table 2). On the other hand, good knowledge of breeding sites increased by 52.8% in the intervention clusters compared with 27.5% in the control clusters. The difference between both was significant (period × group interaction, OR 1.50). There were also no significant differential changes in the already high perception that dengue infection can be fatal. However, risk perception regarding the possibility of contracting dengue fever increased 316% in the intervention clusters, significantly more than the 211% in the control clusters (interaction OR 1.63) notwithstanding an intensive nationwide mass media campaign on the subject in 2007. The most notable differential change concerned adequate *A. aegypti* control practices at household level: no change was observed in the control clusters compared with a 36.2% increase in the intervention clusters (interaction OR 3.23).

3.3. Entomological impact

Figure 2 shows the evolution in mean monthly BIs and the fitted differences over time between intervention and control clusters. At baseline, entomological indices were approximately 0.1 and were comparable in intervention and control clusters. They fluctuated and showed a raising trend over time but their difference became marginally significant mid-2005 (after the intensification of *A. aegypti* surveillance in the intervention clusters) and substantially increased from September 2006 onwards (the launch of the CWG activities for dengue control). At the end of the observation period, *A. aegypti* infestation levels in the intervention clusters were substantially and significantly lower than those in the control clusters. The GEE analysis (Table 3) indicates that the difference over the intervention period was 53% (period × group interaction = 1.53, 95% CI 1.22–1.92).

4. Discussion

The level of participation achieved, changes in preventive behaviours and the entomological outcome provide converging evidence of the effectiveness of the deployed community empowerment strategy. In particular, adequate preventive practices at the household level had increased 36% in the intervention clusters compared with no changes in the control clusters and over the 2-year intervention period the BI remained 53% lower in the former compared with the latter.

The risk of falsely attributing these results to the intervention is minimal since a cluster randomised controlled design was used. In addition, while the procedures used for collecting entomological data by the routine vector control programme may not have been fully standardised, possible underestimations of the BI, if any, should be non-differential. The presence *of A. albopictus* is not an issue: it predominantly breeds in man-made containers and makes up hardly 1% of the infestation in the selected CPs.[21] A

Table 2
Changes in knowledge, risk perception and dengue-related practices in intervention and control clusters before (November 2004) and after (April 2007) the intervention, La Lisa Municipality, Havana City, Cuba

	Control clusters (%)			Intervention clusters (%)			OR (95% CI)[a]		
	Before (n = 390)	After (n = 400)	Relative difference	Before (n = 389)	After (n = 400)	Relative difference	Control/ intervention	Before/after	Period × group interaction
Good knowledge of dengue symptoms	85.6	91.3	6.7	82.0	90.8	10.7	0.76 (0.46–1.28)	1.74 (1.12–2.72)	1.22 (0.66–2.26)
Good knowledge of breeding sites	42.6	54.3	27.5	40.9	62.5	52.8	0.93 (0.63–1.37)	1.50 (1.10–2.04)	1.50 (1.01–2.22)
Good knowledge of preventive measures	68.5	76.5	11.7	67.9	78.5	15.6	0.98 (0.62–1.55)	1.59 (1.21–2.10)	1.33 (0.73–1.76)
Perception that dengue can be fatal	84.0	81.0	−3.6	90.2	84.0	−6.9	1.70 (1.01–3.01)	0.84 (0.58–1.21)	0.67 (0.38–1.17)
Perception that dengue could be contracted	23.6	73.5	211.4	18.5	77.0	316.2	0.73 (0.45–1.18)	8.99 (6.54–12.33)	1.63 (1.02–2.60)
Adequate preventive practices	63.8	62.0	−2.8	60.2	82.0	36.2	0.86 (0.55–1.35)	0.92 (0.70–1.22)	3.23 (2.10–4.96)

[a] Estimated with a generalised estimating equation models with binomial link function.

further strength of this study is that the effect of the intervention was assessed over a period of 2 years, a timeframe that allowed an observation of trends in the vector infestation level and in the behavioural changes leading to them.

Two recent reviews on dengue prevention and *A. aegypti* control[5,28] indicate that there is little evidence on the large-scale effectiveness of community-based interventions owing to limitations in study designs. Besides, most studies are small scale.[5,29] The only exception that we are aware of is a study in Vietnam, which reported the expansion of a community-based strategy from 6 to 46 communes, resulting in the elimination of the vector in 40 of them.[30]

In Cuba, pilot projects in Havana City[7] and in Santiago de Cuba[6] demonstrated the effectiveness of community-based dengue vector control strategies at a small scale. The present study, together with a study carried out in Guantanamo,[31] demonstrates the effectiveness at intermediate scale of a participatory strategy developed from these pilot experiences.

In the current trial, the strategy was adapted to the different settings through working with local stakeholders.[22] Consequently, in some intervention clusters, local actors introduced changes to the original design and, furthermore, the level of participation varied. This was documented in detail through process-oriented fidelity research that revealed important heterogeneity in the implementation.[24] It is reasonable to assume that positive adaptations which respect the original purposes of an intervention[32] or its underlying functioning principles[33] are possible without loss of effectiveness. However, information on process is needed to understand better which adaptations lead to desired outcomes.[15,34]

Few dengue vector control studies have tested the empowerment approach,[7,8,30,31] but research on other health problems demonstrates the importance of structural strengthening of community participation to improve disease control effectiveness.[35] The vector control personnel in the intervention clusters acquired communication and problem-solving skills and gained know-how to work with communities and to facilitate group processes and negotiations leading to collective action and specific behavioural change. Furthermore, the participatory process empowered the community to develop concrete actions, to change practices, to propose operational improvements and to initiate innovations of *A. aegypti* control activities.

Notwithstanding, the relationship between the output of community-based programmes and *A. aegypti* infestation is not straightforward.[28] Most participatory strategies are complex and encompass an array of activities and it is generally unclear to which elements or specific actions an effect should be attributed.[5] On the other hand, flexibility and adaptability of community-based dengue control strategies is important for success.[24] Identifying the appropriate blend of core strategy components required to maintain effectiveness and those components that can be adapted and tailored to local conditions seems the way forward.

Finally, it should be noted that the intervention was more effective relative to routine control only, but that in a period with raising general trends it did not manage to reduce the BI in absolute terms. In non-endemic areas with

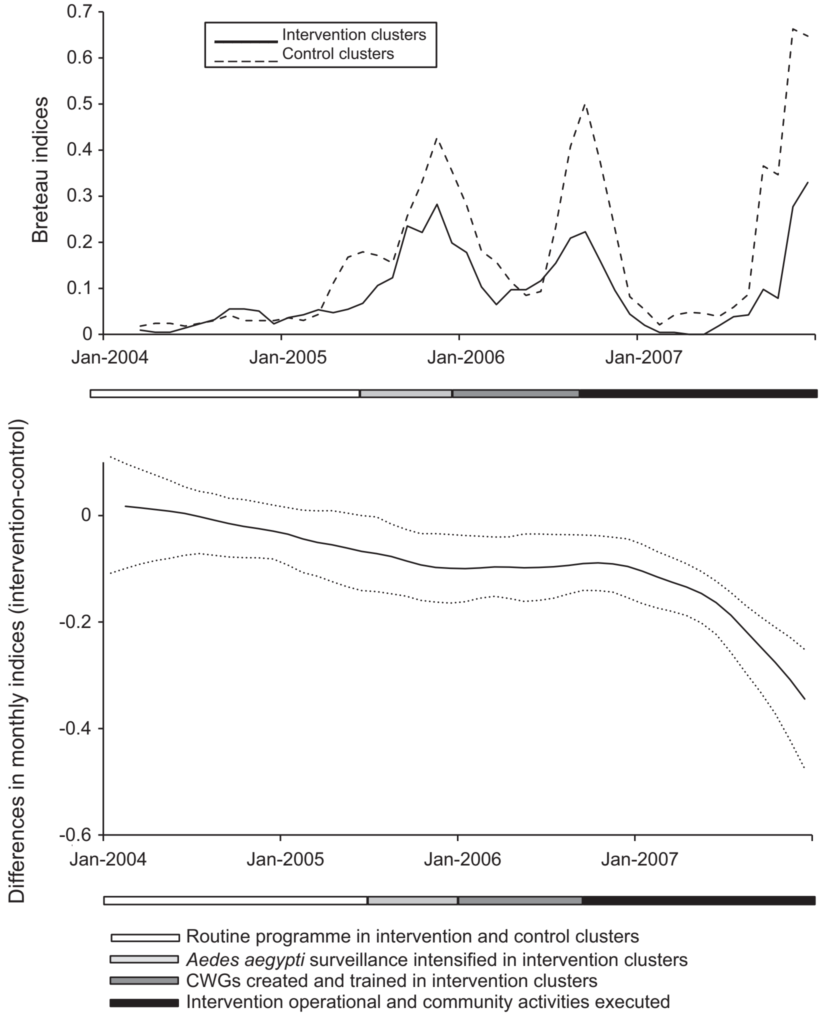

Figure 2. Mean Breteau indices (moving average of three cycles) in intervention and control clusters (top) and fitted differences (intervention–control) (with 95% confidence bands) (bottom), January 2004–December 2007, La Lisa Municipality, Havana City, Cuba. CWG: community working group.

Table 3
Average monthly Breteau indices (BI) in intervention clusters (IC) and control clusters (CC), pre-intervention (January 2004–December 2005) and during the intervention (January 2006–December 2007), and BI rate ratio (RR), La Lisa Municipality, Havana City, Cuba

Average BI						RR of BI (95% CI)[a]		
IC			CC					
Pre	During	% change	Pre	During	% change	CC/IC	During/pre	Interaction term[b]
0.08	0.11	37.5	0.11	0.24	118.2	1.67 (1.29–2.15)	1.20 (1.00–1.43)	1.53 (1.22–1.92)

[a] Estimated with generalised estimating equation models with negative binomial.
[b] Period × group interaction term.

already low infestation levels it is not straightforward to assess the public health implications hereof. Still, Toledo et al.[11] recently demonstrated that in such settings modest absolute differences in BI and pupae per person statistic can eventually result in meaningful differences in dengue incidence during an outbreak.

Authors' contributions: LS, DP, VV and PVdS conceived and designed the study; MC, LS and DP supervised field activities and data collection; LS, NC and PVdS designed quantitative data analysis and analysed the data; MC, DP and PL designed qualitative data analysis and analysed the data; all authors contributed to the interpretation of the results; MC, LS and PVdS drafted the manuscript. All authors revised subsequent drafts of the manuscript, contributed to the content and read and approved the final version. MC and PVdS are guarantors of the paper.

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Competing interests: None declared.

Ethical approval: The intervention was approved by the Research and Ethics Committee of the Institute of Tropical Medicine 'Pedro Kouri' (Havana City, Cuba) and by the municipal health authorities.

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