IMPACT OF HETEROGENEITY ON MALARIA DISEASE TRANSMISSION

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ABSTRACT

It is known that the distribution of malaria within an endemic community is non-homogeneous and therefore clustered. This heterogeneity of transmission is partly attributable to unequal susceptibility of human mosquito contact (Dye, 1986, Mendis, et.al, 1992) and partly due to non-geographical factors such as house construction types. Most mathematical models of malaria transmission to date, however, assume homogeneous transmission conditions within an area.

The present model deals with a malaria endemic situation in which humans were grouped into heterogeneous patches. Two types of heterogeneous patches have been considered. The first were geographical patches comprising distinct geographical boundaries having different mosquito densities and the second were conceptual patches definable by one or more of any of the malaria susceptibility factors such as age, sex, house construction type. The model took into consideration two categories of malaria infected persons. The first category contained those with clinical symptoms termed symptomatic patients and the second was those without clinical symptoms termed asymptomatic carriers.

A mathematical model of two first order coupled differential equations were developed separately to describe symptomatic patients and asymptomatic carriers. Using this model it was possible to estimate the variation which indicated the crossover of asymptomatics to symptomatics and vice versa during the period of transmission, which was observed at Kataragama , a malaria endemic area in southern Sri Lanka.

In the case of geographical patches, a method of computing the transmission of malaria between patches due to infected mosquitoes flying across boundaries was developed. The model incorporates a newly defined parameter named heterogeneous vectorial capacity, which is the heterogeneous version of the conventional vectorial capacity definition that has been extensively used to quantify transmission in homogeneous situations. Further the model is linked to

Geographical Information Systems (GIS) which is capable of performing spatial analysis.

In order to justify the mathematical model, it was tested by using the data from a comprehensive field study done at Kataragama, Sri Lanka, or realistic estimates taken from these data. In the case of geographical patches simple heterogeneous patches were used as shown in chapter 3 (Fig. 3.1). At this stage the conceptual patches were categorised according to house construction types.

Further the model was used to simulate the malaria cases in a well-surveyed area at Kataragama and compared the simulated values with observed malaria incidence. These simulations showed the close association between simulated and observed malaria incidence as shown in chapter 4.

Vector-borne parasitic diseases are a significant part of the disease burden in developing countries. Many countries devote substantial resources to the prevention and control of such diseases. These resources are limited in supply and need to be used wisely. It is important, therefore, to design control measures well, and to choose appropriate technologies, management systems and other elements of the control strategy, by using a variety of alternative control approaches. The present model predicts malaria incidences in the specific locality with reasonable manner. This is important in planning and designing effective and economic malaria control measures.

It is now being understood that eradication of malaria is a difficult task. The objective has now shifted to control or management of the disease in an optimum fashion. In order to perform control interventions efficiently it is necessary to consider the heterogeneous aspect of the disease transmission.

The results obtained from the heterogeneous transmission model are reasonable and within the bounds of the approximations we have made. In malaria control, it becomes important to understand the dynamics of transmission in a heterogeneous situation. This will enable targeted and economic forms of control, rather than using methods of blanket coverages.

Finally, it gives health planners a sophisticated mathematical model, linked with the geographic information systems, which enables the pre and post processing of detailed data and hence the ability to design optimum control strategies, which has become important from two angles;

1) Due to vector and parasite adaptation to disease

2) Due to rising economic cost of malaria control.