Objective I: Departmental Seminars (Biomaths Coffee)

Venue: Department of Mathematics, University of Pretoria, Pretoria

General Theme: The malaria control problem

Period: March-May 2018

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ABSTRACT

A series of lectures in the form of seminars during Biomath coffee were presented during the period March 15-31st May 2018 to the Biomath group at the University of Pretoria.

The first Seminar took place on the 27 March 2018 and was essentially on our research activities on the malaria control problem. During this seminar discussions centred on the notions and understanding of the differences between directly and indirectly transmitted diseases of humans and the definition of disease vectors and what the characteristics of the malaria vector are. Old or existing mathematical models for malaria were discussed while at the same time highlighting the author’s contributions. The aspects of stochastic modelling as applicable and used in the malaria transmission problem were also described. Finally, the author pointed to a new framework for modelling malaria that has been developed by the author and collaborators sighting the challenges that lie ahead. The new framework was going to be the subject of future seminars.

The second lecture centred on the dynamics of mosquito populations. It motivated the framework for modelling mosquito populations taking into the consideration the fact that mosquito must complete its reproductive of gonothrophic cycles if the mosquito population must survive. This particular lecture showed how one can quantify the reproductive gains that accrue to the mosquito population because of its interactions with the human population, and points out that the malaria parasite has exploited the life style of the mosquito by adapting its cycle so that one part of it is in the mosquito and the other part
completed in the human. This way the parasite can be transmitted from human to human as the mosquito bites humans for blood meals. Ways of modelling and counting mosquito populations were presented and discussed.

The third lecture was entitled “The Mosquito Centred Approach to the Dynamics and Transmission of malaria”. This lecture is the last and final one in which the techniques learnt in the two other parts of the lectures are used to demonstrate how mosquito centred activities can be used to study the dynamics and transmission of malaria within human and mosquito populations. The Lecture went over the structure of the Ross-type model for malaria transmission. It then looked at mosquito only dynamic model, human centred models for malaria dynamics and eventually the malaria model with mosquito demographics. The new frame work for modelling malaria dynamics was introduced to the group in a formal mathematical development. Eventually there was a list of open challenges for the future that were also discussed.

**Main outcome of the Seminars:** A main outcome of the seminar is the very fruitful interaction between members of the department that has resulted in a joint manuscript, tentatively entitled “On a three-stage structured model for the dynamics of malaria transmission with human treatment, adult vector demographics and one aquatic stage” that is under preparation. The work on the manuscript is at an advanced stage and there is a distinct and good possibility of a follow up scientific meeting during which the results of this joint interactive research will be presented.
Objective II: Public Lecture to the Pretoria University Community May 2018.

Title: The Dynamics of Malaria in Human and Mosquito Populations -- A Mathematical Modelling Perspective for the Case of Malaria Control

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ABSTRACT
Mathematical models have been used to improve our understanding of the biology of disease vectors as well as transmission dynamics of the diseases that vectors carry. The malaria disease is caused by a parasitic organism of the genus Plasmodium and is transmitted from human to human by the mosquito of the genus Anopheles. The use of insecticide impregnated bed nets and indoor spraying with insecticides, for the purpose of mosquito control, introduces a large variability in the mosquito’s population size which in turn has great impact on the malaria transmission and control. It is often customary, when addressing the malaria control problem, to treat the mosquito’s population density as a simple parameter that can be eliminated by insect control strategies, or treat the malaria infection itself as a simple parameter that can be treated with specified drugs or even the human population as compliant when it comes to drug use. So, one easily finds control programmes that treat the different aspects of the malaria control problem in isolation. However, the malaria parasite, an independent organism with survival instincts, has exploited the mosquito’s blood feeding habit by adapting its life history so that part of it is in the mosquito and the other part is in the human. So, in addition to the need to account for the behavioural traits of the mosquito as well as all those interactions with humans that can lead to the transfer of the infection from one human to the other via the mosquito, it is necessary to also quantify the net reproductive gain that accrues to mosquito when it successfully draws blood from humans, or to the parasite when it successfully gets transferred from one host to the other. The human-mosquito-Plasmodium interactive framework has become a complex African problem that must be well understood and controlled. The complexity of the problem partly explains the difficulty in controlling malaria as a disease in Africa, and also offers a rich source of problems and opportunities for interdisciplinary science. This Lecture shall dwell on a framework based on continuous time mathematical modelling approaches involving the three components (Human, malaria parasite and mosquito) in the malaria transmission chain showing the novelty in the approaches and the results obtained so far. We posit that collaborative endeavours involving mathematicians and experimental scientists and other stakeholders can speedily resolve the malaria control problem.
**Key words:** Mathematical modelling, Disease components, Mosquito-Human-Parasite interactive Framework

**Areas of Research:** Mathematical Epidemiology, Mathematical Modelling in Biological