Supplementary material

**Spatio-temporal epidemiology of SARS-CoV-2 virus lineages in Teesside, UK, in 2020: effects of socio-economic deprivation, weather, and lockdown on lineage dynamics**

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# **Supplementary Figures and Tables**

## **Data and Trends**

**Table S1:** Total resident population and proportion of the population within the 10th decile of the Index of Multiple Deprivation (when assessed at the scale of England as a whole), for each Teesside postcode district.

|  |  |  |
| --- | --- | --- |
| Postcode district | Population | Proportion 10th Decile |
| TS1 | 16994 | 0.997 |
| TS2 | 780 | 1 |
| TS3 | 29253 | 0.949 |
| TS4 | 16966 | 0.789 |
| TS5 | 39387 | 0.133 |
| TS6 | 30239 | 0.410 |
| TS7 | 22058 | 0.141 |
| TS8 | 21266 | 0.204 |
| TS9 | 12832 | 0 |
| TS10 | 36800 | 0.303 |
| TS11 | 11822 | 0 |
| TS12 | 22491 | 0.070 |
| TS13 | 9975 | 0.160 |
| TS14 | 17548 | 0.077 |
| TS15 | 12891 | 0 |
| TS16 | 10422 | 0 |
| TS17 | 44889 | 0.163 |
| TS18 | 24163 | 0.422 |
| TS19 | 37087 | 0.380 |
| TS20 | 20663 | 0.229 |
| TS21 | 12472 | 0.004 |
| TS22 | 8662 | 0 |
| TS23 | 30241 | 0.120 |
| TS24 | 22019 | 0.630 |
| TS25 | 38616 | 0.392 |
| TS26 | 25253 | 0.204 |
| TS27 | 12193 | 0.207 |
| TS28 | 5318 | 0.001 |
| TS29 | 6300 | 0.002 |

## **Disease Mapping**

A picture containing map

Description automatically generated

**Figure S1**: Map of the exceedance probabilities for relative risk threshold of 1.5. Relative risk is very likely to exceed 1.5 when probabilities are close to 1, and very unlikely when values are close to 0 (values around 0.5 have the highest uncertainty).

Timeline, map

Description automatically generated

**Figure S2**: Map of the exceedance probabilities for relative risk threshold of 2. Relative risk is very likely to exceed 2 when probabilities are close to 1, and very unlikely when values are close to 0 (values around 0.5 have the highest uncertainty).

## **Mixed-effect Modelling**

A picture containing diagram

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**Figure S3**: Predicted and observed total number of positive cases of COVID-19 (across all lineages) in Teesside during 2020. The predicted estimates (blue) are fitted values from the simplified version of the GLMM for all cases with a random intercept for postcode.

**Table S2**: Summary of the simplified version of the all-cases GLMM with a random intercept for postcode; effects of spatial (10th Decile of IMD, postcode district total population) and temporal variables (mean weekly temperature and rainfall, and government interventions and subsidy) on the total number of positive PCR tests recorded each week of 2020 in each postcode district. All temporal variables include a two-week time lag to account for the delay in symptom onset (and testing) after infection. Variables with a VIF > 3 were removed from this model (Week of year). Estimates are on the original model scale (log).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Estimate | Std. Error | z value | p value |
| Intercept | -0.997 | 0.236 | -4.219 | <0.001 |
| Temperature | -0.039 | 0.013 | -3.088 | 0.002 |
| Rainfall | 0.055 | 0.026 | 2.151 | 0.031 |
| Lockdown 1 | -0.087 | 0.016 | -5.346 | <0.001 |
| Lockdown 2 | 0.270 | 0.048 | 5.628 | <0.001 |
| Tier 2 | 0.486 | 0.063 | 7.674 | <0.001 |
| Tier 3 | 0.535 | 0.066 | 8.052 | <0.001 |
| Restaurant Subsidy | 0.065 | 0.061 | 1.072 | 0.284 |
| IMD 10th Decile | 0.478 | 0.241 | 1.986 | 0.047 |
| Total Population | 0.061 | 0.007 | 9.285 | <0.001 |

**Table S3**: Summary of the full version of the all-cases GLMM with a random intercept for postcode; effects of spatial (10th Decile of IMD, postcode district total population) and temporal variables (mean weekly temperature and rainfall, week of year, and government interventions and subsidy) on the total number of positive PCR tests recorded each week of 2020 in each postcode district. All temporal variables include a two-week time lag to account for the delay in symptom onset (and testing) after infection. The VIF of Week of Year was > 3, which means all of the below standard errors, z values, and p values may be unreliable (though the estimates are accurate). Estimates are on the original model scale (log).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Estimate | Std. Error | z value | p value |
| Intercept | -0.990 | 0.233 | -4.249 | <0.001 |
| Temperature | -0.129 | 0.015 | -8.676 | <0.001 |
| Rainfall | -0.097 | 0.028 | -3.418 | <0.001 |
| Lockdown 1 | -0.020 | 0.017 | -1.192 | 0.233 |
| Lockdown 2 | -0.235 | 0.064 | -3.687 | <0.001 |
| Week of Year | 0.057 | 0.005 | 10.845 | <0.001 |
| Tier 2 | 0.051 | 0.069 | 0.735 | 0.463 |
| Tier 3 | -0.135 | 0.083 | -1.632 | 0.103 |
| Restaurant Subsidy | 0.270 | 0.061 | 4.414 | <0.001 |
| IMD 10th Decile | 0.505 | 0.246 | 2.052 | 0.040 |
| Total Population | 0.061 | 0.007 | 9.079 | <0.001 |

**Table S4**: Summary of the all-cases GLMM with a random gradient for week of year for each postcode; effects of spatial (10th Decile of IMD, postcode district total population) and temporal variables (mean weekly temperature and rainfall, and government interventions and subsidy) on the total number of positive PCR tests recorded each week of 2020 in each postcode district. All temporal variables include a two-week time lag to account for the delay in symptom onset (and testing) after infection. VIF values for all variables were < 3. Estimates are on the original model scale (log).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Estimate | Std. Error | z value | p value |
| Intercept | -1.312 | 0.279 | -4.701 | <0.001 |
| Temperature | -0.121 | 0.014 | -8.421 | <0.001 |
| Rainfall | -0.089 | 0.028 | -3.230 | 0.001 |
| Lockdown 1 | -0.016 | 0.016 | -0.964 | 0.335 |
| Lockdown 2 | -0.243 | 0.061 | -3.990 | <0.001 |
| Week | 0.064 | 0.007 | 8.917 | <0.001 |
| Tier 2 | 0.040 | 0.066 | 0.605 | 0.545 |
| Tier 3 | -0.173 | 0.080 | -2.172 | 0.030 |
| Restaurant Subsidy | 0.258 | 0.059 | 4.380 | <0.001 |
| IMD 10th Decile | 0.348 | 0.226 | 1.536 | 0.124 |
| Total Population | 0.062 | 0.006 | 10.321 | <0.001 |

**Table S5**: Random effect estimates for the all-cases GLMM with a random gradient for week of year for each postcode. Estimates are on the original model scale (log).

|  |  |  |  |
| --- | --- | --- | --- |
| Postcode District | Estimate | Std. Error | 95% CI |
| TS1 | -0.037 | 0.012 | [-0.06, -0.014] |
| TS10 | -0.018 | 0.011 | [-0.04, 0.004] |
| TS11 | -0.023 | 0.014 | [-0.05, 0.005] |
| TS12 | -0.008 | 0.013 | [-0.034, 0.018] |
| TS13 | 0.003 | 0.017 | [-0.031, 0.037] |
| TS14 | -0.026 | 0.013 | [-0.051, -0.001] |
| TS15 | -0.003 | 0.016 | [-0.034, 0.027] |
| TS16 | 0.010 | 0.017 | [-0.024, 0.043] |
| TS17 | 0.013 | 0.012 | [-0.01, 0.037] |
| TS18 | 0.017 | 0.014 | [-0.009, 0.044] |
| TS19 | 0.027 | 0.013 | [0.002, 0.052] |
| TS2 | -0.010 | 0.019 | [-0.046, 0.027] |
| TS20 | 0.014 | 0.014 | [-0.013, 0.042] |
| TS21 | 0.006 | 0.016 | [-0.025, 0.038] |
| TS22 | -0.014 | 0.015 | [-0.043, 0.014] |
| TS23 | 0.019 | 0.014 | [-0.008, 0.046] |
| TS24 | 0.035 | 0.016 | [0.004, 0.065] |
| TS25 | 0.026 | 0.013 | [0.001, 0.052] |
| TS26 | 0.023 | 0.014 | [-0.004, 0.051] |
| TS27 | 0.019 | 0.017 | [-0.014, 0.052] |
| TS28 | 0.026 | 0.020 | [-0.014, 0.065] |
| TS29 | 0.031 | 0.019 | [-0.007, 0.069] |
| TS3 | -0.031 | 0.011 | [-0.052, -0.009] |
| TS4 | -0.018 | 0.011 | [-0.04, 0.005] |
| TS5 | -0.014 | 0.011 | [-0.036, 0.008] |
| TS6 | -0.019 | 0.011 | [-0.041, 0.003] |
| TS7 | -0.017 | 0.012 | [-0.04, 0.007] |
| TS8 | -0.042 | 0.011 | [-0.064, -0.019] |
| TS9 | -0.015 | 0.014 | [-0.042, 0.013] |

Diagram

Description automatically generated

**Figure S4**: Rate of change in predicted positive tests of COVID-19 (across all lineages) in Teesside during 2020, from the GLMM with a random gradient for week for each postcode district. Predicted values represent the increase in cases over time relative to the mean, when all fixed effects are held constant, and only the random effects (week and postcode) are allowed to vary. Predicted values were calculated via the “ggeffects” R package.

**Table S6**: Summary of the simplified versions of the separate lineage GLMMs with a random intercept for postcode; effects of spatial (10th Decile of IMD, postcode district total population) and temporal variables (mean weekly temperature and rainfall, week of year, and government interventions and subsidy) on the total number of positive PCR tests recorded each week of 2020 in each postcode district, for each of the 8 most common lineages of SARS-CoV-2. All temporal variables include a two-week time lag to account for the delay in symptom onset (and testing) after infection. Variables with a VIF > 3 were removed from this model. All models include a random intercept for postcode, except where the model was singular (B.1.1.309 and B.1.1.37). Estimates are on the original model scale (log) (Continued on next page).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Lineage | Variable | Estimate | Std. Error | z value | p value |
| B.1.1.1 | Intercept | -1.574 | 0.749 | -2.102 | 0.036 |
| B.1.1.1 | Temperature | -0.248 | 0.047 | -5.326 | <0.001 |
| B.1.1.1 | Rainfall | -0.165 | 0.096 | -1.714 | 0.087 |
| B.1.1.1 | Lockdown 1 | 0.132 | 0.040 | 3.301 | <0.001 |
| B.1.1.1 | Lockdown 2 | -1.267 | 0.547 | -2.315 | 0.021 |
| B.1.1.1 | Tier 2 | -0.334 | 0.272 | -1.229 | 0.219 |
| B.1.1.1 | Tier 3 | -1.558 | 0.658 | -2.368 | 0.018 |
| B.1.1.1 | Restaurant Subsidy | 0.567 | 0.220 | 2.575 | 0.010 |
| B.1.1.1 | IMD 10th Decile | 1.163 | 0.630 | 1.845 | 0.065 |
| B.1.1.1 | Total Population | 0.053 | 0.019 | 2.808 | 0.005 |
| B.1.1.119 | Intercept | -1.202 | 0.652 | -1.845 | 0.065 |
| B.1.1.119 | Temperature | -0.281 | 0.040 | -6.976 | <0.001 |
| B.1.1.119 | Rainfall | -0.094 | 0.086 | -1.088 | 0.276 |
| B.1.1.119 | Lockdown 1 | 0.118 | 0.039 | 3.005 | 0.003 |
| B.1.1.119 | Restaurant Subsidy | -0.202 | 0.351 | -0.575 | 0.565 |
| B.1.1.119 | IMD 10th Decile | 1.388 | 0.708 | 1.961 | 0.050 |
| B.1.1.119 | Total Population | 0.063 | 0.021 | 3.038 | 0.002 |
| B.1.1.309 | Intercept | -2.937 | 0.428 | -6.869 | <0.001 |
| B.1.1.309 | Rainfall | 0.109 | 0.049 | 2.245 | 0.025 |
| B.1.1.309 | Lockdown 2 | -1.854 | 0.951 | -1.949 | 0.051 |
| B.1.1.309 | Week of Year | -0.043 | 0.042 | -1.031 | 0.303 |
| B.1.1.309 | Tier 2 | -0.273 | 0.234 | -1.166 | 0.244 |
| B.1.1.309 | IMD 10th Decile | -0.838 | 0.528 | -1.588 | 0.112 |
| B.1.1.309 | Total Population | 0.072 | 0.011 | 6.526 | <0.001 |
| B.1.1.315 | Intercept | -2.693 | 0.320 | -8.411 | <0.001 |
| B.1.1.315 | Rainfall | 0.229 | 0.051 | 4.497 | <0.001 |
| B.1.1.315 | Lockdown 2 | -0.160 | 0.097 | -1.648 | 0.099 |
| B.1.1.315 | Tier 2 | 0.326 | 0.087 | 3.740 | <0.001 |
| B.1.1.315 | Tier 3 | -1.316 | 0.302 | -4.352 | <0.001 |
| B.1.1.315 | Restaurant Subsidy | -0.563 | 0.107 | -5.249 | <0.001 |
| B.1.1.315 | IMD 10th Decile | 0.593 | 0.354 | 1.673 | 0.094 |
| B.1.1.315 | Total Population | 0.055 | 0.010 | 5.680 | <0.001 |
| B.1.1.37 | Intercept | -5.824 | 1.204 | -4.836 | <0.001 |
| B.1.1.37 | Temperature | 0.211 | 0.074 | 2.840 | 0.005 |
| B.1.1.37 | Rainfall | -0.187 | 0.079 | -2.366 | 0.018 |
| B.1.1.37 | Lockdown 2 | 0.028 | 0.220 | 0.126 | 0.900 |
| B.1.1.37 | Tier 2 | -0.127 | 0.254 | -0.500 | 0.617 |
| B.1.1.37 | IMD 10th Decile | 0.259 | 0.600 | 0.431 | 0.666 |
| B.1.1.37 | Total Population | 0.066 | 0.015 | 4.474 | <0.001 |
| B.1.1.7 | Intercept | -7.203 | 0.878 | -8.202 | <0.001 |
| B.1.1.7 | Temperature | -0.062 | 0.083 | -0.743 | 0.457 |
| B.1.1.7 | Rainfall | -0.306 | 0.129 | -2.363 | 0.018 |
| B.1.1.7 | Week of Year | 0.737 | 0.078 | 9.439 | <0.001 |
| B.1.1.7 | Tier 2 | -0.233 | 0.659 | -0.354 | 0.723 |
| B.1.1.7 | IMD 10th Decile | 0.413 | 0.490 | 0.844 | 0.399 |
| B.1.1.7 | Total Population | 0.065 | 0.013 | 5.160 | <0.001 |
| B.1.177 | Intercept | -2.073 | 0.209 | -9.931 | <0.001 |
| B.1.177 | Rainfall | 0.210 | 0.039 | 5.420 | <0.001 |
| B.1.177 | Lockdown 2 | 0.419 | 0.050 | 8.334 | <0.001 |
| B.1.177 | Tier 2 | 0.512 | 0.066 | 7.785 | <0.001 |
| B.1.177 | Tier 3 | 0.501 | 0.066 | 7.605 | <0.001 |
| B.1.177 | Restaurant Subsidy | -0.414 | 0.076 | -5.485 | <0.001 |
| B.1.177 | IMD 10th Decile | 0.395 | 0.234 | 1.685 | 0.092 |
| B.1.177 | Total Population | 0.054 | 0.006 | 8.473 | <0.001 |
| B.1.177.10 | Intercept | -5.053 | 1.476 | -3.423 | <0.001 |
| B.1.177.10 | Temperature | -0.191 | 0.098 | -1.962 | 0.050 |
| B.1.177.10 | Lockdown 2 | -0.069 | 0.102 | -0.671 | 0.502 |
| B.1.177.10 | Week of Year | 0.254 | 0.072 | 3.516 | <0.001 |
| B.1.177.10 | Tier 2 | 0.287 | 0.193 | 1.487 | 0.137 |
| B.1.177.10 | IMD 10th Decile | 1.036 | 0.660 | 1.568 | 0.117 |
| B.1.177.10 | Total Population | 0.079 | 0.018 | 4.460 | <0.001 |

**Table S7**: Summary of the full versions of the separate lineage GLMMs with a random intercept for postcode; effects of spatial (10th Decile of IMD, postcode district total population) and temporal variables (mean weekly temperature and rainfall, week of year, and government interventions and subsidy) on the total number of positive PCR tests recorded each week of 2020 in each postcode district, for each of the 8 most common lineages of SARS-CoV-2. All temporal variables include a two-week time lag to account for the delay in symptom onset (and testing) after infection. The VIF of at least one variable in each model was > 3, which means all of the below standard errors, z values, and p values may be unreliable (though the estimates are accurate). All models include a random intercept for postcode, except where the model was singular (B.1.1.309 and B.1.1.37). Estimates are on the original model scale (log) (Continued on next page).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Lineage | Variable | Estimate | Std. Error | z value | p value |
| B.1.1.1 | Intercept | -1.654 | 0.765 | -2.161 | 0.031 |
| B.1.1.1 | Temperature | -0.230 | 0.060 | -3.868 | <0.001 |
| B.1.1.1 | Rainfall | -0.137 | 0.111 | -1.236 | 0.031 |
| B.1.1.1 | Lockdown 1 | 0.124 | 0.043 | 2.869 | 0.004 |
| B.1.1.1 | Lockdown 2 | -1.121 | 0.605 | -1.854 | 0.064 |
| B.1.1.1 | Week of Year | -0.011 | 0.022 | -0.482 | 0.630 |
| B.1.1.1 | Tier 2 | -0.238 | 0.335 | -0.712 | 0.476 |
| B.1.1.1 | Tier 3 | -1.348 | 0.770 | -1.751 | 0.080 |
| B.1.1.1 | Restaurant Subsidy | 0.535 | 0.228 | 2.348 | 0.019 |
| B.1.1.1 | IMD 10th Decile | 1.164 | 0.634 | 1.835 | 0.066 |
| B.1.1.1 | Total Population | 0.053 | 0.019 | 2.786 | 0.005 |
| B.1.1.119 | Intercept | -2.542 | 0.683 | -3.720 | <0.001 |
| B.1.1.119 | Temperature | 0.030 | 0.069 | 0.437 | 0.662 |
| B.1.1.119 | Rainfall | 0.098 | 0.088 | 1.115 | 0.265 |
| B.1.1.119 | Lockdown 1 | 0.065 | 0.040 | 1.651 | 0.099 |
| B.1.1.119 | Week of Year | -0.197 | 0.044 | -4.457 | <0.001 |
| B.1.1.119 | Restaurant Subsidy | 0.016 | 0.351 | 0.045 | 0.964 |
| B.1.1.119 | IMD 10th Decile | 1.417 | 0.700 | 2.022 | 0.043 |
| B.1.1.119 | Total Population | 0.060 | 0.020 | 2.973 | 0.003 |
| B.1.1.309 | Intercept | -7.076 | 2.632 | -2.688 | 0.007 |
| B.1.1.309 | Temperature | 0.188 | 0.139 | 1.360 | 0.174 |
| B.1.1.309 | Rainfall | 0.042 | 0.098 | 0.424 | 0.672 |
| B.1.1.309 | Lockdown 2 | -2.311 | 0.971 | -2.380 | 0.017 |
| B.1.1.309 | Week of Year | 0.169 | 0.099 | 1.699 | 0.089 |
| B.1.1.309 | Tier 2 | -0.446 | 0.254 | -1.755 | 0.079 |
| B.1.1.309 | Restaurant Subsidy | 0.268 | 0.177 | 1.514 | 0.130 |
| B.1.1.309 | IMD 10th Decile | -0.876 | 0.525 | -1.669 | 0.095 |
| B.1.1.309 | Total Population | 0.072 | 0.011 | 6.638 | <0.001 |
| B.1.1.315 | Intercept | -8.859 | 1.739 | -5.093 | <0.001 |
| B.1.1.315 | Temperature | 0.259 | 0.087 | 2.986 | 0.003 |
| B.1.1.315 | Rainfall | 0.200 | 0.068 | 2.935 | 0.003 |
| B.1.1.315 | Lockdown 2 | -0.801 | 0.196 | -4.078 | <0.001 |
| B.1.1.315 | Week of Year | 0.338 | 0.072 | 4.679 | <0.001 |
| B.1.1.315 | Tier 2 | -0.031 | 0.128 | -0.243 | 0.808 |
| B.1.1.315 | Tier 3 | -2.616 | 0.491 | -5.323 | <0.001 |
| B.1.1.315 | Restaurant Subsidy | -0.301 | 0.147 | -2.055 | 0.040 |
| B.1.1.315 | IMD 10th Decile | 0.604 | 0.357 | 1.693 | 0.091 |
| B.1.1.315 | Total Population | 0.056 | 0.010 | 5.691 | <0.001 |
| B.1.1.37 | Intercept | -10.959 | 3.080 | -3.558 | <0.001 |
| B.1.1.37 | Temperature | 0.455 | 0.166 | 2.743 | 0.006 |
| B.1.1.37 | Rainfall | -0.178 | 0.180 | -0.985 | 0.325 |
| B.1.1.37 | Lockdown 2 | -0.410 | 0.294 | -1.397 | 0.162 |
| B.1.1.37 | Week of Year | 0.305 | 0.129 | 2.363 | 0.018 |
| B.1.1.37 | Tier 2 | -0.303 | 0.257 | -1.181 | 0.238 |
| B.1.1.37 | Restaurant Subsidy | 0.253 | 0.332 | 0.763 | 0.446 |
| B.1.1.37 | IMD 10th Decile | 0.274 | 0.592 | 0.464 | 0.643 |
| B.1.1.37 | Total Population | 0.066 | 0.015 | 4.532 | <0.001 |
| B.1.1.7 | Intercept | -11.498 | 3.226 | -3.564 | <0.001 |
| B.1.1.7 | Temperature | 0.208 | 0.199 | 1.046 | 0.296 |
| B.1.1.7 | Rainfall | 4.461 | 3.443 | 1.295 | 0.195 |
| B.1.1.7 | Lockdown 2 | 5.368 | 3.888 | 1.380 | 0.167 |
| B.1.1.7 | Week of Year | -2.002 | 2.240 | -0.894 | 0.371 |
| B.1.1.7 | Tier 2 | -5.413 | 7.233 | -0.748 | 0.454 |
| B.1.1.7 | Tier 3 | 7.648 | 5.845 | 1.308 | 0.191 |
| B.1.1.7 | IMD 10th Decile | 0.399 | 0.493 | 0.809 | 0.418 |
| B.1.1.7 | Total Population | 0.065 | 0.013 | 5.137 | <0.001 |
| B.1.177 | Intercept | -1.964 | 0.982 | -2.001 | 0.045 |
| B.1.177 | Temperature | -0.068 | 0.048 | -1.406 | 0.160 |
| B.1.177 | Rainfall | -0.008 | 0.051 | -0.149 | 0.881 |
| B.1.177 | Lockdown 2 | -0.088 | 0.085 | -1.038 | 0.299 |
| B.1.177 | Week of Year | 0.122 | 0.041 | 3.001 | 0.003 |
| B.1.177 | Tier 2 | 0.187 | 0.075 | 2.479 | 0.013 |
| B.1.177 | Tier 3 | -0.236 | 0.134 | -1.771 | 0.077 |
| B.1.177 | Restaurant Subsidy | 0.104 | 0.103 | 1.014 | 0.311 |
| B.1.177 | IMD 10th Decile | 0.363 | 0.235 | 1.543 | 0.123 |
| B.1.177 | Total Population | 0.055 | 0.006 | 8.489 | <0.001 |
| B.1.177.10 | Intercept | -8.105 | 2.534 | -3.198 | 0.001 |
| B.1.177.10 | Temperature | -0.052 | 0.137 | -0.380 | 0.704 |
| B.1.177.10 | Rainfall | -0.314 | 0.423 | -0.743 | 0.457 |
| B.1.177.10 | Lockdown 2 | -0.746 | 0.483 | -1.544 | 0.123 |
| B.1.177.10 | Week of Year | 0.676 | 0.211 | 3.212 | 0.001 |
| B.1.177.10 | Tier 2 | 0.042 | 0.280 | 0.150 | 0.880 |
| B.1.177.10 | Tier 3 | -1.286 | 0.617 | -2.084 | 0.037 |
| B.1.177.10 | IMD 10th Decile | 1.087 | 0.670 | 1.624 | 0.104 |
| B.1.177.10 | Total Population | 0.078 | 0.018 | 4.298 | <0.001 |

**Table S8**: Summary of the simplified version of the second-wave lineages GLMM with a random intercept for postcode; effects of spatial (10th Decile of IMD, postcode district total population, and total cases of lineages B.1.1.1 and B.1.1.119 during the first wave (up to week 28)) and temporal variables (mean weekly temperature and rainfall, and government interventions and subsidy) on the total number of positive PCR tests of the six second wave lineages (B.1.1.309, B.1.1.315, B.1.1.37, B.1.1.7, B.1.177, and B.1.177.10) recorded each week of 2020 in each postcode district. All temporal variables include a two-week time lag to account for the delay in symptom onset (and testing) after infection. Variables with a VIF > 3 were removed from this model (Week of year). Estimates are on the original model scale (log).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Estimate | Std. Error | z value | p value |
| Intercept | -1.369 | 0.177 | -7.728 | <0.001 |
| First wave cases | 0.001 | 0.008 | 0.114 | 0.909 |
| Rainfall | 0.148 | 0.028 | 5.325 | <0.001 |
| Lockdown 2 | 0.264 | 0.039 | 6.736 | <0.001 |
| Tier 2 | 0.376 | 0.052 | 7.298 | <0.001 |
| Tier 3 | 0.470 | 0.049 | 9.525 | <0.001 |
| Restaurant Subsidy | -0.261 | 0.053 | -4.957 | <0.001 |
| IMD 10th Decile | 0.286 | 0.255 | 1.124 | 0.261 |
| Total Population | 0.060 | 0.006 | 9.476 | <0.001 |

**Table S9**: Summary of the full version of the second-wave lineages GLMM with a random intercept for postcode; effects of spatial (10th Decile of IMD, postcode district total population, and total cases of lineages B.1.1.1 and B.1.1.119 during the first wave (up to week 28)) and temporal variables (mean weekly temperature and rainfall, week of year, and government interventions and subsidy) on the total number of positive PCR tests of the six second wave lineages (B.1.1.309, B.1.1.315, B.1.1.37, B.1.1.7, B.1.177, and B.1.177.10) recorded each week of 2020 in each postcode district. All temporal variables include a two-week time lag to account for the delay in symptom onset (and testing) after infection. The VIF of Week of Year was > 3, which means all of the below standard errors, z values, and p values may be unreliable (though the estimates are accurate). Estimates are on the original model scale (log).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Estimate | Std. Error | z value | p value |
| Intercept | -7.325 | 1.440 | -5.087 | <0.001 |
| First wave cases | 0.000 | 0.008 | 0.007 | 0.994 |
| Temperature | 0.062 | 0.038 | 1.665 | 0.096 |
| Rainfall | 0.049 | 0.038 | 1.299 | 0.194 |
| Lockdown 2 | -0.115 | 0.067 | -1.702 | 0.089 |
| Week of Year | 0.167 | 0.031 | 5.346 | <0.001 |
| Tier 2 | 0.126 | 0.061 | 2.063 | 0.039 |
| Tier 3 | -0.177 | 0.103 | -1.714 | 0.086 |
| Restaurant Subsidy | 0.041 | 0.073 | 0.555 | 0.579 |
| IMD 10th Decile | 0.292 | 0.257 | 1.137 | 0.255 |
| Total Population | 0.061 | 0.006 | 9.469 | <0.001 |

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**1** Barking, Havering and Redbridge University Hospitals NHS Trust, **2** Barts Health NHS Trust, **3** Belfast Health & Social Care Trust, **4** Betsi Cadwaladr University Health Board, **5** Big Data Institute, Nuffield Department of Medicine, University of Oxford, **6** Blackpool Teaching Hospitals NHS Foundation Trust, **7** Bournemouth University, **8** Cambridge Stem Cell Institute, University of Cambridge, **9** Cambridge University Hospitals NHS Foundation Trust, **10** Cardiff and Vale University Health Board, **11** Cardiff University, **12** Centre for Clinical Infection and Diagnostics Research, Department of Infectious Diseases, Guy's and St Thomas' NHS Foundation Trust, **13** Centre for Enzyme Innovation, University of Portsmouth, **14** Centre for Genomic Pathogen Surveillance, University of Oxford, **15** Clinical Microbiology Department, Queens Medical Centre, Nottingham University Hospitals NHS Trust, **16** Clinical Microbiology, University Hospitals of Leicester 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