

Improving the effectiveness of water, sanitation, and hygiene interventions

A simulation approach to generalizing the outcomes of intervention trials

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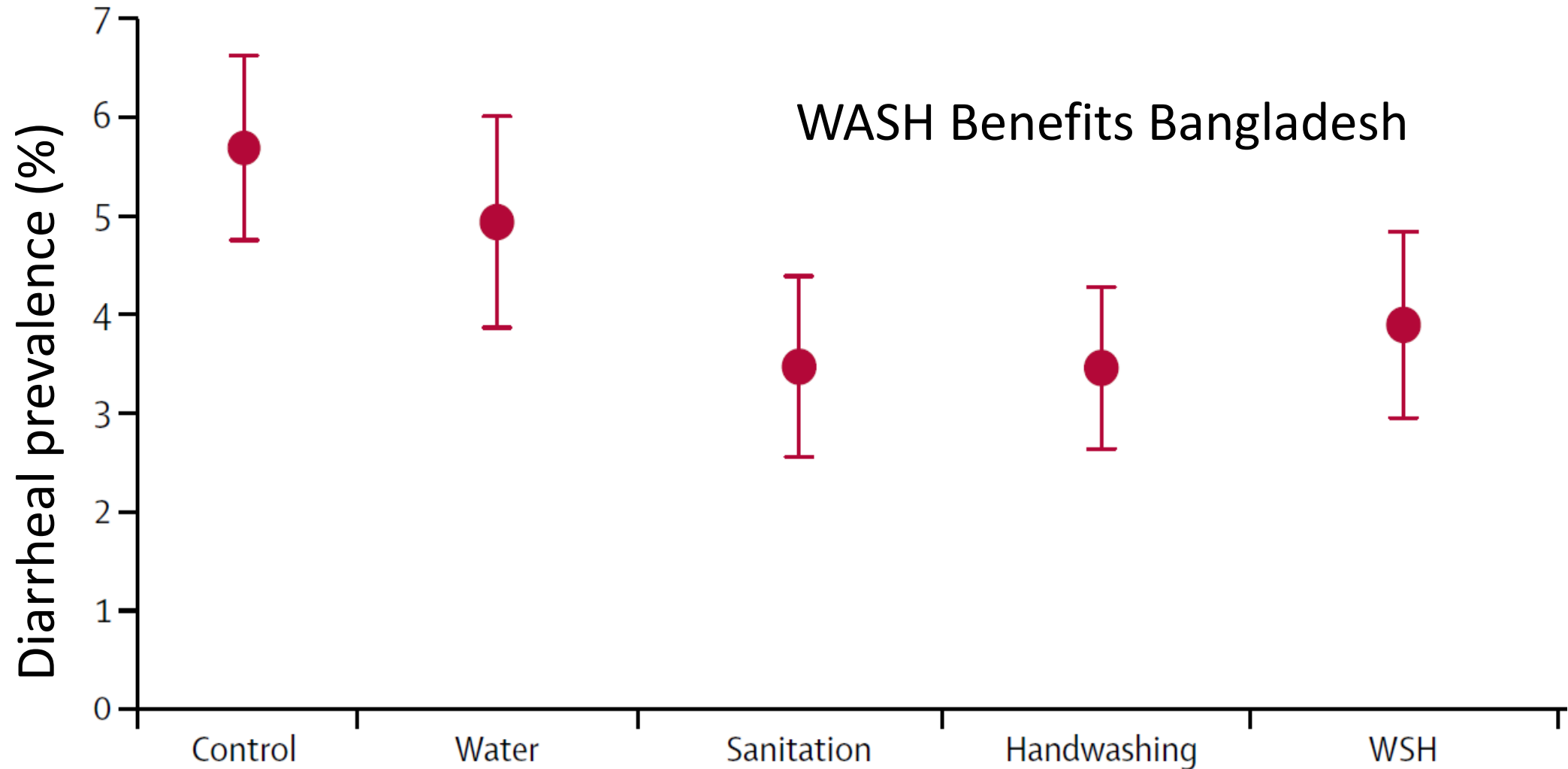


EMORY

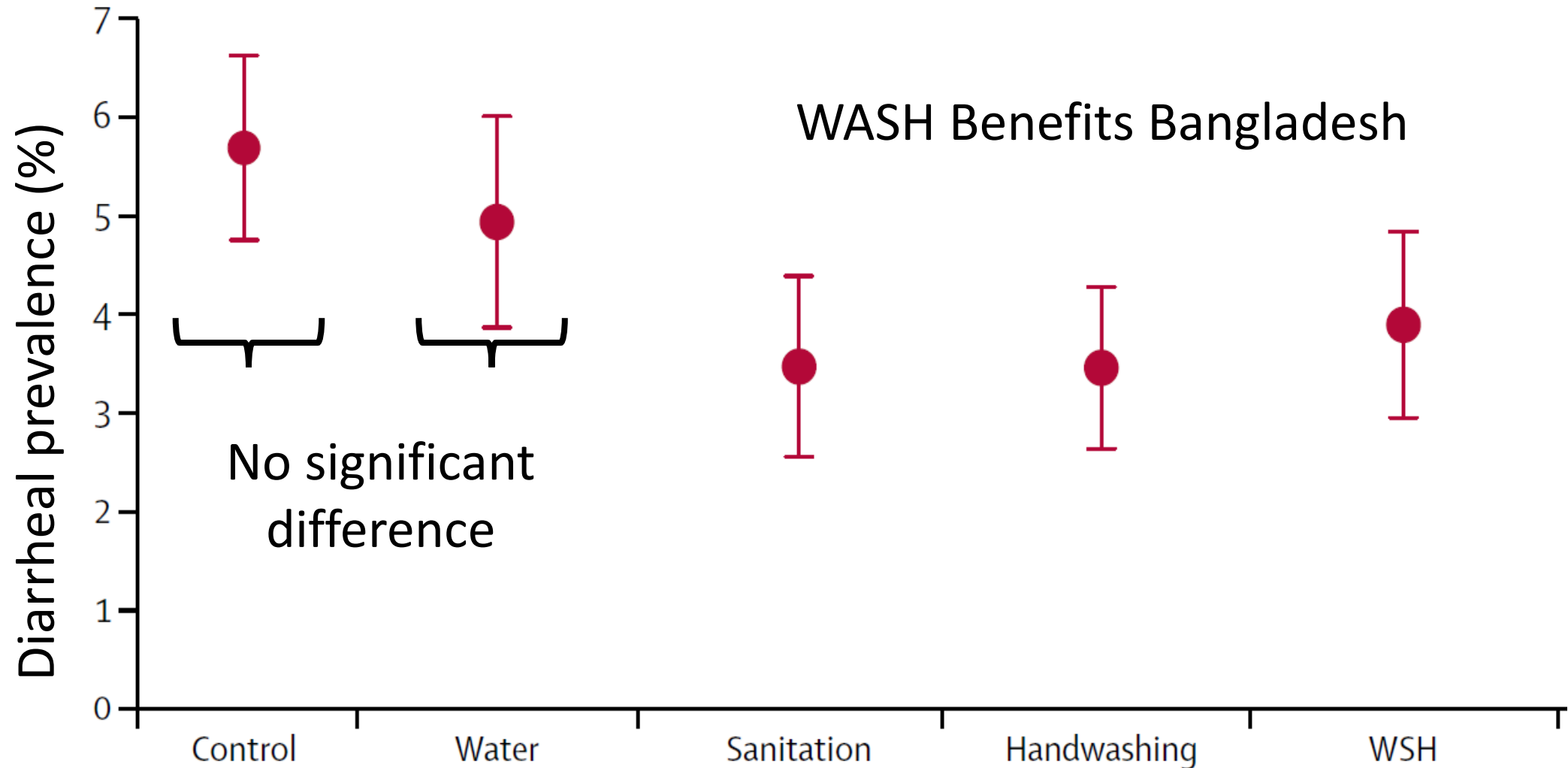
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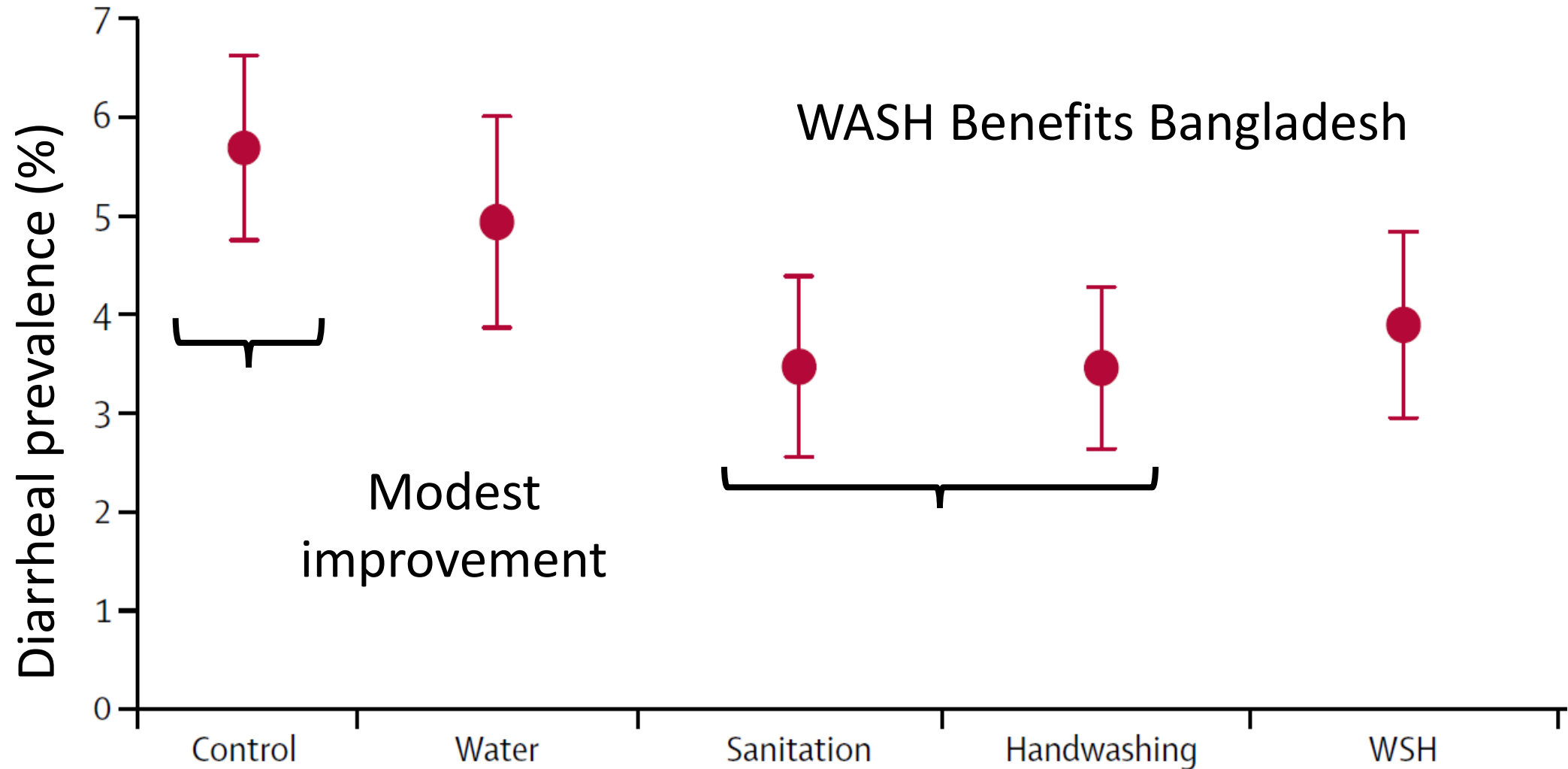
While WASH interventions have shown promise at reducing diarrhea in observational studies, many recent clinical trials have reported modest-to-null results.



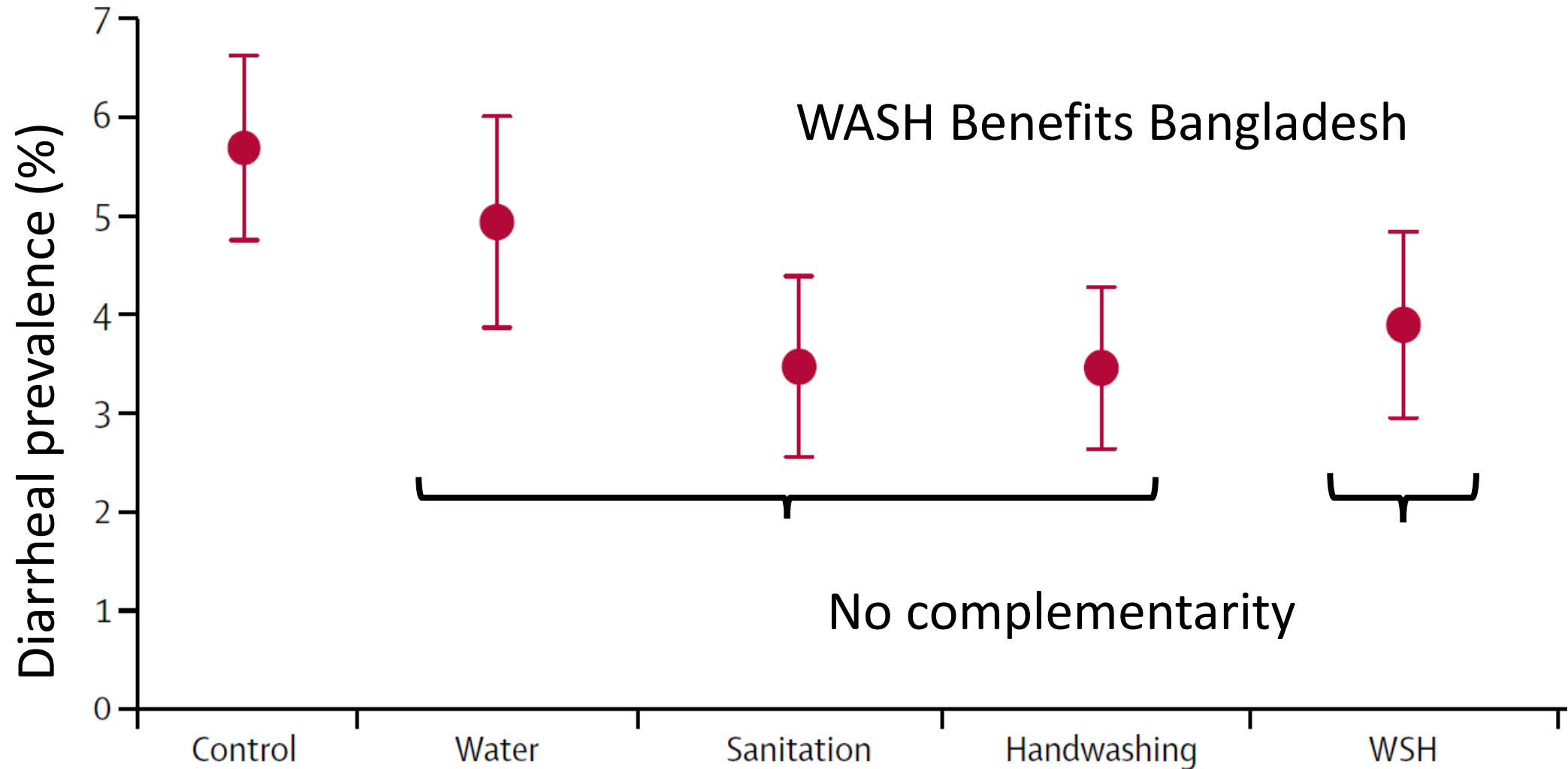
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Efficacy

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Adherence & fidelity

People aren't receiving or using the interventions

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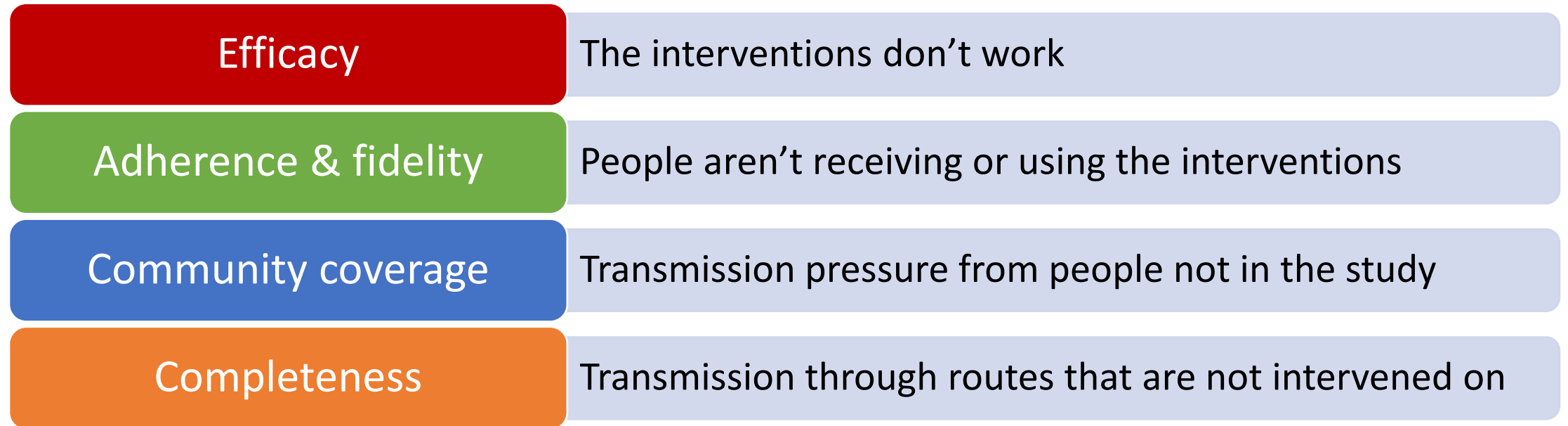
Adherence & fidelity

People aren't receiving or using the interventions

Community coverage

Transmission pressure from people not in the study

Which factor do you think is the most important?



Magnitude of transmission pathways



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Completeness

Transmission through routes that are not intervened on

Baseline WASH conditions

Interventions are not a meaningful improvement

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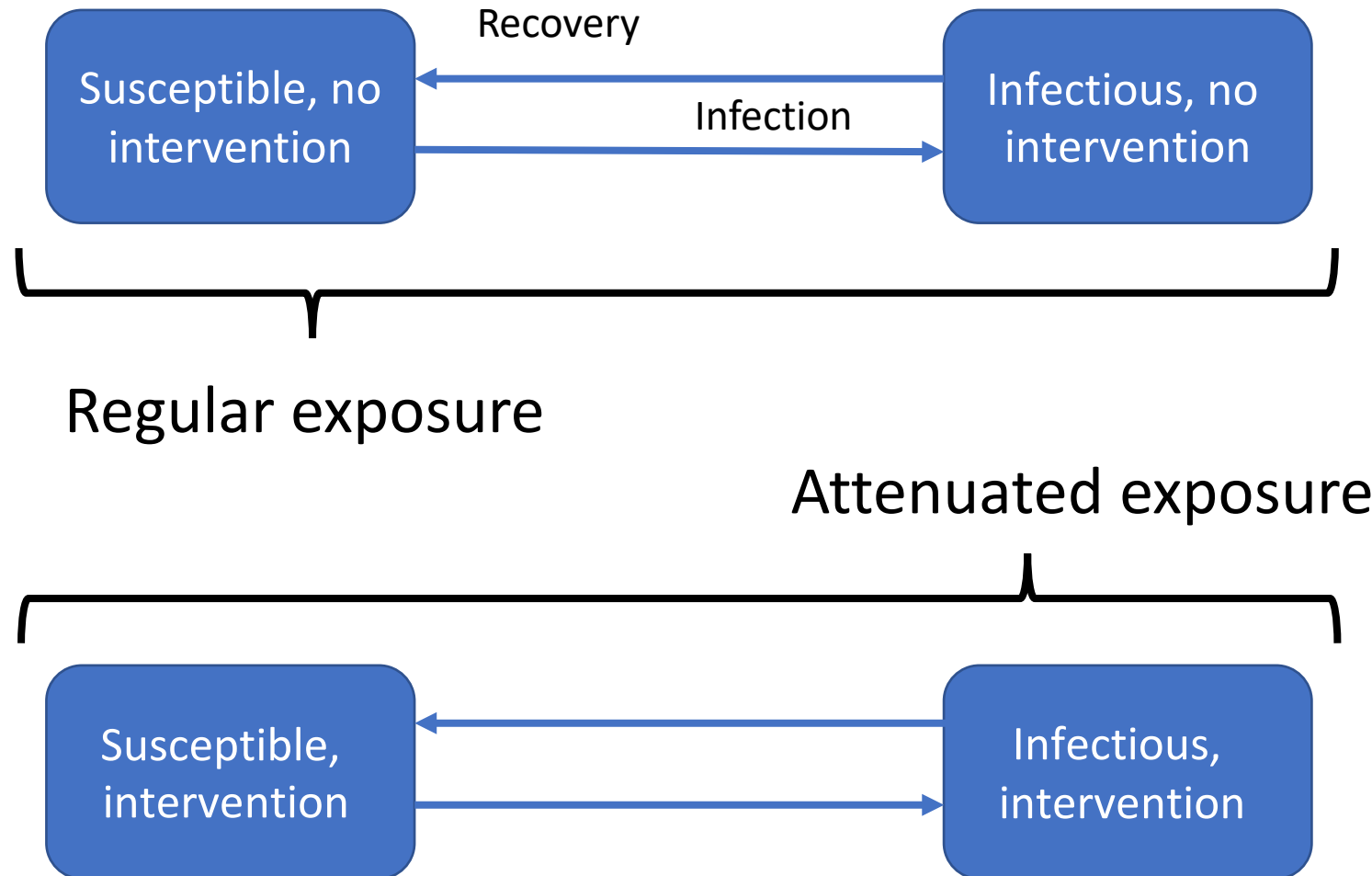
Baseline disease conditions

There is too little/too much disease

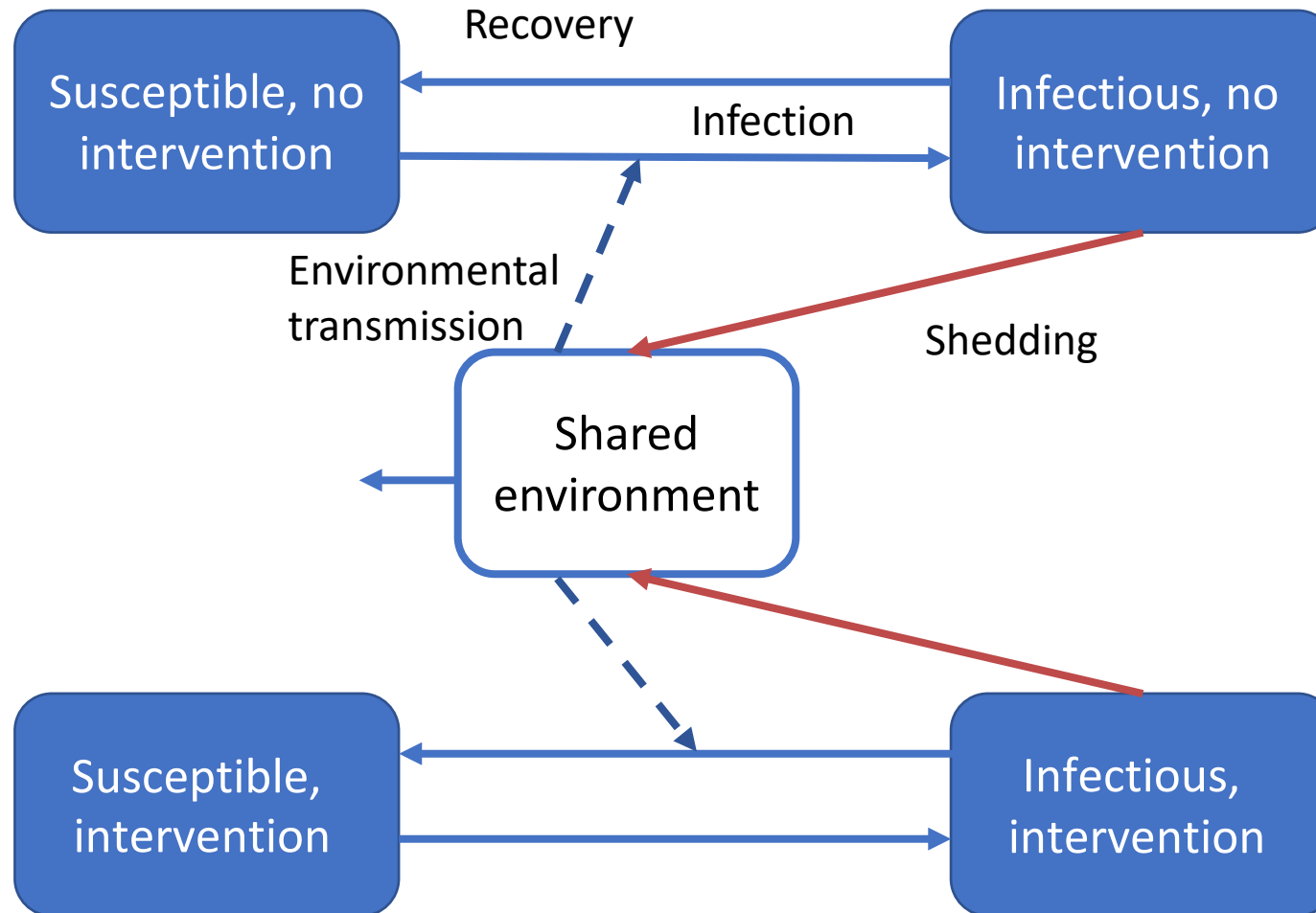
Mechanistic transmission modeling can evaluate these explanations.



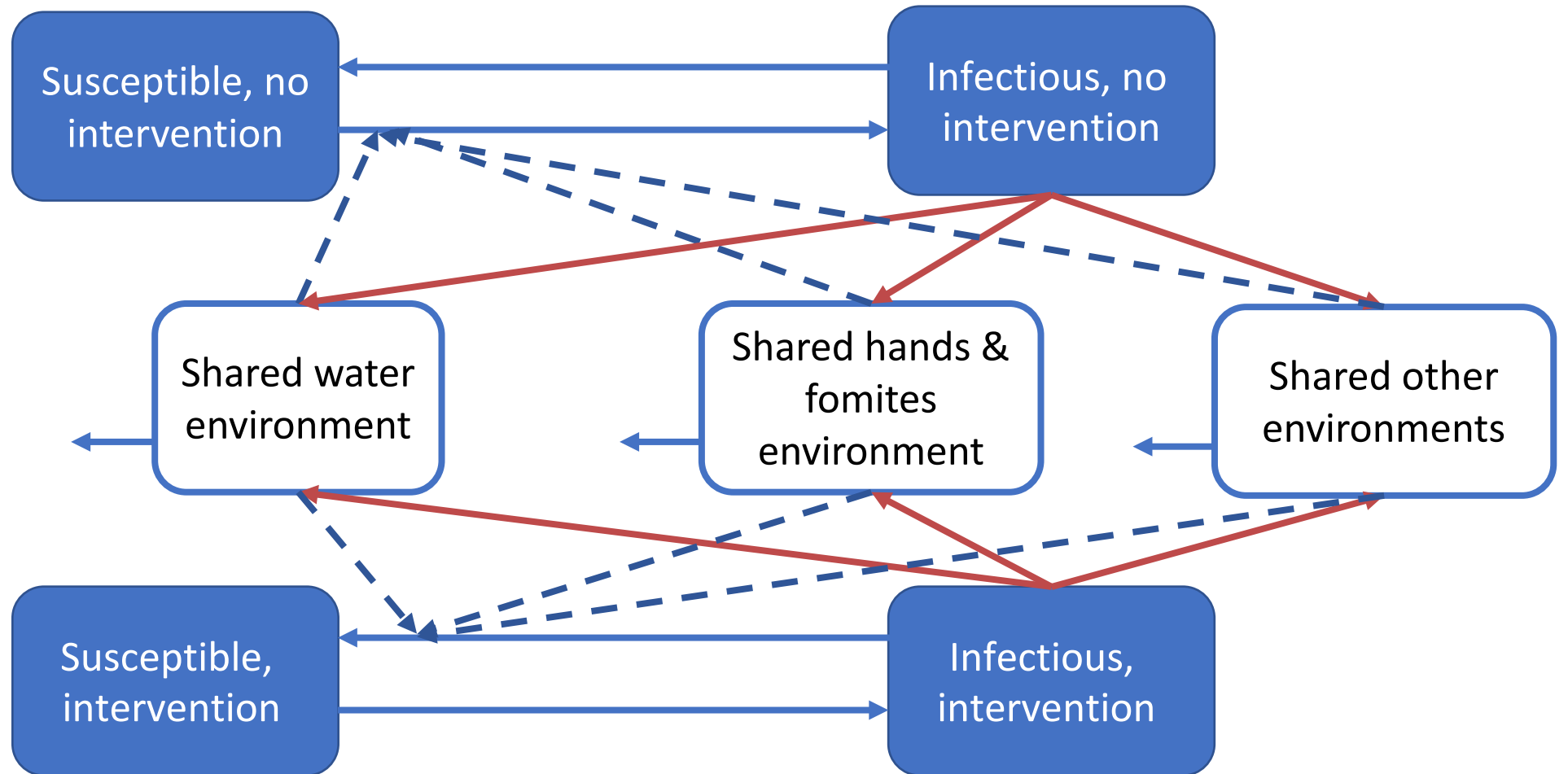
Our transmission model accounts for people not using interventions...



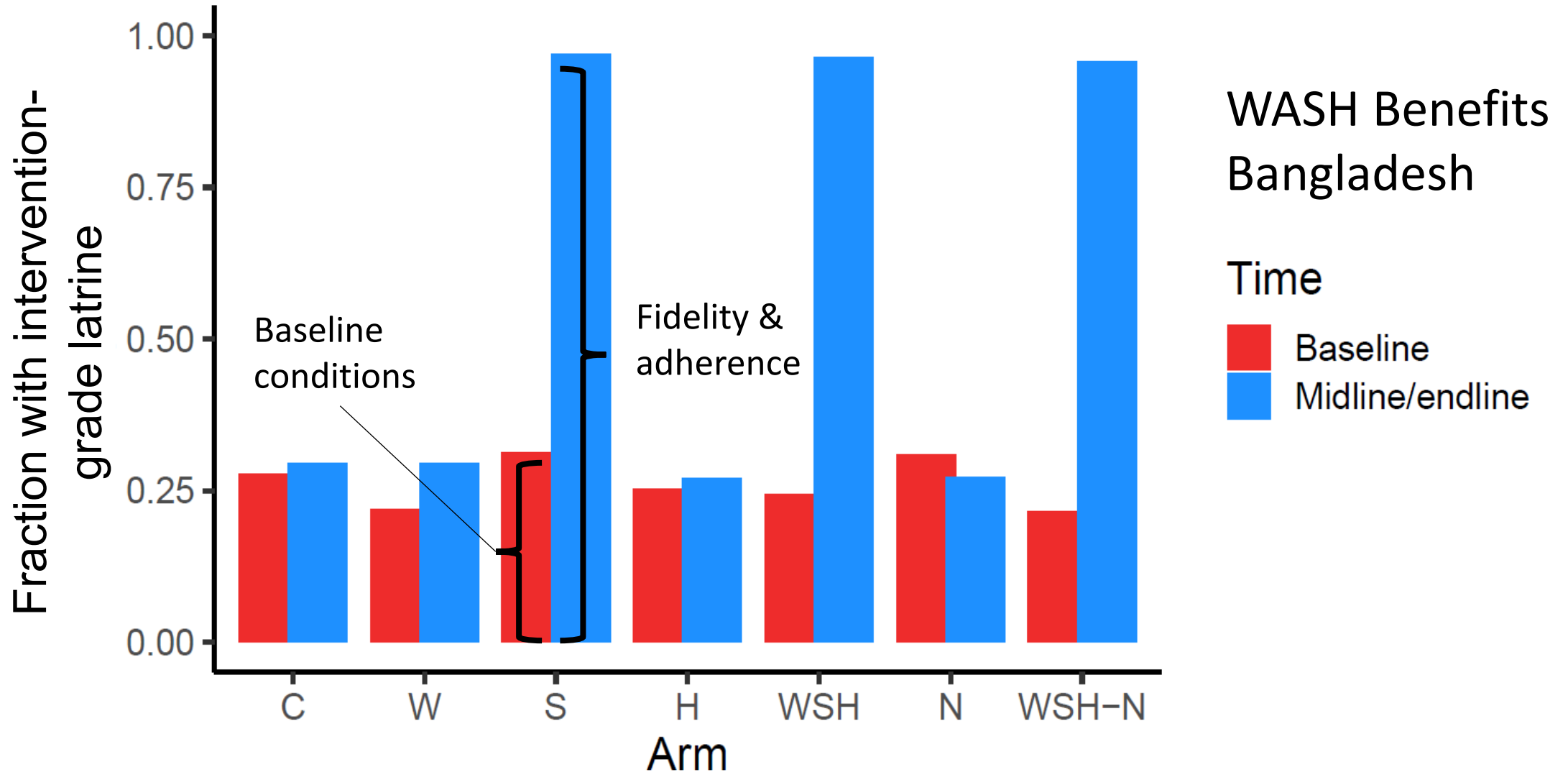
... a shared environment ...



... and multiple transmission pathways.



We also need to account for adherence/fidelity and baseline WASH conditions.



Model parameters determine estimated prevalence.

Community coverage

Fraction of the population that is in the study

Magnitude of transmission pathways (R_0)

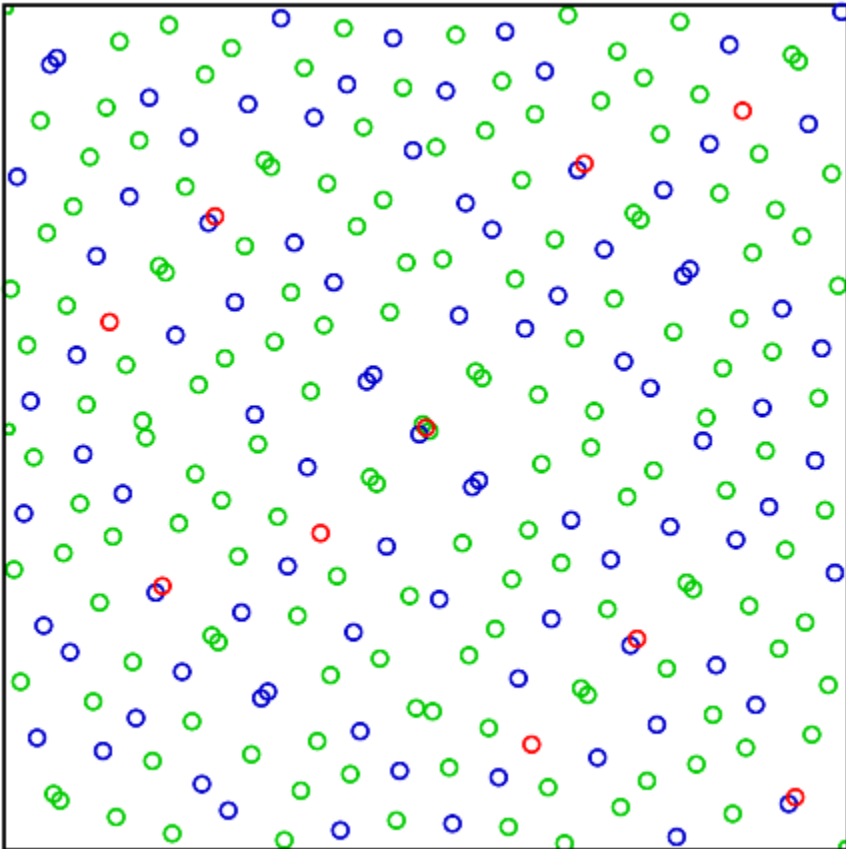
Water
Hands & fomites
Other

Efficacy of interventions

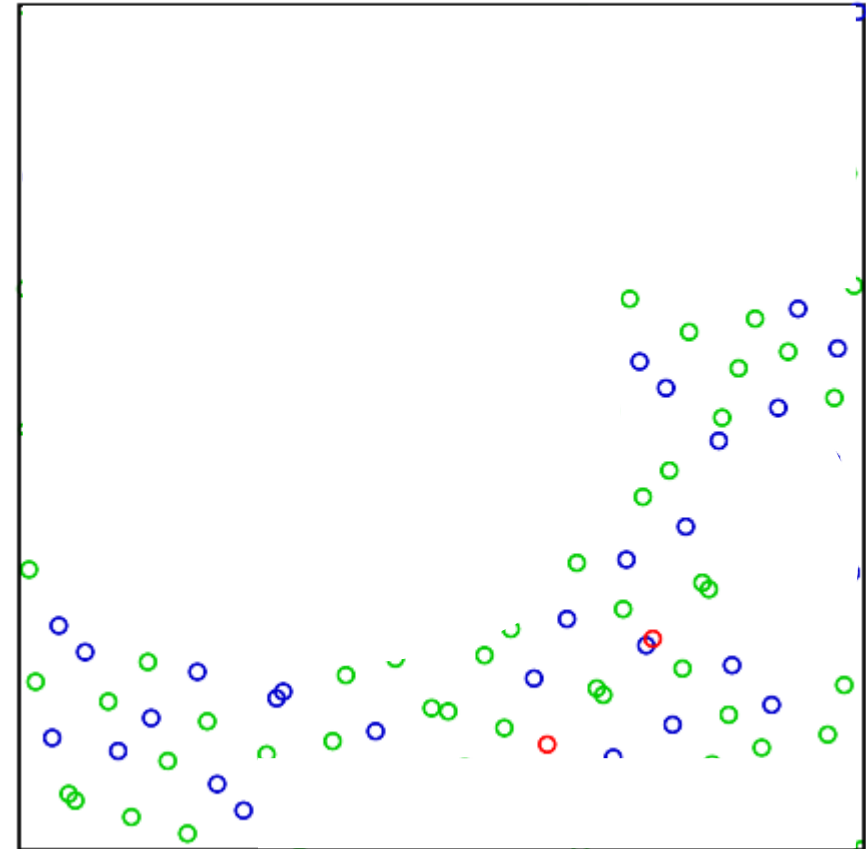
Water – chlorination reduces transmission from water pathway
Sanitation – latrine water seal reduces shedding into water pathway
Hygiene – handwashing reduces transmission from fomite pathway

Calibration - sample parameter sets and see if they fit the data.

Test a large number of parameter combinations...



... only keep the ones that fit well



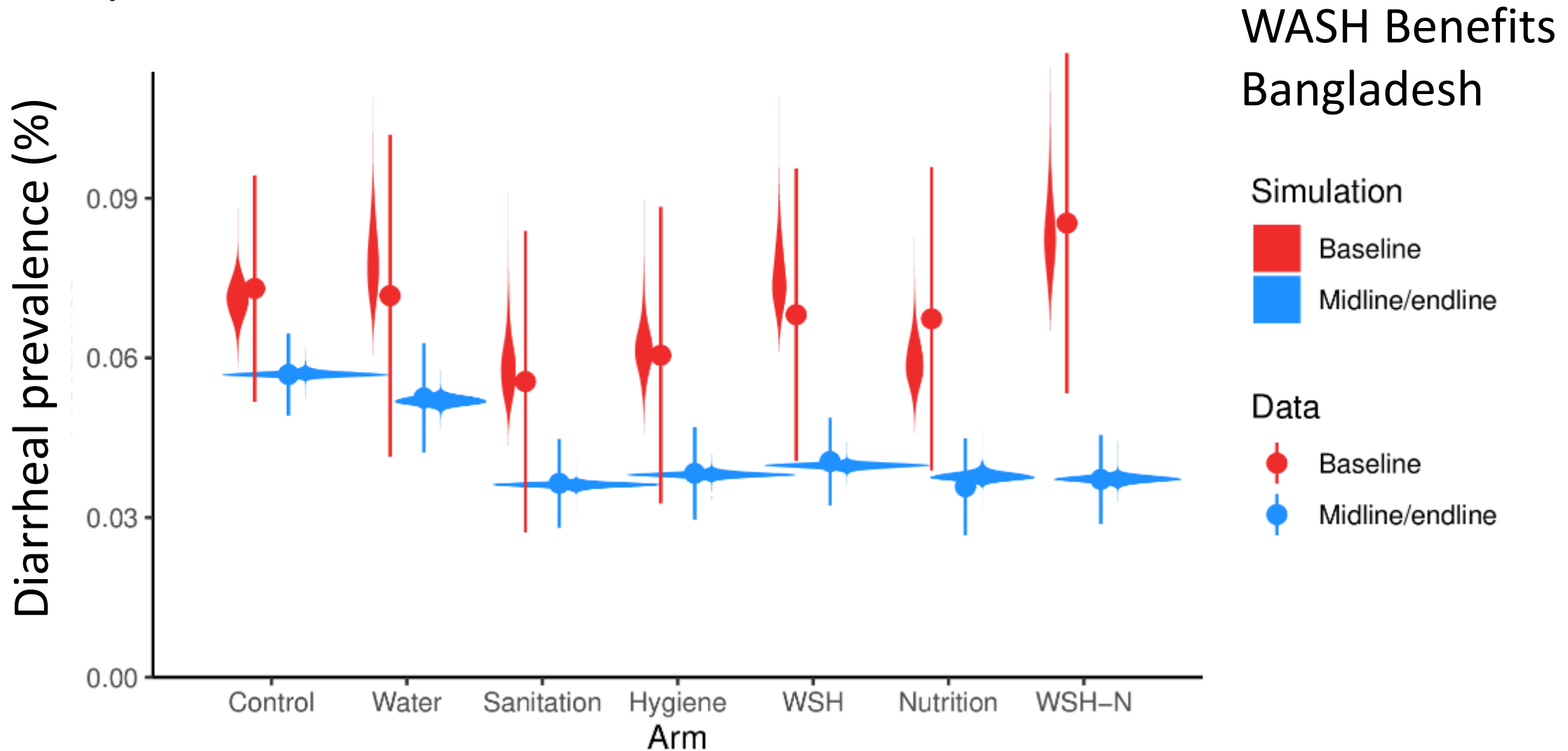
What kinds of results do we generate?

Comparison of simulation and data

Parameter uncertainty (posterior distributions)

Counterfactuals: what would we have observed if ... ?

The model successfully captures diarrheal prevalence in the trial.



What would have happened if we...

Counterfactual	Intervention effectiveness			
	Water	Sanitation	Hygiene	WSH
Original scenario	8%	36%	33%	30%
Doubled chlorine efficacy				
Doubled latrine efficacy				
Doubled handwashing efficacy				
Had full adherence				
Increased coverage to 20%				
Had no baseline WASH conditions				
Doubled baseline prevalence				

What would have happened if we...

Counterfactual	Intervention effectiveness			
	Water	Sanitation	Hygiene	WSH
Original scenario	8%	36%	33%	30%
Doubled chlorine efficacy	+7%	+0%	+0%	+6%
Doubled latrine efficacy	+0%	+17%	+0%	+15%
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Doubled handwashing efficacy	+0%	+0%	+20%	+20%
Had full adherence	+4%	+0%	+1%	+4%
Increased coverage to 20%				
Had no baseline WASH conditions				
Doubled baseline prevalence				

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Had full adherence	+4%	+0%	+1%	+4%
Increased coverage to 20%	+13%	+6%	+8%	+30%
Had no baseline WASH conditions				
Doubled baseline prevalence				

What would have happened if we...

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Had full adherence	+4%	+0%	+1%	+4%
Increased coverage to 20%	+13%	+6%	+8%	+30%
Had no baseline WASH conditions	-0%	-14%	-8%	-9%
Doubled baseline prevalence				

What would have happened if we...

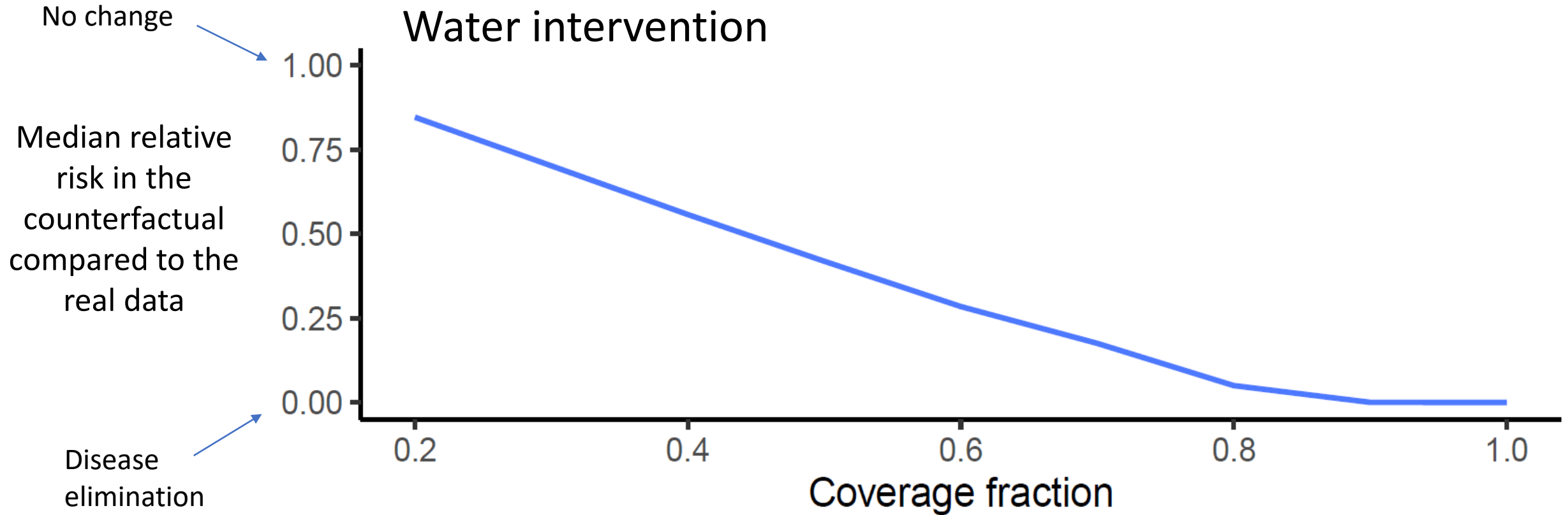
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Had full adherence	+4%	+0%	+1%	+4%
Increased coverage to 20%	+13%	+6%	+8%	+30%
Had no baseline WASH conditions	-0%	-14%	-8%	-9%
Doubled baseline prevalence	-2%	-21%	-17%	-12%

What about completeness?

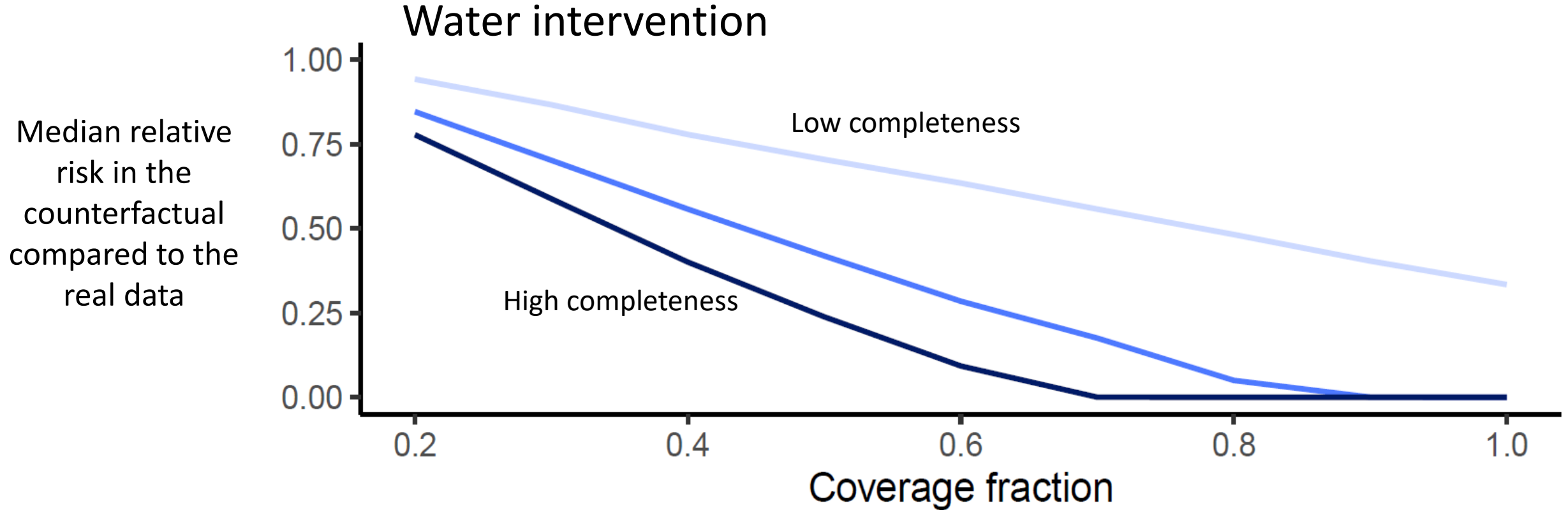
Magnitude of transmission pathways



Consider the impact of increasing coverage



Completeness is an effect modifier



Summary

- **Coverage** is essential – interventions have little individual-level effectiveness if there is disease pressure from people not covered by interventions.
- **Completeness** is an important modifier of the impact of **coverage** on intervention effectiveness.
- **Efficacy** and **adherence/fidelity** have limits to their impact.
- Easier to have an effect when the system is already closer to elimination (**baseline WASH conditions** and **baseline disease conditions**).

Conclusion

Investments in interventions should be addressed in this order.

- 1. *Completeness*.** Without completeness, addressing the other factors will have little impact. The relevance of food, animal, etc. pathways needs to be better understood.
- 2. *Coverage*.** If interventions are complete, increasing coverage can dramatically impact outcomes.
- 3. *Efficacy, fidelity, and adherence*.** These factors will have little impact without first addressing completeness and coverage.

Take-aways

Transmission models can generalize trial relative risks to other contexts

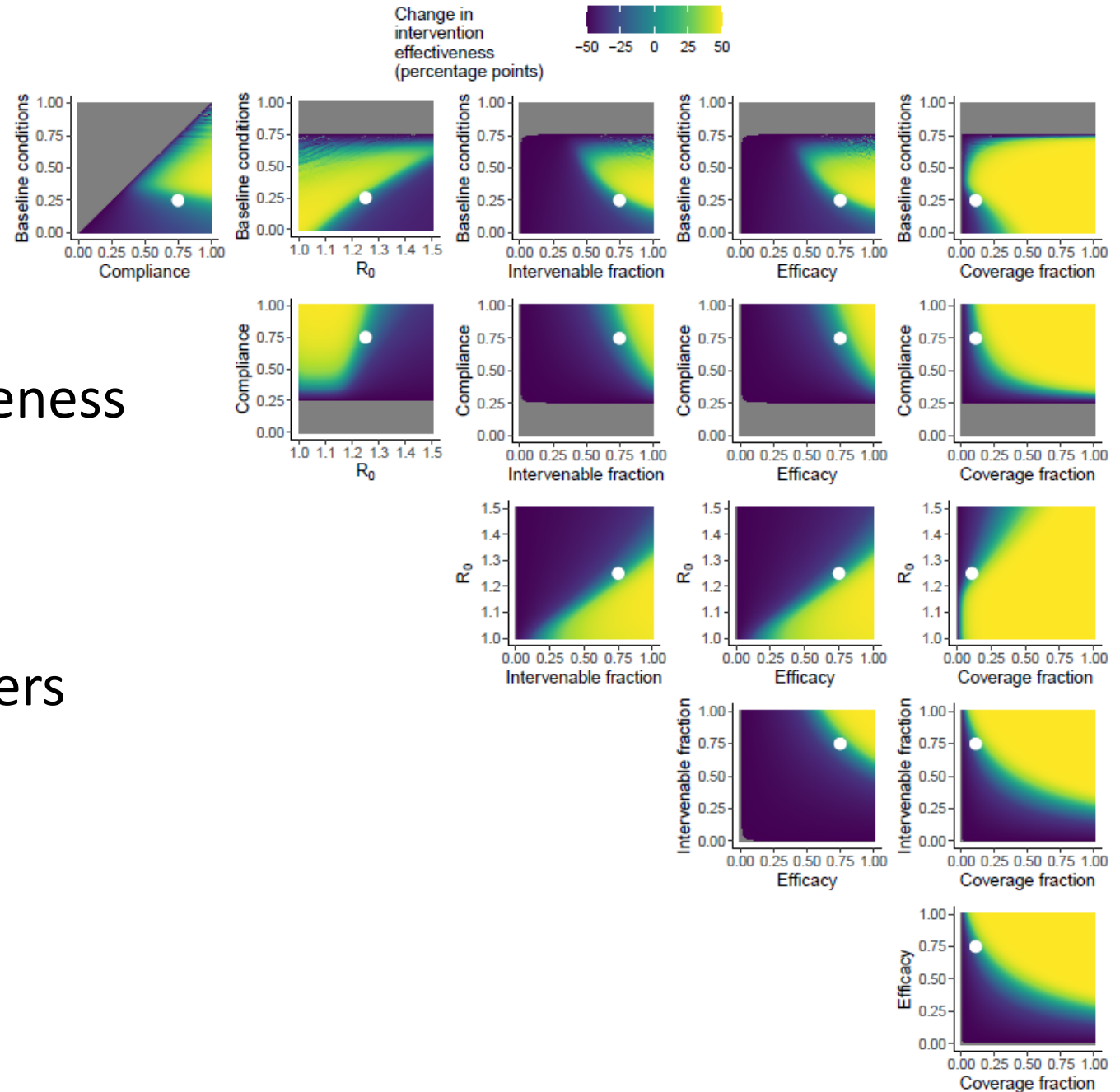
- Incorporate models into trial design
- Use models to choose programmatic targets for local contexts

Our results support

- Community-level interventions seeking to achieve herd protection
- Evaluation of strength of transmission pathways (including those not traditionally covered by WASH)

Shiny App coming soon!

- Estimate intervention effectiveness for a specific set of baseline conditions and intervention parameters
- Explore sensitivity to parameters to determine how to achieve disease reduction goals



Acknowledgments

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