Malaria dynamics with long incubation period in hosts

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The incubation period of malaria can vary depending on the species of parasite or the geographic regions. In particular, in endemic areas of temperate climate (for example in Korea), the incubation period of *Plasmodium vivax* shows bimodal distribution of short and long term incubation periods. Assuming fixed length for the long term incubation period (DDE) gives a distribution that is much closer to the empirical distribution in the most common probability metrics, than the exponentially distributed long term incubation period (ODE).

In this talk, we compare two transmission models for *P. vivax* malaria, where we model the long term incubation period using ordinary differential equations or delay differential equations. We identify the basic reproduction number R_0 and show that it is a threshold parameter for the global dynamics of the model. For the DDE model, the global analysis is performed using persistence theory and Lyapunov functionals. We show that, while the qualitative behaviors of the two models are similar, the ODE model overestimates the basic reproduction number and also the level of endemicity, compared to the DDE model. By calculating R_0, we can see that long incubation time is not beneficial to the parasite in a constant environment, thus its presence is connected to the seasonal mosquito activity in Korea. In contrast to the autonomous case, when we incorporate seasonality into our model equations, the interplay of the time delay and the periodicity results that in some situations the DDE model predicts higher prevalence of malaria. The periodic DDE model is also superior to periodic ODE in capturing the qualitative properties of the observed Korean malaria time series, while its mathematical analysis is rather challenging.

[1] K. Nah, G. Röst and Y. Kim, Modelling malaria dynamics in temperate regions with long term incubation period. *BIOMAT 2013 - Proc. International Symposium on Mathematical and Computational Biology* (2014), 263–285.

[2] K. Nah, Y. Nakata, G. Röst, Malaria dynamics with long incubation period in hosts. *Computers and Mathematics with Applications* (2014).