

Non-
mathematical
description of a

▼
A MATHEMATICAL MODEL OF
HERD PROTECTION FROM
SANITATION

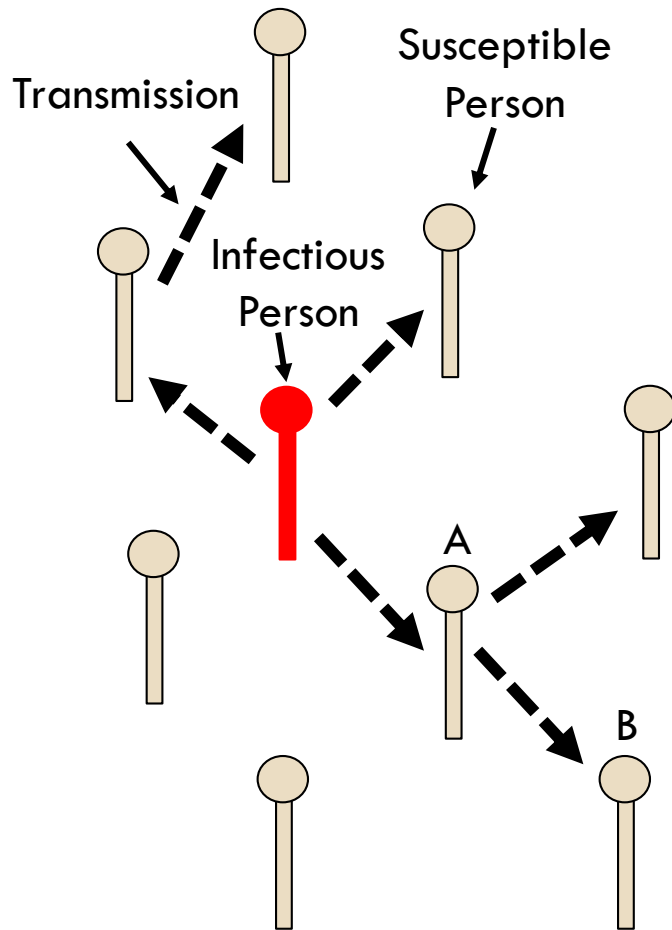
James Fuller

University of Michigan

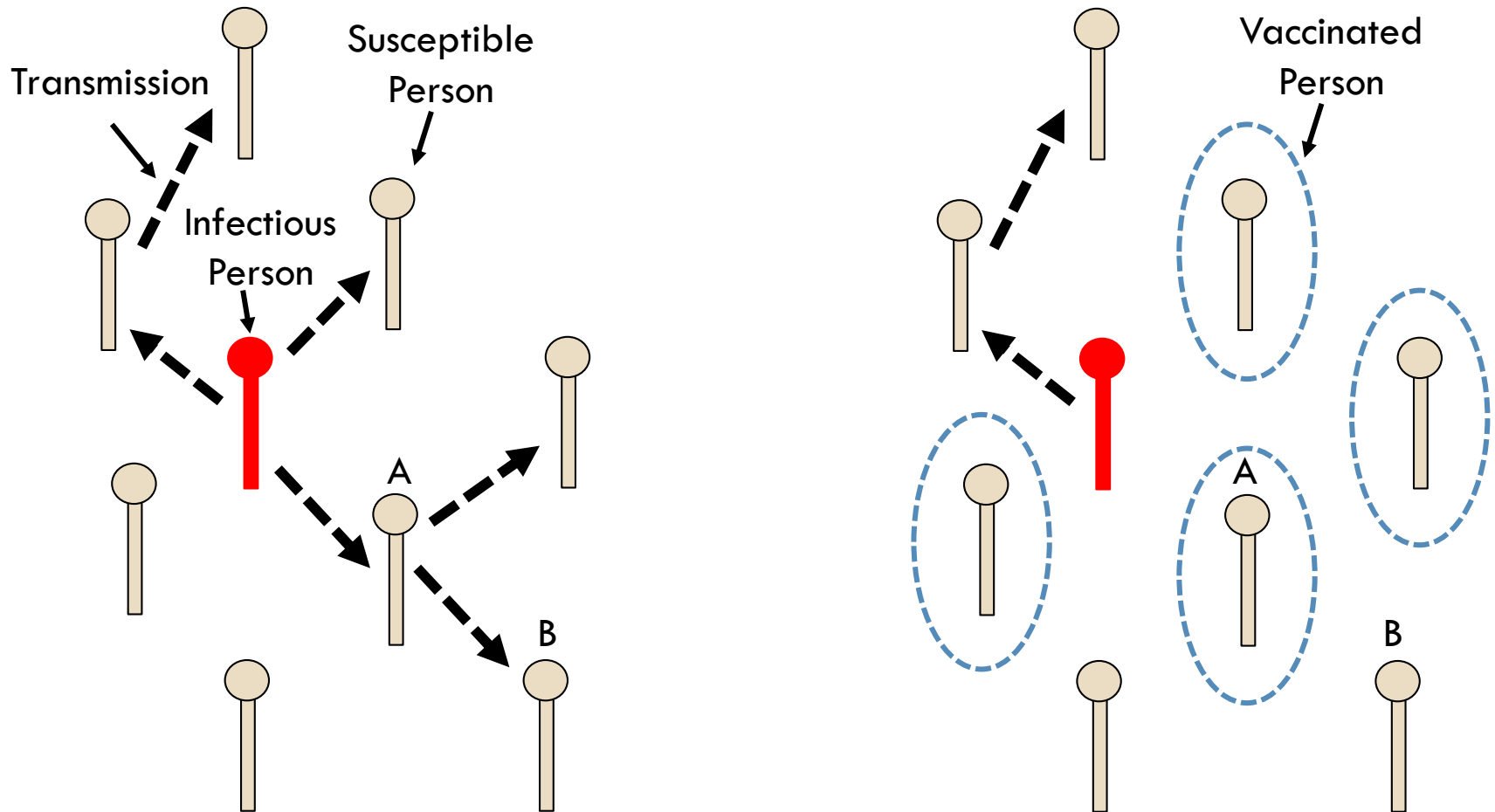
Background



Herd Immunity from a Vaccine



Herd Immunity from a Vaccine

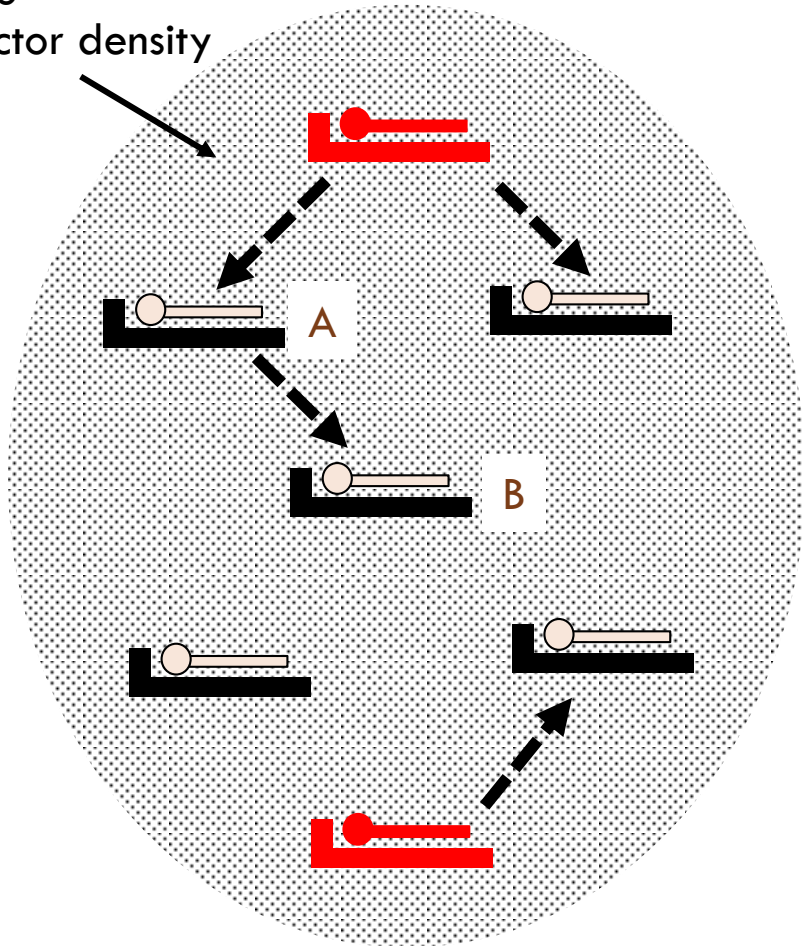


Herd Immunity

- **Herd Immunity**: The non-immune have a lower risk of infection due to high levels of immunity in the surrounding population

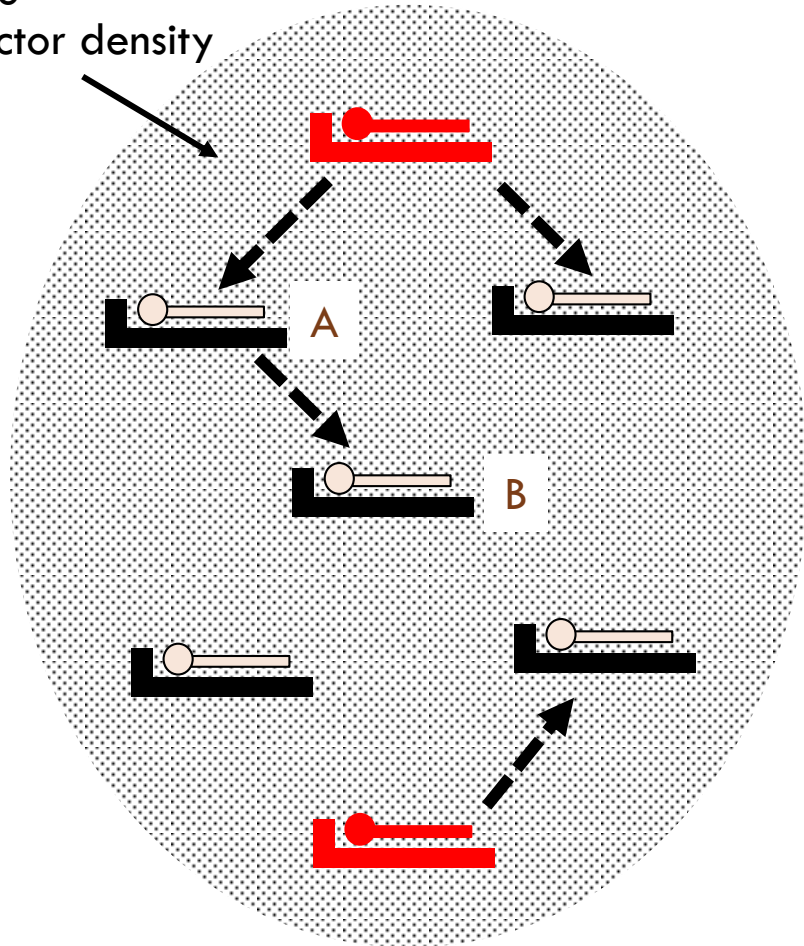
Herd Protection from ITNs

High infected
vector density



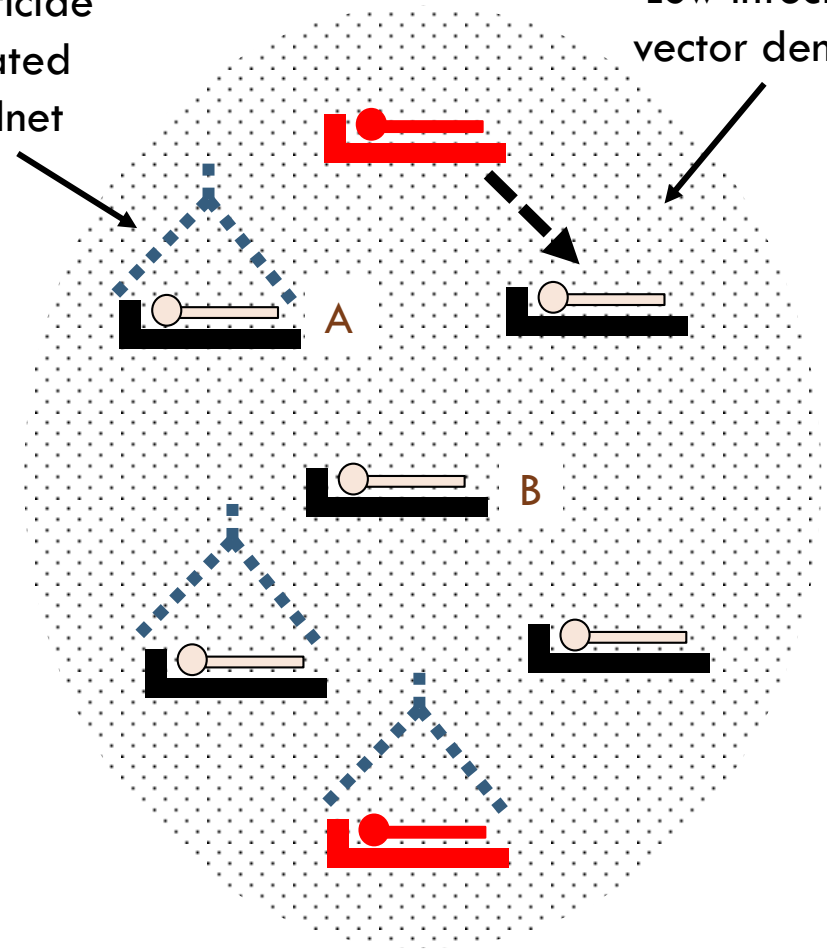
Herd Protection from ITNs

High infected
vector density



Insecticide
Treated
Bednet

Low infected
vector density



Herd Immunity vs. Herd Protection

- Herd Immunity: The non-immune have a lower risk of infection due to high levels of immunity in the surrounding population
- Herd Protection: Non-recipients of an intervention have a lower risk of infection due to others receiving the intervention in the surrounding population

Evidence of Herd Protection

- Vaccines
- Insecticide Treated Bednets and Malaria
- Albendazole and Helminths
- Antibiotics and Trachoma
- Natural immunity and Measles
- Household mosquito larvae removal and Dengue

Different Names for the Same Thing

- Externalities
- Herd Immunity
- Ecologic Effect
- Mass Effect
- Community Effect
- Herd Effect
- Dependent Happenings
- Indirect Effect
- Spillover



**Herd
Protection**

The Model

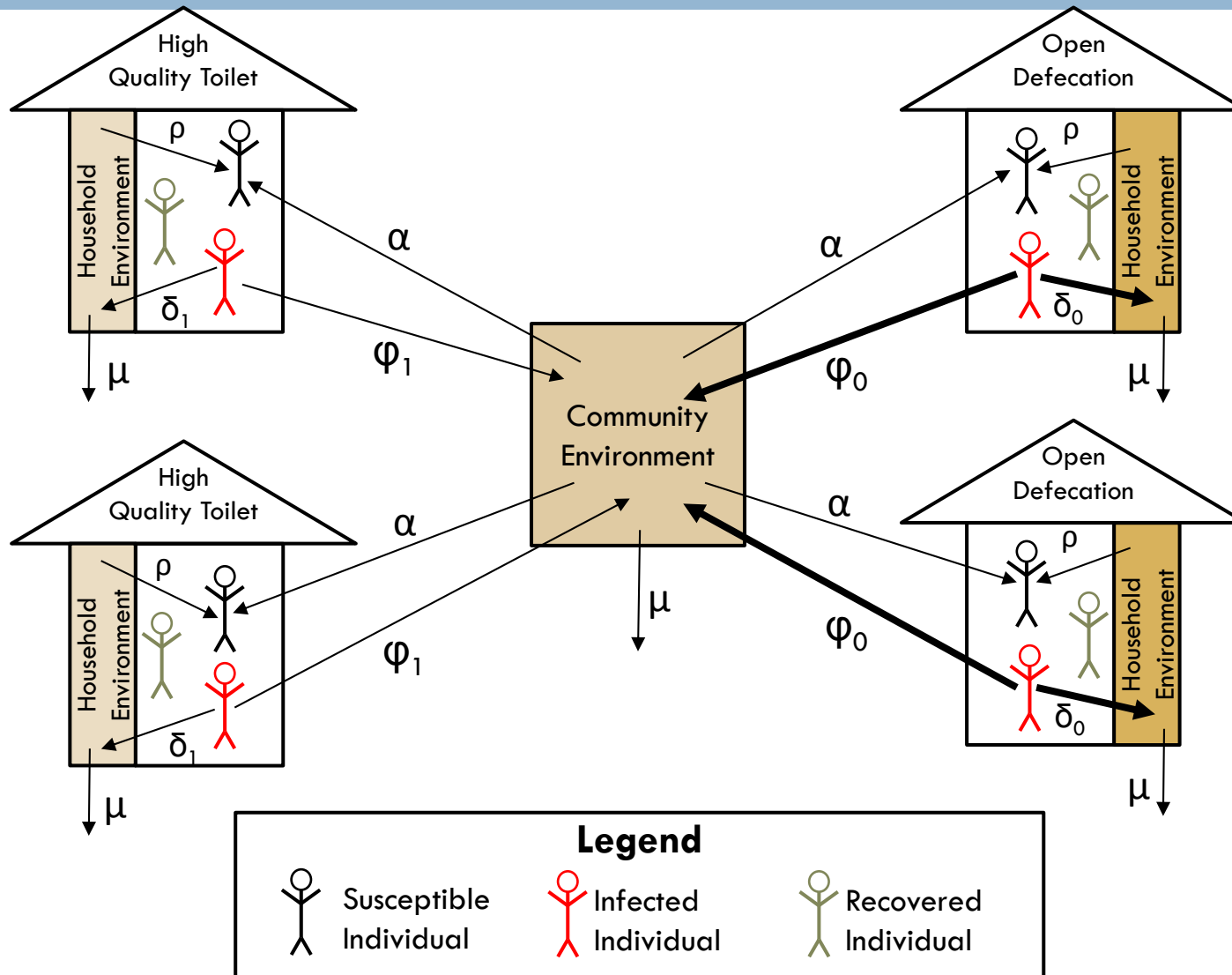


The Model



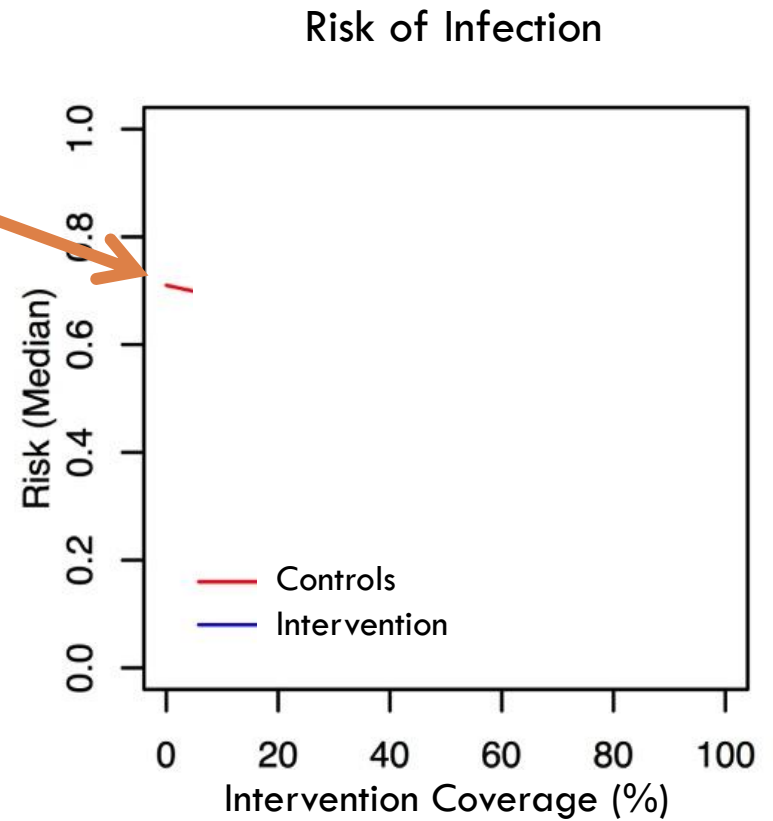
- “All models are wrong, but some are useful”
- My goal is not to estimate or predict
- My goal is to explain

The Model



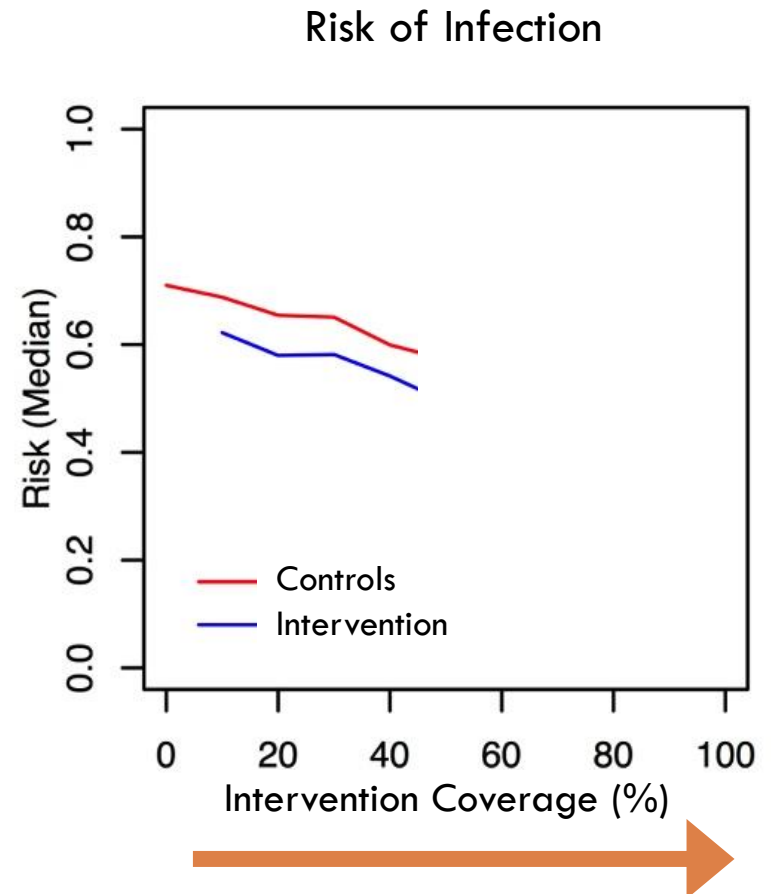
Model Results

1. Run Model with 0% Coverage



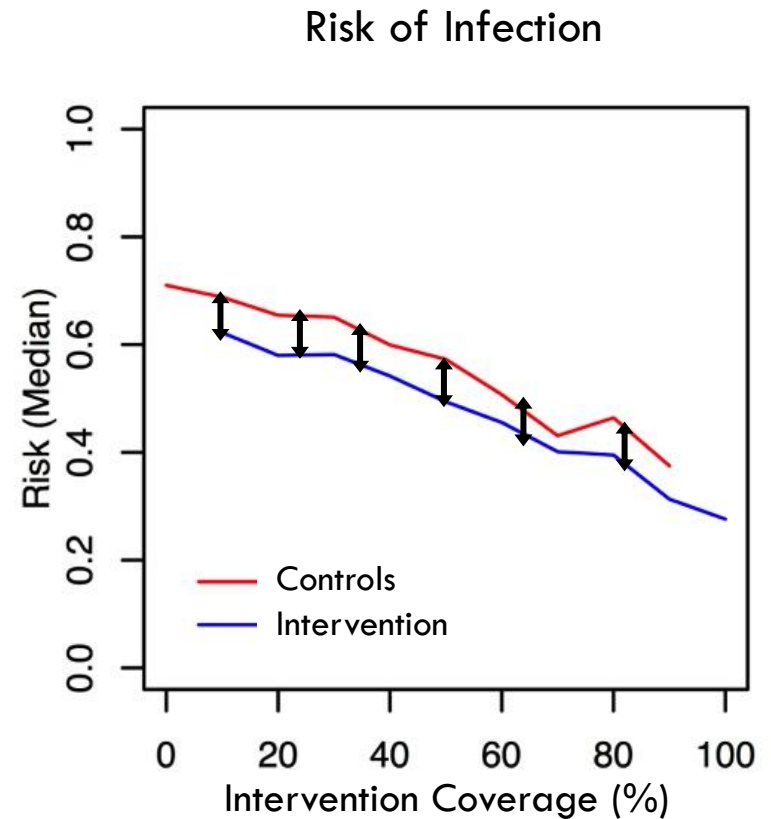
Model Results

1. Run Model with 0% Coverage
2. Incrementally Increase Coverage



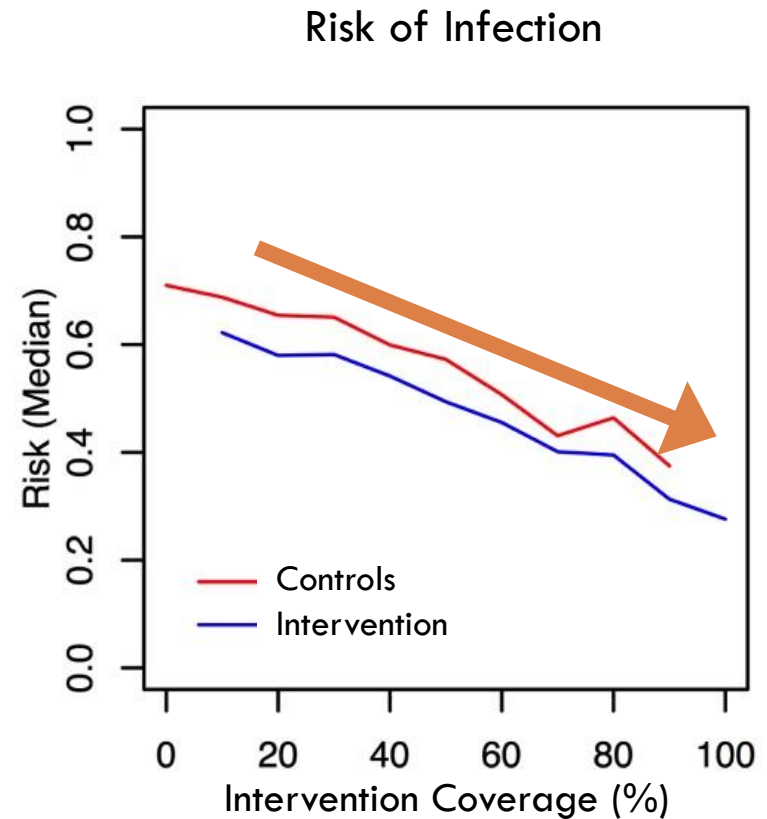
Model Results

1. Run Model with 0% Coverage
2. Incrementally Increase Coverage
3. Difference=Direct effect



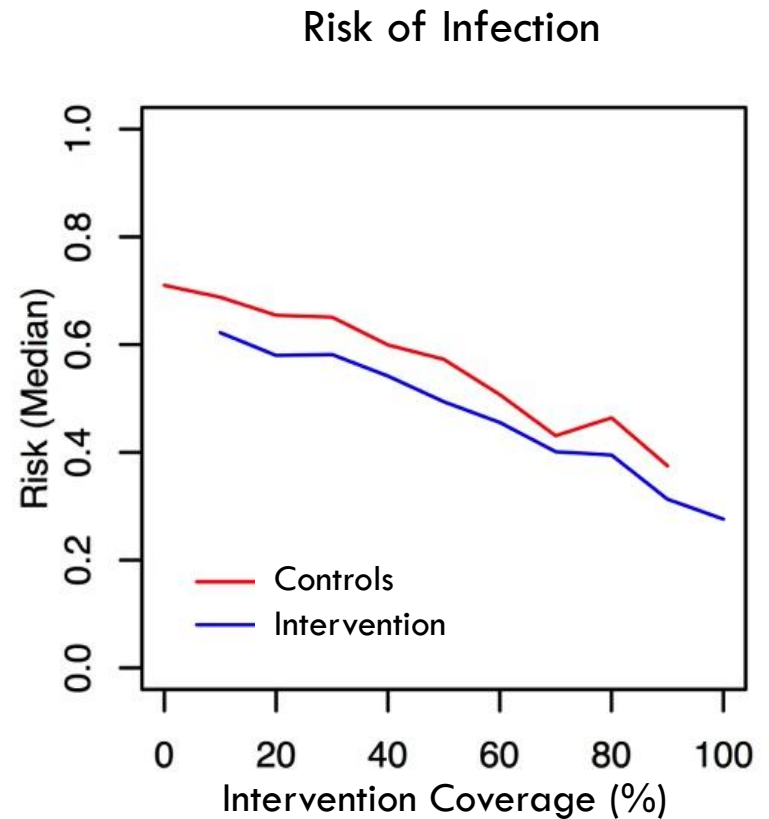
Model Results

1. Run Model with 0% Coverage
2. Incrementally Increase Coverage
3. Difference=Direct effect
4. Slope=Herd protection



Model Results

Traditional epidemiology drastically underestimates the total effect of sanitation



Empirical Example

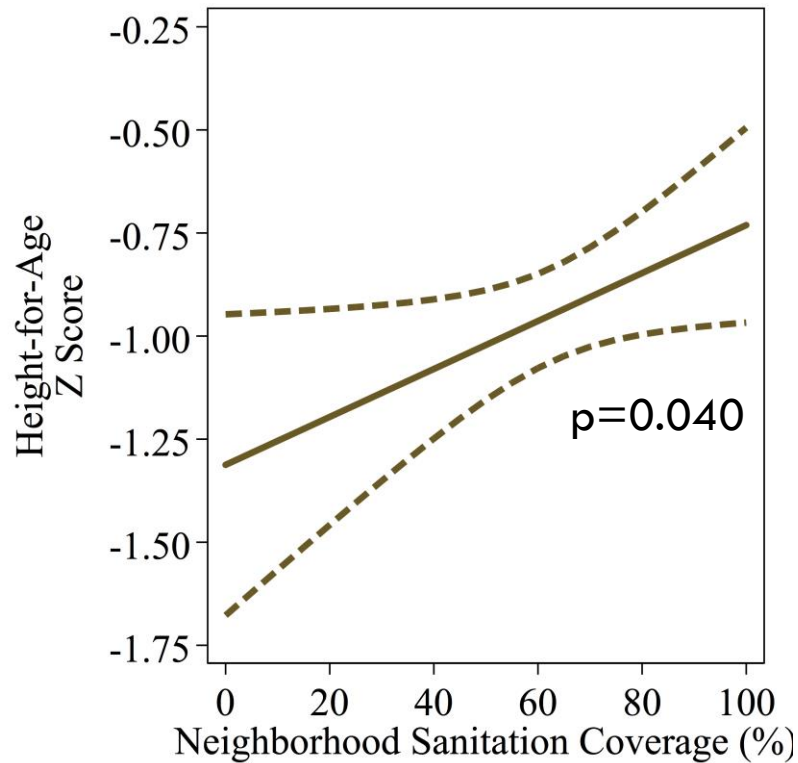


Methods

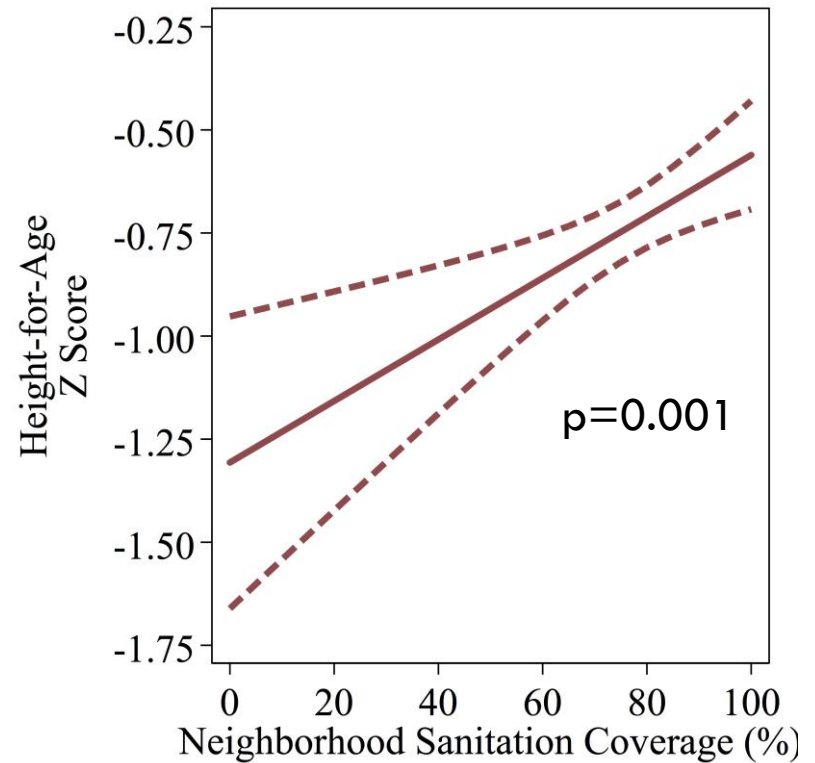
- 24 rural villages in Ecuador
- Sanitation practices and GPS locations of all households
- Sanitation coverage within 500-meter radius
- Height-for-Age Z Scores (Stunting) on 1 476 children (2503 observations)
- Adjusted for Household SES and Neighborhood SES

Results

Households with **Unimproved** Sanitation



Households with **Improved** Sanitation



Conclusions

- **Sanitation** can provide herd protection by reducing environmental contamination
- Sanitation is **more protective** than we think it is
- Special **study designs** are needed to detect herd protection

Thank you!!

REFERENCES

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