A Spatial Agent-Based Simulation Modeling in Public Health: Design, Implementation, and Applications for Malaria Epidemiology (Wiley Series in Modeling and Simulation)

Arifin, S. M. Niaz, Madey, Gregory R. and Collins, Frank H.
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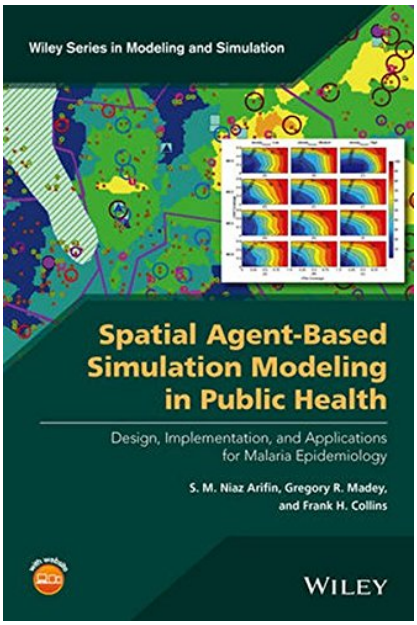

Malaria is still a major public health problem in developing countries, particularly in Sub-Saharan Africa and South Asia despite hundreds of millions of dollars spent on malaria prevention and treatment every year. According to the World Health Organization, about 212 million malaria cases occurred in 2015 and an estimated 429 000 people died of the disease. Malaria interventions are expensive to design, deploy and test, and computational tools to test the design of interventions before they are deployed offer a powerful way to make the whole process more effective. Agent Based Models with their ability to handle spatio-temporal dynamics of individuals as they interact with their environment and with each other provide a virtual laboratory for public health researchers to tackle such a complex task.

Arifin, Madey and Collins (AMC) provide a detailed account of their extensive research program on applying Agent Based Modelling (ABM) to malaria epidemiology and intervention testing in their 2016 book “Spatial Agent-Based Simulation Modeling in Public Health: Design, Implementation, and Applications for Malaria Epidemiology” (SABSMPH). SABSMPH is roughly (and expectedly) split into 2 parts: 1) malaria epidemiology and 2) agent based modelling. Both parts provide a lot of useful detail for members of the respective and opposite research communities. As a computational modeller I am much more familiar with ABM methods and ABM literature than with malaria epidemiology and I found the chapters and appendices dealing with malaria invaluable for my understanding of AMC’s research program and vector based infectious diseases in general. Modellers interested in simulating other vector based infectious diseases will benefit from information provided in chapters 2 (general introduction), 4 (biological core model of malaria), 9 (vector control interventions), and appendix A (enzyme kinetics model for vector growth and development).

SABSMPH provides a concise introduction to ABM (chapter 3) that provides non-modellers

with the necessary background information to appreciate the in-depth descriptions of the three different model implementations (non-spatial, spatial and landscape epidemiology). Chapter 5 introduces the basic, non-spatial, malaria model with a detailed description of the most important components of the model and their sequence of execution. No results are presented in this chapter. In chapter 6 space (including explicit environmental features such as aquatic habitats) is added to the model and the modelling of mosquito movement is described. This chapter also includes a description of the custom built landscape generator tool VectorLand. Results are presented here for the first time in this book including a comparison of outputs from the non-spatial and spatial models showing that outputs match very closely. As a reader I would have liked to see a discussion of the additional knowledge gained by adding space to the basic model. Unfortunately no such discussion is included. The spatial model is further refined with a Geographical Information System (GIS) layer in chapter 11 where the authors introduce their landscape epidemiological framework. Many results are presented in this chapter but again no critical discussion is provided that addresses the strengths and weaknesses of the most complex model of the three presented, nor are results put into context of earlier results.

AMC dedicated considerable space to the discussion of key aspects of any modelling approach: verification, validation, replication and reproducibility (chapters 7, 8, and 9). These necessary chapters make for a curious read: they offer a lot of detail (e.g. docking of various instances of the model written in C++ and Java) but detail that is outdated. Take for example chapter 9 where the authors lay out guidelines to promote replication and reproducibility. The first guideline refers to importance of a “conceptual image of the model”. Agreed, this is of major importance but why don’t the authors refer to the ODD (Overview, Design concepts, and Details; Grimm *et al.* 2006, 2010) protocol that provides a standardised way of describing a model in ever increasing layers of detail? A further guideline refers to the need for data and code sharing. The authors mention journals that make source code available but a much easier way would be a single access point for model code. OpenABM (https://www.openabm.org) is such a model repository that allows the versioned storage, sharing and referencing of model source code. OpenABM, unfortunately, does not provide unique digital object identifiers (doi). Most of what AMC suggest in 9.4 could be addressed by a wide spread adoption of the ODD protocol.

The presentation of some chapters feels disjoint from the rest of the book, a theme that is ever present in SABSMPH. Appendix A, for example, offers the reader a very detailed vector growth model with the content never used in the model. This appendix is briefly referenced in the main text but never properly contextualized. Vector control interventions are described in greatest detail in a chapter that is focused on replication and reproducibility (chapter 9). Other examples include chapter 10 (Landscape Epidemiology) and 11 (EMOD model). Chapter 10 does reference previous chapters but it reads more like a self-contained journal chapter than a chapter in a book. The EMOD chapter (written by guest authors from the Institute for Disease Modeling where the EMOD microsimulation framework was developed) is a complete stand-alone chapter and no attempt is made to integrate it into the rest of the book.

Readability of SABSMPH could have been greatly improved by providing a unifying frame for the chapters in this book. One obvious option would have been the systematic comparison of all the models presented in this book. What are the respective strengths and weaknesses of the non-spatial, spatial, landscape epidemiological and EMOD malaria

models? What deeper understanding (if any) does the spatial and landscape epidemiological model produce compared to the non-spatial model? How do assumptions of the EMOD and AMC models differ and how do these differences translate into different model outputs?

In summary, “Spatial Agent-Based Simulation Modeling in Public Health: Design, Implementation, and Applications for Malaria Epidemiology” is a very useful book for computational modellers and public health researchers alike. Its nostalgic flavour (exhibited mostly in chapters 7-9; also, the analysis tool is written in Perl!) prevents the book from being an up-to date resource on agent-based modelling (despite a 2016 publication date) but the presented comprehensive information on modelling a vector based disease such as malaria makes up for the missing discussion of recent trends in ABM design and dissemination.

References

GRIMM, V., *et al.* (2006). A standard protocol for describing individual-based and agent-based models. In: *Ecological Modelling*, 198, p. 115-126.

GRIMM, V., Berger, U., DeAngelis, D., Polhill, G., Giske, J. and S. Railsback (2010). The ODD protocol: A review and first update. In: *Ecological Modelling*, 221, p. 2760-2768.

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