### Model setup

Let be the number of new cases country has on day .   
*Note: we will need to decide on how many countries and days are in our model!*

We assume that each , where the mean and variance of is assumed to be some .

Let the covariate vector pertaining to the country in the month be defined as

We assume an intercept, , in our model, as well as…Not sure exactly how we want to word our inclusion of the other covariates.

Thus, we have .

Then, we assume the counts can be modeled with a Poisson GLMM such that

where is a vector of unobserved country-level random effects. We assume that

So, in our model, is the deviation of the country from the baseline number of new cases, and is the deviation of the country from the average effect of (these covariates?) on number of new cases.

### Poisson GLMM with random intercept and slope:

As in all GLMM’s, the random effects are actually unobservable. Therefore, in order to obtain the likelihood, we must integrate them out.

Thus, we must perform separate integrals for each , NUMBER OF COUNTRIES in total, which share common distribution determined by .

This likelihood can be represented as the following:

The log-likelihood is therefore

is the Poisson PMF with mean , as defined above, and is the bivariate Normal PDF with mean 0 and covariance matrix .

### GOAL: Maximize log likelihood with to obtain estimates for and .

**(An article that might be helpful:** <https://www.jstage.jst.go.jp/article/jjb/29/2/29_2_61/_pdf> **)**

Marginal posterior distribution over the random effects:

is conditional Poisson likelihood given , with the joint prior distribution for .

**STEPS TO FIND THE MLEs:**

* Function for the log likelihood for the ith subject
* Log proposal density function
* Proposal function, MVN(0,G)
* Random Walk Metropolis – within - Gibbs
* E – step
* M – step