Perspectives of the WHO on the use of new technologies for the control of *Aedes spp.*

Dr Raman Velayudhan

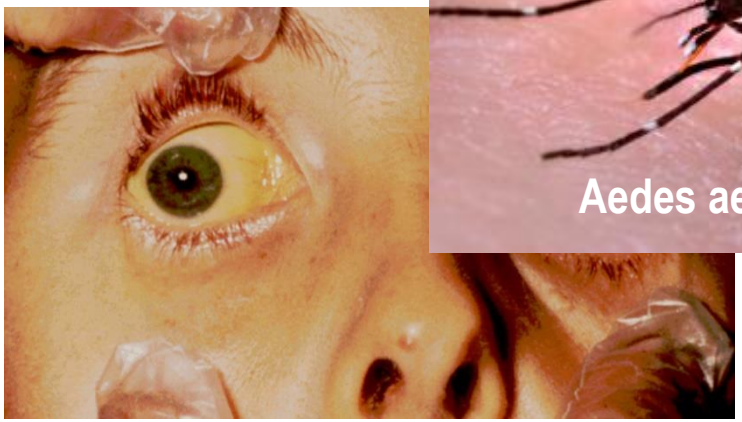
Coordinator,

World Health Organization
Geneva

Aedes-borne diseases are urban diseases

Severe Dengue

Zika



yellow fever

chikungunya

Aedes aegypti: the enemy within the gates

1. It is the world's most efficient vector of viruses
2. Is an invasive species
3. It has evolved to exploit humans

Rainforest

Urban environment

Aedes aegypti

- Heavily adapted to human beings and dwelling
- Highly adaptable to distinct urban and rural ecologies
- Eggs can remain dry (upto 400 days)
- Anthrophophillic
- Blood feeding frequency (multiple times per gonotrophic cycle)
- Day biter
- Low density mosquito
- Artificial containers
  - Adaptation to cryptic sites
- Megacities versus rural communities

Predicted distribution of *Aedes aegypti* in 2015

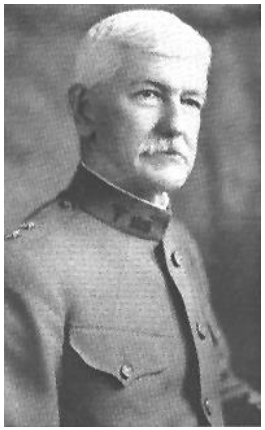
Cities >1M inhabitants

Aedes aegypti distribution

Nick Golding unpublished

Aedes aegypti Control Prevents Disease

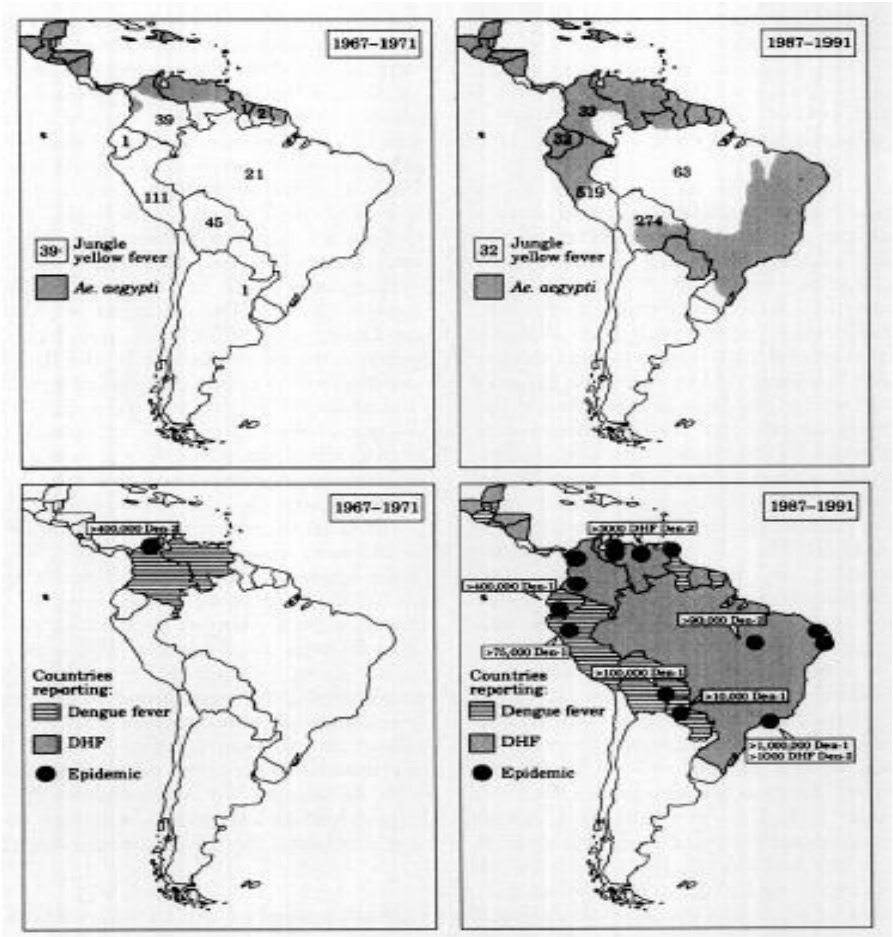
William Gorgas



- Vertically structured
- Disease prevention

Fred Soper

- Difficult to do properly
- Difficult to sustain

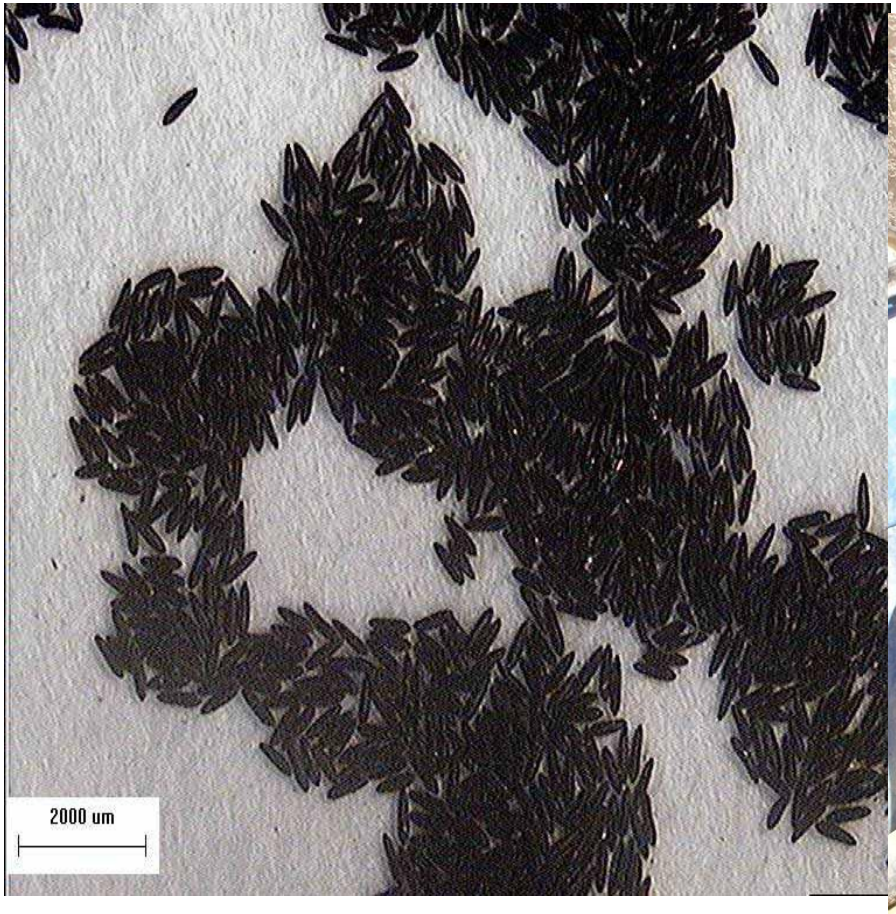


seminars in VIROLOGY, Vol 5, 1994 : pp 133-145

Yellow fever and dengue—the interactions of virus, vector and host in the re-emergence of epidemic disease

Thomas P. Monath

REMOVAL OF EGGS - SCRUBBING



Existing Methods

Immature control

Major categories

- Container cleaning (bleach/wash/dump)
- Container manipulation (polystyrene beads)
- Container treatment
- Social campaigns (education, source reduction)
- Environmental Management
- Legislation

Conatiner treatment

Insecticides

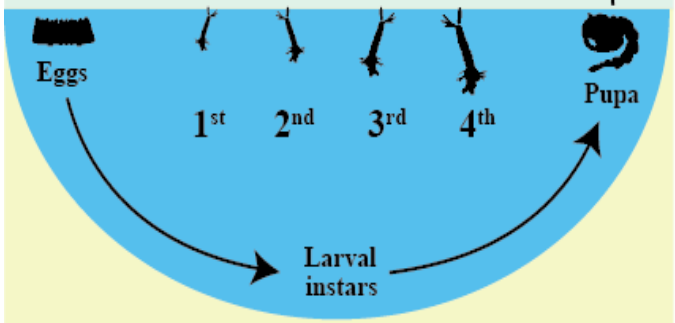
- Temephos
- Novaluron
- Spinonsad
- Diflubenzuron
- Bti

Bleach

Methoprene
Pyriproxyfen

Biologicals

- Copepods
- Larvivorous fish



New entomopathogenic fungi

Adult control

Major categories

- Space spraying
- Indoor residual spraying
- Personal protection

A Critical Assessment of Vector Control for Dengue Prevention

NL Achee, F Gould, TA Perkins, RC Reiner, Jr., AC Morrison, S Richie, DJ Gubler, and TW Scott

Space spraying: Truck ULV, Low-flying aircraft, hand-held portables, perifocal treatment

Personal protection

- DEET
- Picaridin
- Bed nets
- Consumer products

Indoor residual spraying

RIDL and fsRIDL

Toxic sugar baits

Behavior modification

Lethal Ovitraps
Auto-dissemination

Wolbachia
Other within-tissue symbionts
Para-transgenesis
Antipathogen genes without drive

Curtains / IRS

Molecular insecticides, medea/HEGs, new insecticides

Methods under Development

New Vector Control Product Classes (n=17)

Stage 3 epi trials (n=10)

New Product - Variation	Generic Exemplar	Product Example
Treated walls against IR vector (extend IRS)	IRS/wall linings for IR pop	No claim reviewed
Peri-focal residual spraying (extend IRS)	Outdoor RS	PFS formulation, Bayer
Insecticide-treated curtain (extend ITN)	Fully screened house	FSH pyrethroid netting
New Product Class – (chemical)	**Generic Exemplar**	**Product Example**
ITN against IR Vector	Pyrethroid + PBO	Olyset, PermaNet 3
	Pyrethroid + Chlorfenapyr	Interceptor G2
	Organophosphate	Yorkool LN G2.0 and G2.1
Attract and kill baits	Attractive Toxic Sugar Bait	Bait station
Spatial repellents	Passive emanator	Metofluthrin or Transfluthrin
ITM for specific risk groups	ITM	Blanket, Clothes
Vector traps	Adulticidal Oviposition traps	ALOT, AGO, TNK, IN2TRAP
Lethal house lures	Eave tubes	Eave tubes
Systemic insecticide	Rodent bait	Imidicloprid based bait
New Product Class – (biological)	**Generic Exemplar**	**Product Example**
Microbial control in adult vectors	Bacterial infection	wMel *Wolbachia* in *Ae. aegypti*
Pop. reduction through genetic manipulation	GMM, self limiting	OX513A *Ae. aegypti* (RIDL)
	GMM, gene-drive	CRISP/Cas9 in *An. gambiae*
Pop. alteration of malaria vector mosquitoes	GMM, gene-drive	CRISP/Cas9 anti-parasite
SIT & incompatible insect technique (IIT)	Radiation + bacterial infection	Sterilized *Aedes* spp. + *Wolbachia*

Emergency VCAG Meeting on New Tools for Zika: 14-15 March 2016

Major Conclusions:

- **Well implemented vector control programmes using existing tools and strategies are effective in reducing the transmission of *Aedes*-borne diseases, including Zika virus. These tools should be promoted and used to control the Zika virus. They include: (i) targeted residual spraying; (ii) space spraying; (iii) larval control; and (iv) personal protection measures.**
- **Full-scale programmatic deployment is not currently recommended for any of the new potential tools reviewed by VCAG. However, the VCAG recommended the carefully planned pilot deployment under operational conditions of two tools (*Wolbachia*-based biocontrol and OX513A transgenic mosquitoes) accompanied by rigorous independent monitoring and evaluation.**
- **The VCAG concluded that more evidence is required before consideration of the pilot deployment of the additional tools reviewed.**

Vector control interventions covered by existing policy/ recommendations

Insecticide-treated nets

Pyrethroid-only nets including LLINs:

- Covered by existing policy
- Eligible for PQT assessment

Pyrethroid plus synergist (PBO) nets:

- Covered by existing policy limiting deployment to pilot exploratory implementation
- To be reviewed by ERG in June 2017

Non-pyrethroid insecticide nets:

- Not covered by existing policy
- To be assessed by VCAG

Nets containing IGR or sterilizing agent/s:

- Not covered by existing policy
- To be assessed by VCAG

Indoor residual sprays

OP, organochlorine, carbamate or pyrethroid formulations:

- Covered by existing policy
- Eligible for PQT assessment

Fast-acting insecticide formulations:

- Covered by existing policy
- Eligible for PQT assessment based on non-inferior entomological performance

Slow-acting insecticide formulations:

- Not covered by existing policy
- To be assessed by VCAG

Formulations containing an IGR or sterilizing agent/s:

- Not covered by existing policy
- To be assessed by VCAG

Mosquito Larvicides

OP, benzoylurea, spinosyn, juvenile hormone mimics, bacterial compounds & larvicidal devices:

- Covered by existing policy
- Eligible for PQT assessment

Larvicide not meeting above classification:

- Not covered by existing policy
- To be assessed by VCAG

Products providing personal protection

Topical repellents for personal protection:

- Covered by existing policy
- Eligible for PQT assessment

Products designed for personal protection not meeting above classification:

- Not covered by existing policy
- To be assessed by VCAG

Space spray products

Indoor space spray with OP and pyrethroid formulations

- Covered by existing policy
- Eligible for PQT assessment

Space Spray products not meeting above classification

- Not covered by existing policy
- To be assessed by VCAG

Aircraft disinsection products

Pyrethroid based products (eg. d-phenothrin, 1R trans-phenothrin and permethrin)

- Covered by existing policy
- Eligible for PQT assessment

Aircraft disinsection products not meeting above classification

- Not covered by existing policy
- To be assessed by VCAG

Molluscicide products

Single , fast acting compound recommended (Niclosamide). New similar products:

- Covered by existing policy
- Eligible for PQT assessment

New molluscicide products not meeitng above classification

- Not covered by existing policy
- To be assessed by VCAG

Rodenticide products

Anticoagulants and fast acting products applied with / just after insecticides (for flea control) in outbreaks

- Covered by existing policy
- Eligible for PQT assessment

New rodent based strategies (eg. endectocides

- Not covered by existing policy
- To be assessed by VCAG

Environmental management

Environmental manipulation

- New approaches / strategies to be assessed by VCAG

Environmental modification

- New approaches / strategies to be assessed by VCAG

Abbreviations

ERG: Evidence Review Group

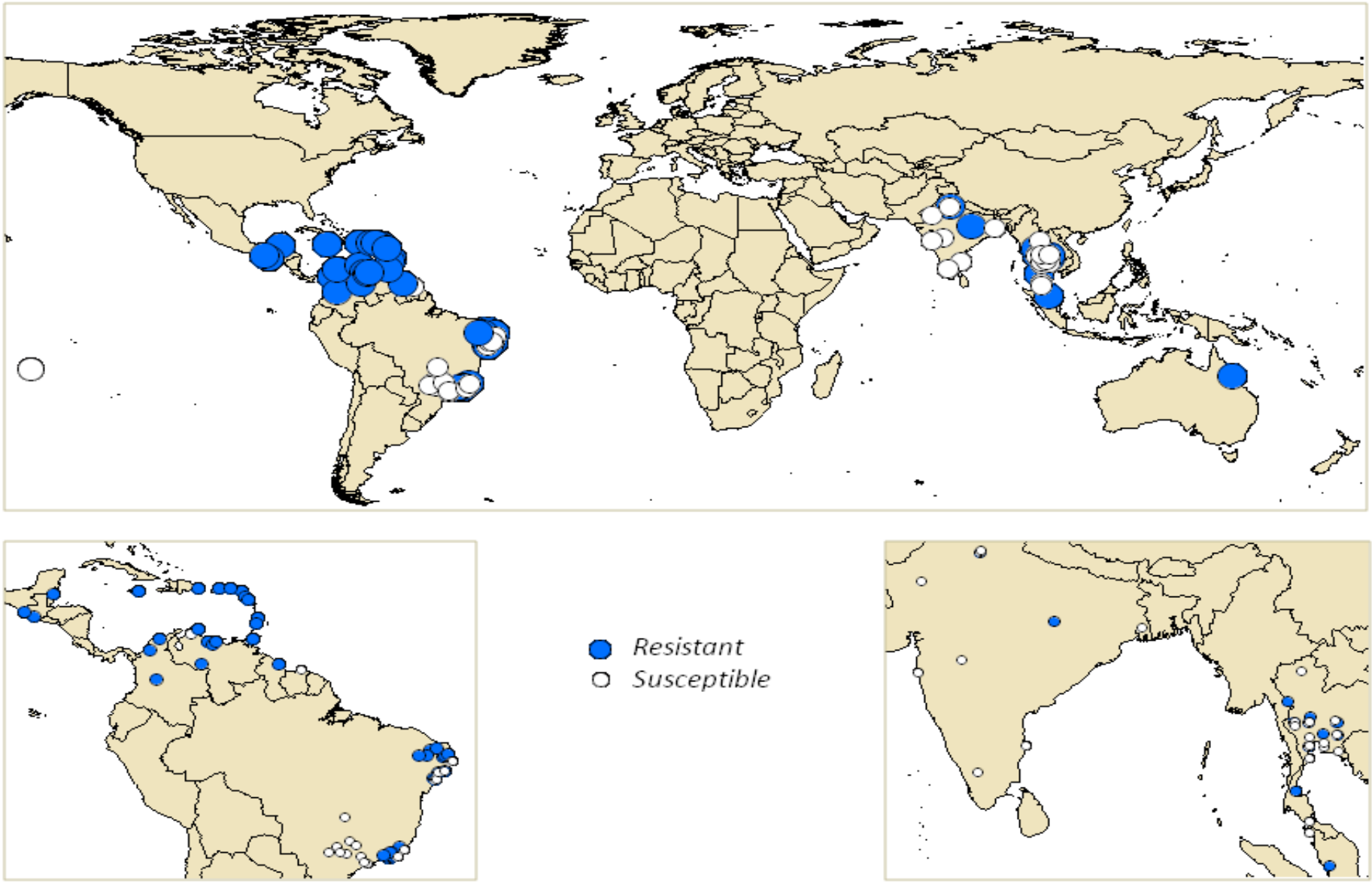
IGR: Insect Growth Regulator

OP: Organophosphate

PQT: Prequalification Team

VCAG: Vector Control Advisory Group

Pyrethroid resistance in *Aedes aegypti*



Climate change favours the vectors

- ✓ **Erratic access to piped water may aggravate dengue incidence if it leads to increased domestic water storage.**
- ✓ **Increase in temperature favours the multiplication of the vector and the virus**
- ✓ **Rainfall, relative humidity, El nino all plays a role in transmission and more studies are needed**
- ✓ **Increase in cases of dengue in Asia in 2016**

OPEN ACCESS Freely available online

PLOS | NEGLECTED TROPICAL DISEASES

The Effects of Weather and Climate Change on Dengue

Felipe J. Colón-González[1,2,3]*, Carlo Fezzi[4], Iain R. Lake[3], Paul R. Hunter[5]

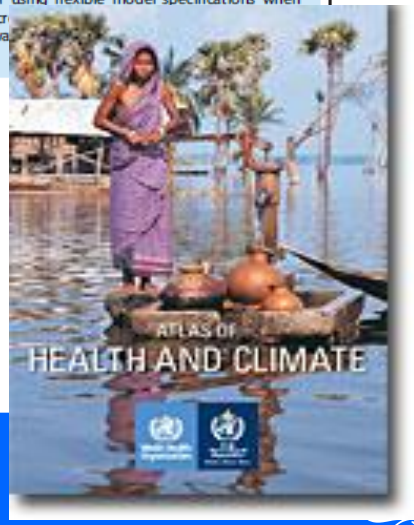
1 The Abdus Salam International Centre for Theoretical Physics, Earth System Physics Section, Trieste, Italy, 2 Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom, 3 School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom, 4 Department of Economics, University of California, San Diego, La Jolla, California, United States of America, 5 Norwich Medical School, University of East Anglia, Norwich, United Kingdom

Abstract

Background: There is much uncertainty about the future impact of climate change on vector-borne diseases. Such uncertainty reflects the difficulties in modelling the complex interactions between disease, climatic and socioeconomic determinants. We used a comprehensive panel dataset from Mexico covering 23 years of province-specific dengue reports across nine climatic regions to estimate the impact of weather on dengue, accounting for the effects of non-climatic factors.

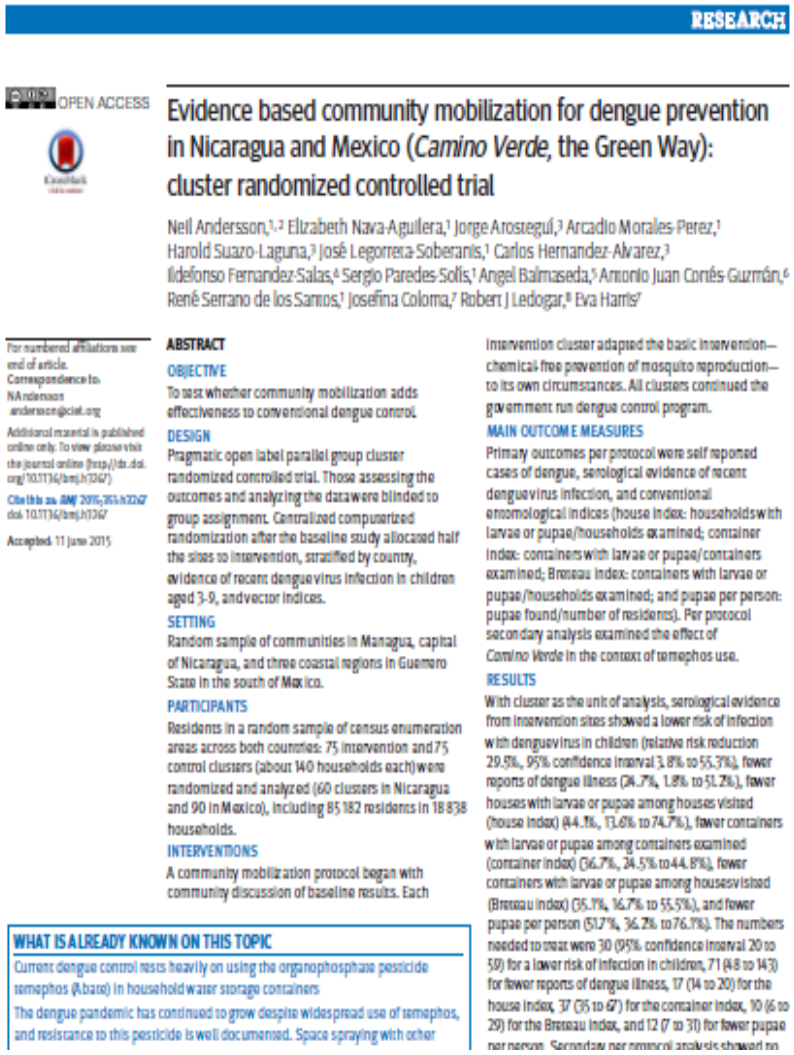
Methods and Findings: Using a Generalized Additive Model, we estimated statistically significant effects of weather and access to piped water on dengue. The effects of weather were highly nonlinear. Minimum temperature (Tmin) had almost no effect on dengue incidence below 5°C, but Tmin values above 18°C showed a rapidly increasing effect. Maximum temperature above 20°C also showed an increasing effect on dengue incidence with a peak around 32°C, after which the effect declined. There is also an increasing effect of precipitation as it rose to about 550 mm, beyond which such effect declines. Rising access to piped water was related to increasing dengue incidence. We used our model estimations to project the potential impact of climate change on dengue incidence under three emission scenarios by 2030, 2050, and 2080. An increase of up to 40% in dengue incidence by 2080 was estimated under climate change while holding the other driving factors constant.

Conclusions: Our results indicate that weather significantly influences dengue incidence in Mexico and that such relationships are highly nonlinear. These findings highlight the importance of using flexible model specifications when analysing weather–health interactions. Climate change may contribute to an incr
piped water may aggravate dengue incidence if it leads to increased domestic wa
influence the success or failure of future efforts against dengue.



Epidemiological end points –Cluster randomised controlled trial

- The Camino Verde (Green Way) is pesticide-free evidence based community mobilization, each community choosing and implementing its own mix of dengue prevention actions based on local vector reservoirs and community resources
- The project had a positive impact on serological evidence of dengue virus infection in children, reported illness at all ages, and all dengue vector control indices
- This is the first report of serological evidence of impact of community interventions



RESEARCH

OPEN ACCESS

Evidence based community mobilization for dengue prevention in Nicaragua and Mexico (*Camino Verde*, the Green Way): cluster randomized controlled trial

Neil Andersson,[1,2] Elizabeth Nava-Aguilera,[1] Jorge Arosteguí,[3] Arcadio Morales-Perez,[1] Harold Suazo-Laguna,[3] José Legorreta-Soberanis,[1] Carlos Hernandez-Alvarez,[3] Ildefonso Fernandez-Salas,[4] Sergio Paredes-Solís,[1] Angel Balmaseda,[5] Antonio Juan Cortés-Guzmán,[6] René Serrano de los Santos,[7] Josefina Coloma,[7] Robert J Ledogar,[8] Eva Harris[7]

ABSTRACT

OBJECTIVE

To test whether community mobilization adds effectiveness to conventional dengue control.

DESIGN

Pragmatic open label parallel group cluster randomized controlled trial. Those assessing the outcomes and analyzing the data were blinded to group assignment. Centralized computerized randomization after the baseline study allocated half the sites to intervention, stratified by country, evidence of recent dengue virus infection in children aged 3-9, and vector indices.

SETTING

Random sample of communities in Managua, capital of Nicaragua, and three coastal regions in Guerrero State in the south of Mexico.

PARTICIPANTS

Residents in a random sample of census enumeration areas across both countries: 75 intervention and 75 control clusters (about 140 households each) were randomized and analyzed (60 clusters in Nicaragua and 90 in Mexico), including 85 182 residents in 18 838 households.

INTERVENTIONS

A community mobilization protocol began with community discussion of baseline results. Each intervention cluster adapted the basic intervention—chemical-free prevention of mosquito reproduction—to its own circumstances. All clusters continued the government run dengue control program.

MAIN OUTCOME MEASURES

Primary outcomes per protocol were self reported cases of dengue, serological evidence of recent dengue virus infection, and conventional entomological indices (house index: households with larvae or pupae/households examined; container index: containers with larvae or pupae/containers examined; Breteau index: containers with larvae or pupae/households examined; and pupae per person: pupae found/number of residents). Per protocol secondary analysis examined the effect of *Camino Verde* in the context of temephos use.

RESULTS

With cluster as the unit of analysis, serological evidence from intervention sites showed a lower risk of infection with dengue virus in children (relative risk reduction 29.5%, 95% confidence interval 3.8% to 55.3%), fewer reports of dengue illness (24.7%, 1.8% to 51.2%), fewer houses with larvae or pupae among houses visited (house index) (64.1%, 73.6% to 74.7%), fewer containers with larvae or pupae among containers examined (container index) (36.7%, 24.5% to 44.8%), fewer containers with larvae or pupae among houses visited (Breteau index) (35.1%, 16.7% to 55.5%), and fewer pupae per person (51.7%, 36.2% to 76.1%). The numbers needed to treat were 30 (95% confidence interval 20 to 59) for a lower risk of infection in children, 71 (48 to 143) for fewer reports of dengue illness, 17 (14 to 20) for the house index, 37 (25 to 67) for the container index, 10 (6 to 29) for the Breteau index, and 12 (7 to 31) for fewer pupae per person. Secondary per protocol analysis showed no

WHAT IS ALREADY KNOWN ON THIS TOPIC

Current dengue control rests heavily on using the organophosphate pesticide temephos (Abate) in household water storage containers

The dengue pandemic has continued to grow despite widespread use of temephos, and resistance to this pesticide is well documented. Space spraying with other

For numbered affiliations see end of article.
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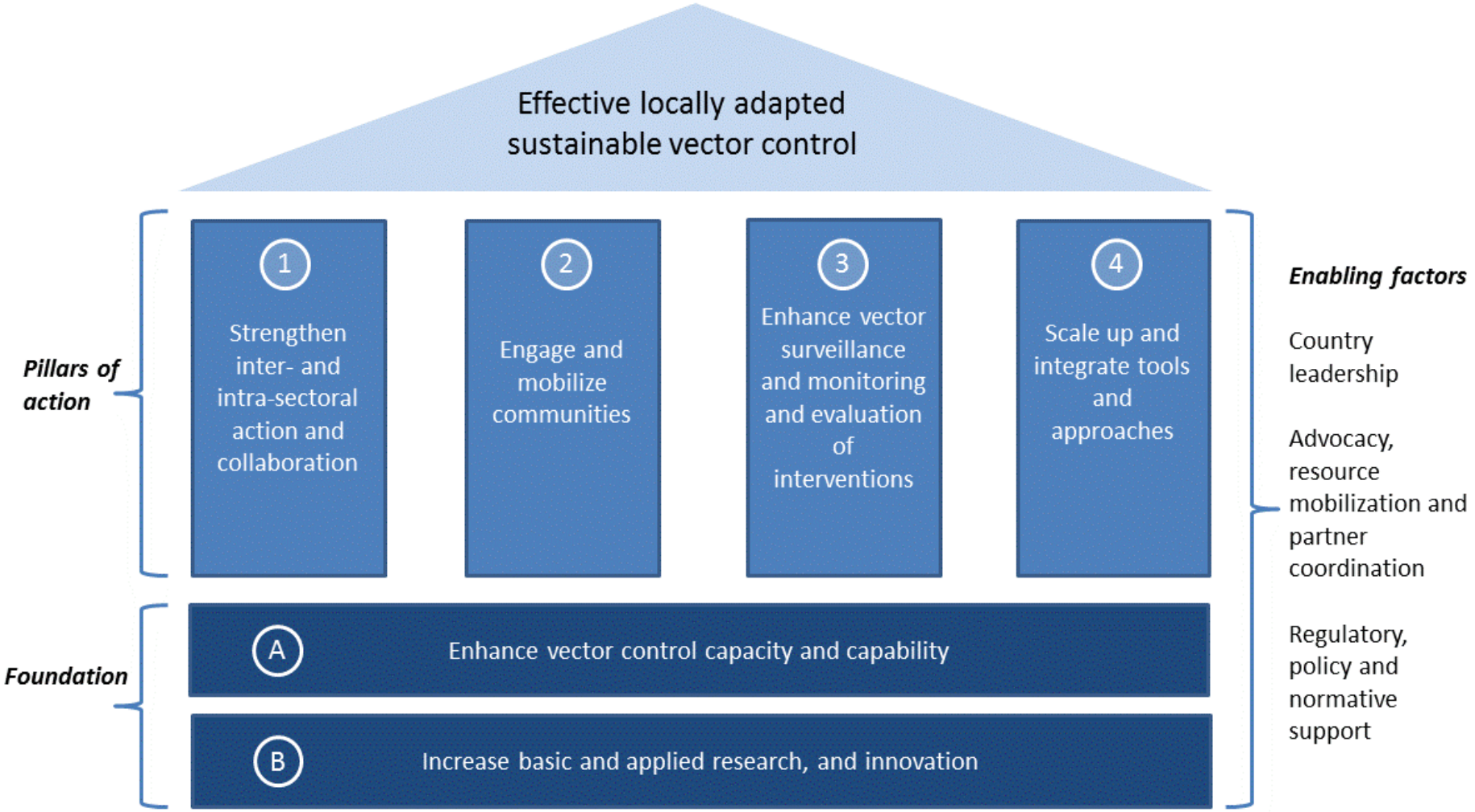
Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/bmj.h3267)

Cite this as: BMJ 2015;351:h3267
doi: 10.1136/bmj.h3267

Accepted: 11 June 2015

WHO's Global Vector Control Response 2017-2030

Reduce the burden and threat of vector-borne diseases that affect humans



Aedes control is linked to many SDGs

Each goal is important in itself…

And they are all connected

New designs reduce indoor mosquito entry & keep the house cool

Sustained Vector Control

- Program Management
- Integrated surveillance
  - Vector surveillance
  - Clinical surveillance/ confirmation (lab)/ notifiable disease
- Resource and Personnel management
- Integrated Vector Management
  - Source reduction
  - Combination Vector control based on cost effectiveness and sustainability
  - Perifocal spraying
  - ITMs, curtains and other innovative tools to be sustained for 2-3 years
- Monitoring and Evaluation

Aedes borne diseases in the 21st century

- Uncertain distribution and burden
- As malaria declines, dengue, Chikungunya, Zika, WNV rises
- Urban health and delivery of services needs to be addressed
- Insecticide Resistance Management must be addressed
- Impact of Environmental changes
- Silent expansion and cryptic breeding of the vector
- Two vectors transmitting more than 4 diseases

Conclusion

- Current tools & strategies have not been evaluated for dengue /CHIK prevention (epidemiologic outcomes)
- There is current research on new tools/strategies, but little support for improving delivery & coverage of vector control for dengue prevention
- The biggest gap in current vector control for is how much coverage is necessary for disease reduction goals
- General consensus is that 1 approach will not solve the problem by itself, we need to use a combination of approaches
  - Larval and adult control
  - Vector control & vaccines: How exactly should this be done?
- Urban health and delivery of services needs to be addressed

Thank you

VelayudhanR@who.int