E^2M^2 2019: Ecological & Epidemiological Modeling in Madagascar

Seasonality of tuberculosis in Madagascar

RAHERINANDRASANA Antso Hasina

MD, MPH

Plan

- Background
- Questions of research
- Methods
- Results
- Future directions

Background (1)

PMC full text: J Glob Infect Dis. 2011 Jan-Mar; 3(1): 46–55.
doi: 10.4103/0974-777X.77296

Table 1

A summary of studies deals with TB seasonality

References	Study period	Patients no.	Country	Months peak	Months decline
Akhtar and Mohammad[1]	January I, 1997 to December 31, 2006	4608	Kuwait	March –August (Sping-summer)	August–December (autumn–winter)
Leung *et al.*[7]	1999–2002	82,104	Hong Kong	July–August (summer)	January–February (winter)
Nagayama and Ohmori[4]	1998 and 2000–2003	NA	Japan	March–August (spring – summer)	November–February (autumn–winter)
Thorpe *et al.*[8]	April 1,1996 to June 31, 2001	11 11,101	India	April –June (spring)	October and December (autumn)
Ríos *et al.*[9]	1971–1996	9187	Spain	February–June (spring)	July–January (summer–winter)
Luquero *et al.*[10]	1996–2004	71,553	Spain	First peak in June and second peak in March and October	October–February (autumn–winter)
Ane-Anyangwe *et al.*[11]	April, 2002–July 2004	2809	South Western Cameroon	April–November (winter)	November–March (summer)
Schaaf *et al.*[6]	1 November 1983 to 31 October 1993	1204	South Africa	September–November (spring)	March–August (autumn–winter)
Atun *et al.*[12]	January 1999–December 2002	420,00	Russia	No seasons peak	
Douglas *et al.*[13]	1983–1992	57,313	UK	April–September (summer)	October–March (winter)
Kelsey *et al.*[14]	1993–1994	55	UK and Ireland	April–September (summer)	October–March (winter)
Naranbat *et al.*[15]	1998–2006	149,07	Mongolia	April –June (spring)	September–December (autumn– winter)

Background (2)

- Potential stimuli of seasonal tuberculosis disease: Vit D deficiency, indoor activities, seasonal change in immune function, delays in the diagnosis and treatment of tuberculosis
- Factors related to tuberculosis notification variability seasonal variation in food availability and food intake, age, sex

Background (3)

- The prevalence of tuberculosis was influenced by the time and space interaction effect
- Average temperature, rainfall, wind speed, and air pressure has influenced tuberculosis prevalence

Research questions

1. What is the seasonality of TB in Madagascar?
2. What are the drivers of TB seasonality in Madagascar?

Methods

Data

- TB data was extracted from TB register at the center of diagnostic and treatment of TB in Analakely Antananarivo.
- Period: 2010-2014
- Climate data

Methods

Analysis

- Winter period: April to September
- Summer period: October to march

Question 1 :

- Generalized additive model

Question 2:

- Generalized linear model (drivers of seasonality)
- SEIR model to assess the mechanism of seasonality

4. Results (1)

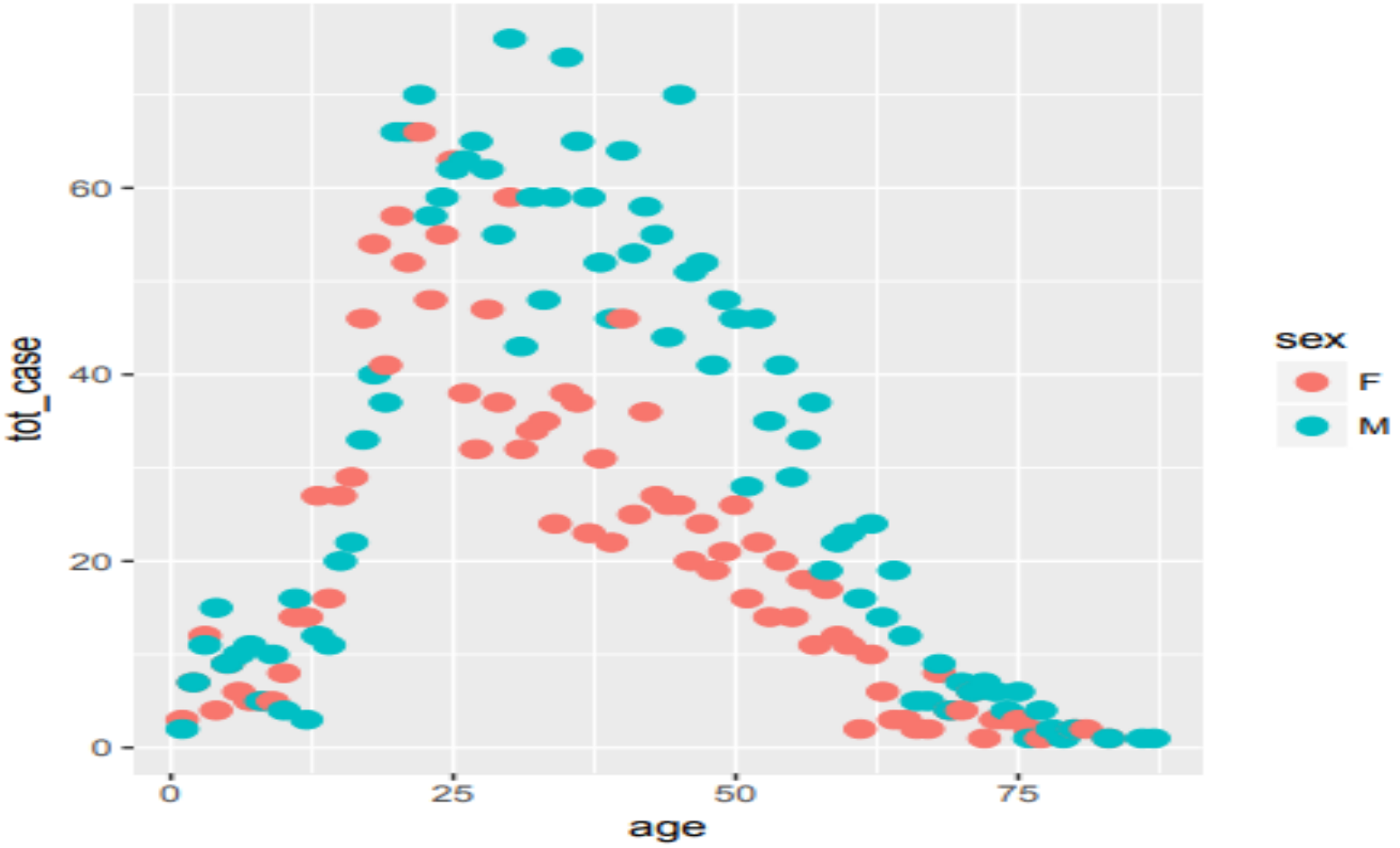


Figure 1: distribution of tb cases by age and gender

4. Results (2)

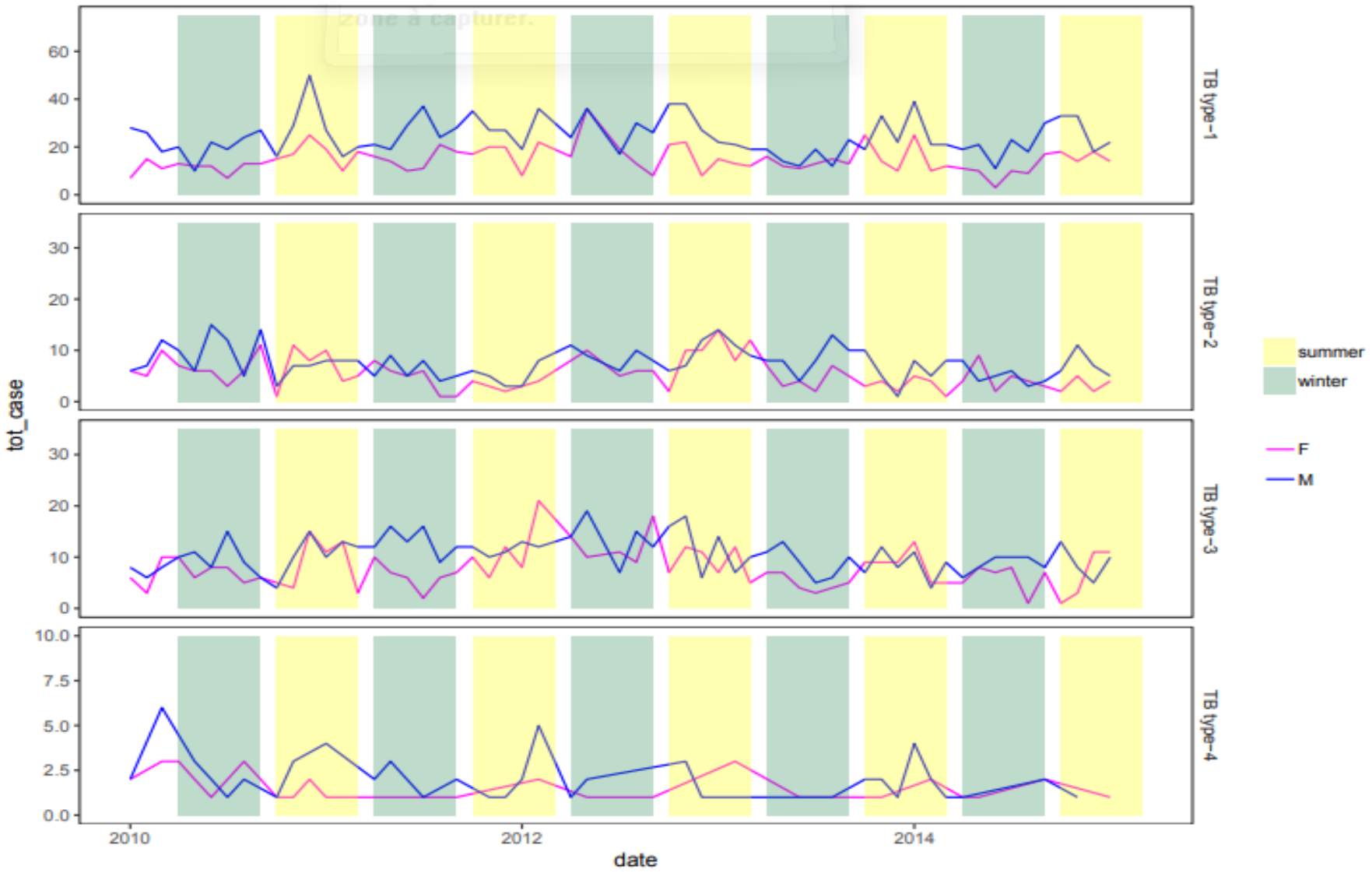


Figure 2: seasonal variation of TB case through time by gender and TB type

4. Results (3)

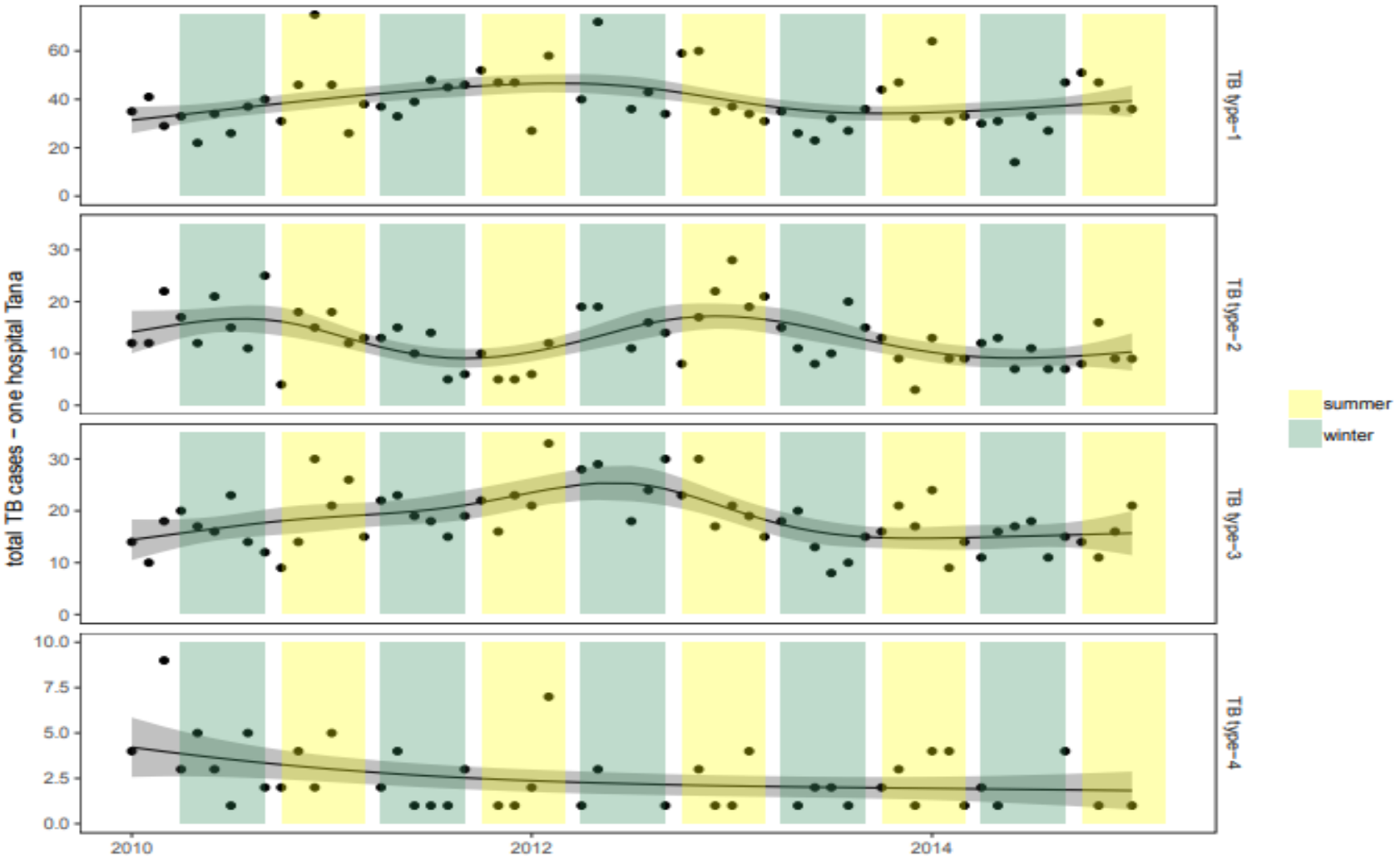


Figure 3: GAM by TB type accros the time series

4. Results (5)

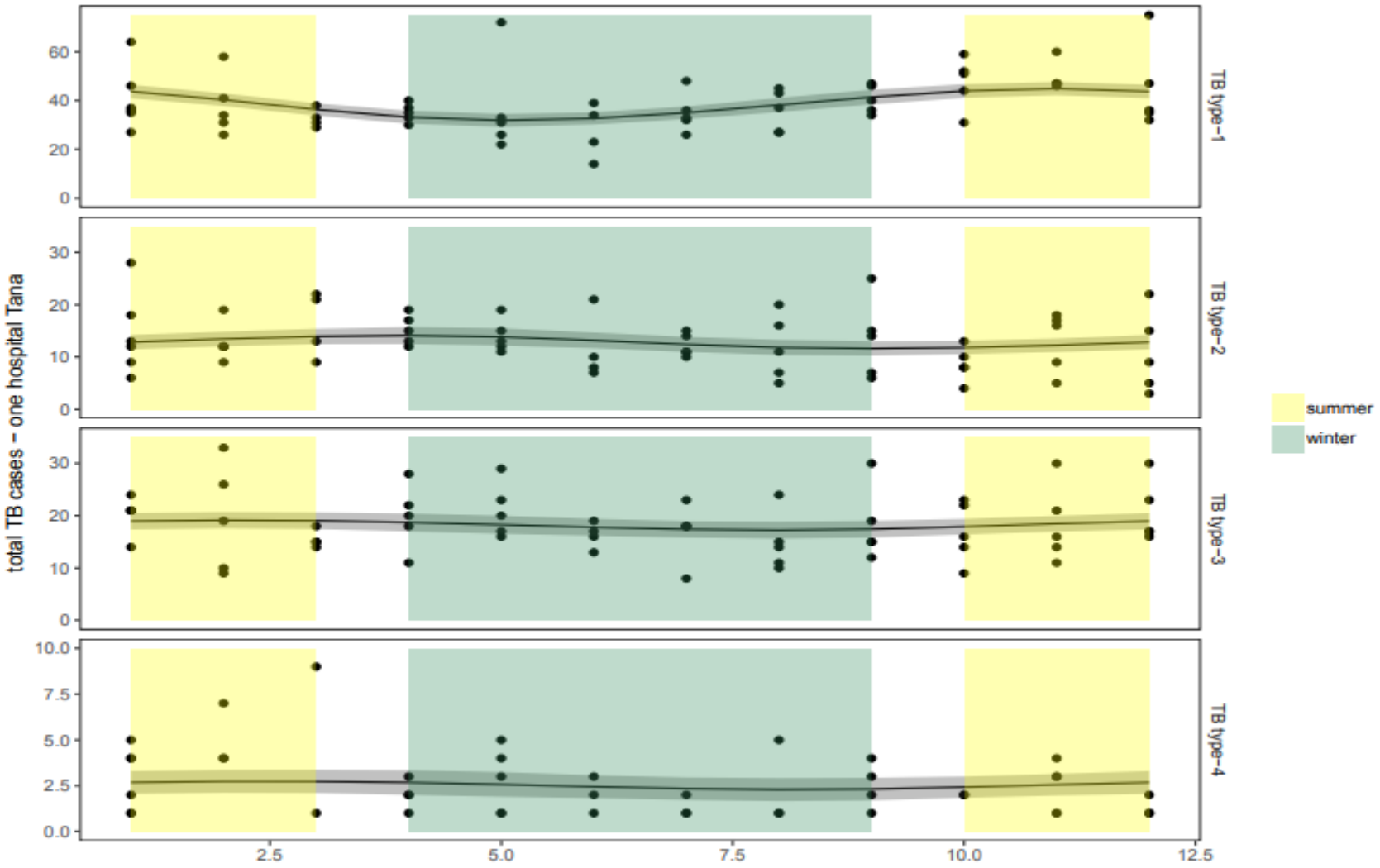


Figure 4: GAM by TB type within a year

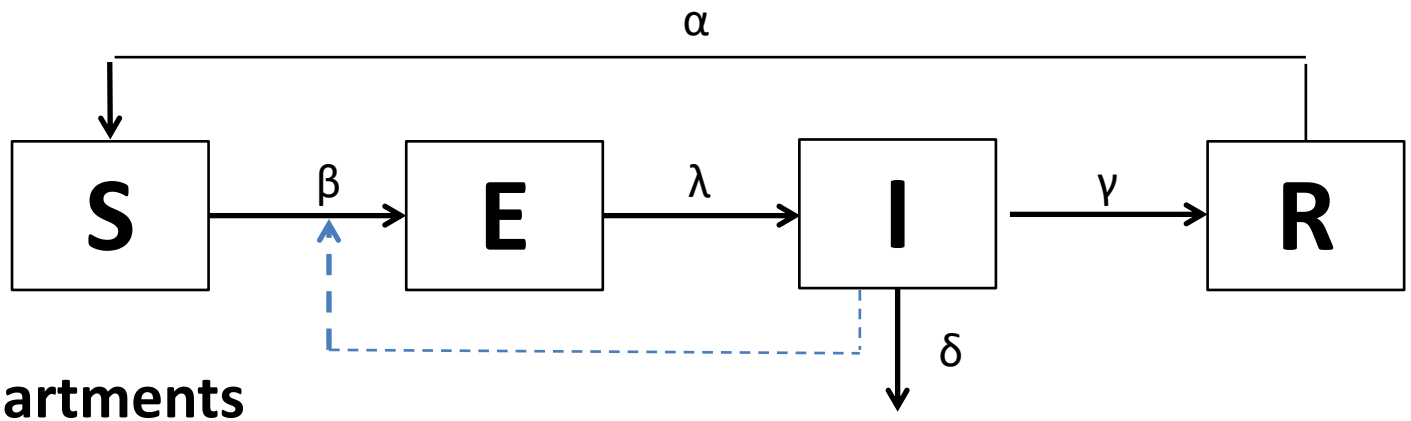
Next steps

- Collect more data (more sites, more years, HIV data)
- Go through the second objective (drivers of seasonality and the mechanism of tb seasonality)

Drivers of seasonality

m=glm(**tb_case_month**~age+sexe+tb_type+rainfall+temperature +humidity, family='poisson', data=tb.data)

Mechanistic model



Compartments

S: susceptible

E: Exposed (Infected)

I: infectious

R: recovered

Parameters

β : transmission rate

λ: progression rate

γ : recovery rate

δ: disease induced mortality

α: replenishment rate

Equations

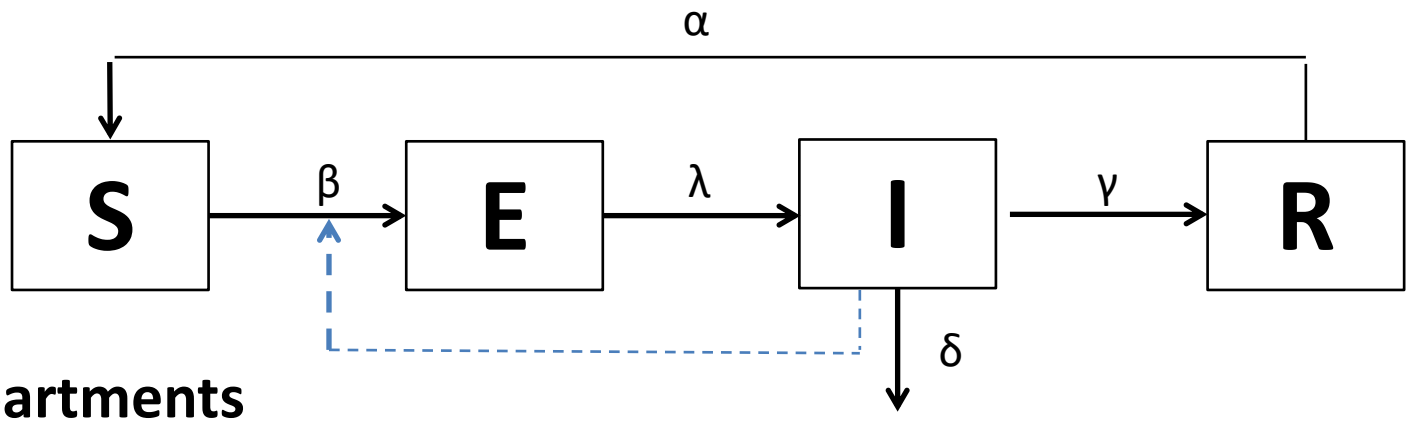
$dS/dt = -\beta S(t)I(t) + \alpha R(t)$

$dL/dt = \beta S(t)E(t) - \lambda L(t)$

$dI/dt = \lambda L(t) - \gamma I(t) - \delta I(t)$

$dR/dt = \gamma I(t) - \alpha R(t)$

Mechanistic model



Compartments

S: susceptible

E: Exposed (Infected)

I: infectious

R: recovered

Equations

$dS/dt = -\beta S(t)I(t)+\alpha R(t)$

$dL/dt = \beta S(t)E(t) - \lambda L(t)$

$dI/dt = \lambda L(t) - \gamma I(t) - \delta I(t)$

$dR/dt = \gamma I(t) - \alpha R(t)$

Parameters

β : transmission rate

λ: progression rate

γ : recovery rate

δ: disease induced mortality

α: replenishment rate

$\beta = \beta 1 * \phi$

MISAOTRA INDRINDRA!