Part A: Intestinal & urogenital schistosomiasis dual-infection focus:
Investigating age-infection relationships for school-aged children along shoreline of Lake Malawi

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Introduction

Schistosomiasis can cause lifelong morbidity with children most vulnerable to disease. Infection rates are often characterized by local heterogeneities in transmission, which leads to the importance of identifying high risk areas and ways to improve tailored control.

Along the shoreline of Lake Malawi, both intestinal (IS) and urogenital (UGS) schistosomiasis is now occurring from *Schistosoma mansoni* and *S. haematobium* infections respectively, despite annual praziquantel treatment in all schools.

In this poster, I present a secondary analysis of epidemiological data collected from school-aged children (SAC) in Mangochi District, Lake Malawi to assess age-infection profiles.

Photo credit: JR Stothard

Data sources

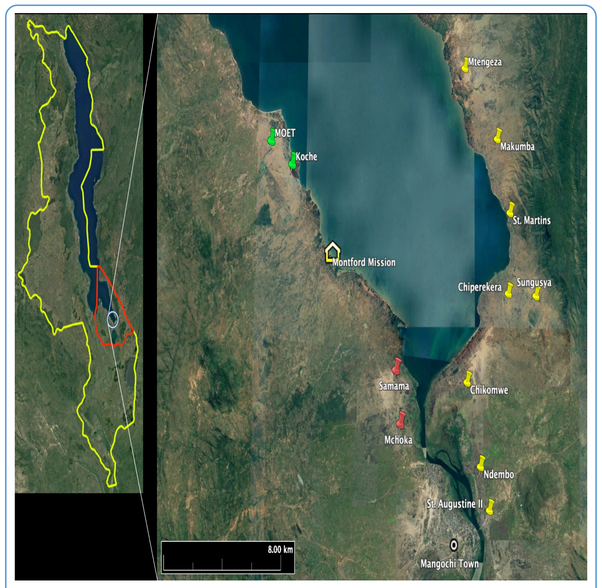
In 2019, a parasitology survey of SAC was carried out in June[1], being a follow-up and expanded surveillance study upon initial confirmation of the emergence and outbreak of IS[2]. There were three phases of the 2019 study:

Phase 1: 80 SAC from Mchoka (MC) and Samama (SA) school (red) – *an annual follow-up,*

Phase 2: 60 SAC from Moet and Khoche school (green) – *a thorough assessment of two schools near known snail vectors,*

Phase 3: 30 SAC sampled at all the others schools (yellow) – *a rapid surveillance map of lakeshore schools.*

The schools' locations are shown on the map.



Model Formulation

Let Yij be a **binary response** for individual SAC i at a named school j. This follows Yij is either Yij=1 if SAC had an **infection-positive** result or Yij=0 if the SAC has an **infection-negative** result at named school j. The following equations can represent the distribution of the model as.

$$Y_{ij}|X_{ij} \sim Bernoulli(p_{ij}),$$
$$p_{ij} = E(Y_{ij}|x_{ij}).$$

These give a logistic regression with Bernoulli distribution and mean p_{ij}. The x_{ij} is a vector of the explanatory variables with the ith subject (i=1, 2,….n) with jth school (j=1,2,…..k), where n is the number of subjects and k is the sample of schools. We then represent the model as a generalised additive model (GAM),

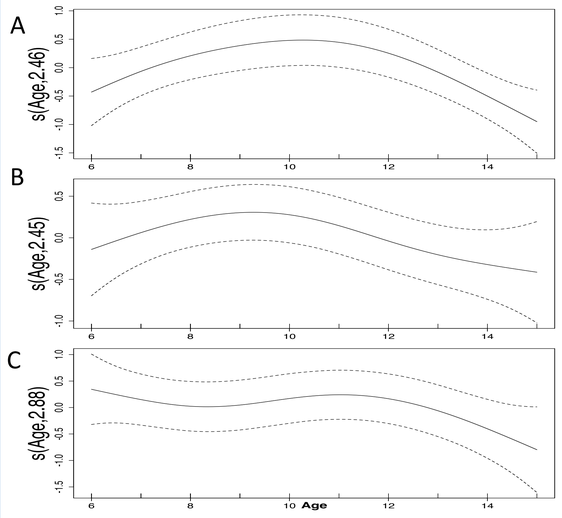
$$\boldsymbol{logit}(\boldsymbol{p_{ij}}) = \boldsymbol{\alpha} + \boldsymbol{x_{ij}^T} + \boldsymbol{\beta} + \boldsymbol{s}(\boldsymbol{z_{ij}}, \boldsymbol{\phi})$$

where s is the smooth function of z_{ij} given ϕ where z_{ij} denotes the age of the SAC i at school j. GAM allow us to adjust the smoothness of the predictor functions and make the assumption that the predictor relationship is smooth in nature when the true predictor relationship may be more noisy.

Results

GAM smooth term

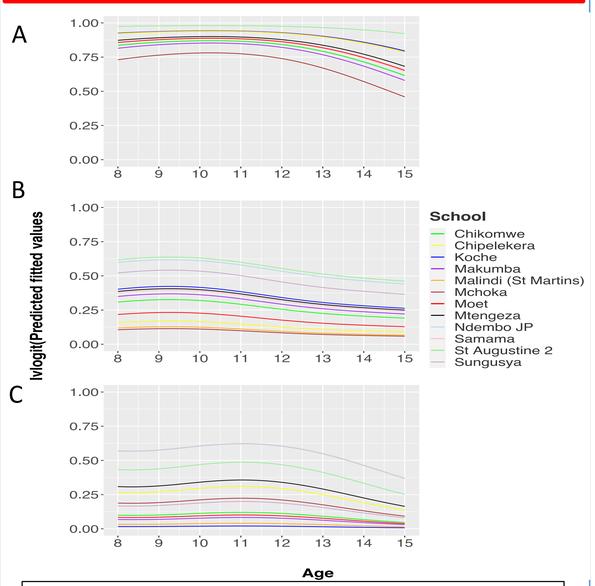
Inverse logit of smooth term for Schistosoma *infection association with age of SAC adjusted for age and school*



All schools dual-infection of **A** *S.m.* [T+] **B** *S.m.* [T-] **C** *S.h.*

GAM covariates

Inverse logit predicted values for Schistosoma *infection association with age of SAC adjusted for age and school*



Dual-infection of **A** *S.m.* [T+] **B** *S.m.* [T-] **C** *S.h.*

Table 2: IS and UGS GAM of the smooth term age adjusted for school

	S.mansoni				*S.haematobium*	
	T+	CI	T-	CI		CI
AIC	468		581		475	
Smooth term						
Age (p-value)	0.000844***		0.111		0.115	
Factors (estimate coefficient)						
School						
Samama	0.767*	[0.0206, 1.51]	1.63***	[0.718, 2.54]	1.75***	[1.03, 2.47]
Moet	0.796.	[−0.0251, 1.62]	0.856.	[−0.162, 1.87]	-0.940.	[−0.202, 0.138]
Koche	1.52**	[0.540, 2.50]	1.72***	[0.797, 2.68]	-2.62*	[−4.68, −0.567]
StAugustine2	2.63*	[0.576, 4.69]	2.61***	[1.55, 3.68]	1.19*	[0.271, 2.12]
NdemboJP	0.621	[−0.465, 1.71]	2.53***	[1.47, 3.60]	1.74***	[0.807, 2.67]
Sungusya	1.48*	[0.186, 2.78]	2.21***	[1.16, 3.28]	-0.143	[−1.26, 0.975]
Malindi(StMartins)	1.47*	[0.169, 2.76]	0.132	[−1.29, 1.56]	-1.92.	[−3.99, 0.155]
Chikomwe	0.634	[−0.393, 1.66]	1.33	[0.201, 2.45]	-0.745	[−2.07, 0.578]
Chipelekera	1.47*	[0.168, 2.76]	0.461	[−0.851, 1.77]	0.445	[−0.546, 1.44]
Makumba	0.484	[−0.503, 1.47]	1.51**	[0.408, 2.62]	-1.16	[−2.70, 0.386]
Mtengeza	0.928.	[−0.160, 2.02]	1.67**	[0.580, 2.76]	0.656	[−0.314, 1.63]
Mchoka						

Summary of Results

- Six schools (SA, Koche, St Augustine 2, Sungusya, Malindi (St Martins), Chipelekera) all had significant evidence to suggest as SAC aged the log odds of being positive for *S.m.* increased compared to MC school.
- Koche school had significant evidence to suggest as SAC the log odds of being positive *S.h.* decreases and St Augustine 2 and Ndembo increases compared to MC school.
- *S.m.* infection [T+] smooth term prediction goes from negative to positive versus age up to age 11 and before decreasing back to negative.
- For *S.m.*, St Augustine 2 had the highest and Sungusya school had the lowest prevalence rates.
- For *S.h.,* there was no clear pattern for prevalence versus age for SAC at all the schools.

Conclusions

There is an increasing prevalence of IS in SAC up to around 11 years before decreasing there afterwards. By contrasts, no clear age-infection pattern for UGS was found. Peak of infection is expected around adolescent. This peak in prevalence at age 11 may be due acquired immunity which is known as 'peak shift' phenomenal or could be explained by factors for instance water exposure[3]. A further investigation (Part B) was carried out to study the role of IS and UGS co-infection impact on disease dynamics and whether the age-profiling of infection changes.

Acknowledgements

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1. Kayuni, S.A., O'Ferrall, A.M., Baxter, H., Hesketh, J., Mainga, B., Lally, D., Al-Harbi, M.H., LaCourse, E.J., Juziwelo, L., Musaya, J. and Makaula, P., 2020. An outbreak of intestinal schistosomiasis, alongside increasing urogenital schistosomiasis prevalence, in primary school children on the shoreline of Lake Malawi, Mangochi District, Malawi. *Infectious Diseases of Poverty*, 9(1), pp.1-10.

2. Mohammad H Alharbi et al. "Biomphalaria pfeifferi Snails and Intestinal Schistosomiasis, Lake Malawi, Africa, 2017-2018". In: 25.3 (2019), pp. 613–615

3. M. E.J Woolhouse. "Patterns in Parasite Epidemiology: The Peak Shift". In: *Parasitology Today* 14.10 (1998), pp. 428–434.