

Project Details	
Project Code	PHS27Br Unwin
Title	Who Infects Whom? Probabilistic Modelling of Malaria Transmission
Research Theme	Population Health Sciences
Project Type	Dry lab
Summary	This project offers an exciting opportunity to tackle a global health challenge using cutting-edge statistical and computational methods such as Hawkes Processes. You will develop and apply probabilistic models to uncover how malaria spreads without relying on unreliable travel histories. The project combines real-world data, genetics, spatial modelling, and modern probabilistic programming, giving you the chance to shape new methodology and see it make a tangible impact. You will collaborate with international experts and engage with stakeholders to ensure your work informs elimination strategies. This is ideal for students interested in statistics and data science with meaningful real-world impact.
Description	Background According to the World Health Organisation's (WHO's) World Malaria Report there were 282 million cases of malaria around the world in 2024. Malaria is a tropical disease transmitted to humans through the bite of an infected female mosquito; when the mosquito feeds on blood, it injects malaria parasites into the bloodstream that go on to cause illness. The WHO launched a global technical strategy in 2016 to reduce malaria cases and deaths by 90% and eliminate the disease in multiple countries by 2030 through universal access to care, targeted elimination efforts, and strong surveillance systems. Elimination is achieved when local person to person transmission is disrupted, however it is hard to ascertain where a person is infected with the disease. State of the art methods include asking individuals about their travel history, which is flawed since individuals don't necessarily recall their movements correctly, or using genetic sequencing in rare occasions, which is expensive. Therefore there is scope to develop a new way of understanding transmission that is inexpensive and doesn't require travel information. Previous research (Unwin et al 2021) has shown that Hawkes Process can be successfully used to tease apart contributions to transmission between locally driven infections and importations. Hawkes Processes are mathematically well-founded point processes that comprise of a background term, representing importations, and a kernel term, representing locally acquired infection. These methods can be fit to data using your favourite inference frameworks such as Maximum Likelihood or Bayesian methods. It is easy to work out the probability that each infection in your list of cases infected each other, either through a latent parameter in your inference scheme or a simple calculation. Additional data sources such as the spatial location of infections and genetic distances between the parasites sampled from individuals give us a unique opportunity to develop novel methodology to recreate who infected whom and so understand the dynamics of transmission without relying on existing unsatisfactory methods.

	This project will focus on understanding transmission in areas such as Zanzibar, which is an archipelago consisting of two islands off the coast of Tanzania. In 2018, the island developed a national malaria strategic plan to eliminate the disease by 2023. However, despite early promise and the success of vector control campaigns and good case detection and treatment, there has been a rebound. This has partially been attributed to malaria being imported into the islands by locals from regions in Tanzania where malaria is highly endemic. A project partner, Prof Jon Juliano, collected case information as part of a 1.5-year study that finished at the end of 2023 to explore what insights our modelling can have to inform the elimination programme. Additional data will be sought from additional countries to provide a comparison. Key Research Question The overarching research question is: Can Hawkes Processes be used to recreate transmission chains and elucidate on what is driving malaria transmission in areas such as Zanzibar? Objectives Objective 1: Probabilistic programming language (PPL) comparison - Conduct a comprehensive literature review to identify PPLs that could be used to fit infectious disease models. PPLs are programming languages designed to make it easy to define, manipulate, and perform inference on probabilistic models. - Compare the ease of use and accuracy of these different tools for Hawkes Processes Ownership opportunity: The student can use this to familiarise themselves with the existing software and choose what coding language and PPL they want to use for the following objectives. Objective 2: Hawkes process model development - Consider seasonal transmission to parameterise the kernel and background infection intensity. - Explore how to parameterise different species of parasite (e.g. falciparum or vivax) - Explore efficient inference algorithms to ensure accurate but efficient results. Ownership opportunity: The student can choose to explore data from different global settings to identify differences. Objective 3: Recreating transmission chains - Increase the model complexity to include genetic and spatial data in the Hawkes Process. First we will consider simulated data building up to analyse the Zanzibar case study and any other additional data found. - Develop methodology to recreate who infected whom. Ownership opportunity: The student will be able to visit Dr Shazia Ruybal-Pesántez and Prof Jon Juliano to become an expert in the data and own the application of applying these new methods to these data. They will also have opportunities to seek out additional data to consider. Objective 4: Stakeholder engagement - Conduct a PPIE (Patient and Public Involvement and Engagement) event to help explore model assumptions. - Estimate what is driving transmission in different case studies - Develop resources to communicate findings with nation malaria elimination control programmes
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	Ownership opportunity: The student will design activities to engage members of the public in discussion as well as create non-technical outputs to share with stakeholders
Can be completed part time?	Yes
Supervisory Team	
Lead Supervisor	
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