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Statistical power analysis framework to design robust vector control experiments in semi-field systems.

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Introduction

- Vector control (VC) remains one of the most efficient strategies against malaria.
- Primary VCs: Long-lasting insecticide net (LLIN) and Indoor residual spraying (IRS)
- Supplementary measures e.g., larviciding are potential complement to primary VCs

Source: cdc.gov

Credit: Gerald Kiwelu, IHI

Semi-field experiments (SFE)

- Most of people doing SFE neglect power analysis due to limited number of people with particular expertise
- Semi-field is self-contained system with all necessary conditions for vector lifecycle where SFE are conducted
- SFE are good first way of understanding the impacts of potential new vector controls before field trials.
- However, proper design of SFE is critically important to ensure the outcomes are measurable and robust.

Lwetoijera et al. (2019)

Power analysis

- It is crucial to have information on whether the experimental study will be informative before its commencement. This is the aim of power analysis

- The use of power analysis in vector control studies can potentially help to avoid;
  - Waste of resources
  - Ethical concerns
  - Promising control methods being prematurely dismissed

Johnson *et al*., (2015), Jennions & Moller (2003), and Ioannidis (2005)

This statistical power analysis framework

- Standard methods for power analysis are suitable only for simple statistical analysis i.e., comparing means using t-tests or ANOVA

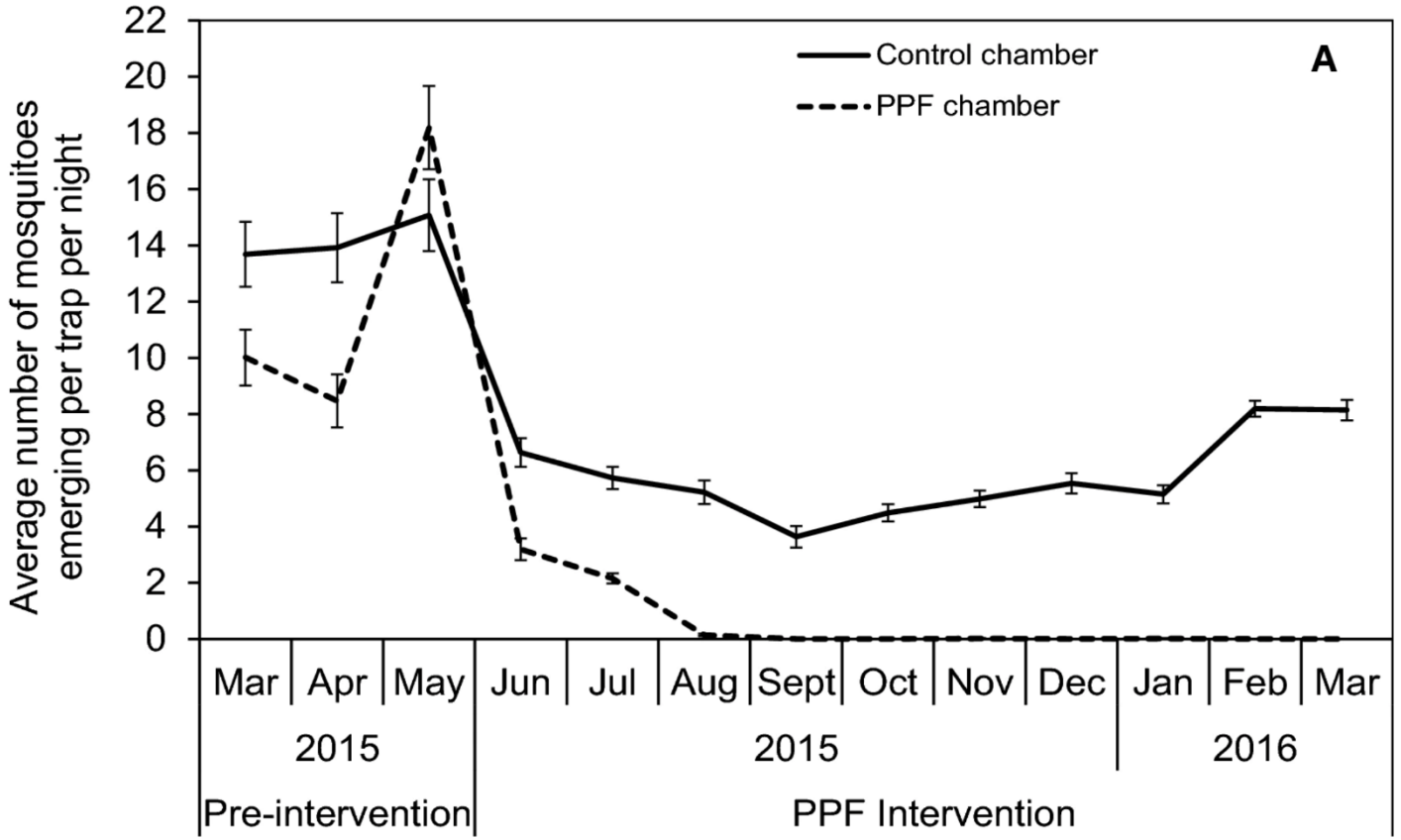
- This simulation-based power statistical power analysis framework is flexible, easy to extend and can accommodate sources of random variations compared to standard power frameworks

Objectives

- **Objective:** Developing a statistical power analysis framework to design robust vector control experiments in semi-field systems
- **Research questions:**
  i. How many treatment chambers are needed?
  ii. How often should mosquitoes be sampled?
  iii. How many mosquitoes should be sampled?
- Case study;
  - LLIN alone, combination of LLIN and autodissemination of pyriproxyfen (PPFa).

Autodissemination of pyriproxyfen (PPFa)

- PPFa reduced and suppressed stable populations of mosquitoes under semi-controlled settings



Lwetoijera *et al*. (2019)

Methods

- Estimated statistical power across a range of semi-field experimental design objectives and scenarios
- Experiments were testing LLIN alone and the LLIN-PPFa interaction

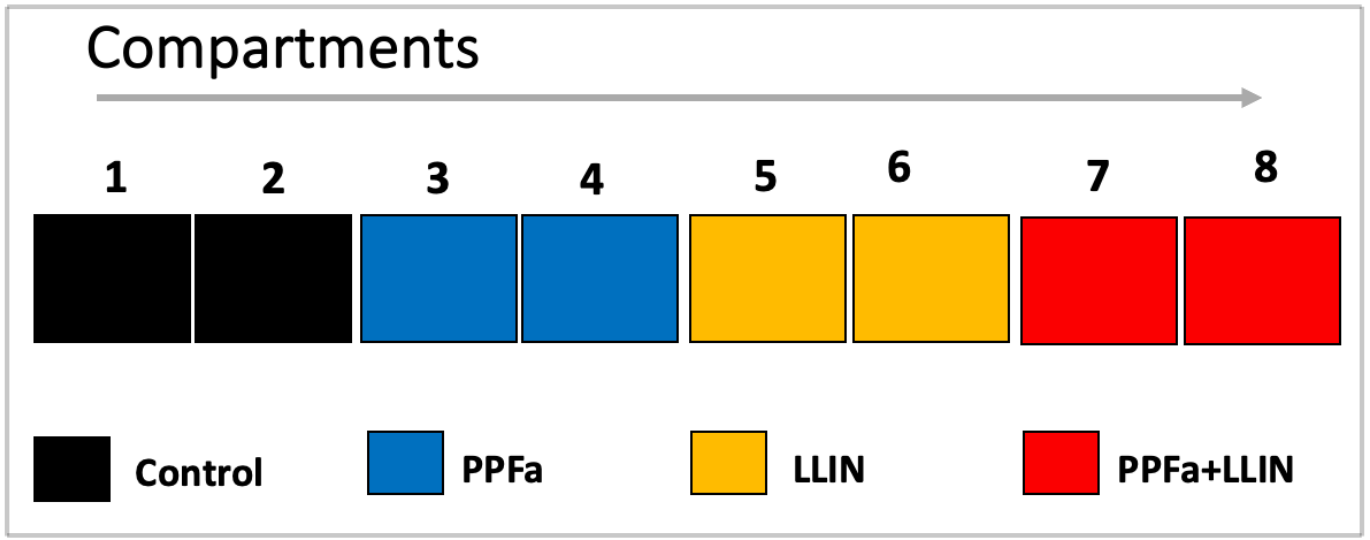


Fig 1: Example of number of chambers per treatment

Methods…

- Simulated 1000 data sets assuming that the alternative hypothesis is true i.e., intervention effect is non zero.

- For each simulated data set, a generalized linear mixed-effects model (GLMM) was fitted and a statistical test of the null hypothesis (H0) was performed.

- Calculated the proportion of simulated data sets in which the H0 was rejected. This proportion is the power estimate.

GLMM: single intervention

- A GLMM with a negative binomial distribution
- Response variable: mosquito counts from treatment chambers
- Explanatory variables;
  - LLIN
  - Time (in week)
  - LLIN*Time
  - Inter-chamber variance – random effect
- LLIN reduced population by 80% at the end of an experiment

GLMM: combined interventions

- A GLMM with a negative binomial distribution
- Response variable: mosquito counts from treatment chambers
- Explanatory variables:
  - LLIN
  - PPF
  - Time (in week)
  - LLIN*Time
  - PPF*Time
  - LLIN*PPF
  - LLIN*PPF*Time
  - Inter-chamber variance – random effect

Interactions

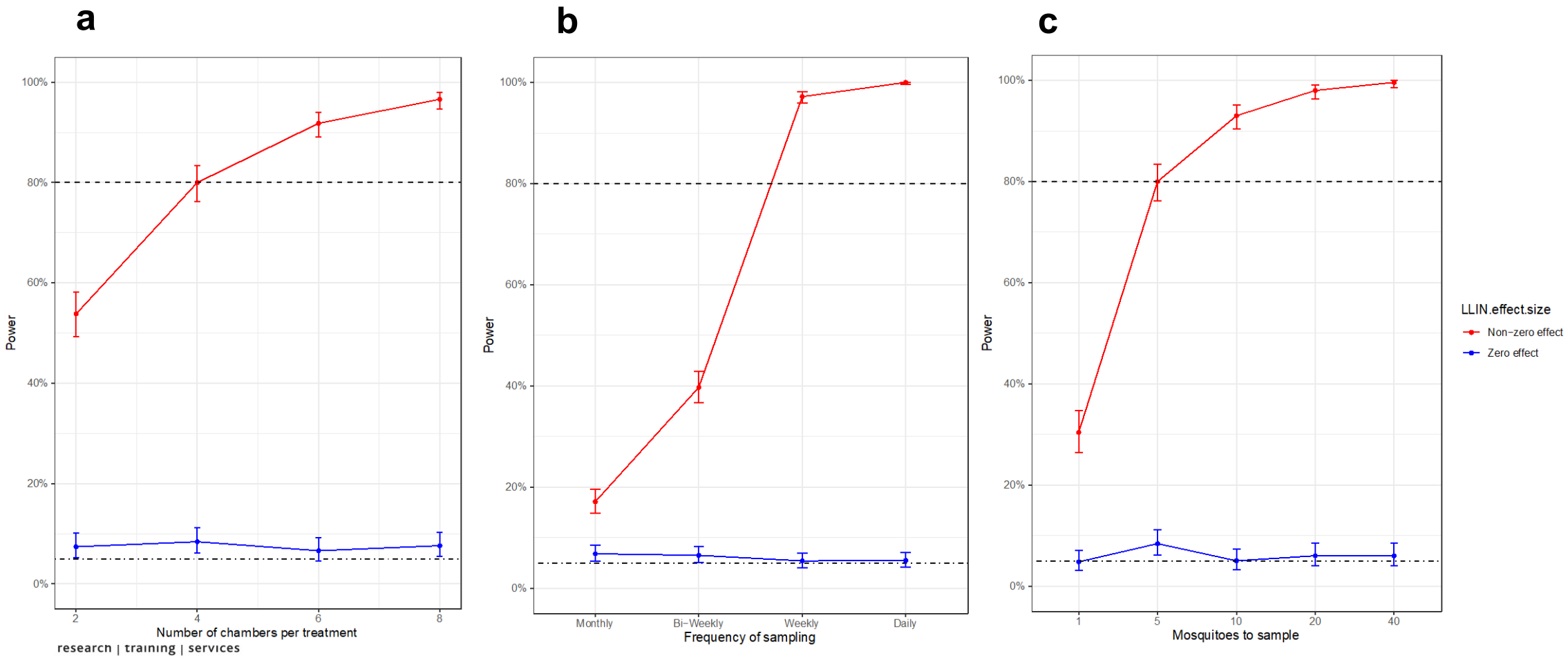
Treatment effects

Table 1: Proportions of mosquitoes we are assuming will remain in each compound at the end of the experiment

		PPF	
		0	1
LLIN	0	100%	30%
	1	20%	3%

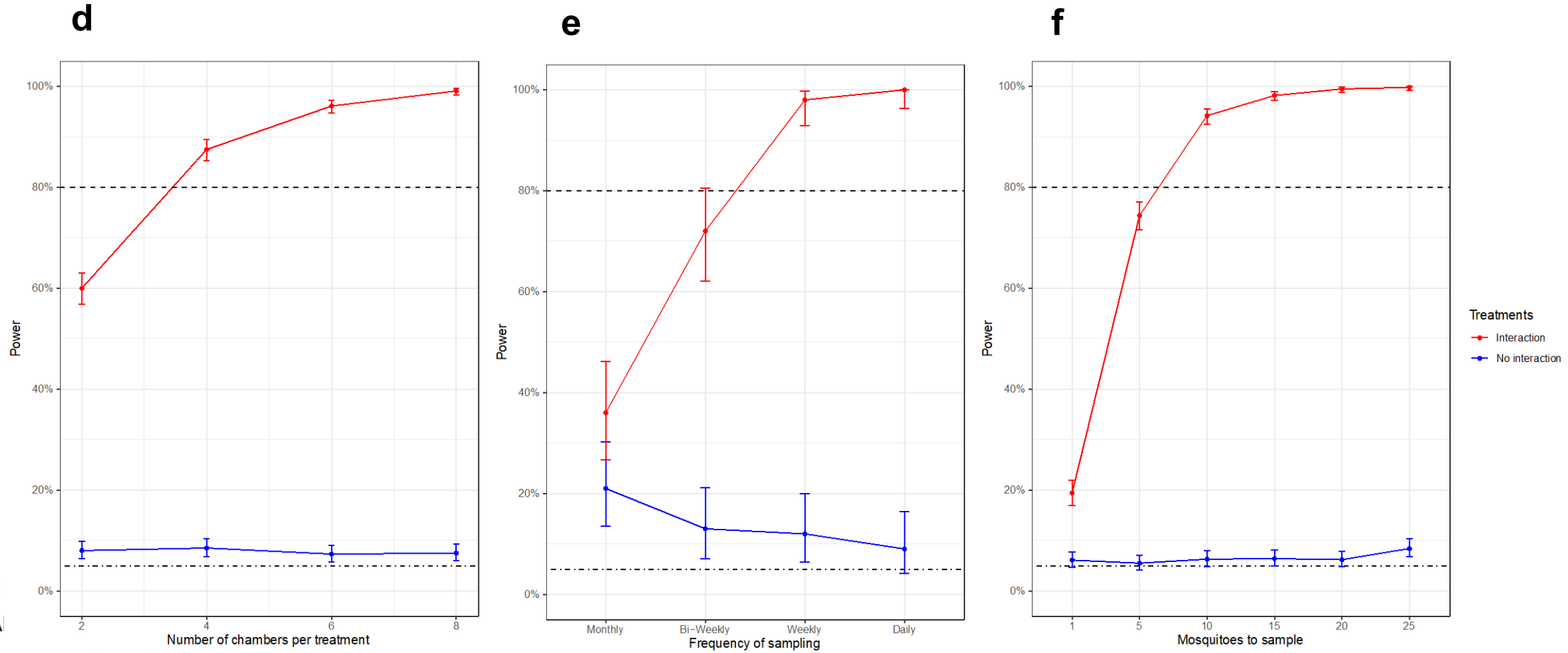
Results 1: Single intervention

- Power increased with increasing chambers per treatment, sampling frequency and number of mosquitoes to be sampled.



Results 2: Combined interventions

- Power increased with increasing chambers per treatment, sampling frequency and number of mosquitoes to be sampled.



Conclusion and future works

- For this case study, four chambers and weekly sampling, with at least ten mosquitoes to be sampled were recommend.

- A generic statistical power analysis framework developed may be adapted to design robust vector control experiments in semi-field settings.

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