## Supplementary- model specifications

## 1 Model 1A - Poisson log linear model without temporal parametric trend

$$
\begin{aligned}
y_i &\sim Poisson(\mu_i) \\
\mu_i &= \theta_i\, e_i \\
log(\mu_i) &= \beta_0 + \beta_{PM2.5} PM2.5 + \beta_{Rural} I + log(e_i) \\
\beta_k &\sim Normal(0{,}3^2)
\end{aligned}
$$

## 2 Model 1B - Poisson log linear model with temporal parametric trend

$$
\begin{aligned}
y_i &\sim Poisson(\mu_i) \\
\mu_i &= \theta_i\, e_i \\
log(\mu_i) &= \beta_0 + \beta_{PM2.5} PM2.5_i + \beta_{Rural} I_i + \beta_{Year} Year_i + log(e_i) \\
\beta_k &\sim Normal(0{,}3^2)
\end{aligned}
$$

## 3. Model 2A - Poisson log linear model with county level random intercept without temporal parametric trend

$$
\begin{aligned}
y_i &\sim Poisson(\mu_i) \\
\mu_i &= \theta_i\, e_i \\
log(\mu_i) &= \beta_0 + \beta_{PM2.5} PM2.5_i + \beta_{Rural} I_i + \beta_{Year} Year_i + v_i + log(e_i) \\
\beta_0 &\sim Normal(-0.0207, 0.0117) \\
\beta_{PM2.5} &\sim Normal(0.0731, 0.0227) \\
\beta_{Rural} &\sim Normal(0.0313, 0.0180) \\
v_i &\sim Normal(0, \sigma_v^2) \\
\sigma_v^2 &\sim Inverse - Gamma(1, 0.01)
\end{aligned}
$$

## 4. Model 2B - Poisson log linear model with county level random intercept with temporal parametric trend

$$
\begin{aligned}
y_i &\sim Poisson(\mu_i) \\
\mu_i &= \theta_i\, e_i \\
log(\mu_i) &= \beta_0 + \beta_{PM2.5} PM2.5_i + \beta_{Rural} I_i + \beta_{Year} Year_i + v_i + log(e_i) \\
\beta_0 &\sim Normal(-0.0264, 0.0175) \\
\beta_{PM2.5} &\sim Normal(0.0747, 0.0233)
\end{aligned}
$$

$$\beta_{Rural} \sim Normal(0.0316, 0.0182)$$

$$\beta_{Year} \sim Normal(0.00210, 0.00488)$$

$$v_i \sim Normal(0, \sigma_v^2)$$

$$\sigma_v^2 \sim Inverse - Gamma(1, 0.01)$$

**5. Model 3A - Poisson log linear model with county level spatial random intercept without temporal parametric trend**

$$y_i \sim Poisson(\mu_i)$$

$$\mu_i = \theta_i \, e_i$$

$$log(\mu_i) = \beta_0 + \beta_{PM2.5} PM2.5_i + \beta_{Rural} I_i + \beta_{Year} Year_i + u_i + log(e_i)$$

$$\beta_0 \sim Normal(-0.0207, 0.0117)$$

$$\beta_{PM2.5} \sim Normal(0.0731, 0.0227)$$

$$\beta_{Rural} \sim Normal(0.0313, 0.0180)$$

$$u_i | u_{j \neq i} \sim Normal\left(\frac{\sum_{j \neq i} c_{ij} u_i}{\sum_{j \neq i} c_{ij}}, \frac{\sigma_u^2}{\sum_{j \neq i} c_{ij}}\right)$$

$$\sigma_u^2 \sim Inverse - Gamma(1, 0.01)$$

**6. Model 3B - Poisson log linear model with county level spatial random intercept with temporal parametric trend**

$$y_i \sim Poisson(\mu_i)$$

$$\mu_i = \theta_i \, e_i$$

$$log(\mu_i) = \beta_0 + \beta_{PM2.5} PM2.5_i + \beta_{Rural} I_i + \beta_{Year} Year_i + u_i + log(e_i)$$

$$\beta_0 \sim Normal(-0.0264, 0.0175)$$

$$\beta_{PM2.5} \sim Normal(0.0747, 0.0233)$$

$$\beta_{Rural} \sim Normal(0.0316, 0.0182)$$

$$u_i | u_{j \neq i} \sim Normal\left(\frac{\sum_{j \neq i} c_{ij} u_i}{\sum_{j \neq i} c_{ij}}, \frac{\sigma_u^2}{\sum_{j \neq i} c_{ij}}\right)$$

$$\sigma_u^2 \sim Inverse - Gamma(1, 0.01)$$

**7. Model 4A - Poisson log linear model with county level spatial and non-spatial random intercept without temporal parametric trend**

$$y_i \sim Poisson(\mu_i)$$

$$\mu_i = \theta_i e_i$$

$$log(\mu_i) = \beta_0 + \beta_{PM2.5} PM2.5_i + \beta_{Rural} I_i + \beta_{Year} Year_i + u_i + v_i + log(e_i)$$

$$\beta_0 \sim Normal(-0.0207, 0.0117)$$

$$\beta_{PM2.5} \sim Normal(0.0731, 0.0227)$$

$$\beta_{Rural} \sim Normal(0.0313, 0.0180)$$

$$u_i | u_{j \neq i} \sim Normal\left(\frac{\sum_{j \neq i} c_{ij} u_i}{\sum_{j \neq i} c_{ij}}, \frac{\sigma_u^2}{\sum_{j \neq i} c_{ij}}\right)$$

$$v_i \sim Normal(0, \sigma_v^2)$$

$$\sigma_u^2 \sim Inverse - Gamma(6.3462, 0.1280)$$

$$\sigma_v^2 \sim Inverse - Gamma(22.8692, 0.6121)$$

**8. Model 4B - Poisson log linear model with county level spatial and non-spatial random intercept without temporal parametric trend**

$$y_i \sim Poisson(\mu_i)$$

$$\mu_i = \theta_i e_i$$

$$log(\mu_i) = \beta_0 + \beta_{PM2.5} PM2.5_i + \beta_{Rural} I_i + \beta_{Year} Year_i + u_i + v_i + log(e_i)$$

$$\beta_0 \sim Normal(-0.0264, 0.0175)$$

$$\beta_{PM2.5} \sim Normal(0.0747, 0.0233)$$

$$\beta_{Rural} \sim Normal(0.0316, 0.0182)$$

$$\beta_{Year} \sim Normal(0.00210, 0.00488)$$

$$u_i | u_{j \neq i} \sim Normal\left(\frac{\sum_{j \neq i} c_{ij} u_i}{\sum_{j \neq i} c_{ij}}, \frac{\sigma_u^2}{\sum_{j \neq i} c_{ij}}\right)$$

$$v_i \sim Normal(0, \sigma_v^2)$$

$$\sigma_u^2 \sim Inverse - Gamma(6.3361, 0.1262)$$

$$\sigma_v^2 \sim Inverse - Gamma(22.8458, 0.6145)$$