

Simulating the Effects of Risk Perception and Human Behaviour on a Vector-borne Disease with Agent-based Modelling

MCS Oral Presentation

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Preventive behaviour: a shared example



- Think of a time when you wore—or didn't wear—a face mask (when masks weren't mandated).

Source: SCIG¹

¹<https://southerncrossgroup.com.au/product/disposable-medical-face-mask/>

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Preventive behaviours (the use of preventive measures) differ among individuals because of unique thought processes and varying motivating factors for protection.

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Vector-borne diseases



Source: James Gathany/CDC¹

- E.g. malaria, dengue, chikungunya, leishmaniasis.
 - $\geq 700,000$ deaths annually.
 - Account for more than 17% of all infectious diseases [1].
-
- Community-based interventions
 - Chemical: insecticides, coils
 - Non-chemical: long-sleeved clothing, staying indoors

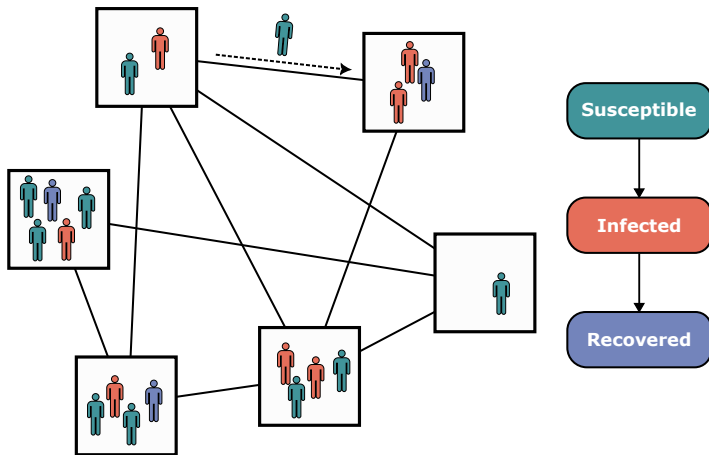
There is a need to better understand the dynamics between vector-borne diseases and preventive behaviours to design effective community-based interventions.

¹<http://phil.cdc.gov/phil/details.asp?pid=1969>

Agent-based modelling

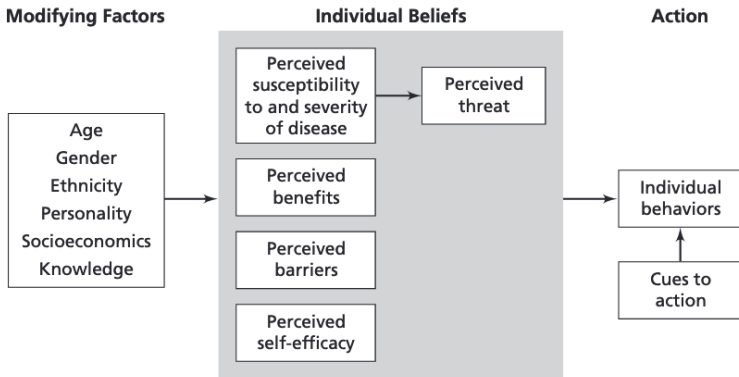
Agent-based models (ABMs) define a population of decentralised, autonomous *agents* that interact with one another to reproduce or “grow” emergent phenomena.

An agent-based version of the *SIR* (Susceptible, Infected, Recovered) model:



Psychological behavioural theories

Behavioural theories from psychology aim to model how people behave. E.g. the Health Belief Model [2]:



Multiple behavioural theories exist, but few research efforts have investigated differences in system dynamics for disease spread and preventive measures when agents act according to various behavioural theories.

Research aims and questions

This project aims to:

- 1 Use agent-based modelling to quantify the **effects of different behavioural theories** on the **adoption of preventive measures**.
- 2 Investigate effective **strategies for community-based interventions**.

Via the following research questions:

- 1 How does the choice of **behavioural theory** influence the **dynamics of agent-based models** for vector-borne disease spread and preventive behaviours?
- 2 In such models, how do targeted **community-based interventions** influence **preventive behaviours**?

Proposed methods

Phase 1: Behavioural theory comparison

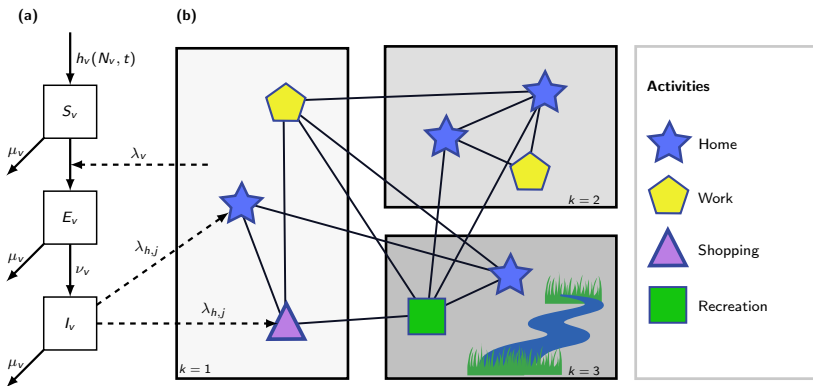
- 1 Extend an existing model [3] to incorporate preventive measures.
- 2 Computationally encode three behavioural theories.
- 3 Compare the impacts on preventive behaviours and disease spread across the three behavioural theories.

Phase 2: Simulation of community-based interventions

- 1 Use the model from the first phase to simulate community-based interventions.
- 2 Analyse the characteristics of effective interventions.

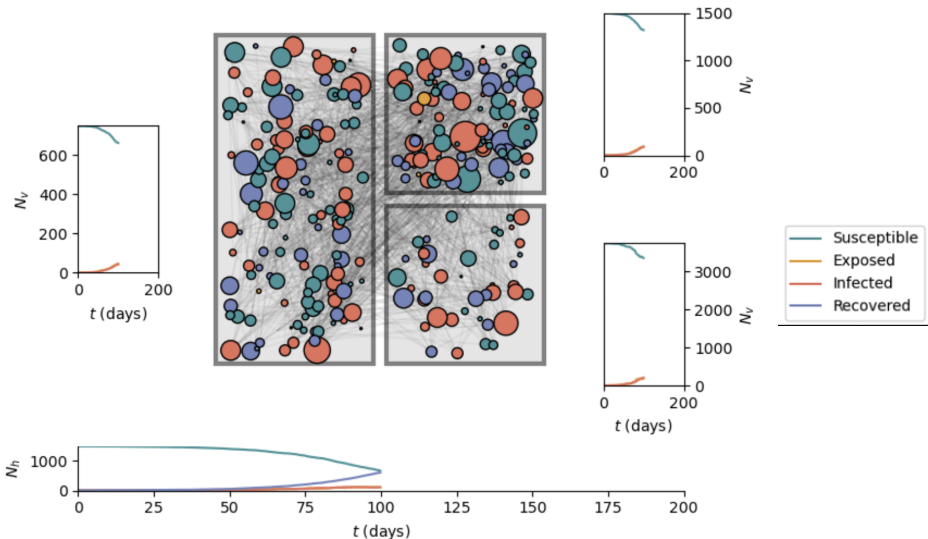
The baseline model

Adapted from Manore, Hickmann, Hyman, Foppa, Davis, Wesson, and Mores [3]:



- (a) Mosquito model.
- (b) Agent-based model.

Reproducing the baseline model



Reproducing the baseline model

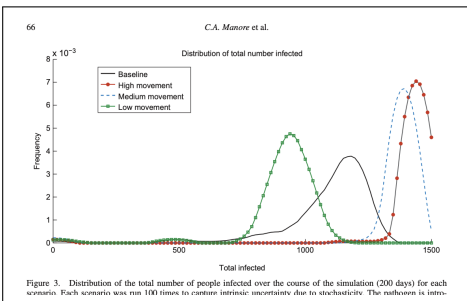
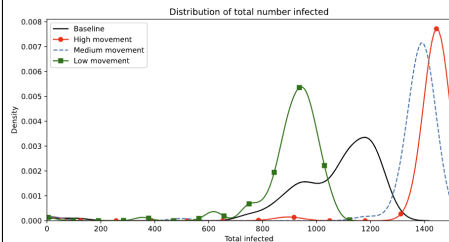


Figure from original paper [3].



Reproduced figure from simulations.

Research timeline

To achieve the research objectives within the required timeframe, I propose the following timeline:

	SEMESTER 1			WINTER BREAK								SEMESTER 2															
	May			Jun				Jul				Aug				Sep				Oct							
TASK TITLE	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	X2	30	31	32	33	34	
Thesis																											
Draft initial table of contents/structure, receive feedback																											
Problem, question, and literature																											
Organize relevant literature, create early draft of literature review																											
Draft of first chapter for context/motivation/purpose, etc.																											
Implementation and methods																											
Identify key technology and prelim. implementation details																											
Computationally encode behavioural frameworks																											
Reproduce/implement baseline VBD model																											
Extend model to build first version																											
Validation and preliminary experiments																											
Experiments and discussion (Phase 1 & 2)																											
Conduct final experiments																											
Analysis of resulting data from final experiments																											
Draft results chapter for analysis, results																											
Content and writing																											
Write full draft																											
Solicit feedback from supervisors																											
Incorporate feedback, re-draft & proofread																											
Submit thesis																											

Expected contributions and implications

This project will contribute a **methodological contribution** to the modelling community and an **investigation into an understudied area of research** in the field of vector-borne diseases:

Phase 1 will contribute:

- 1 an extension of an existing agent-based model with computational implementations of three psychological behavioural theories;
- 2 insights into how these decision-making processes affect the dynamics between disease spread and preventive behaviours.

Phase 2 will contribute:

- 1 an analysis of intervention characteristics that effectively promote preventive behaviours and curb disease spread.

Questions

Thank you—any questions?

Bibliography

- [1] W. H. O. (WHO), "Vector-borne diseases," Tech. Rep., Mar. 2020.
- [2] V. L. Champion and C. S. Skinner, "The Health Belief Model," in *Health behavior: Theory, research, and practice*, 5th ed., 2015, pp. 75–94.
- [3] C. A. Manore, K. S. Hickmann, J. M. Hyman, I. M. Foppa, J. K. Davis, D. M. Wesson, and C. N. Mores, "A network-patch methodology for adapting agent-based models for directly transmitted disease to mosquito-borne disease," en, *Journal of Biological Dynamics*, vol. 9, no. 1, pp. 52–72, Jan. 2015, ISSN: 1751-3758, 1751-3766. DOI: 10.1080/17513758.2015.1005698.