

### Supplementary Material 3 - Estimates and 95% credibility intervals of posterior of model effects and observed versus predicted series

The statistical model was adjusted for the time series,  $y_{itk}$ , with  $t$  indicating the week  $t$ ,  $t = 1$  is the first epidemiological week of 2008 and  $t = 766$  is the 37<sup>th</sup> epidemiological week of 2022, and  $k = 1,2,3$ , indicates the age range (below, within and above vaccine range).

The expected number of cases for each location, age group and year to be considered in the model is then given by

$$E_{itk} = m_0 P_{ika}/n_a$$

where  $P_{ika}$  is the population at location  $i$ , age range  $k$  and year  $a$ , which is repeated for every epidemiological week  $t$  within year  $a$ , and  $n_a$  is the number of epidemiological weeks within year  $a$ ; and  $m_0$  is the gross annual rate obtained from the absolute incidence in the ten regions in the whole period, calculated as

$$m_0 = \frac{\sum_{i=1}^{40} \sum_{a=1}^{15} \sum_{k=1}^3 y_{ika}}{\sum_{i=1}^{40} \sum_{a=1}^{15} \sum_{k=1}^3 P_{ika}},$$

where  $y_{ika}$  and  $P_{ika}$  are the number of dengue cases and population in location  $i$ , age group  $k$  and year  $a$ , respectively, for  $i = 1, \dots, 40$ ,  $k = 1,2,3$ , and  $a = 1, \dots, 15$  ( $a = 1$  is the year 2008).

A Poisson probability distribution was assumed for  $y_{itk}$

$$y_{itk} \sim \text{Poisson}(E_{itk}\lambda_{itk})$$

where  $\lambda_{itk}$  is the hazard ratio for location  $i$ , at time  $t$  and age group  $k$  relative to the annual rate of the ten health regions under study.

It is assumed that the linear predictor  $\log(\lambda_{itk})$  is a function of various terms or components, as specified below:

$$\log(\lambda_{itk}) = \alpha_i + \delta_k I(\text{Agegroup}_{ik}) + \beta_1 \text{Serotype}_{1i} + \beta_2 \text{Serotype}_{2i} + \beta_3 \text{Serotype}_{3i} + \beta_4 \text{Serotype}_{4i} + \beta_5 \text{Climate}_{it} + \beta_6 \text{VC}_{it} + r_{itk} \text{ where}$$

- $\alpha_i$  logarithm of the hazard ratio at location  $i$  in the vaccine age group,
- $\delta_k$  additional (log)hazard ratio of non-vaccine age group  $k$ ,
- $\beta_1, \dots, \beta_4$  additional (log)hazard ratios due to the presence of serotypes 1 to 4,
- $\beta_5$  effect of the climate variable,
- $\beta_6$  effect of the vaccine coverage,

- $r_{itk}$  residual temporal effect.

Thus, the specific temporal variation for each location  $i$  is given by  $\alpha_i + r_{itk}$ .

### Model estimation method

The Bayesian inference paradigm was used to estimate the model parameters. A Poisson likelihood is considered for the observed data, conditional on the expected number of cases,  $E_{itk}$ , and hazard ratio,  $\lambda_{itk}$ . For the effects of the factors in the model, an a priori distribution of  $N(0,1000)$  is considered. For the specific temporal random effect of each location, an a priori autoregressive distribution of order 2, AR2, is considered for each location but with common parameters. For the precision parameter, we considered an a priori distribution suggested by [21], with  $P(\sigma > 1) = 0.1$ . For the partial autocorrelation parameters, we adopted PC priors with parameters and (3,0.01) and (0.5,0.5)[22].

For the calculation of the posterior distributions, we considered a Laplace approximation, for the conditional distribution to the hyperparameters and the correction proposed by [23].

Table 1: Estimated coefficients with standard deviations and 95% credibility intervals.

| Variables      | mean   | sd    | 0.025quant | 0.975quant |
|----------------|--------|-------|------------|------------|
| Assaí          | -3.468 | 0.168 | -3.799     | -3.138     |
| BV Aparecida   | -4.903 | 0.231 | -5.356     | -4.450     |
| BV Paraíso     | -2.880 | 0.136 | -3.147     | -2.613     |
| C Sul          | -4.051 | 0.232 | -4.506     | -3.597     |
| Cambará        | -4.983 | 0.203 | -5.381     | -4.585     |
| Cambé          | -3.426 | 0.122 | -3.664     | -3.187     |
| F Iguaçu       | -2.754 | 0.113 | -2.974     | -2.533     |
| Ibiporã        | -3.291 | 0.134 | -3.554     | -3.027     |
| Iguaraçu       | -4.649 | 0.266 | -5.172     | -4.128     |
| Itambaracá     | -4.420 | 0.239 | -4.888     | -3.952     |
| Jataizinho     | -1.128 | 0.118 | -1.359     | -0.896     |
| Leópolis       | -5.016 | 0.303 | -5.610     | -4.422     |
| Londrina       | -3.339 | 0.114 | -3.562     | -3.116     |
| M Melo         | -4.640 | 0.275 | -5.179     | -4.102     |
| Mandaguari     | -4.573 | 0.168 | -4.903     | -4.244     |
| Marialva       | -4.431 | 0.159 | -4.743     | -4.120     |
| Maringá        | -4.013 | 0.104 | -4.216     | -3.810     |
| Maripá         | -4.184 | 0.216 | -4.608     | -3.760     |
| Paiçandu       | -4.577 | 0.158 | -4.887     | -4.268     |
| Paranaguá      | -5.620 | 0.165 | -5.943     | -5.297     |
| Porecatu       | -3.182 | 0.154 | -3.485     | -2.879     |
| Santa Fé       | -3.813 | 0.169 | -4.145     | -3.482     |
| Sarandi        | -3.927 | 0.121 | -4.164     | -3.690     |
| Sertanópolis   | -2.755 | 0.137 | -3.024     | -2.486     |
| SI Ivaí        | -3.643 | 0.189 | -4.013     | -3.273     |
| SJ Ivaí        | -5.103 | 0.284 | -5.661     | -4.546     |
| SM Iguaçu      | -4.120 | 0.171 | -4.456     | -3.785     |
| SS Amoreira    | -5.303 | 0.263 | -5.820     | -4.787     |
| ST Itaipu      | -3.078 | 0.142 | -3.357     | -2.798     |
| Tapira         | -3.635 | 0.176 | -3.981     | -3.289     |
| RS 01 (6)      | -5.975 | 0.185 | -6.338     | -5.613     |
| RS 09 (6)      | -3.407 | 0.131 | -3.664     | -3.150     |
| RS 10 (24)     | -4.003 | 0.113 | -4.225     | -3.782     |
| RS 12 (20)     | -3.388 | 0.096 | -3.576     | -3.200     |
| RS 14 (26)     | -3.467 | 0.107 | -3.676     | -3.258     |
| RS 15 (21)     | -3.710 | 0.110 | -3.925     | -3.495     |
| RS 17 (13)     | -2.019 | 0.112 | -2.238     | -1.799     |
| RS 18 (18)     | -4.280 | 0.125 | -4.525     | -4.035     |
| RS 19 (21)     | -4.791 | 0.119 | -5.025     | -4.558     |
| RS 20 (17)     | -4.056 | 0.108 | -4.267     | -3.846     |
| Abaixo vacinal | -0.475 | 0.004 | -0.483     | -0.466     |
| Acima vacinal  | -0.044 | 0.004 | -0.051     | -0.038     |
| DENV1          | 1.252  | 0.127 | 1.004      | 1.501      |
| DENV2          | 0.005  | 0.087 | -0.165     | 0.175      |
| DENV3          | -0.299 | 0.179 | -0.649     | 0.052      |
| DENV4          | 0.051  | 0.072 | -0.091     | 0.193      |
| VC             | -0.207 | 0.023 | -0.252     | -0.161     |
| Climate        | 1.832  | 0.095 | 1.646      | 2.018      |

Table 2: Summary of model hyperparameters.

| Parameters | mean | sd | 0.025quant | 0.975quant |
|------------|------|----|------------|------------|
|------------|------|----|------------|------------|

| Parameters         | mean   | sd    | 0.025quant | 0.975quant |
|--------------------|--------|-------|------------|------------|
| Precision for week | 0.200  | 0.007 | 0.186      | 0.213      |
| PACF1 for week     | 0.981  | 0.001 | 0.980      | 0.982      |
| PACF2 for week     | -0.480 | 0.012 | -0.503     | -0.457     |

Figure 1: Estimated specific temporal variation by municipality and 95% credible intervals.

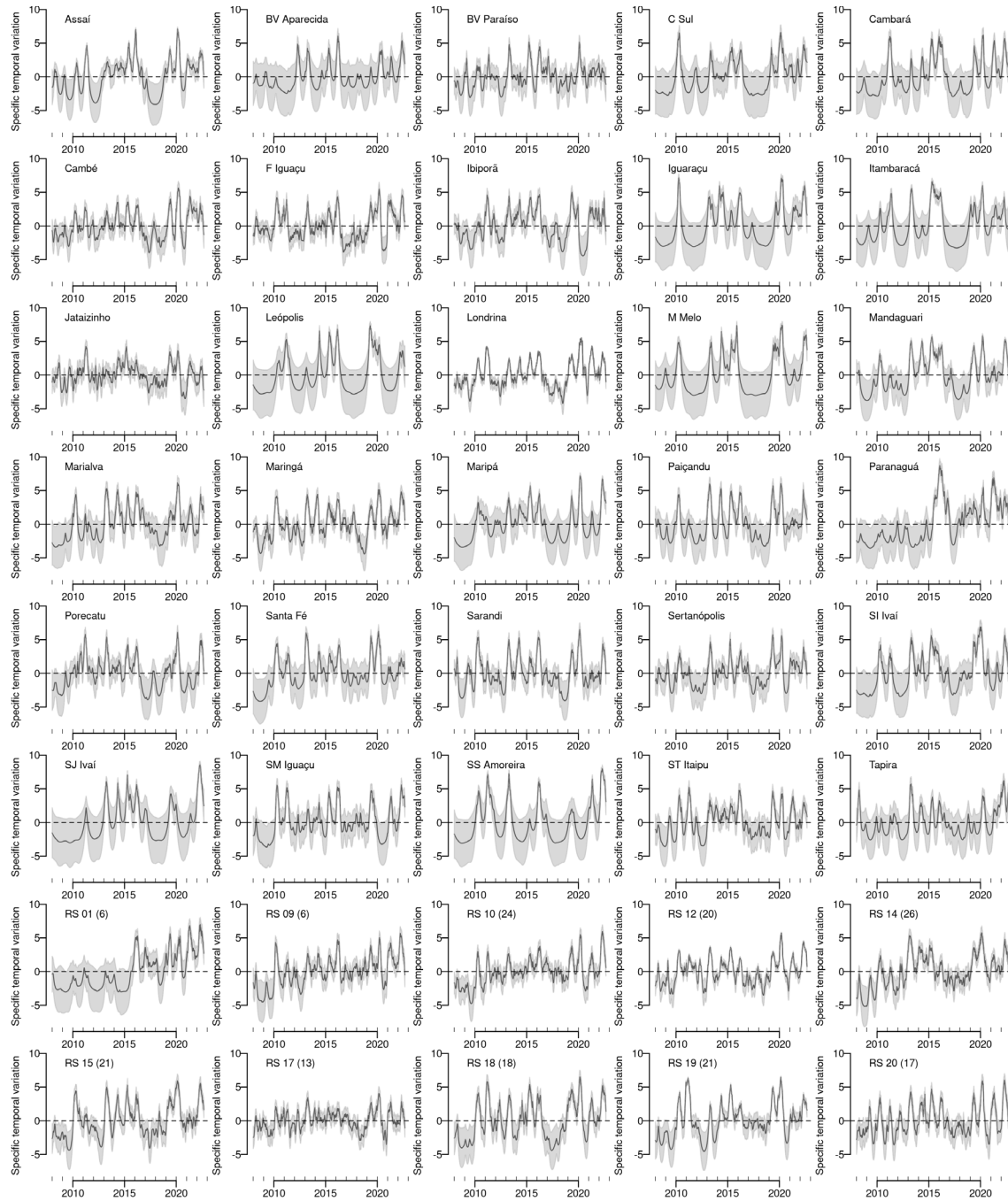


Figure 2: Time series of observed and model estimated cases of dengue, from 2008 to 2022, in 40 locations.

