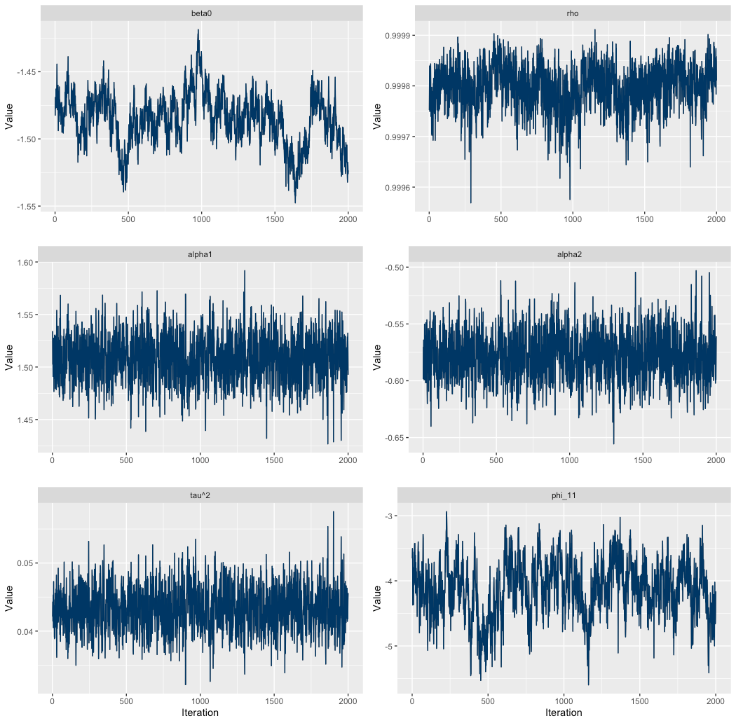
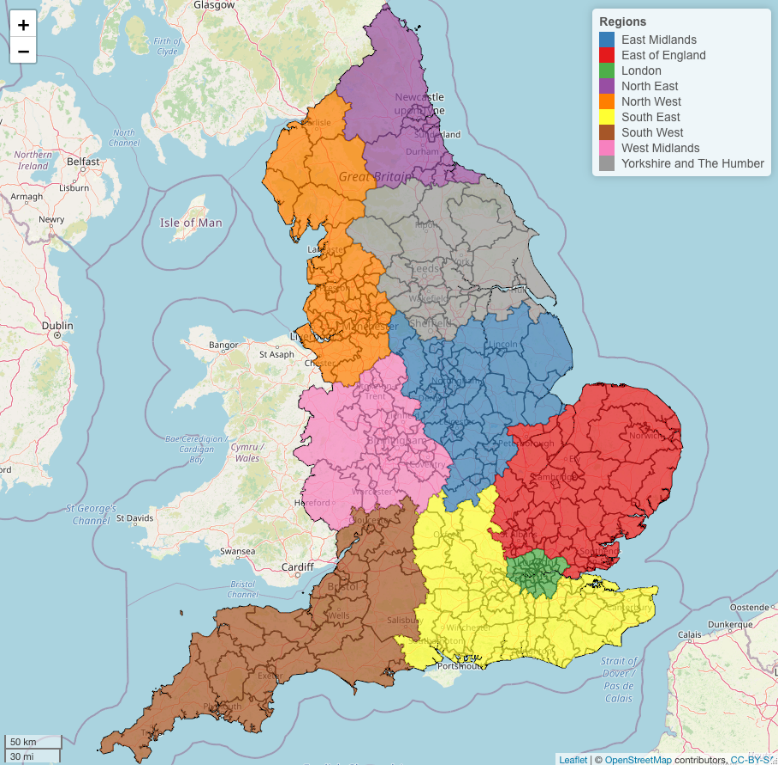
Supplementary Materials

In Section 2.1.4., we accounted for age and sex demographics via indirect standardisation, using weekly expected mortality counts. These are computed as follows. Let denote the number of people in LAD from age-sex group (e.g. females 0-4, females 5-9, etc.) for , and let denote the English national rate of Covid-19 mortality per 100,000 people. The expected weekly number of mortalities in LAD can then be computed as , and they do not change over time as time-varying data on populations or national rates at a weekly scale are not available. However, these expected counts may not be on the same scale as the weekly observed counts , and so the expected counts are rescaled by . The rescaling ensures that , so that the total of observed and expected counts over all areas and weeks are the same.

In Section 3.1., we have provided Geweke diagnostics to comment on the convergence of the MCMC algorithm. Additionally, the following trace plots of the simulated parameter values for , ρ, , , , and from the MCMC algorithm can be viewed:



Note that there are 20,904 (312 x 67) random effects, so we only present the trace plot for here.  
The algorithm is slower to explore the parameter spaces of and but none of the six plots shows any pattern that provides strong evidence against convergence.

Section 3.3. looked at regional differences in temporal trends in mortality risks in England. The regions we are referring to are presented on the map below. The lines within the regions show the LAD borders.  


Section 3.4. identified LADs with similar temporal trends in mortality risks using the k-means algorithm. We confirmed that clustering is meaningful for our data by checking the within-cluster sum of squares plots that showed a substantial drop when moving from one cluster to two clusters. We chose the optimal number of clusters by checking the average silhouette plots, which showed that the average silhouette width was the largest for 2 clusters in lockdowns 1 and 3. The plots are provided below:  
