Aedes aegypti control: indoor residual spraying and the impact of insecticide resistance

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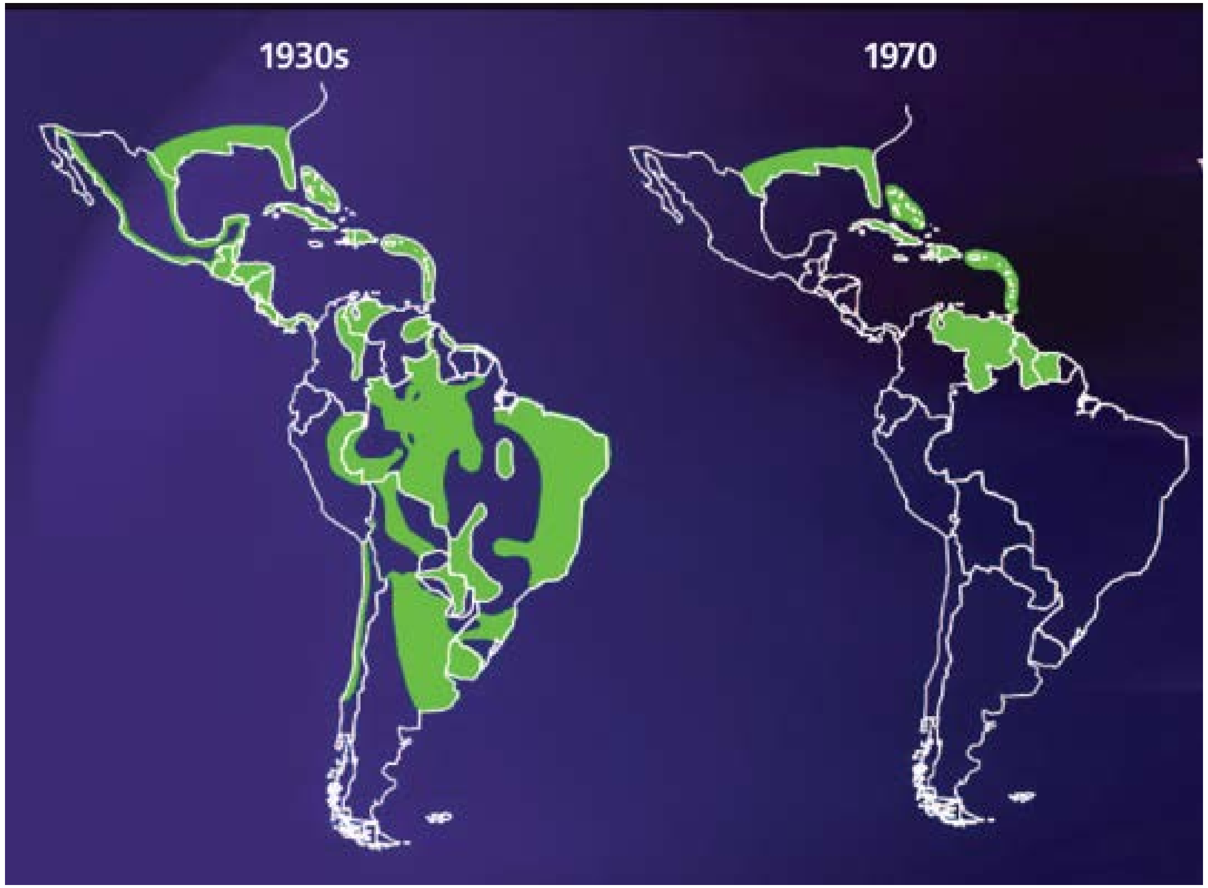
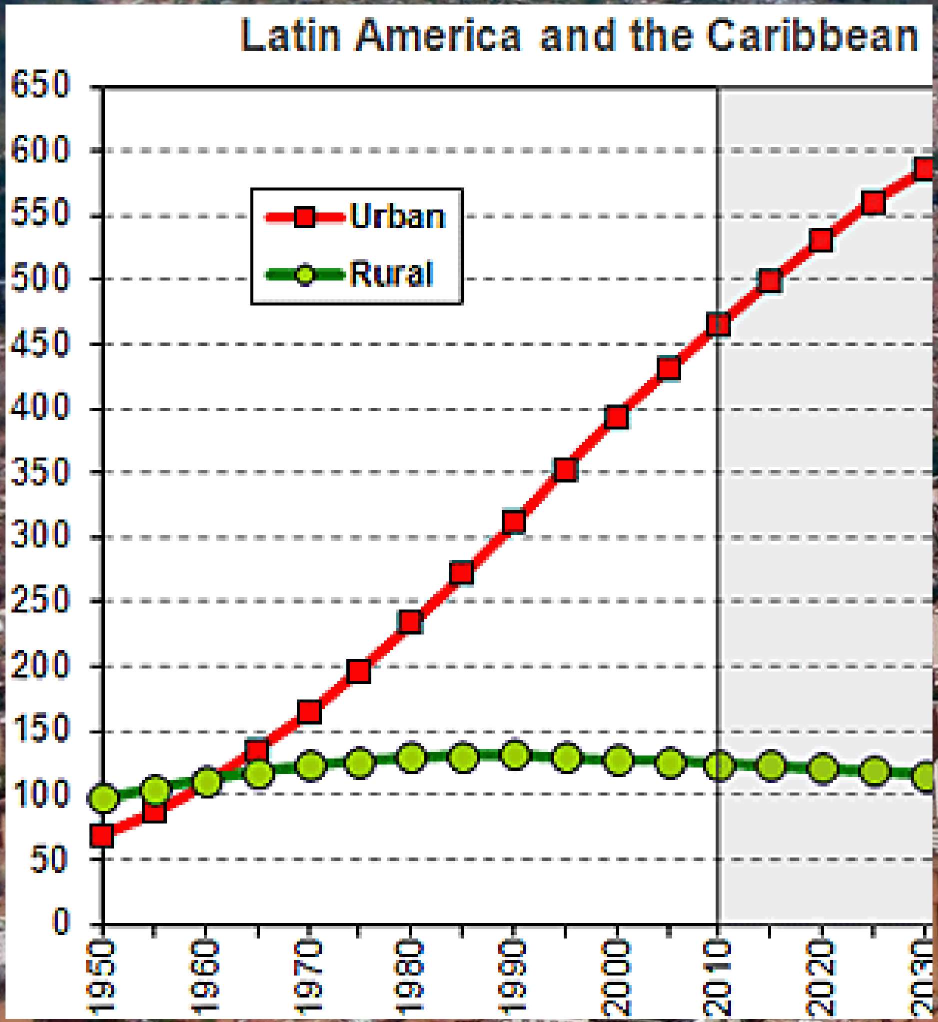
Vector control, if expeditiously implemented and sustained, can be successful at controlling *Ae. aegypti* and interrupting pathogen transmission

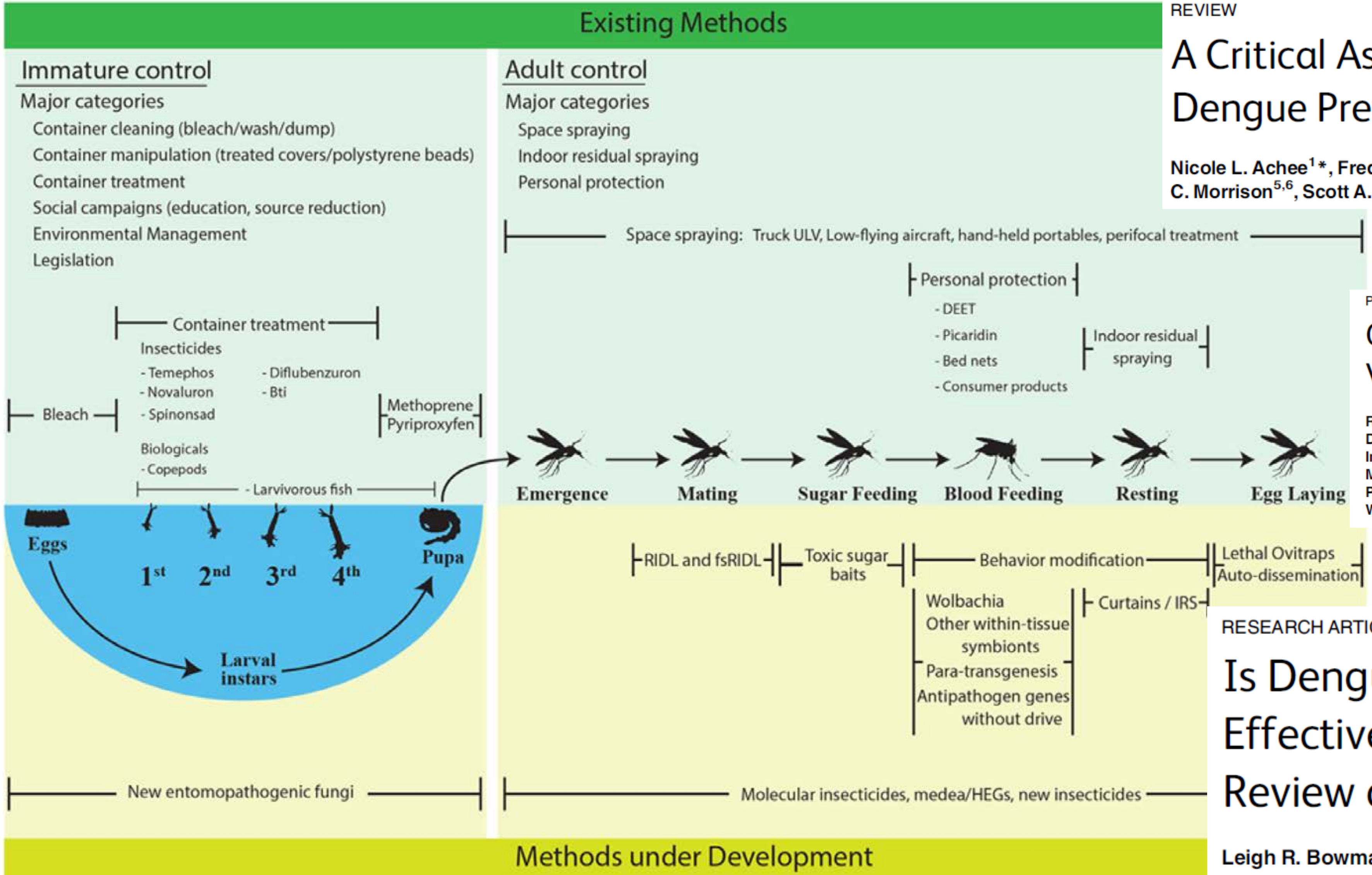
http://history.amedd.army.mil/





Medellin, Colombia

Contemporaneous *Aedes aegypti* control tools: diverse but with limited epidemiological evidence



REVIEW

A Critical Assessment of Vector Control for Dengue Prevention

Nicole L. Achee[1]*, Fred Gould[2], T. Alex Perkins[1,3], Robert C. Reiner Jr.[3,4], Amy C. Morrison[5,6], Scott A. Ritchie[7], Duane J. Gubler[8,9], Remy Teyssou[9], Thomas W. Scott[3,5,9]

POLICY PLATFORM

Quantifying the Epidemiological Impact of Vector Control on Dengue

Robert C. Reiner, Jr.[1,2]*, Nicole Achee[3], Roberto Barrera[4], Thomas R. Burkot[5], Dave D. Chadee[6], Gregor J. Devine[7], Timothy Endy[8], Duane Gubler[9], Joachim Hombach[10], Immo Kleinschmidt[11,12], Audrey Lenhart[13], Steven W. Lindsay[2,14], Ira Longini[15], Mathias Mondy[16], Amy C. Morrison[17], T. Alex Perkins[2,3], Gonzalo Vazquez-Prokopec[18], Paul Reiter[19], Scott A. Ritchie[20], David L. Smith[2,21], Daniel Strickman[22], Thomas W. Scott[2,17]

RESEARCH ARTICLE

Is Dengue Vector Control Deficient in Effectiveness or Evidence?: Systematic Review and Meta-analysis

Leigh R. Bowman[1], Sarah Donegan[2], Philip J. McCall[1]*

Photo Credit: New York Times

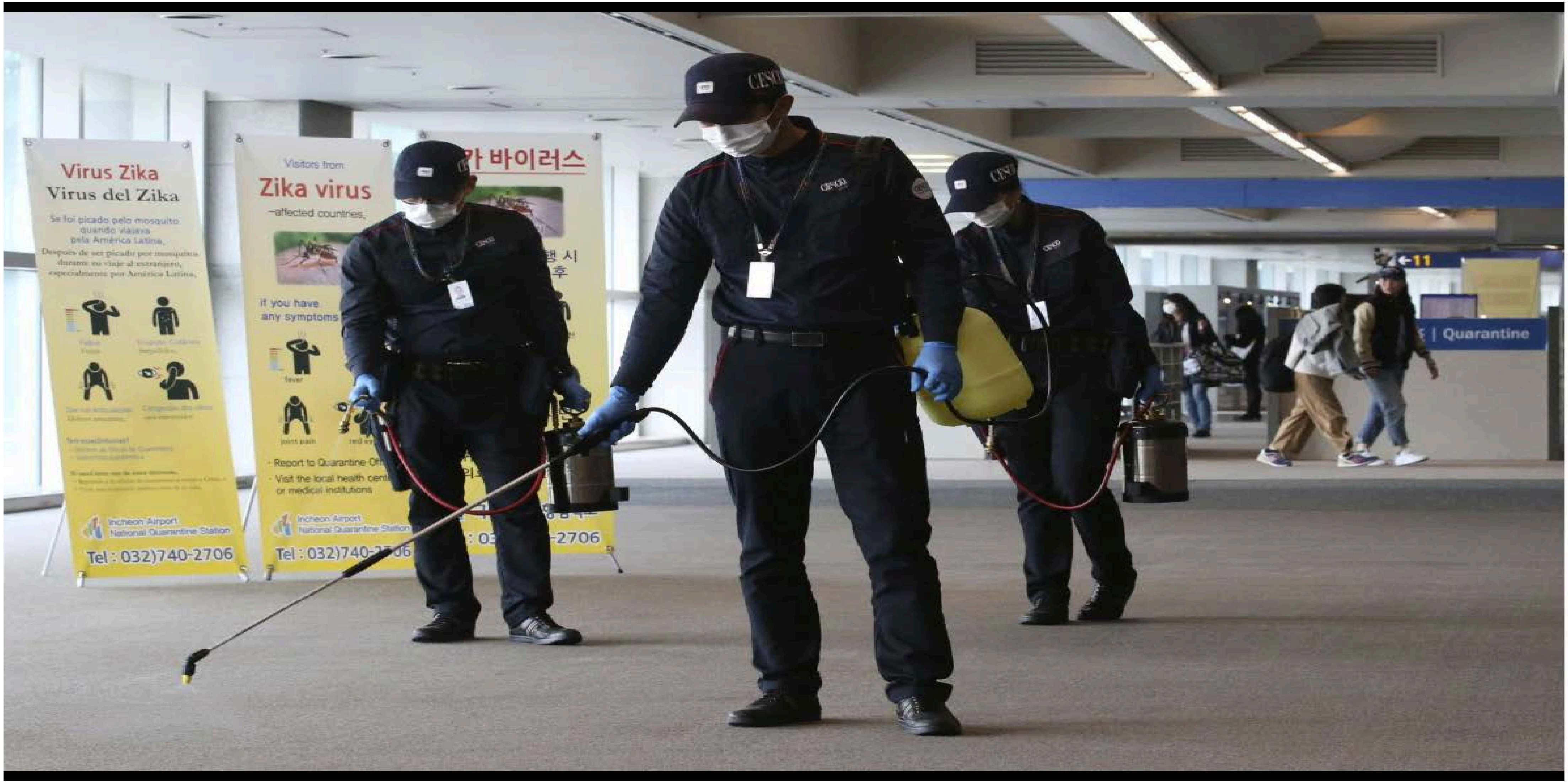
CNN Regions | U.S. Politics | Money | Entertainment | Tech | Sport | Travel | Style | Features | Video International Editio

WHO boss: Zika result of 'massive' mosquito control failures

By Euan McKirdy, CNN
Updated 0652 GMT (1452 HKT) May 24, 2016

Thermal fogging, New Dehli IPL match 2015 (courtesy Bruce Murphy, DFAT)

Feb. 1, 2016 | Municipal workers trim vegetation as part of efforts to prevent the spread of the Zika virus in Tegucigalpa, Honduras. (Jorge Cabrera/Reuters)


Virus Zika
Virus del Zika
Se foi picado pelo mosquito
quando viajava
pela América Latina,
Después de ser picado por mosquitos
durante su viaje al extranjero,
especialmente por América Latina,
Incheon Airport
National Quarantine Station
Tel : 032)740-2706
Visitors from
Zika virus
-affected countries,
If you have
any symptoms
fever
joint pain
Visit the local health cent
or medical institutions
Incheon Airport
National Quarantine Station
Quarantine

World Health Organization

Vector Control Advisory Group (VCAG)

Launched in 2012, the Vector Control Advisory Group (VCAG) on New Tools was established to assess the public health value of new product classes in vector control.

Mosquito (vector) control emergency response and preparedness for Zika virus

18 March 2016 | Geneva

Conclusions and recommendations of VCAG

1. Well-implemented vector control programmes using existing tools and strategies are effective in reducing the transmission of *Aedes*-borne diseases including Zika virus. Appropriate vector control interventions for the response to the Zika virus outbreak include:

- **Targeted residual spraying** of resting sites of *Aedes* spp. mosquitoes primarily inside and, to a lesser extent, around houses as the primary vector control intervention for immediate response.
- **Space spraying** is effective inside buildings where Aedes spp. mosquitoes rest and bite. It has no residual effect. Its application outdoors only suppresses vector populations temporarily and is not as effective as indoor space spraying.
- **Larval control including source reduction** and larviciding should be applied where appropriate through community mobilization.
- **Personal protection measures** should be used to protect against day biting mosquitoes. These include the use of appropriate repellents and wearing of light-coloured loose fitting clothing. This is especially important during pregnancy.

Journal of Medical Entomology, 2016, 1–4
doi: 10.1093/jme/tjw203
Short Communication
OXFORD

Short Communication

Indoor Resting Behavior of *Aedes aegypti* (Diptera: Culicidae) in Acapulco, Mexico

Felipe Dzul-Manzanilla,[1] Jésus Ibarra-López,[1] Wilbert Bibiano Marín,[2] Andrés Martini-Jaimes,[3] Joel Torres Leyva,[4] Fabián Correa-Morales,[1] Her´on Huerta,[5] Pablo Manrique-Saide,[2] and Gonzalo Vazquez-Prokopec[6,7]

OPEN ACCESS Freely available online
PLoS NEGLECTED TROPICAL DISEASES

Quantifying the Spatial Dimension of Dengue Virus Epidemic Spread within a Tropical Urban Environment

Gonzalo M. Vazquez-Prokopec[1,2*], Uriel Kitron[1,2], Brian Montgomery[3], Peter Horne[3], Scott A. Ritchie[3,4]

Scott Ritchie, Pablo Manrique-Saide, Gonzalo Vazquez-Prokopec

SCIENCE ADVANCES | RESEARCH ARTICLE

HEALTH AND MEDICINE

Combining contact tracing with targeted indoor residual spraying significantly reduces dengue transmission

Gonzalo M. Vazquez-Prokopec,[1,2*] Brian L. Montgomery,[3,4] Peter Horne,[3] Julie A. Clennon,[5] Scott A. Ritchie[6,7]

Effectiveness of indoor residual spraying for reducing dengue transmission

Thomas J. Hladish[a,b,1], Carl A. B. Pearson[c], Diana Patricia Rojas[b,d], Hector Gomez-Dantes[e], M. Elizabeth Halloran[f,g,h], Gonzalo M. Vazquez-Prokopec[i], and Ira M. Longini[b,g,j]

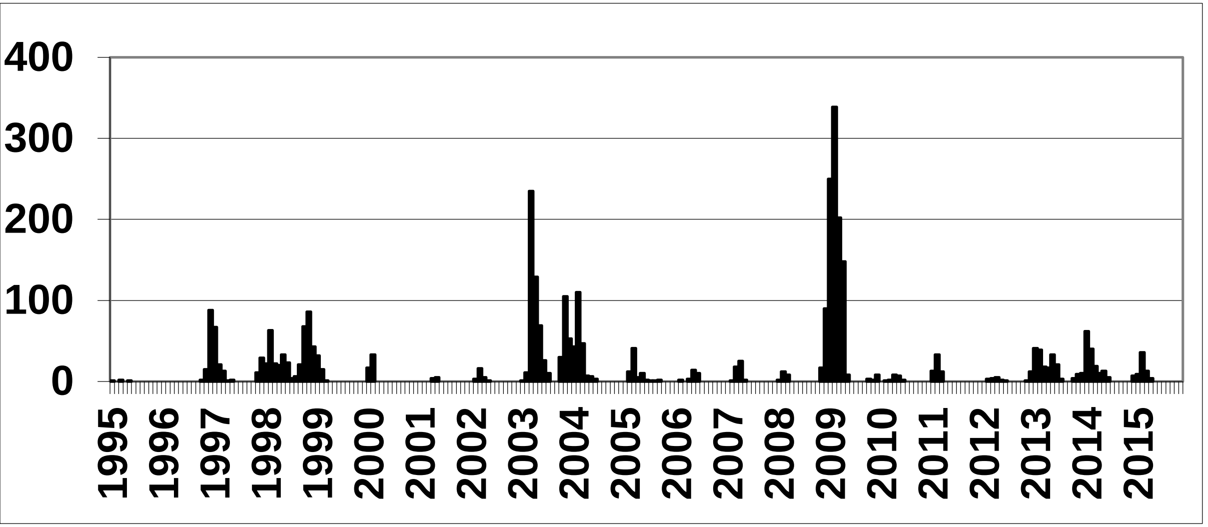
Ae. aegypti resting places

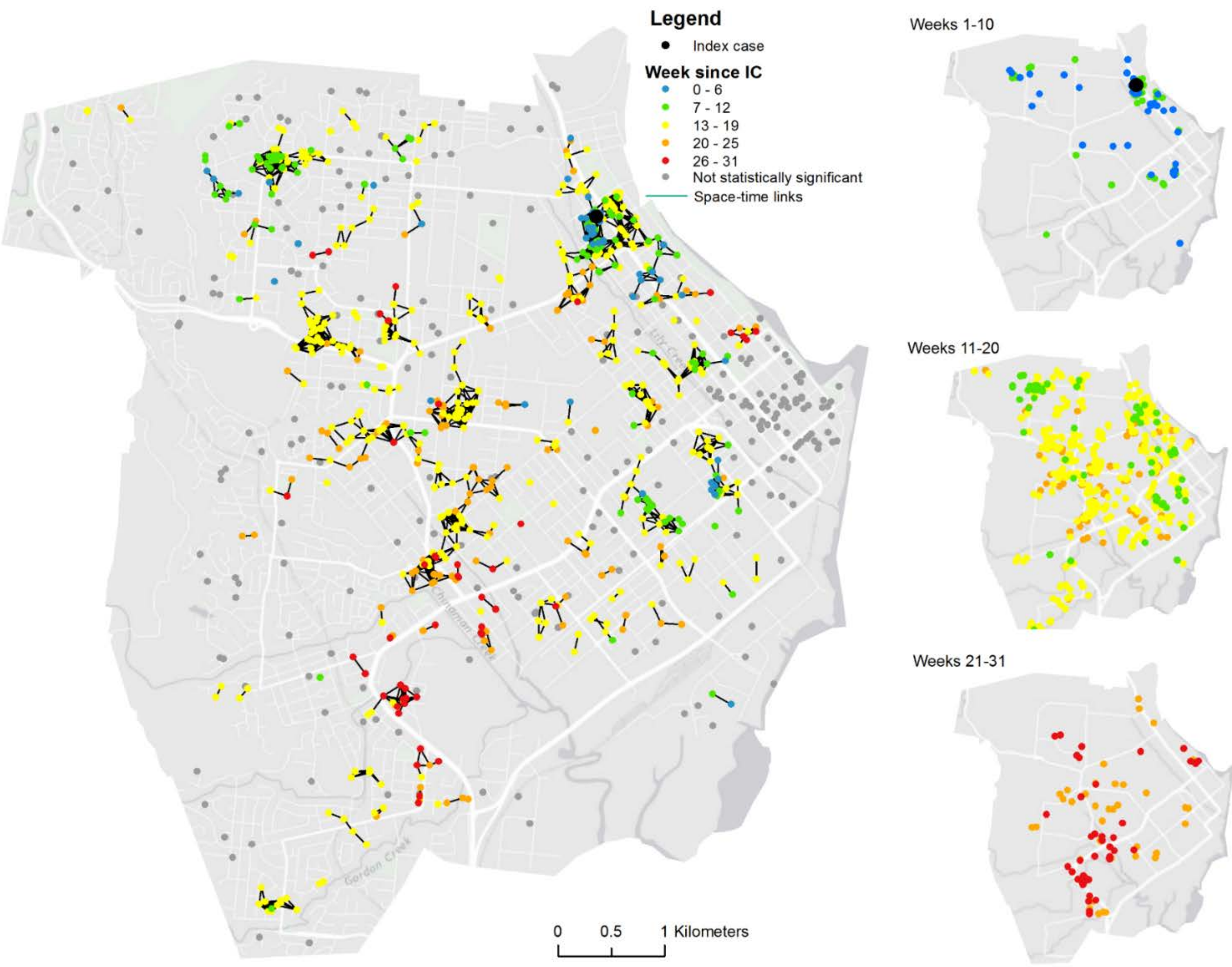
Resting <1.5m 17x more likely than >1.5m & primary resting locations included bedrooms (44%), living rooms (25%), and bathrooms (20%), followed by kitchens (9%) (Dzul-Manzanilla et al. 2017, Vazquez-Prokopec et al. 2009).

Targeted Indoor Residual Spraying (Queensland Health)

SC 2.5% lambda- cyhalothrin on ***Ae. aegypti* resting sites**: exposed low walls (<1.5m), under furniture, inside closets and on any dark and moist surfaces.

Epidemiologic impact of TIRS during 2008-2009 DENV 3 Epidemic in Cairns, Queensland



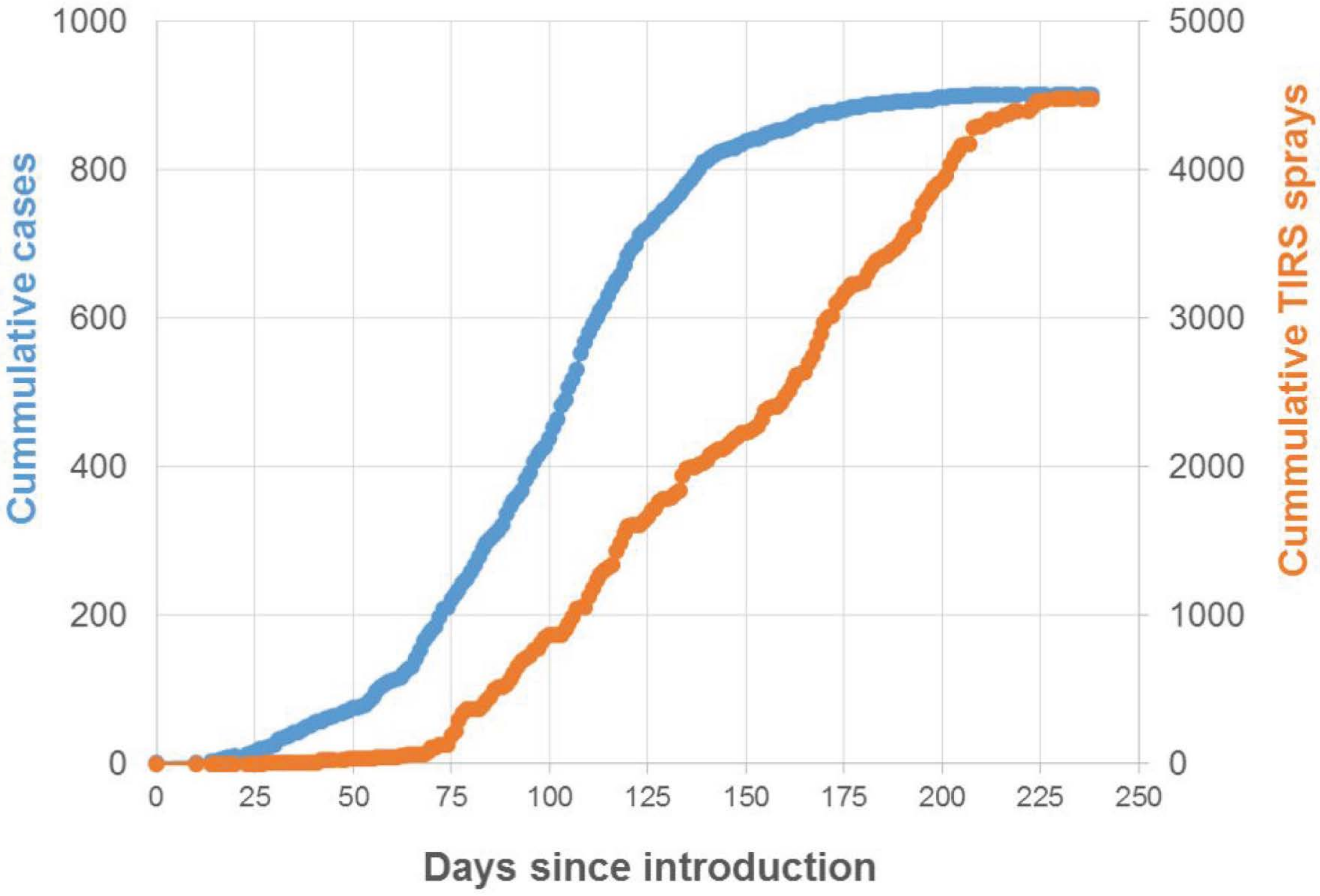


900+ confirmed cases. Tracked to address level.

TIRS performed at the premise level

Vazquez-Prokopec et al. Science Advances

Will controlling exposure locations have a sustained impact on DENV transmission?



(TIRS)

SC 2.5% lambda- cyhalothrin on ***Ae. aegypti*** **resting sites**: exposed low walls (<1.5m), under furniture, inside closets and on any dark and moist surfaces.

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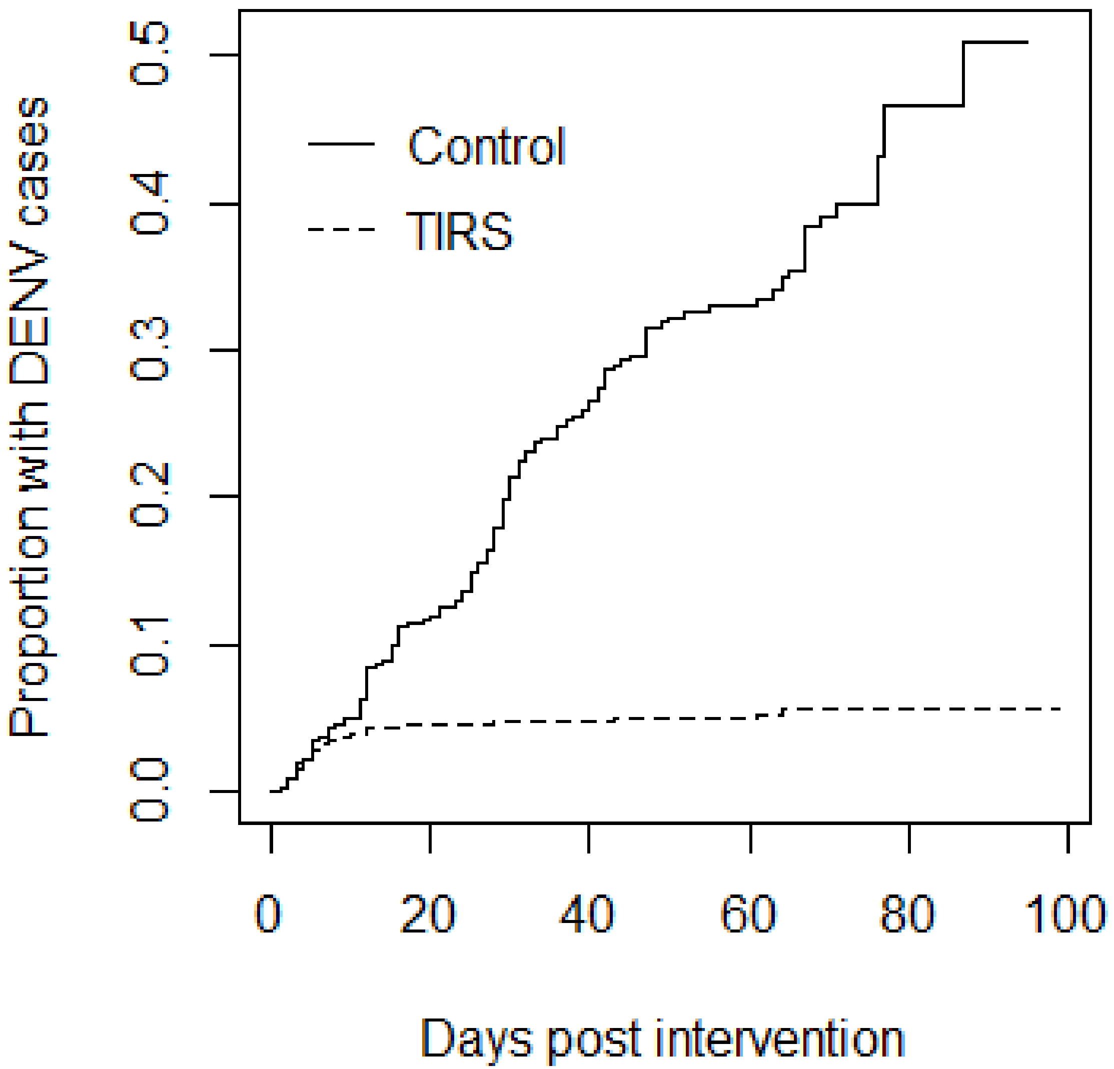
Effectiveness of TIRS



$$Effectiveness = 1 - \frac{Risk\ of\ infection\ in\ treatment\ group}{Risk\ of\ infection\ in\ control\ group}$$

Table 1. Effectiveness of TIRS applied at contact locations in preventing dengue symptomatic infections, Cairns, Australia.

Scenario	Treatment	Total locations	No. DENV positive locations	Proportion infection	Effectiveness
All cases	IRS	1007	52	0.052	0.861
	Control	369	137	0.371	
Excluding first 10 days*	IRS	817	11	0.013	0.961
	Control	325	113	0.348	

*This scenario excludes the first 10 days post intervention to exclude transmission events likely originated prior to the intervention.

Vazquez-Prokopec et al. Science Advances

Insecticide resistance: a threat for TIRS

Primarily to pyrethroids and likely driven by fogging by MOH and also household insecticides.

Advantage for TIRS: other insecticide groups exist (Carbamates and Organophosphates).

Is pyrethroid resistance a problem?

RESEARCH ARTICLE

Deltamethrin resistance in *Aedes aegypti* results in treatment failure in Merida, Mexico

PLOS | NEGLECTED TROPICAL DISEASES

Gonzalo M. Vazquez-Prokopec[1]*, Anuar Medina-Barreiro[2], Azael Che-Mendoza[3], Felipe Dzul-Manzanilla[3], Fabian Correa-Morales[3], Guillermo Guillermo-May[2], Wilbert Bibiano-Marín[2], Valentín Uc-Puc[2], Eduardo Geded-Moreno[2], José Vadillo-Sánchez[2], Jorge Palacio-Vargas[4], Scott A. Ritchie[5,6], Audrey Lenhart[7], Pablo Manrique-Saide[2]

- Randomized Controlled Trial: Merida (Yucatan State, Mexico)
- 14 clusters with 3 treatments: unsprayed controls, bendiocarb spraying (Carbamate, susceptible pop.), deltamethrin spraying (pyrethroid, resistant pop.)

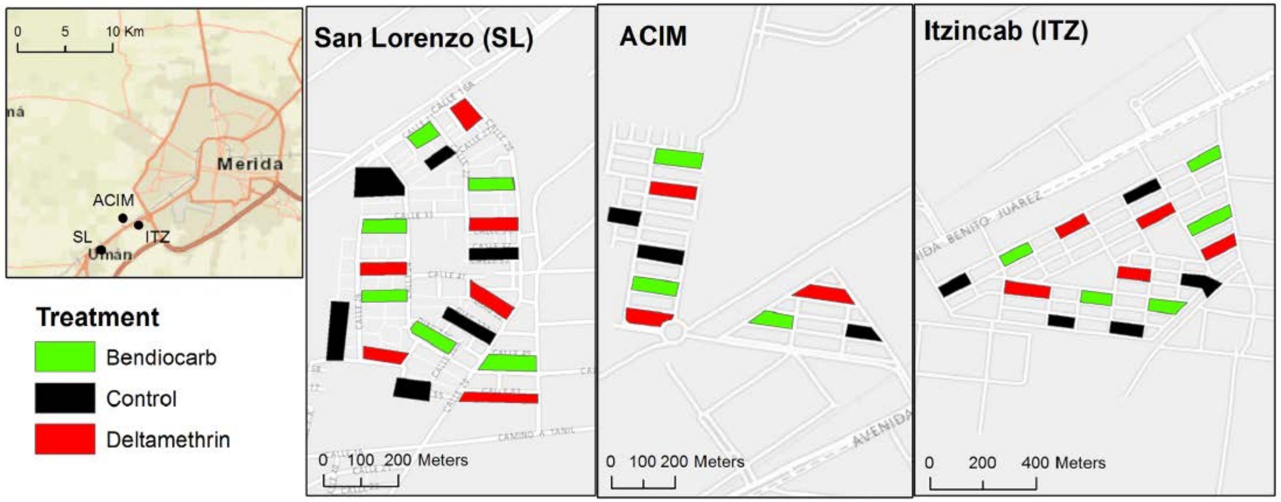
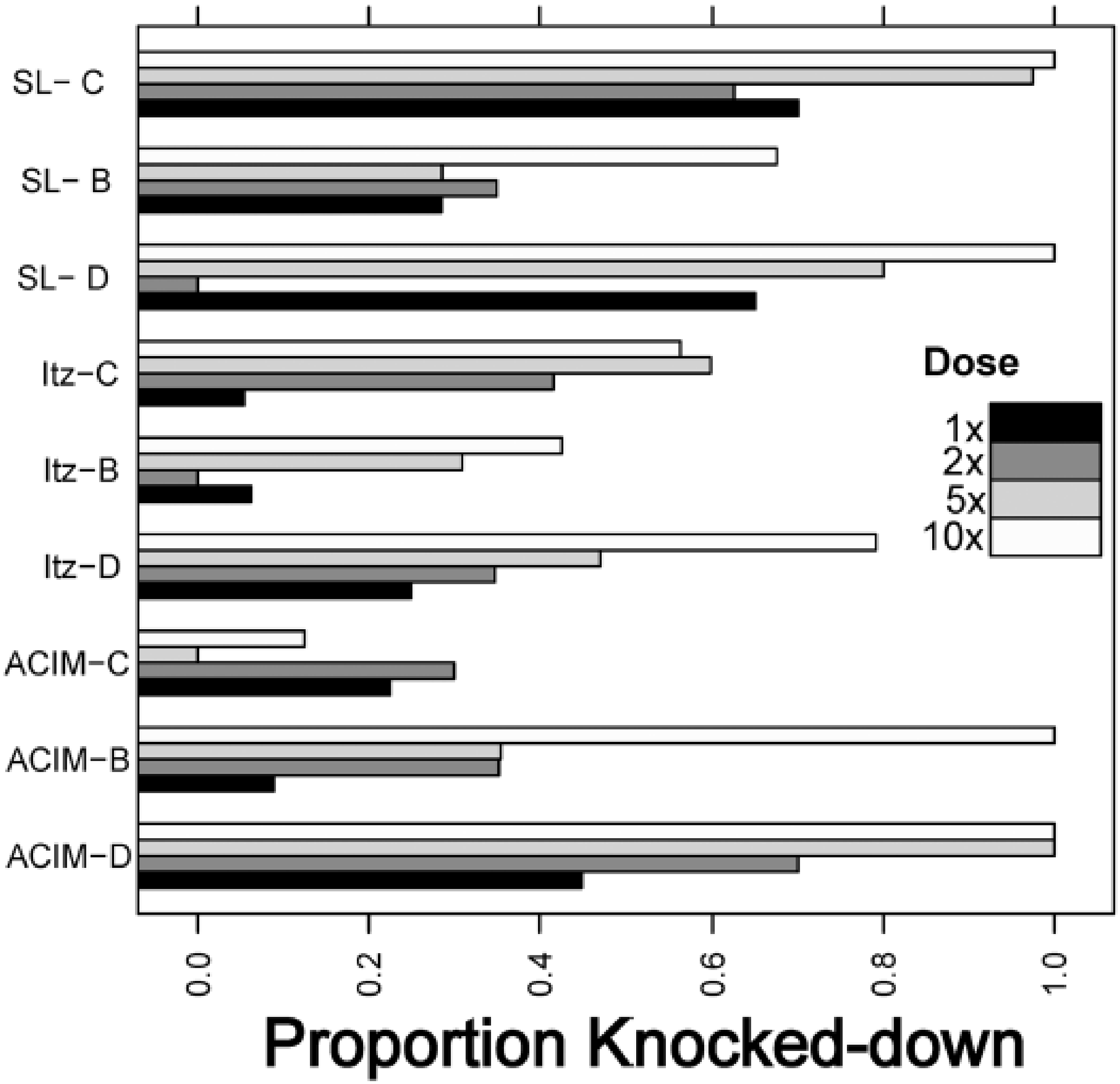
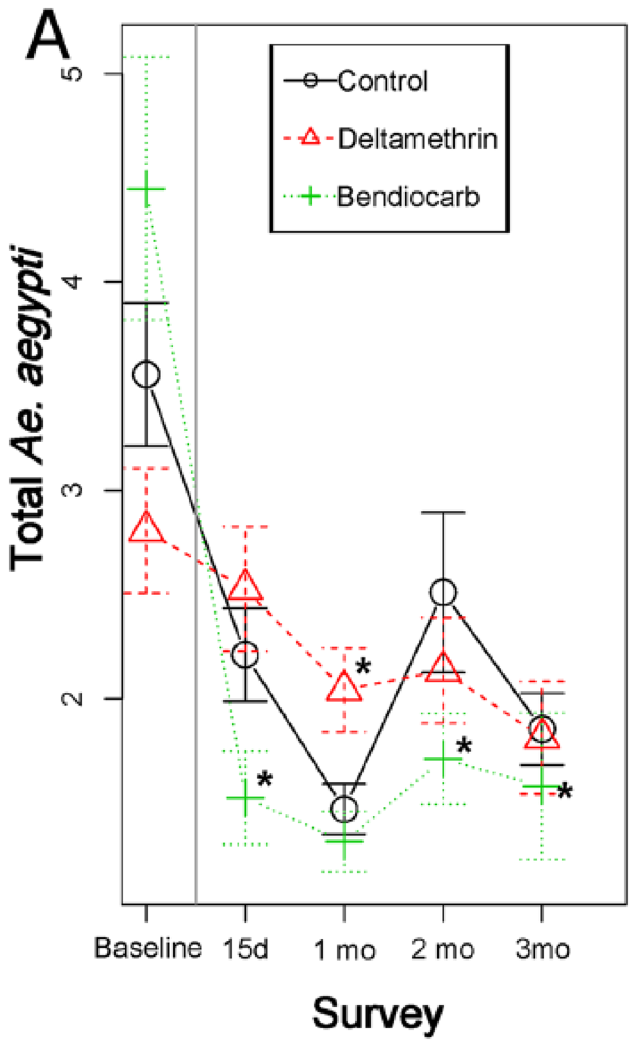


Fig 1. Map of the location of the three Merida suburbs (inset) and distribution of treatment and control blocks within each.

Very high levels of deltamethrin resistance



Ae. aegypti adult abundance

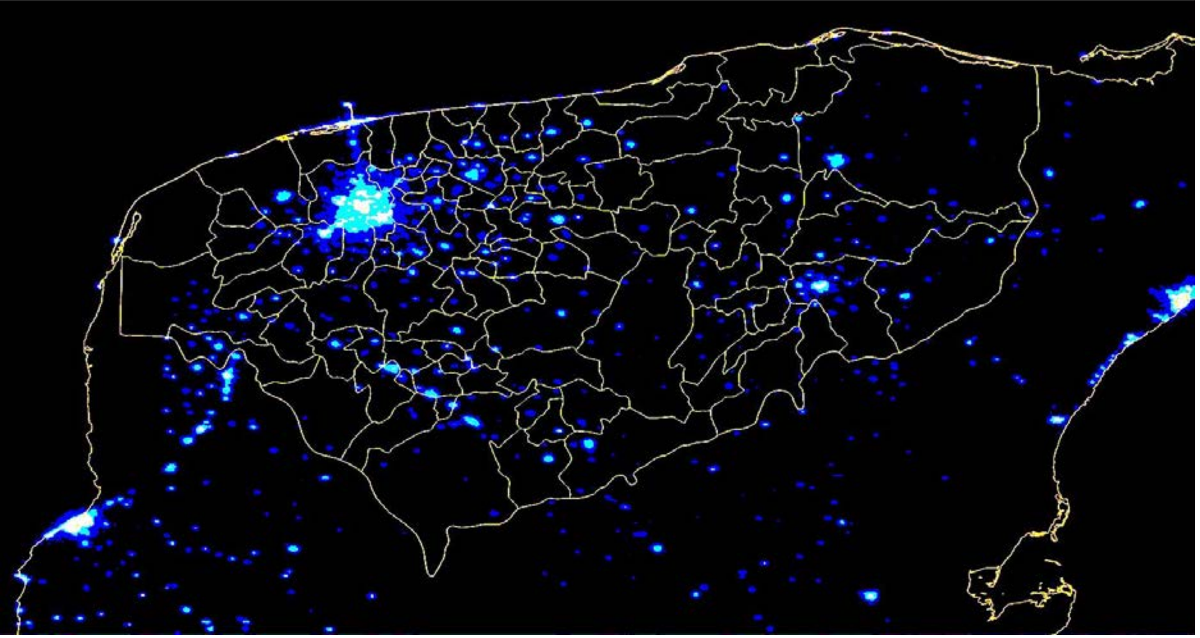


Metric	Survey	Deltamethrin			Bendiocarb		
	Adult abundance	Coefficient	Lower	Upper	Coefficient	Lower	Upper
No. of *Aedes aegypti*	Baseline (pre-spraying)	0.99	0.67	1.46	0.89	0.60	1.32
	15days	1.07	0.66	1.72	**0.23**	0.13	0.41
	1month	2.21	1.42	3.50	**0.57**	0.34	0.94
	2months	1.07	0.64	1.78	**0.48**	0.27	0.83
	3months	0.66	0.35	1.22	**0.33**	0.16	0.64
No. of *Aedes aegypti* females	Baseline (pre-spraying)	1.05	0.72	1.56	0.82	0.55	1.21
	15days	1.07	0.66	1.75	**0.26**	0.13	0.48
	1month	2.18	1.41	3.44	**0.65**	0.37	1.11
	2months	0.94	0.52	1.71	**0.32**	0.16	0.64
	3months	0.72	0.29	1.80	**0.36**	0.13	0.96
No. of bloodfed *Aedes aegypti* females	Baseline (pre-spraying)	1.18	0.72	1.94	0.87	0.52	1.44
	15days	1.19	0.66	2.14	**0.23**	0.10	0.49
	1month	2.08	1.31	3.34	**0.62**	0.35	1.10
	2months	0.86	0.43	1.71	**0.27**	0.11	0.59
	3months	0.52	0.20	1.26	**0.27**	0.09	0.75

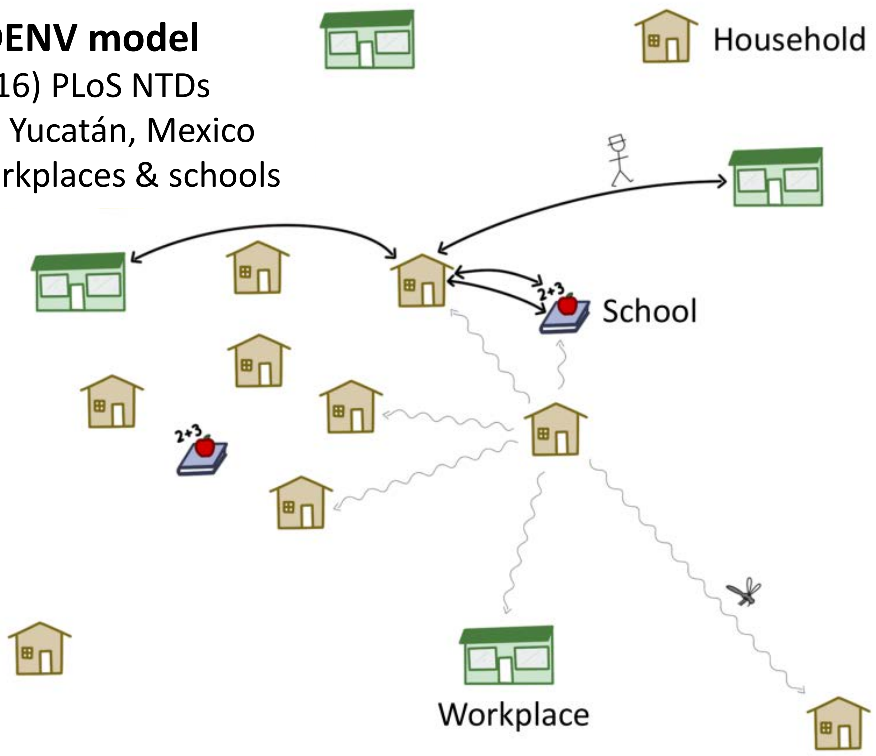
Bold font indicates statistically significant difference with control group

Adult *Ae*. *aegypti* infestation indices significantly lower in houses treated with bendiocarb compared to untreated houses. No statistically significant difference between untreated and deltamethrin-treated houses. On average, bendiocarb spraying reduced *Ae*. *aegypti* abundance by 60%.

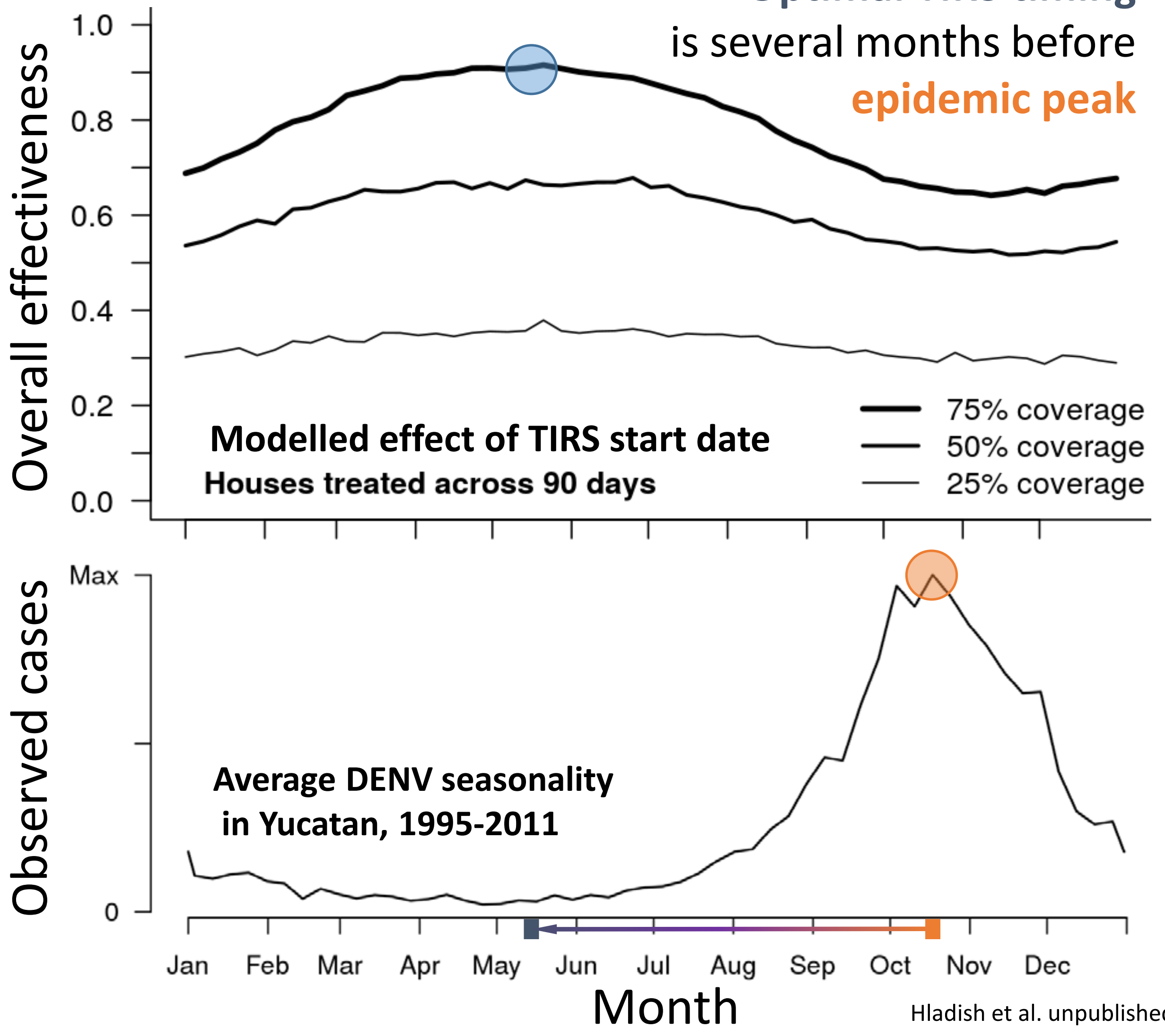
Modeling long-term effectiveness & optimal timing of TIRS campaign



Agent based DENV model
Hladish *et al* (2016) PLoS NTDs
1.8 mil people in Yucatán, Mexico
500k houses, workplaces & schools



Optimal TIRS timing
is several months before
epidemic peak



Hladish et al. unpublished

The challenge ahead: scaling-up interventions

Current paradigms for DENV surveillance and *Ae. aegypti* control need to be adapted to local contexts of virus transmission.

TIRS is an effective vector control approach to prevent DENV. Scalability of TIRS challenged by insecticide resistance and extent of urban environments

Preventive TIRS would lead to higher effectiveness.
How? Target DENV hot-spots.

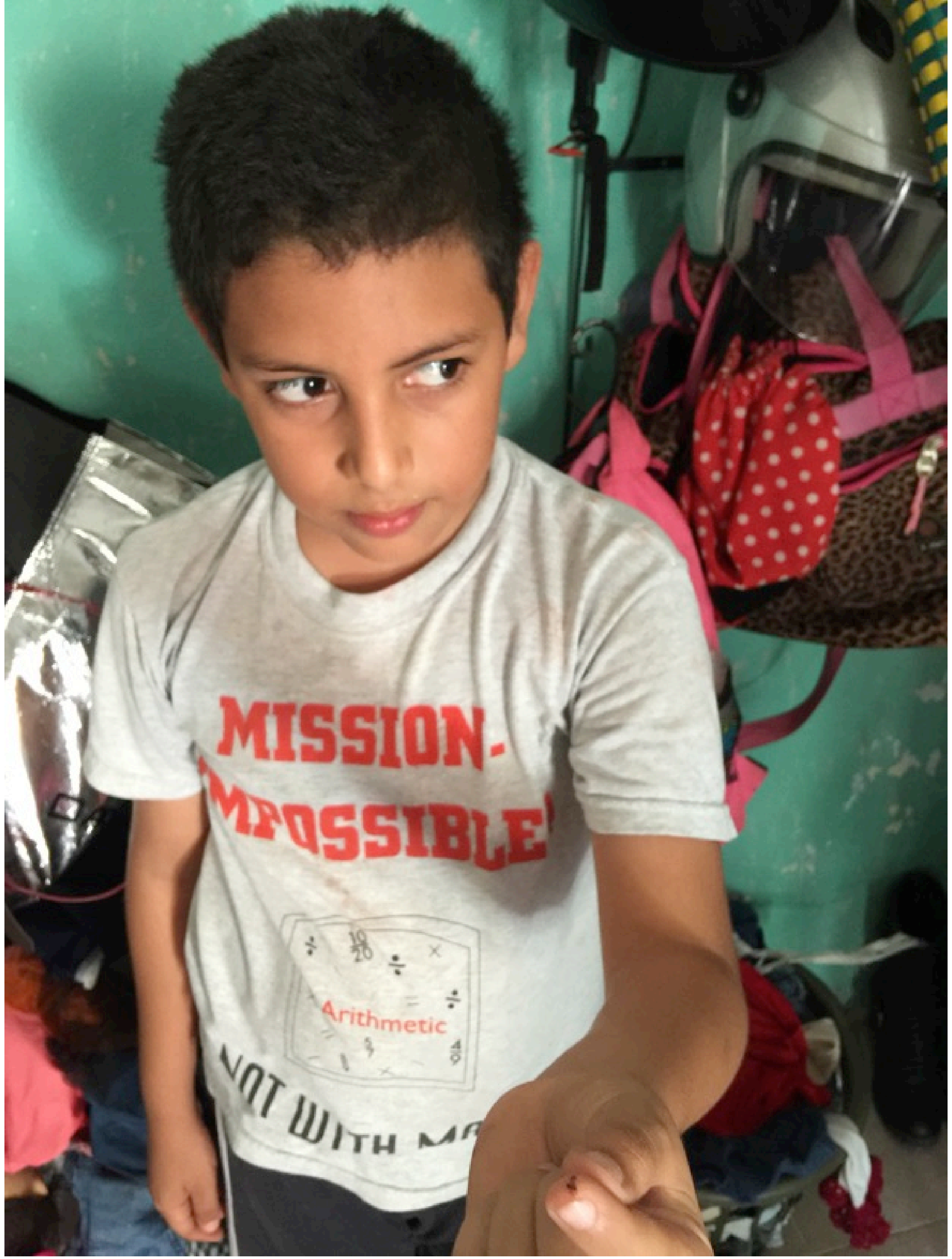


Photo Credit: Scott Ritchie.
Merida, Yucatan, Mexico

Acknowledgements

All those who assisted with the investigation and management of the 2008-2009 DENV outbreak in north Queensland (Ann Richards, Jeffrey Hanna, Rosalie Spencer, Dianne Brookes, Ross Spark, Stuart Heggie, Paul Endres, Lynne Thomson, Brad McCulloch and the members of the Dengue Action Response Team)

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http://www.astmh.org/subgroups/acme