Chapter 5.11
Modeling Malaria with Multi-Agent Systems

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ABSTRACT

Malaria is a vector-borne disease that greatly affects social and economic development. We adopt the complex system paradigm in our analysis of the problem. Our aim is to assess the impact of education on malaria healthcare. Multi-agent systems are employed to model the spread of malaria in Haiti, where we introduce malaria education as a possible way of regulating deaths due to the parasite. We launch three experiments, each with environment modifications: three hospitals; three hospitals and 20 schools; and five hospitals and 20 schools. The results of running 10 simulations for each experiment show that there is a reduction in malaria deaths not only when including schools, but in combination with increasing the number of hospitals.

INTRODUCTION

Our goal is to assess the effect of education on healthcare. We first introduce the global malaria problem, followed by the paradigm adopted for its analysis. This is followed by an insight into the current malaria situation in Haiti, the country we have chosen for our study.

The rest of the paper is organised as follows: the State-of-the-Art section introduces current efforts in the field; the following section discusses the model; then the three experiments and their results are presented; the Discussion part gives some conclusions and a brief analysis; finally, Future Work discusses ideas for future work.

Malaria

Malaria is a vector-borne disease that greatly affects social and economic development in the world. In 1990, it was estimated that approximately 2.2 billion people were at risk of contracting the parasite, and an additional 270 million were already infected. Endemic areas are characterised by "ideal" mosquito (anopheles being the parasite vector) habitats, which are largely where water is present, the temperature is at least 18ºC, and there is little pollution (Baudon, 2000). Many third-world rural areas meet these conditions. Efforts to eradicate this deadly disease have included using DDT to minimise the vector population and administering antimalarial drugs to susceptible people as a prevention. However, both methods have proved only temporarily effective. The former was first adopted in the mid-1950s with a subsequent significant global decrease in mosquito population. This was soon to become a failure when a resurgence of malaria was detected as a result of anopheles developing a resistance to the insecticide (Krogstad, 1996; WHO, 1996). The latter prophylaxis was the use of chloroquine as an antimalarial drug. Resistance of *Plasmodium falciparum* (the more prevalent and deadly of the four existing parasite species) to chloroquine emerged due to the massive usage of the drug (Payne, 1987). As a consequence, a novel way of combating this plague would have to be devised.

Complex Systems

Pavard (2002) describes a complex socio-technical system to be one for which it is difficult, if not impossible, to restrict its description to a limited number of parameters or characterising variables without losing its essential global functional properties. Indeed, from this definition, four characteristics of such a system appear: non-determinism; limited functional decomposability; distributed nature of information and representation; and emergence and self-organisation.

Simulation as a Tool for Understanding Complex Systems

The properties discussed previously show that dealing with a complex system entails dealing with the impossibility to anticipate precisely its behaviour despite knowing completely the function of its constituents. This, combined with non-linear behaviour, means that it is quite problematic, if not impossible, to use a mathematical or statistical approach for its analysis (Bagni et al., 2002; Pavard & Dugdale, 2002). It is for these reasons that computer simulations (in this paper, multi-agent systems, MAS) is a more viable method for exploring complex systems.

Studying complex systems through multi-agent systems has yielded useful results such as in the following: evolutionary population dynamics of settlement systems in the search of emerging spatial regularities (Aschan-Leygonie, 2000); demographic phenomena through its roots in individual choice behaviour and social interactions (Janssen & Martens, 2001); simulations of crowd behaviour aiming to understand its dynamic and consequent control (Gomez & Rowe, 2003; Hamagami et al., 2003).

Haiti

The level of poverty in Haiti is approximately 65% (PAHO, 2001), a socioeconomic factor affecting access to public healthcare. Not only is an adequate health infrastructure not fully developed, but individual poverty also hinders access to healthcare. This is aggravated further by not having the financial resources to travel