

# Impact of indoor residual spraying with Actellic in the context of a comprehensive malaria elimination strategy in Southern Province Zambia

Adam Bennett<sup>1</sup>, Joshua Yukich<sup>2</sup>, Molly Robertson<sup>3</sup>, Busiku Hamainza<sup>4</sup>, Francois Rerolle<sup>1</sup>, Logan Stuck<sup>2</sup>, Travis Porter<sup>2</sup>, Ruben O. Conner<sup>5</sup>, Richard W. Steketee<sup>5</sup>, John M. Miller<sup>6</sup>, Thomas P. Eisele<sup>2</sup>

<sup>1</sup>University of California San Francisco, San Francisco, CA, United States, <sup>2</sup>Tulane University, New Orleans, LA, United States, <sup>3</sup>PATH, Washington, DC, United States, <sup>4</sup>Zambia National Malaria Elimination Centre, Lusaka, Zambia, <sup>5</sup>PATH-Malaria Control and Elimination Partnership in Africa, Seattle, WA, United States, <sup>6</sup>PATH-Malaria Control and Elimination Partnership in Africa, Lusaka, Zambia



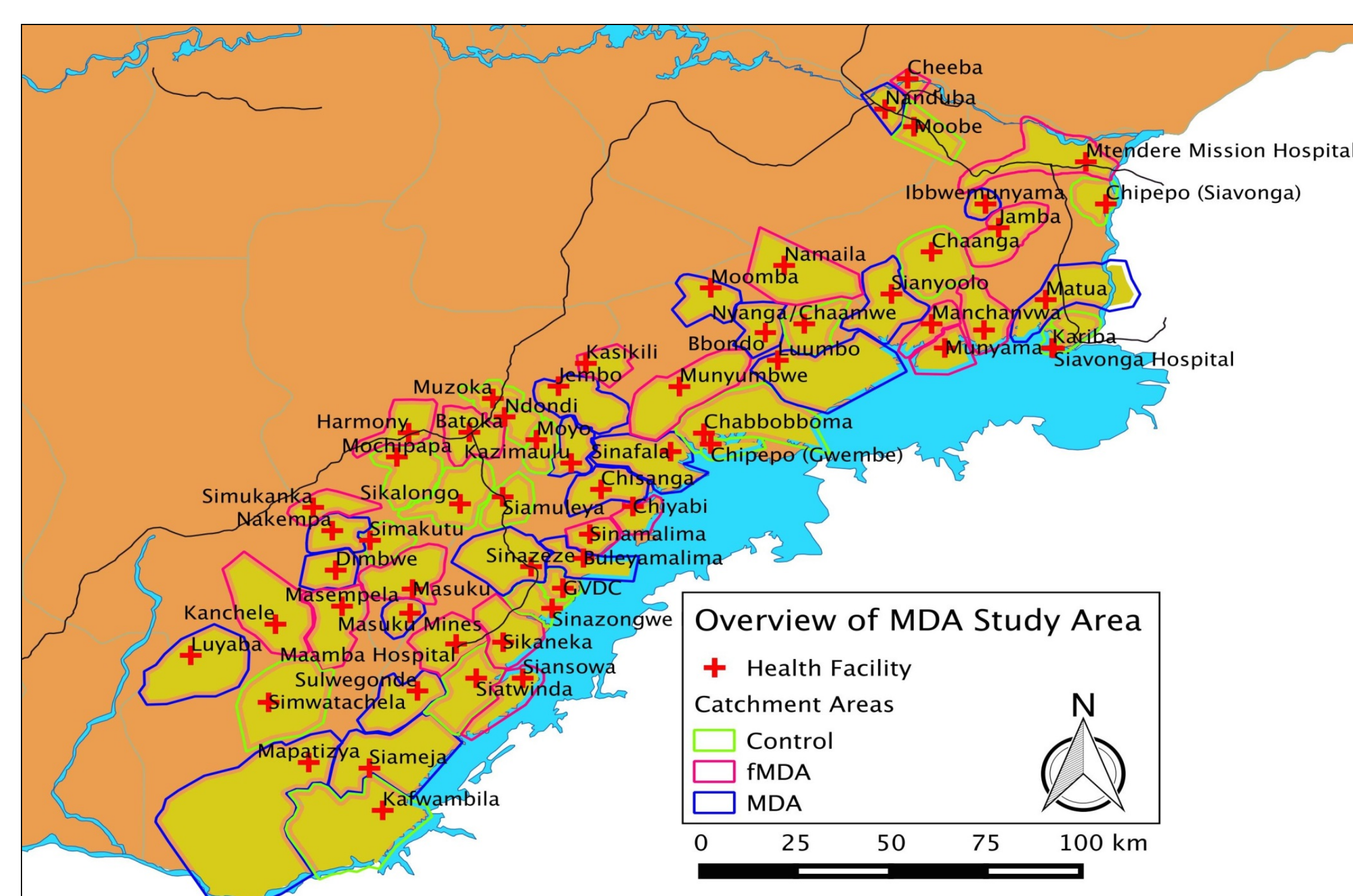
## Introduction

- For country malaria programs implementing indoor residual spraying (IRS) and considering new or additional insecticides to deploy, there is a lack of rigorous evidence on impact, cost and cost-effectiveness to determine the potential benefit of new chemicals (3GIRS insecticides, non-pyrethroids with residual activity of at least 6 months).
- The Zambian government indicated in the National Malaria Elimination Strategy 2017-2021 that effective IRS will be a key component of its vector control programme, including the use of next-generation IRS chemicals such as Actellic CS. Zambia switched to the use of Actellic CS for its IRS programme around 2014. While Actellic CS is thought to be more effective than previously used pyrethroid-based IRS, it is considerably more expensive.
- Annual rounds of indoor residual spraying with Actellic CS (IRS-A) were implemented as part of a comprehensive malaria elimination strategy in Southern Province Zambia from 2014-2016.
- This study collated all data collected as part of community randomized control trials in 2012-2016 conducted to evaluate the impact of Mass testing and treatment (MTAT) and Mass drug administration (MDA) interventions for reducing *Plasmodium falciparum* prevalence and incidence
- These data were retrospectively analyzed to evaluate of the effectiveness of next-generation IRS, such as Actellic CS, on malaria incidence and prevalence in Zambia, including in the context of MDA campaigns in terms of incremental effects attributed to combining the interventions

## Methods

- High-resolution maps of IRS coverage in the mass treatment study areas in Southern Province were estimated at the 1km grid-cell level using campaign data and a predictive geostatistical model for areas without data.
- High resolution IRS maps were then compared with RDT prevalence, collected as part of the mass treatment studies, at the same spatial and temporal scale, to both evaluate IRS targeting (was risk in previous season well targeted by campaigns) and evaluate the association between IRS and parasite infection prevalence.
- Smoothed spatial and temporal random effects were incorporated to account for autocorrelation in a full geostatistical model evaluated using R-INLA. Other potential confounding factors, such as climate variables, mass treatment interventions, access to healthcare, and long-lasting insecticidal net (LLIN) coverage were incorporated into this analysis.

Figure 1. Map of study area in Southern Province, Zambia



## Results

Table 1. Results of annual household surveys

Intervention / exposure	2012-2013 n = 2,516		2014 n = 2,573		2015 n = 2,324		2016 n = 2,764	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Household > 1 LLIN (% households)	74.8	(70.2 – 79.4)	72.9	(68.9 – 76.9)	82.2	(78.8 – 86.2)	77.5	(74.0 – 80.9)
IRS past 12 months (% households)	0.00		0.00		35.7	(27.8 – 43.6)	47.5	(41.1 – 53.9)
IRS (pyrethroids) past 12 months (% households)	27.6	(16.0 – 39.2)	14.5	(9.4 – 19.5)	0.00		0.00	
Mass treatment (% households covered in intervention areas)	0.00		0.00		70.7	(52.0 – 90.5)	73.5	(52.4 – 94.1)
% children with fever taken for treatment	49.6	(45.0 – 54.2)	66.3	(61.8 – 71.2)	63.3	(56.2 – 70.3)	64.6	(57.0 – 72.2)
Mean total rainfall (January – April, millimeters)	131	(104 – 189)	128	(107 – 158)	117	(76 – 153)	104	(78 – 126)
Child parasite prevalence	36.6	(30.7 – 44.7)	31.3	(24.0 – 38.5)	8.4	(5.2 – 11.5)	4.0	(2.4 – 5.7)

Table 1. Summary of all data included in analysis

Year	Number of individuals	Number of households	Number of 1 km <sup>2</sup> grid cells with data
2012	100,124	24,137	2,060
2013	154,504	35,517	3,237
2014	3,036	2,811	1,490
2015	130,290	32,582	4,832
2016	132,352	20,875	4,306

Figure 2. Predicted proportion of households with IRS per year, 2012-2016

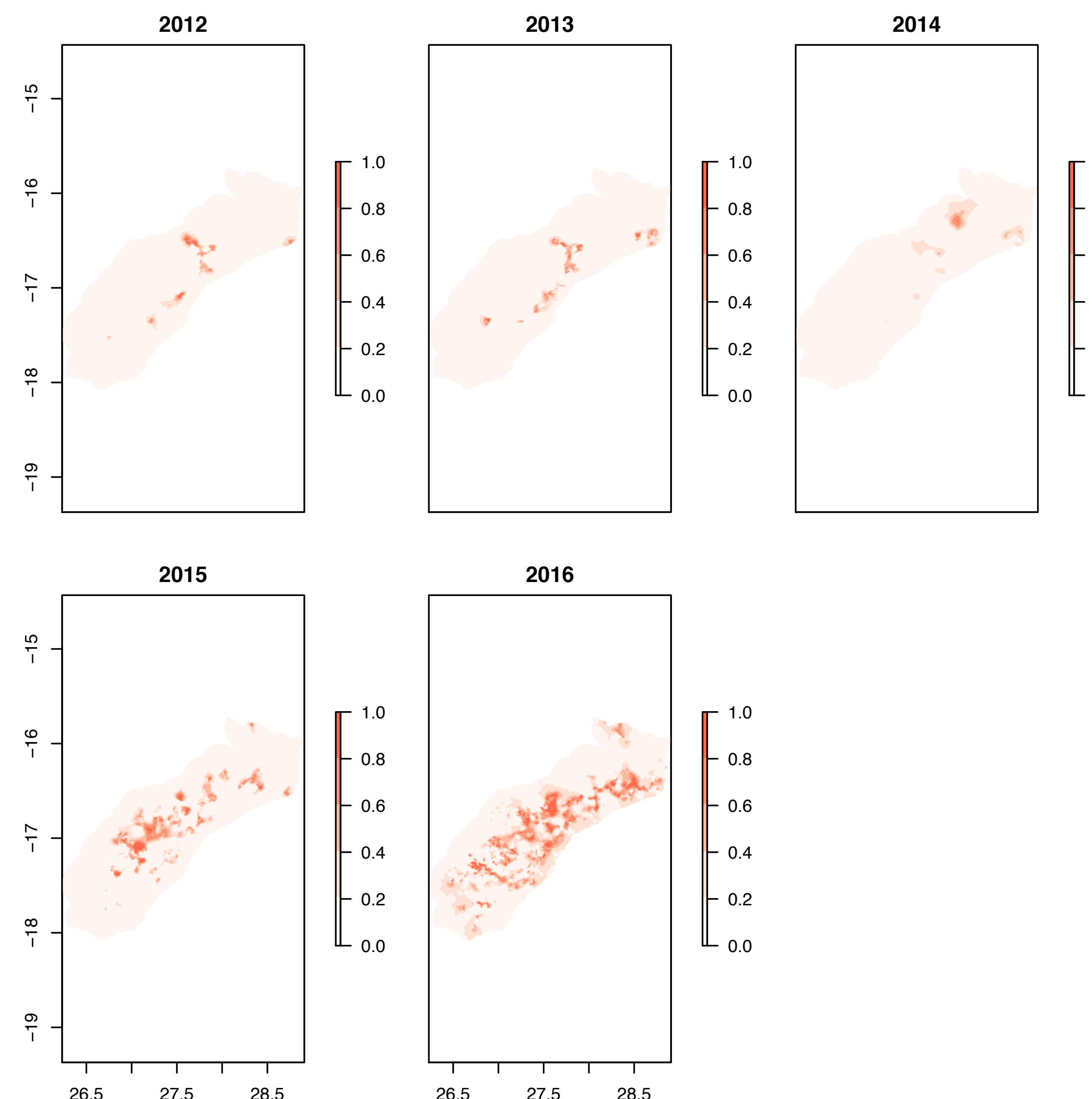


Figure 3. Box plots of IRS coverage (A) and predicted parasite prevalence <5 (B) per year

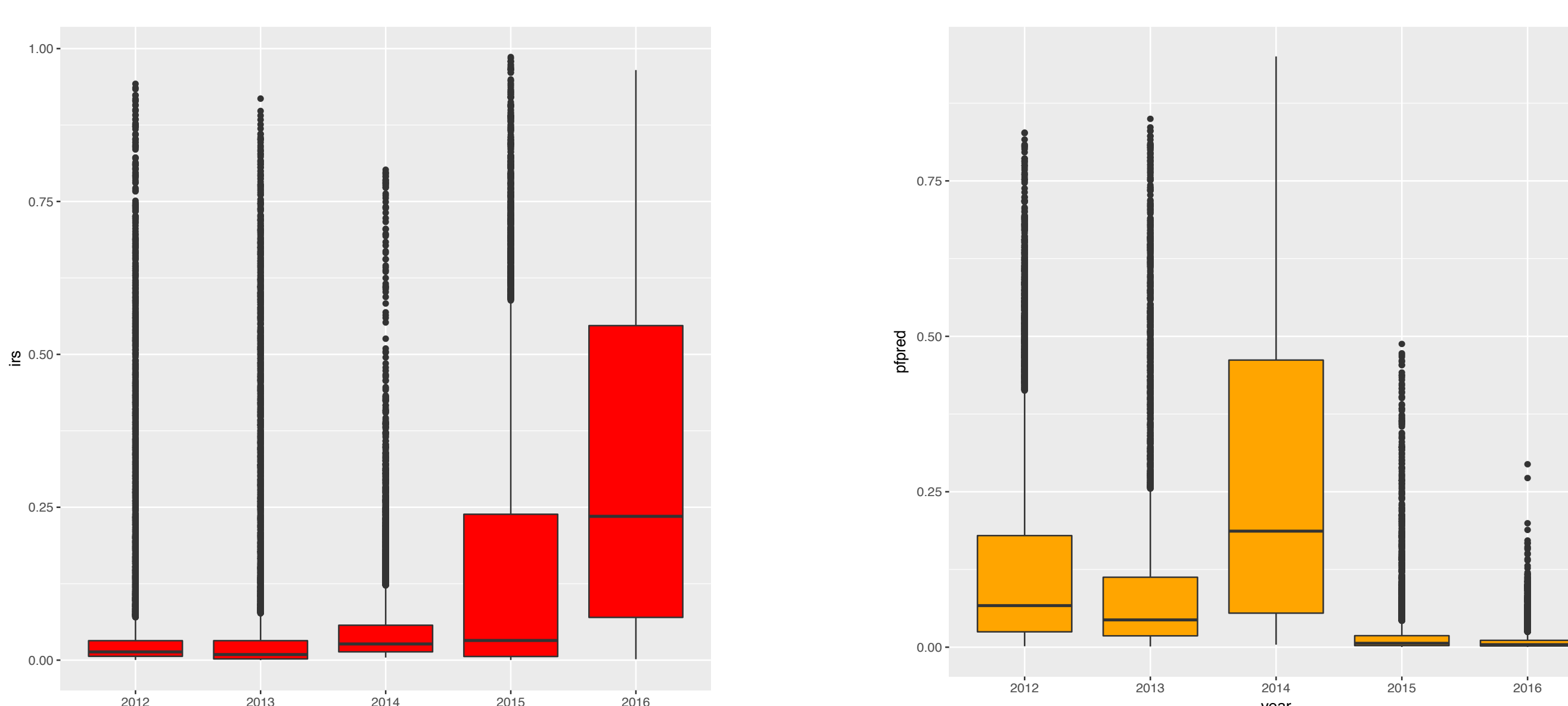


Figure 4. Predicted malaria prevalence <5 per year, 2012-2016

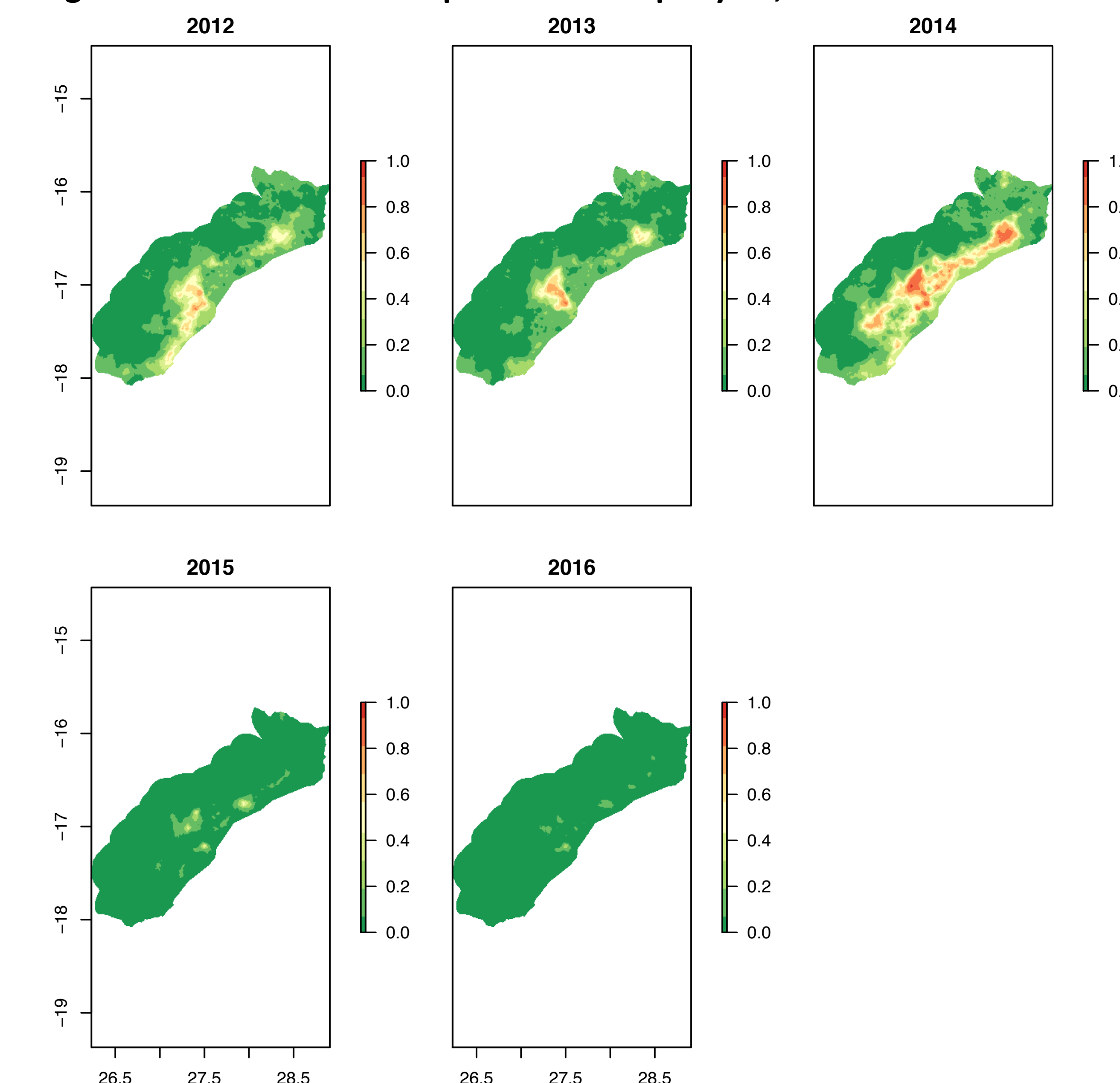


Figure 5. Results of spatio-temporal geostatistical model

Parameter	Mean	0.025 quantile	0.975 quantile
HH IRS coverage	0.91	0.68	1.20
Actellic year (2015/2016 vs. 2012-2014)	0.05	0.03	0.09
IRS*Actellic year interaction	0.82	0.53	1.27
HH ownership of > 1 ITN 1 year old or newer	1.15	0.88	1.50
MDA	0.73	0.55	0.98
Distance to nearest HF/CHW	1.00	1.00	1.00
Elevation (m)	0.99	0.99	0.99
Rainfall (mm)	1.00	0.99	1.01
EVI	3.90	1.73	8.79
HH IRS + Actellic year (linear combination)	0.74	0.44	1.26

## Conclusions

- Dramatic increases in IRS coverage, and decreases in malaria parasite prevalence in children <5 in 2015 and 2016.
- Proportion of households with IRS increased from 14.5% in 2014 to 47.5% in 2016.
- Child parasite prevalence decreased from 31.3% in 2014 to 4.0% in 2016.
- High coverage of MDA in intervention areas, increased access to malaria diagnosis and treatment through community health workers, and decreased rainfall likely contributed to this decline.
- Results of the statistical models used in this study suggest an association between increased coverage of IRS and reduced malaria prevalence after controlling for climate, MDA, and other interventions, although there is substantial uncertainty in the estimate.
- The size of the effect of IRS coverage on malaria prevalence was associated with the choice of insecticide used in this context, with the estimate of effectiveness of IRS chemicals other than Actellic CS being consistent with an approximately 10% reduction in the odds of malaria infection, while the use of Actellic CS was consistent with a greater than doubling of the reduction (approximately 26%).
- Targeted high coverage of IRS with Actellic CS is an important and impactful component of a comprehensive malaria elimination strategy in Zambia