**Table S1.** Biological and epidemic-relevant parameters specified with point estimates for New Jersey.

| Parameter | Value | Description |
|---|---|---|
| $C_P$, $C_M$, $C_S$ | 1 | Relative infectiousness of presymptomatic, mildly symptomatic, and severely symptomatic |
| $\lambda_I$ | 1/4.5 days | 1/Preinfectious period |
| $\lambda_P$ | 1/1.5 days | 1/Presymptomatic infectious period |
| $\lambda_A$ | 1/7 days | 1/Asymptomatic infectious period |
| $\lambda_S$ | 1/5.5 days | 1/Severe infectious period until treatment/hospitalization |
| $\lambda_M$ | 1/5.5 days | 1/Mild infectious period |
| $\rho_R$ | 1/20.5 days | 1/Duration of treatment/hospitalization to recovery |
| $\rho_D$ | 1/17.8 days | 1/Duration of treatment/hospitalization to death |
| $HFR_{min}$ | 0.01 | Minimum treatment/hospitalization fatality rate (for the linear decreasing scenario) |
| $SIP_{start}$ | 2020-3-21 | Shelter-in-place start date |
| $Sim_{start}$ | 2020-3-1 | Simulation start date |
| $Sim_{end}$ | 2020-9-30 | Simulation end date |
| $Fit_{end}$ | 2020-8-2 | Latest date for data fitting |
| pop | | Population size of the focal areas |

**Table S2.** Biological and epidemic-relevant parameters specified with range estimates for New Jersey.

| Parameter | Lower Bound | Upper Bound | Description |
|---|---|---|---|
| $C_A$ | 0.4 | 0.8 | Relative infectiousness of asymptomatic |
| $\alpha$ | 0.3 | 0.5 | Proportion of asymptomatic infections |
| $1-\mu$ | 0.025 | 0.075 | Proportion of symptomatic infections that require treatment/hospitalization |
| $HFR_0$ | 0.05 | 0.28 | Initial treatment/hospitalization fatality rate |
| $E_0$ | 3 | 6 | Number of initial infections |
| $\gamma_{WFH}$ | 0.7 | 0.95 | Work from home transmission scaling factor |
| $Epi_{start}$ | 2020-1-15 | 2020-2-25 | Start date of the epidemic |
| $WFH_{start}$ | 2020-3-6 | 2020-3-15 | Work from home start date |
| $EMM_{start}$ | 2020-4-11 | 2020-4-15 | Start date of enhanced mitigation measures |

**Table S3.** Statistical measures of agreement between modeled and reported confirmed COVID-19 death data across the 21 New Jersey counties. RMSE = root mean squared error, MAPE = mean absolute percentage error, EB = envelope bias (number of days the reported data beyond the 95% confidence interval). The model evaluations are performed for a long period (March 1, 2020 - August 10, 2020) in a total of 163 days.

| Geographic region | County | New deaths | | | | Total deaths | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RMSE | RMSE (rising) | RMSE (falling) | EB | MAPE | MAPE (rising) | MAPE (falling) | EB |
| Gateway Region | Bergen | 10.8 | 15.48 | 6.88 | 23 | 0.10 | 0.24 | 0.02 | 0 |
| | Essex | 12.46 | 16.85 | 10.89 | 27 | 0.15 | 0.45 | 0.08 | 0 |
| | Hudson | 7.71 | 9.74 | 6.87 | 17 | 0.14 | 0.54 | 0.06 | 0 |
| | Middlesex | 6.96 | 8.97 | 5.79 | 18 | 0.24 | 0.84 | 0.02 | 0 |
| | Passaic | 5.82 | 7.83 | 4.42 | 18 | 0.09 | 0.26 | 0.02 | 0 |
| | Union | 5.93 | 7.25 | 5.31 | 10 | 0.17 | 0.69 | 0.02 | 0 |
| Shore Region | Monmouth | 3.66 | 4.46 | 3.17 | 7 | 0.13 | 0.40 | 0.01 | 0 |
| | Ocean | 4.29 | 4.97 | 4.02 | 6 | 0.13 | 0.54 | 0.02 | 0 |
| Skyland Region | Hunterdon | 0.90 | 1.22 | 0.72 | 2 | 0.10 | 0.34 | 0.04 | 0 |
| | Morris | 4.30 | 5.65 | 3.83 | 10 | 0.24 | 1.22 | 0.04 | 0 |
| | Somerset | 2.93 | 3.88 | 2.48 | 12 | 0.13 | 0.45 | 0.02 | 0 |
| | Sussex | 1.45 | 2.18 | 1.19 | 6 | 0.15 | 0.79 | 0.04 | 0 |
| | Warren | 1.44 | 2.05 | 1.09 | 3 | 0.24 | 0.75 | 0.06 | 0 |
| Delaware River Region | Burlington | 2.86 | 2.50 | 2.96 | 4 | 0.09 | 0.36 | 0.03 | 0 |
| | Camden | 2.97 | 3.32 | 2.69 | 5 | 0.21 | 0.57 | 0.03 | 0 |
| | Gloucester | 1.62 | 1.59 | 1.64 | 3 | 0.12 | 0.32 | 0.03 | 0 |
| | Mercer | 3.20 | 4.25 | 2.45 | 9 | 0.16 | 0.55 | 0.02 | 1 |
| | Salem | 0.81 | 0.85 | 0.74 | 1 | 0.16 | 0.23 | 0.05 | 0 |
| Southern Shore Region | Atlantic | 2.04 | 2.51 | 1.55 | 5 | 0.11 | 0.25 | 0.03 | 0 |
| | Cape May | 1.02 | 1.11 | 0.76 | 4 | 0.11 | 0.15 | 0.02 | 0 |
| | Cumberland | 1.27 | 1.29 | 1.25 | 2 | 0.15 | 0.28 | 0.02 | 0 |

**Table S4.** Counterfactual analysis: Deaths averted per 100,000 people and peak date delayed due to social distancing and face masks use across the 21 New Jersey counties.

| Geographic region | County | Social distancing | | Wearing face masks | |
|---|---|---|---|---|---|
| | | Death rate averted | Peak date delayed | Death rate averted | Peak date delayed |
| Gateway Region | Bergen | 173 (117, 218) | 13 (8, 23) | 131 (122, 203) | 6 (3, 8) |
| | Essex | 144 (69, 236) | 16 (15, 18) | 214 (115, 294) | 5 (2, 6) |
| | Hudson | 91 (76, 132) | 21 (19, 24) | 320 (265, 356) | 3 (2, 9) |
| | Middlesex | 177 (146, 276) | 24 (10, 25) | 116 (44, 138) | 8 (4, 12) |
| | Passaic | 115 (88, 129) | 19 (14, 23) | 232 (229, 233) | 8 (2, 10) |
| | Union | 80 (53, 108) | 15 (11, 18) | 141 (105, 184) | 4 (4, 6) |
| Shore Region | Monmouth | 336 (282, 395) | 14 (11, 15) | 47 (38, 60) | 7 (3, 10) |
| | Ocean | 282 (247, 301) | 19 (7, 24) | 84 (55, 99) | 5 (2, 16) |
| Skyland Region | Hunterdon | 179 (153, 213) | 27 (19, 36) | 295 (257, 333) | -14 (-18, 3) |
| | Morris | 199 (172, 290) | 13 (5, 24) | 99 (49, 117) | 6 (2, 8) |
| | Somerset | 197 (144, 223) | 17 (5, 21) | 96 (78, 123) | 2 (0, 7) |
| | Sussex | 212 (174, 260) | 14 (7, 22) | 169 (122, 244) | 0 (-3, 5) |
| | Warren | 334 (279, 399) | 14 (2, 29) | 119 (75, 144) | 2 (-12, 6) |
| Delaware River Region | Burlington | 187 (170, 311) | 29 (23, 38) | 316 (231, 370) | -2 (-8, 8) |
| | Camden | 217 (162, 249) | 39 (33, 42) | 281 (238, 293) | 4 (1, 11) |
| | Gloucester | 120 (95, 155) | 20 (16, 31) | 286 (236, 327) | -18 (-22, -7) |
| | Mercer | 93 (76, 118) | 22 (14, 23) | 208 (168, 244) | 4 (-3, 7) |
| | Salem | 200 (176, 233) | 16 (4, 29) | 289 (198, 325) | -20 (-25, -17) |
| Southern Shore Region | Atlantic | 74 (62, 96) | 15 (11, 21) | 208 (172, 223) | -2 (-11, 8) |
| | Cape May | 296 (284, 371) | 11 (4, 35) | 133 (93, 188) | -19 (-27, -15) |
| | Cumberland | 113 (99, 137) | 3 (-9, 16) | 26 (13, 41) | -3 (-10, 12) |

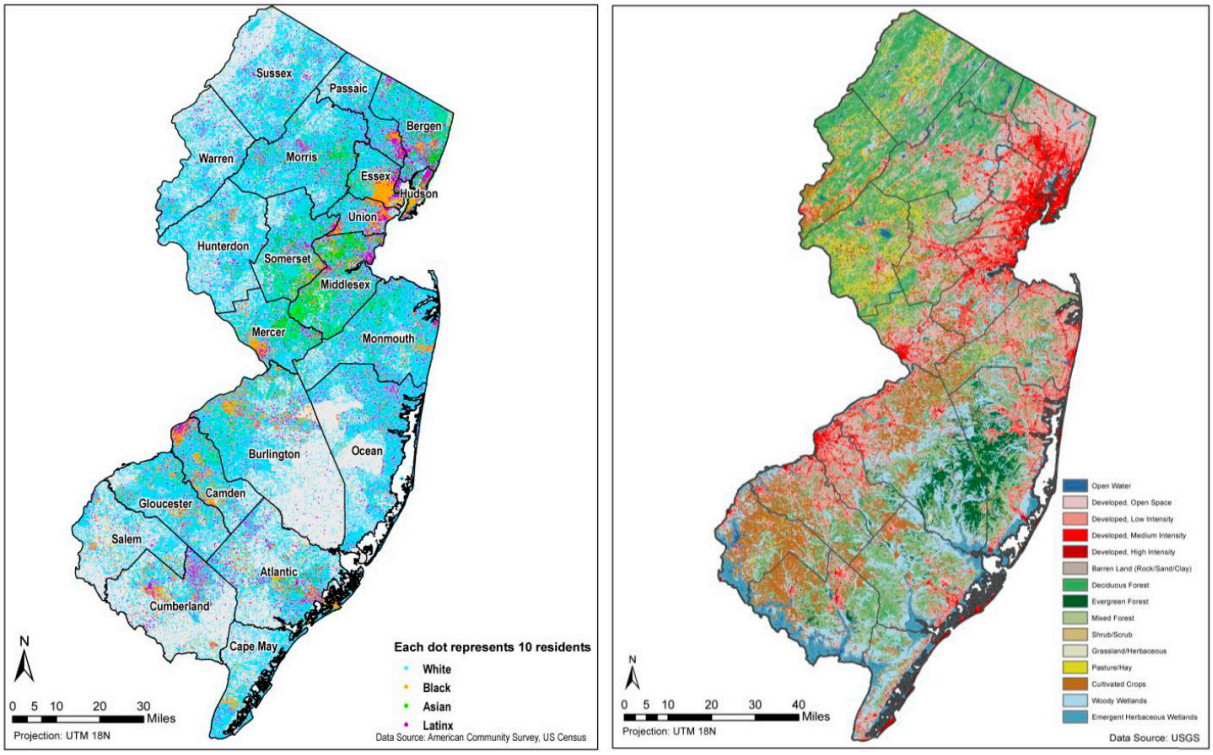



**Figure S1.** Heterogeneity and diversity in demographic (left) and environmental attributes (right) across New Jersey; the map on the left shows the ethnic diversity and the map on the right the heterogeneity in land use across the State.

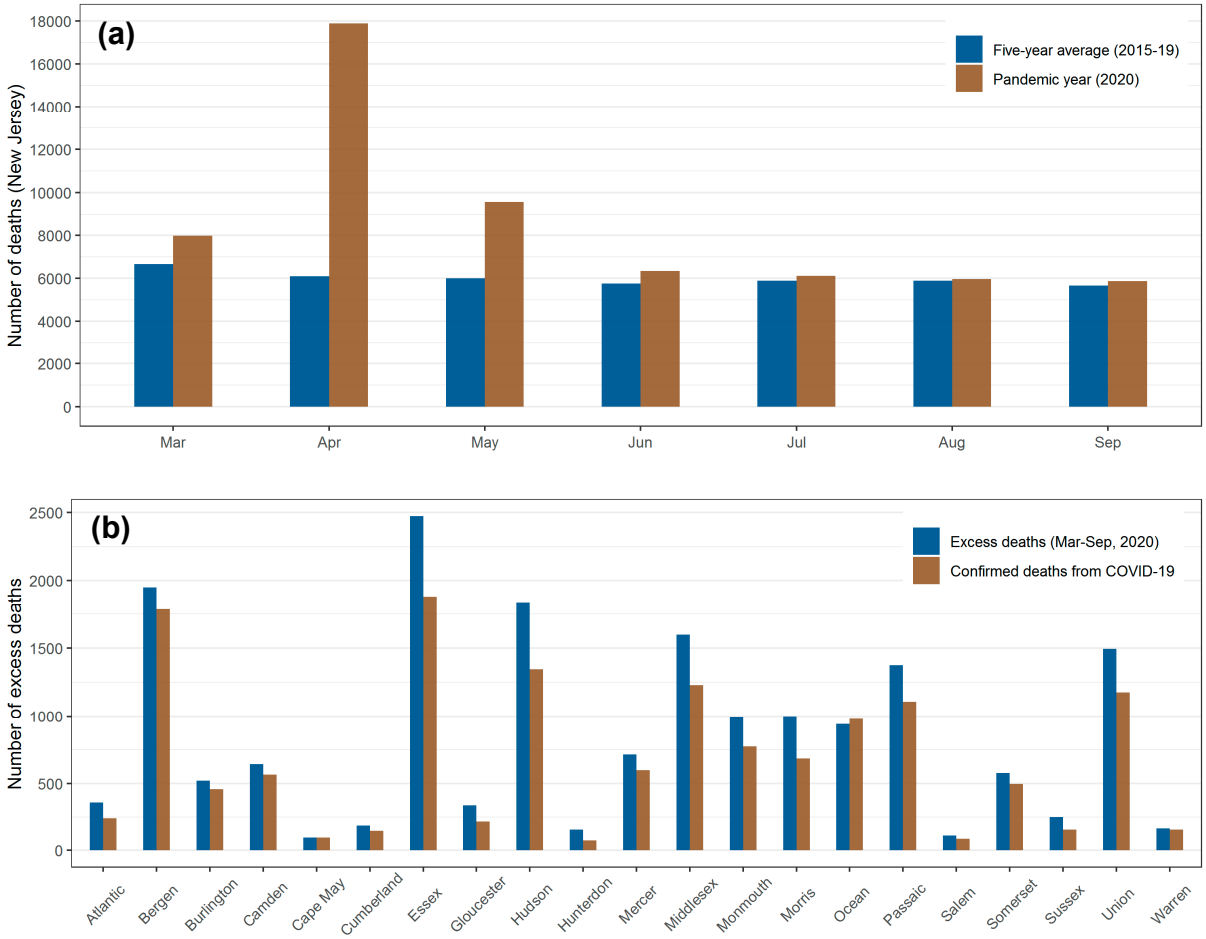



**Figure S2.** New Jersey resident deaths (data available at https://www.state.nj.us/health/chs/documents/2015-2020%20Deaths%20by%20Month%20and%20County%20of%20Residence.pdf): (a) the monthly deaths for five-year average (2015-2019) versus the resident deaths for the pandemic year (2020); (b) the county-level excess deaths (= resident deaths in 2020 - five-year average resident deaths) from March 1 to September 30 versus the reported confirmed COVID-19 deaths.

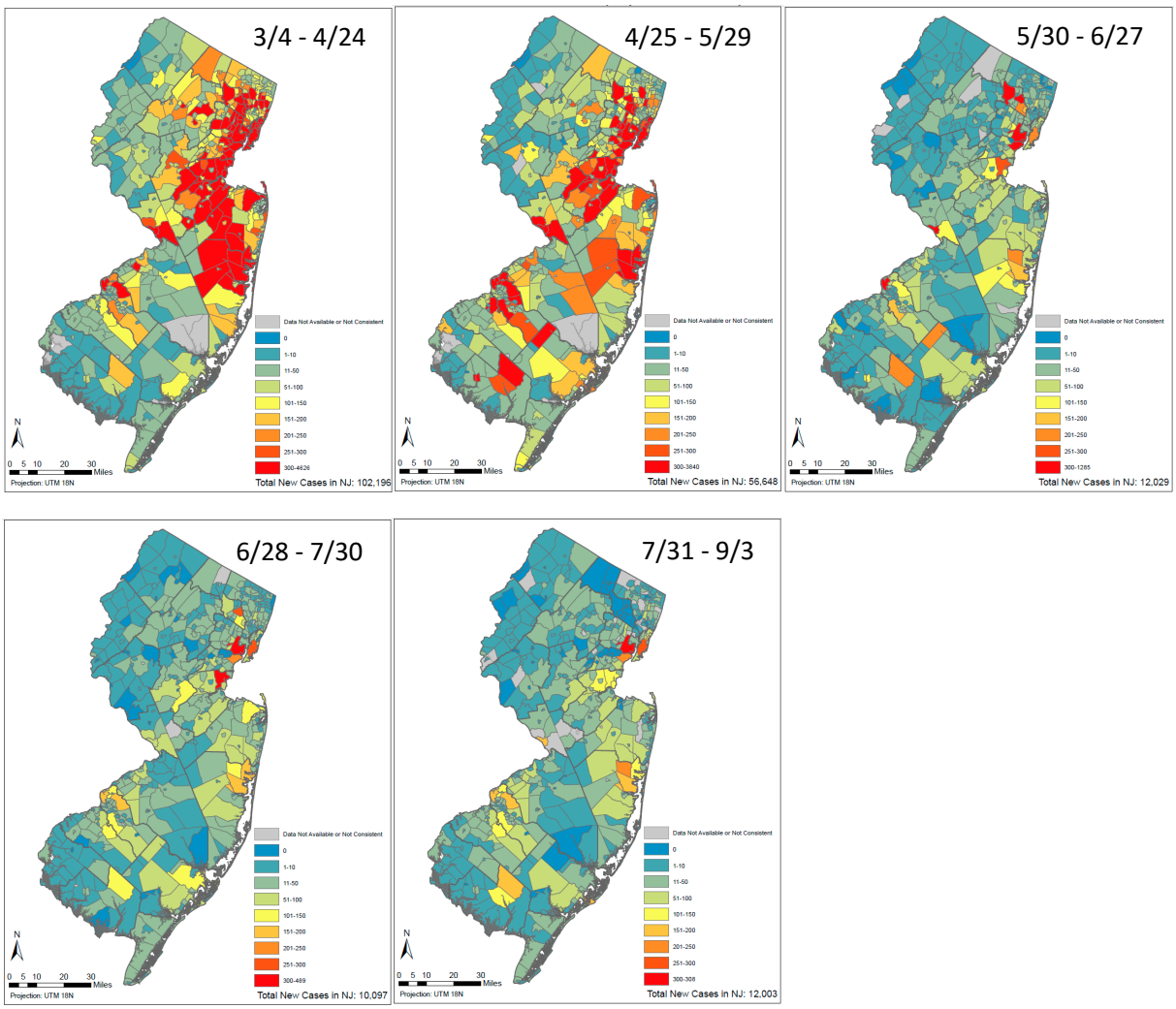



**Figure S3.** Numbers of new confirmed COVID-19 cases at municipality level in New Jersey from March to September, 2020; the maps demonstrate the heterogeneity of disease spread across the State.

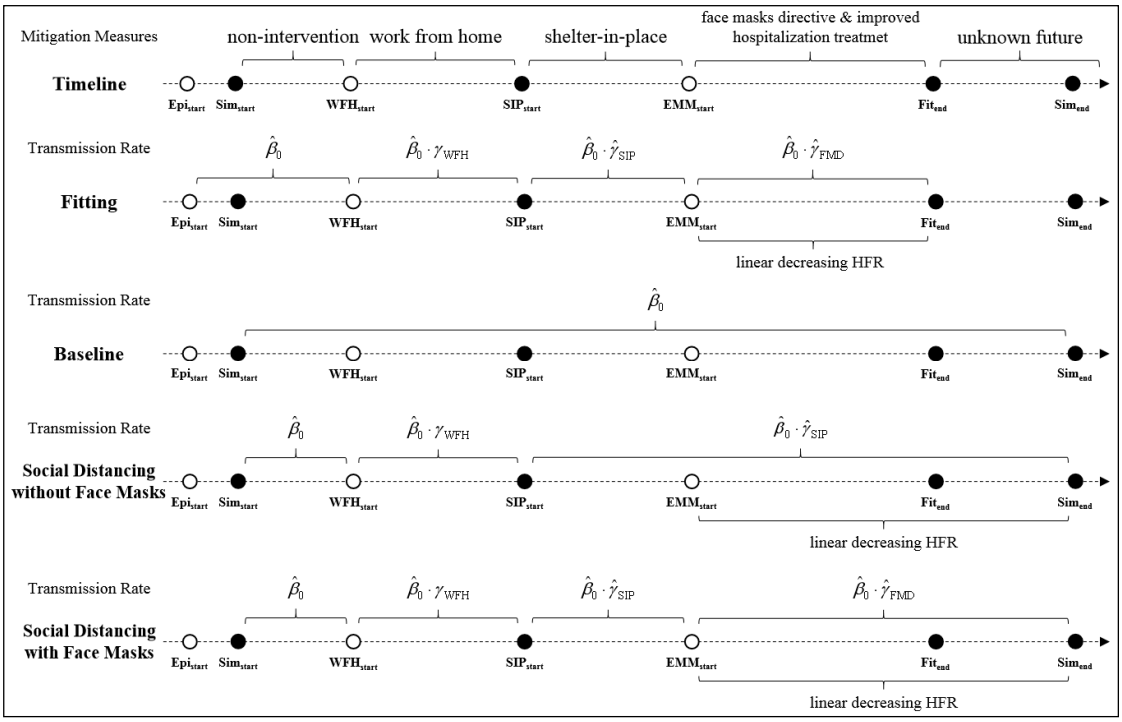



**Figure S4.** Schematic diagram of the stochastic SEIR model with time-varying transmission rate, showing the timeline of mitigation measures/policies implemented in New Jersey, fitting of models with typical intervention and timing, and the simulations for three scenarios (Baseline, Social Distancing without Face Masks, Social Distancing with Face Masks). The solid circles denote the time specified with point estimates (Table S1), and the hollow circles denote the time specified with range estimates (Table S2).

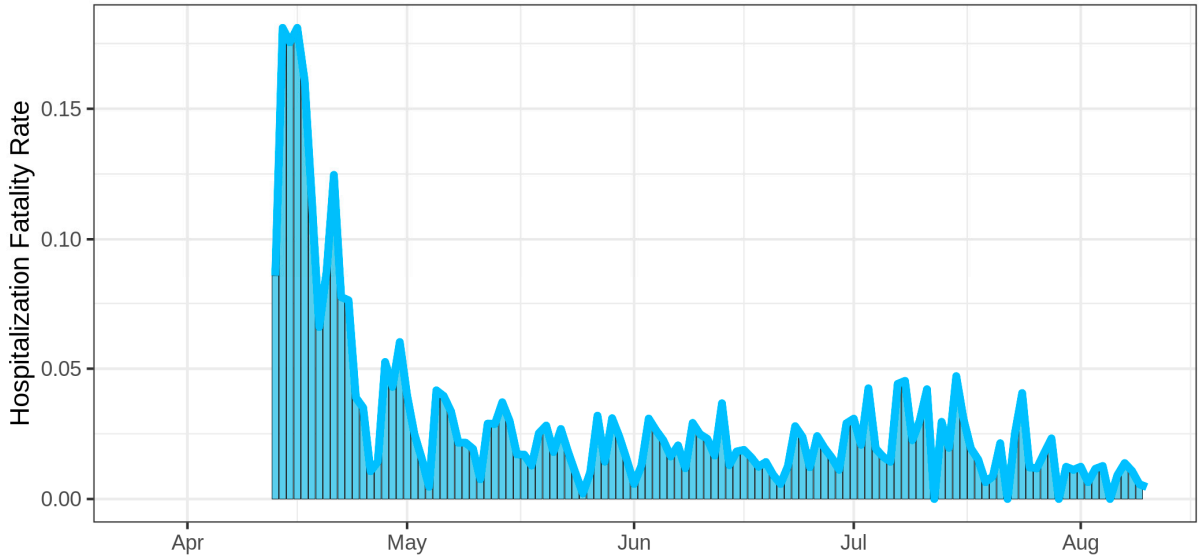



**Figure S5.** The approximated treatment/hospitalization fatality rate (T/HFR) in New Jersey, adjusted by a delay of ~18 days from hospitalization to death (Table S1). In April, a relatively large portion of deaths were probably taking place in long term care facilities instead of in hospitals.

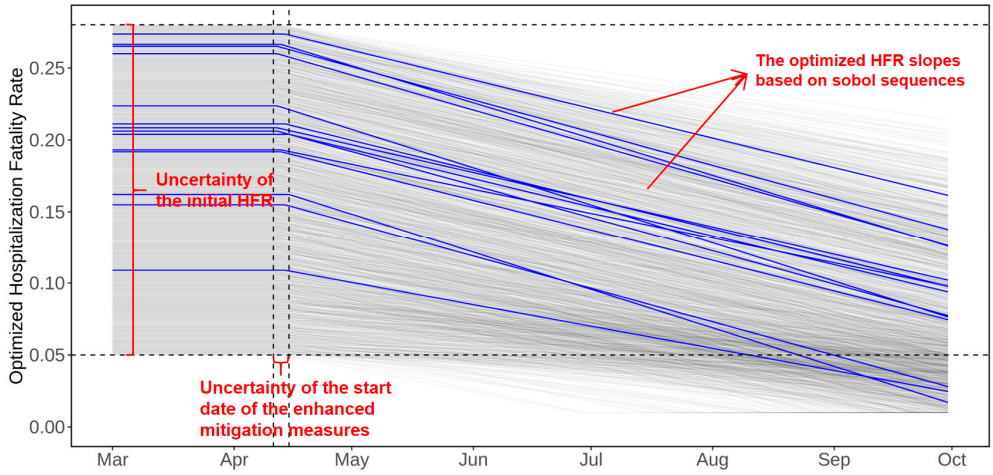



**Figure S6.** Illustration of the selection process for the estimated treatment/hospitalization fatality rates. The gray lines represent 2,000 T/HFR slopes optimized based on the 2,000 parameter sets (i.e., "low discrepancy" Sobol sequences), the blue lines represent the 14 selected T/HFR slopes optimized based on the 14 "most suitable" sobol sequences.

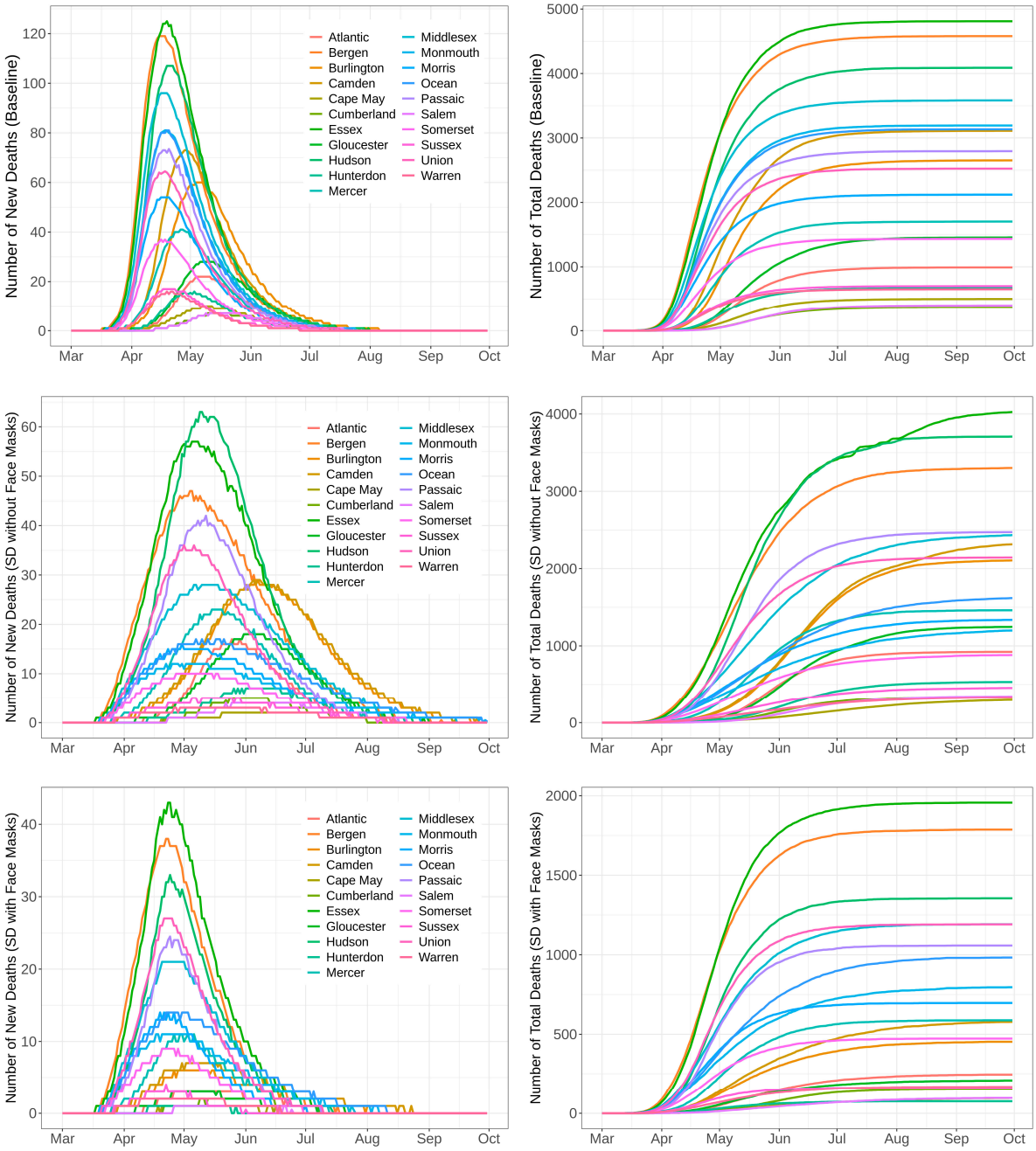



**Figure S7.** Projected median of new/total deaths from COVID-19 for three exposure scenarios (one factual and two counter-factuals) across the 21 New Jersey counties.

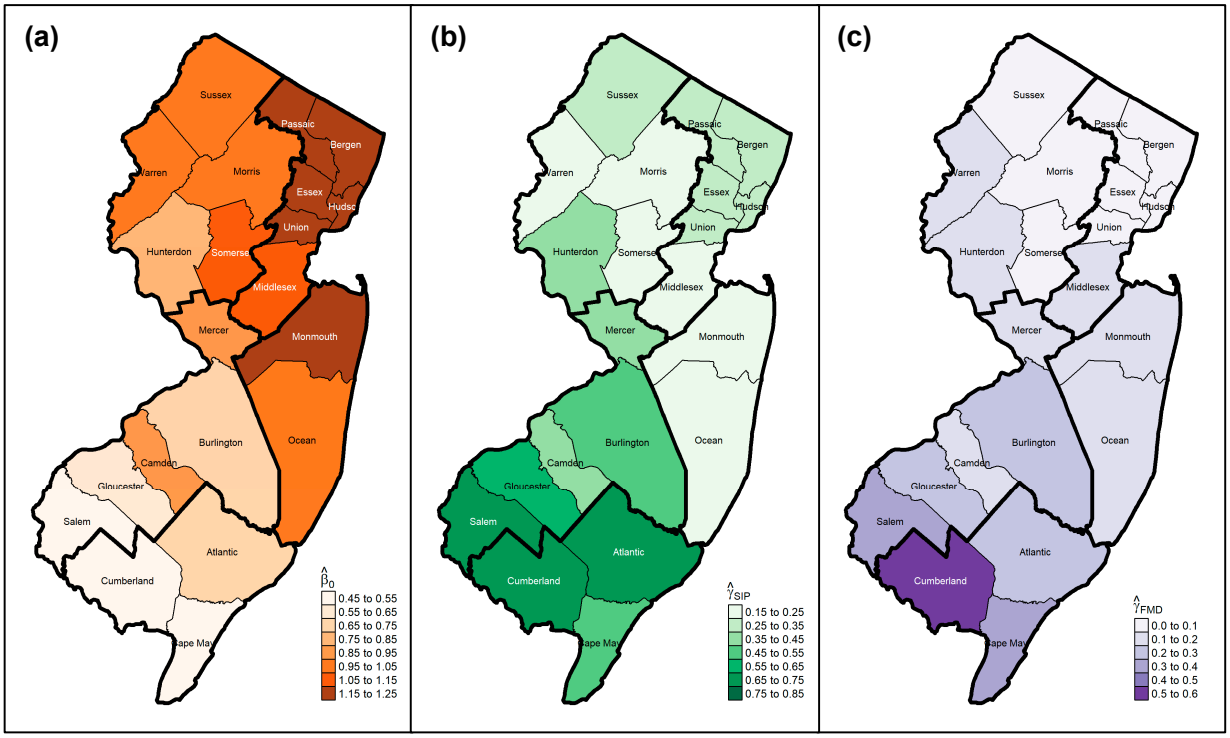



**Figure S8.** Spatial distribution of the median estimates for the (a) basic transmission parameter $\beta_0$, (b) shelter-in-place transmission scaling factor $\gamma_{\text{SIP}}$, and (c) face masks directive transmission scaling factor $\gamma_{\text{FMD}}$ across the 21 New Jersey counties.

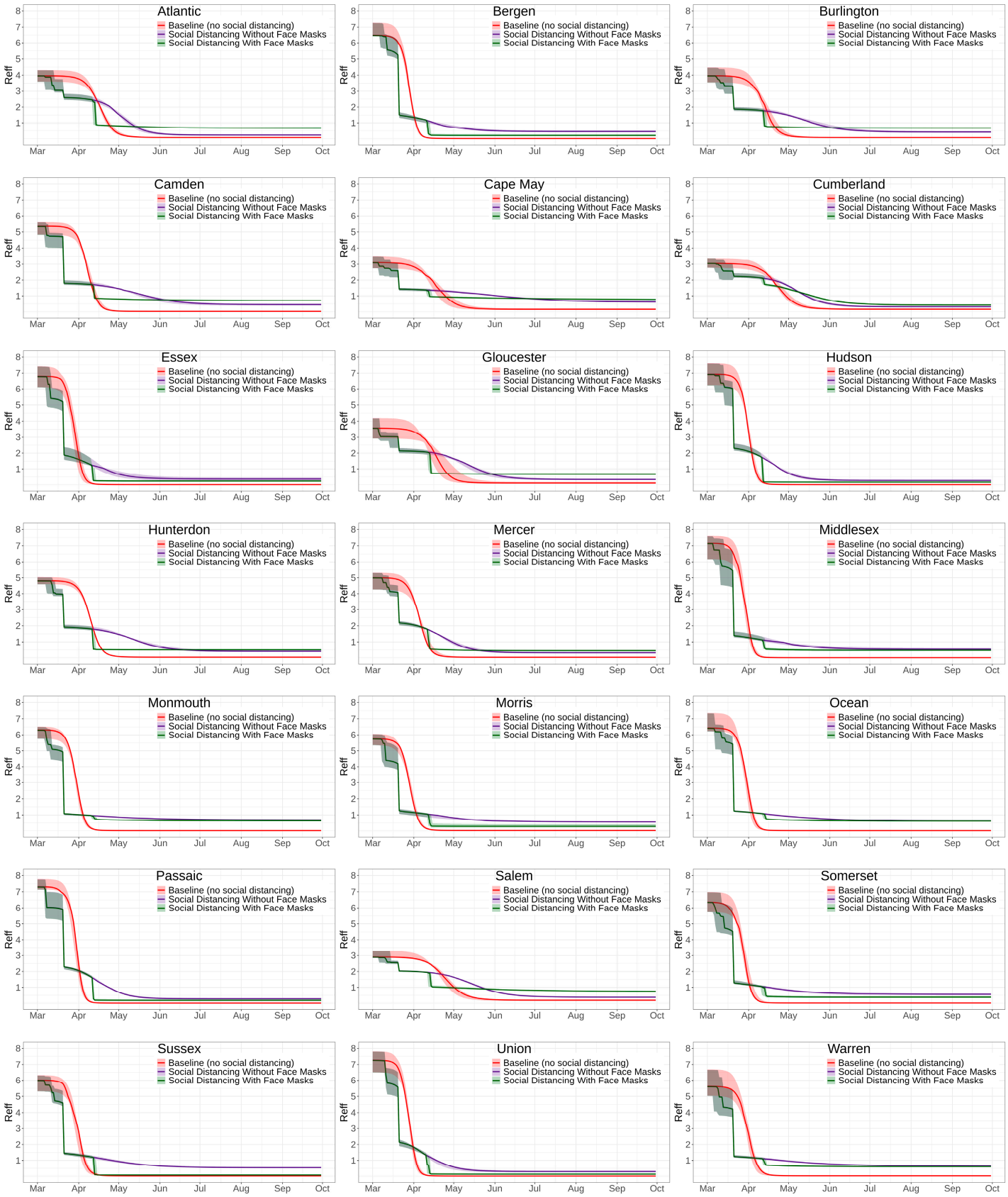



**Figure S9.** Time-varying effective reproduction number ($R_{eff}$) for the 21 New Jersey counties in three scenarios.

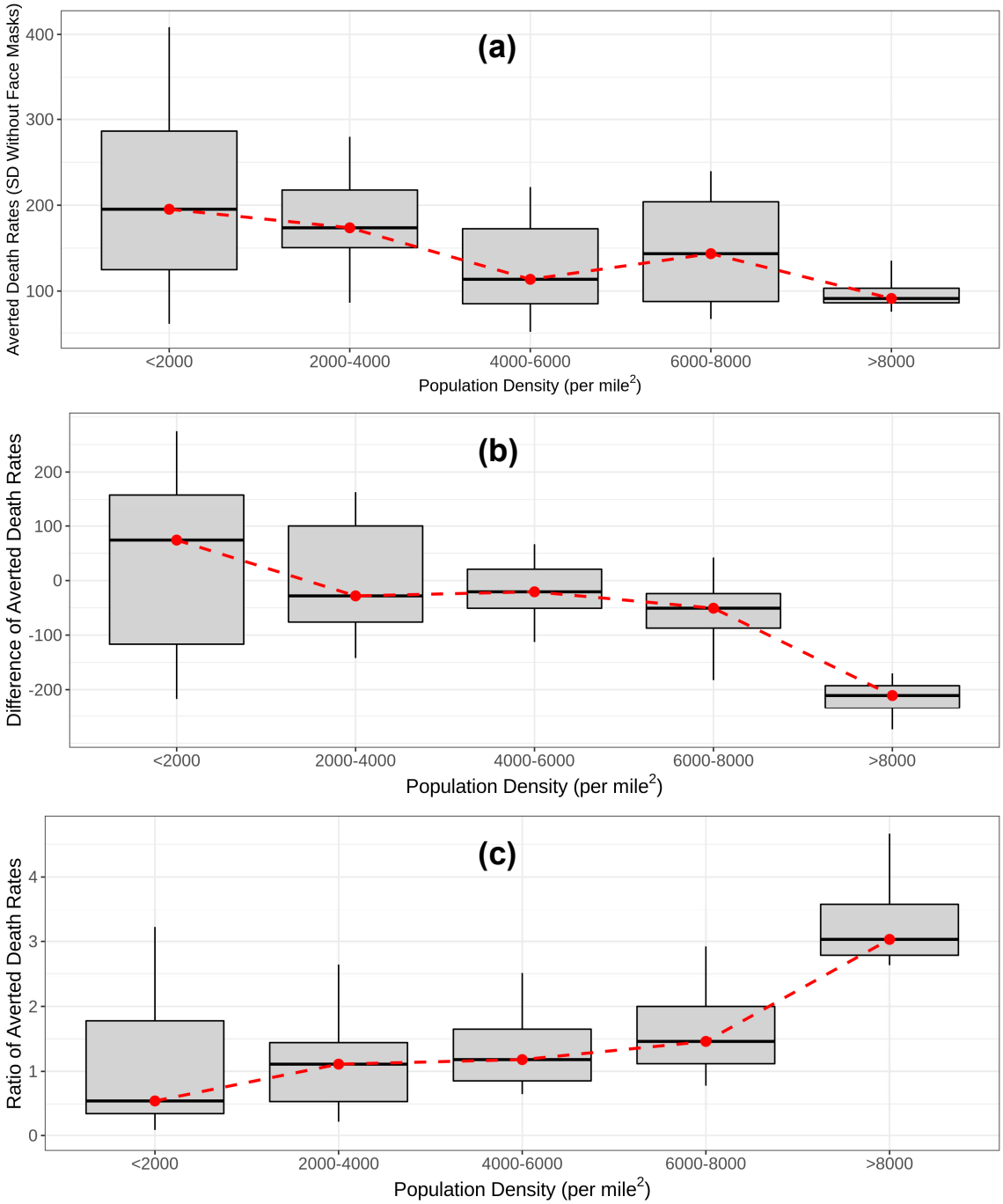



**Figure S10.** Effectiveness of social distancing and wearing face masks with respect to population density in five categories. The effectiveness of social distancing is quantified via (a) the averted deaths per 100,000 people for scenario 2. The relative effectiveness of wearing face masks is quantified via (b) the difference of the averted deaths per 100,000 people between scenario 3 and scenario 2, and (c) the corresponding ratio metric.

**Figure S11. Screenshots of different tabs of the dashboard for the COVID-19 project: https://ccl-eohsi.shinyapps.io/covid19_dashboard/**

**Figure S11(a).** Overview Tab

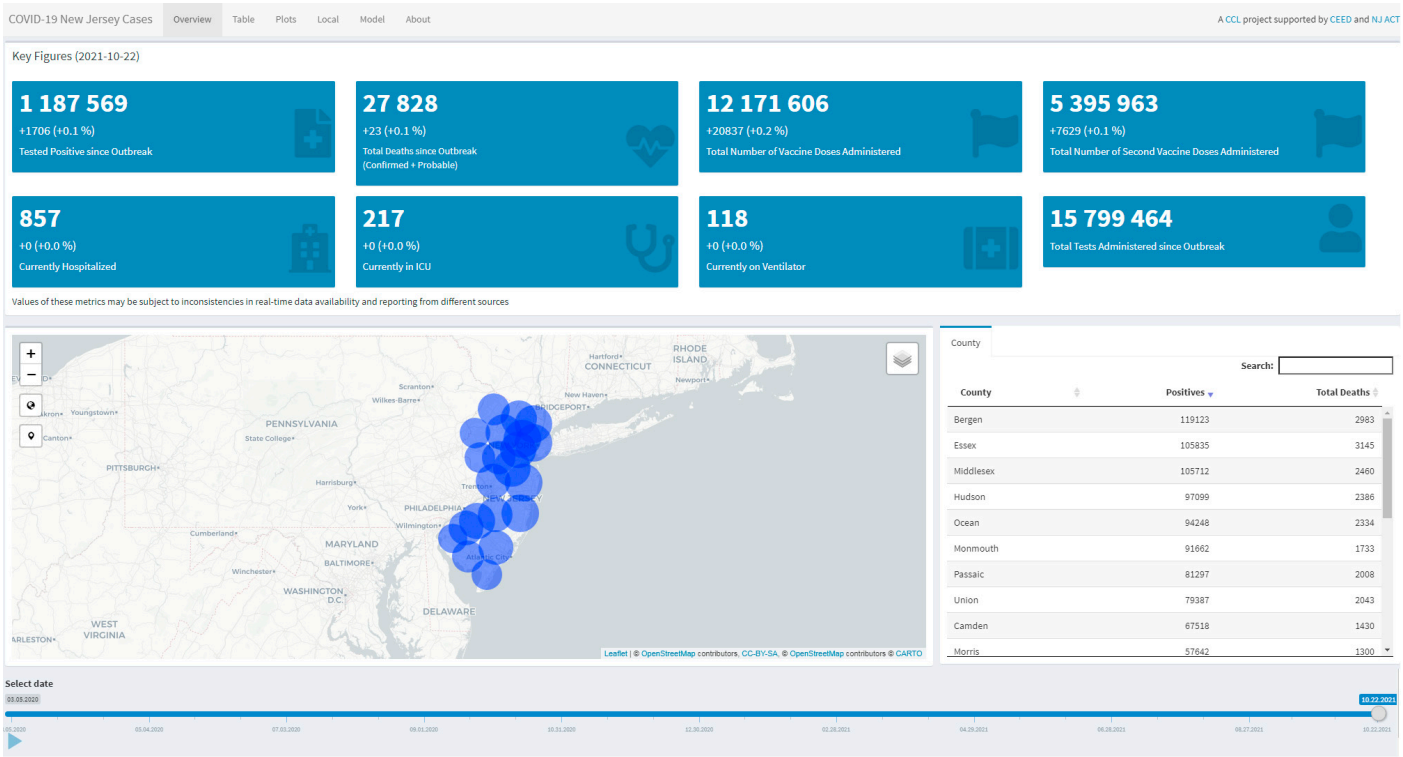
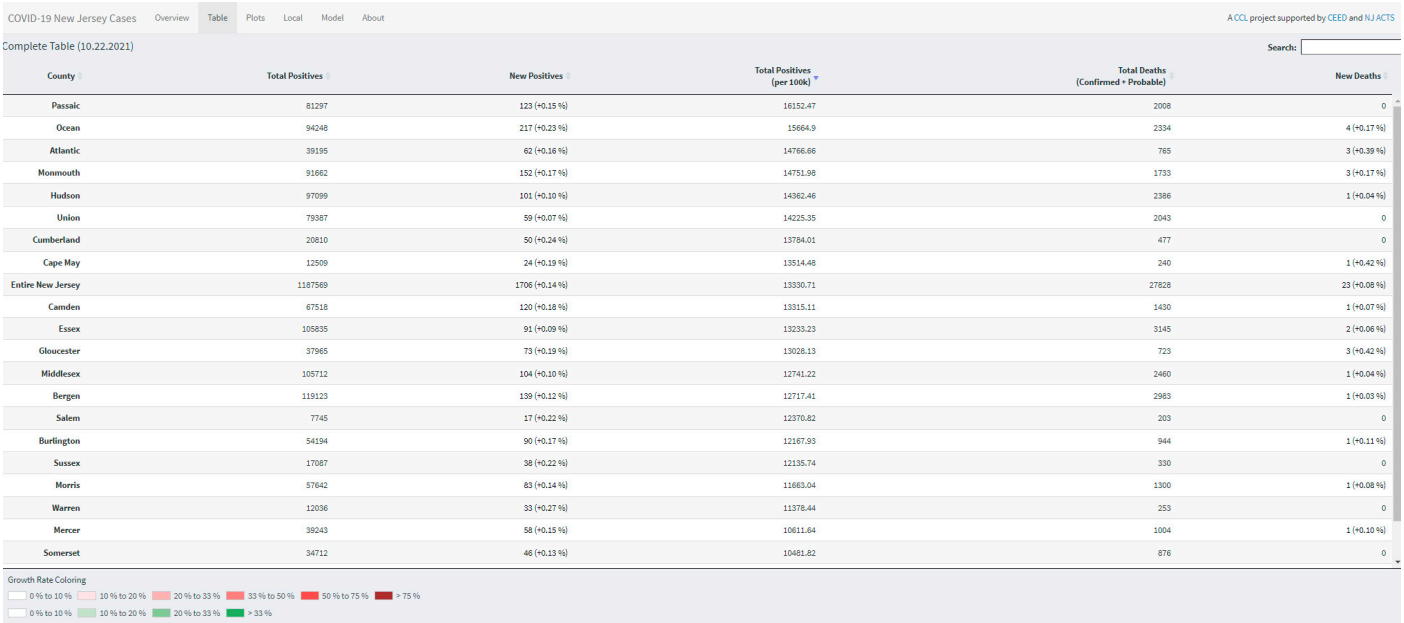



**Figure S11(b).** Table Tab




| County | Total Positives | New Positives | Total Positives (per 100k) | Total Deaths (Confirmed + Probable) | New Deaths |
|---|---|---|---|---|---|
| Passaic | 81297 | 123 (+0.15 %) | 16152.47 | 2008 | 0 |
| Ocean | 94248 | 217 (+0.23 %) | 15664.9 | 2334 | 4 (+0.17 %) |
| Atlantic | 39195 | 62 (+0.16 %) | 14766.66 | 765 | 3 (+0.39 %) |
| Monmouth | 91662 | 152 (+0.17 %) | 14751.98 | 1733 | 3 (+0.17 %) |
| Hudson | 97099 | 101 (+0.10 %) | 14362.46 | 2386 | 1 (+0.04 %) |
| Union | 79387 | 59 (+0.07 %) | 14225.35 | 2043 | 0 |
| Cumberland | 20810 | 50 (+0.24 %) | 13784.01 | 477 | 0 |
| Cape May | 12509 | 24 (+0.19 %) | 13514.48 | 240 | 1 (+0.42 %) |
| Entire New Jersey | 1187569 | 1706 (+0.14 %) | 13330.71 | 27828 | 23 (+0.08 %) |
| Camden | 67518 | 120 (+0.18 %) | 13315.11 | 1430 | 1 (+0.07 %) |
| Essex | 105835 | 91 (+0.09 %) | 13233.23 | 3145 | 2 (+0.06 %) |
| Gloucester | 37965 | 73 (+0.19 %) | 13028.13 | 723 | 3 (+0.42 %) |
| Middlesex | 105712 | 104 (+0.10 %) | 12741.22 | 2460 | 1 (+0.04 %) |
| Bergen | 119123 | 139 (+0.12 %) | 12717.41 | 2983 | 1 (+0.03 %) |
| Salem | 7745 | 17 (+0.22 %) | 12370.82 | 203 | 0 |
| Burlington | 54194 | 90 (+0.17 %) | 12167.93 | 944 | 1 (+0.11 %) |
| Sussex | 17087 | 38 (+0.22 %) | 12135.74 | 330 | 0 |
| Morris | 57642 | 83 (+0.14 %) | 11663.04 | 1300 | 1 (+0.08 %) |
| Warren | 12036 | 33 (+0.27 %) | 11378.44 | 253 | 0 |
| Mercer | 39243 | 58 (+0.15 %) | 10611.64 | 1004 | 1 (+0.10 %) |
| Somerset | 34712 | 46 (+0.13 %) | 10481.82 | 876 | 0 |

**Figure S11(c).** Plots Tab

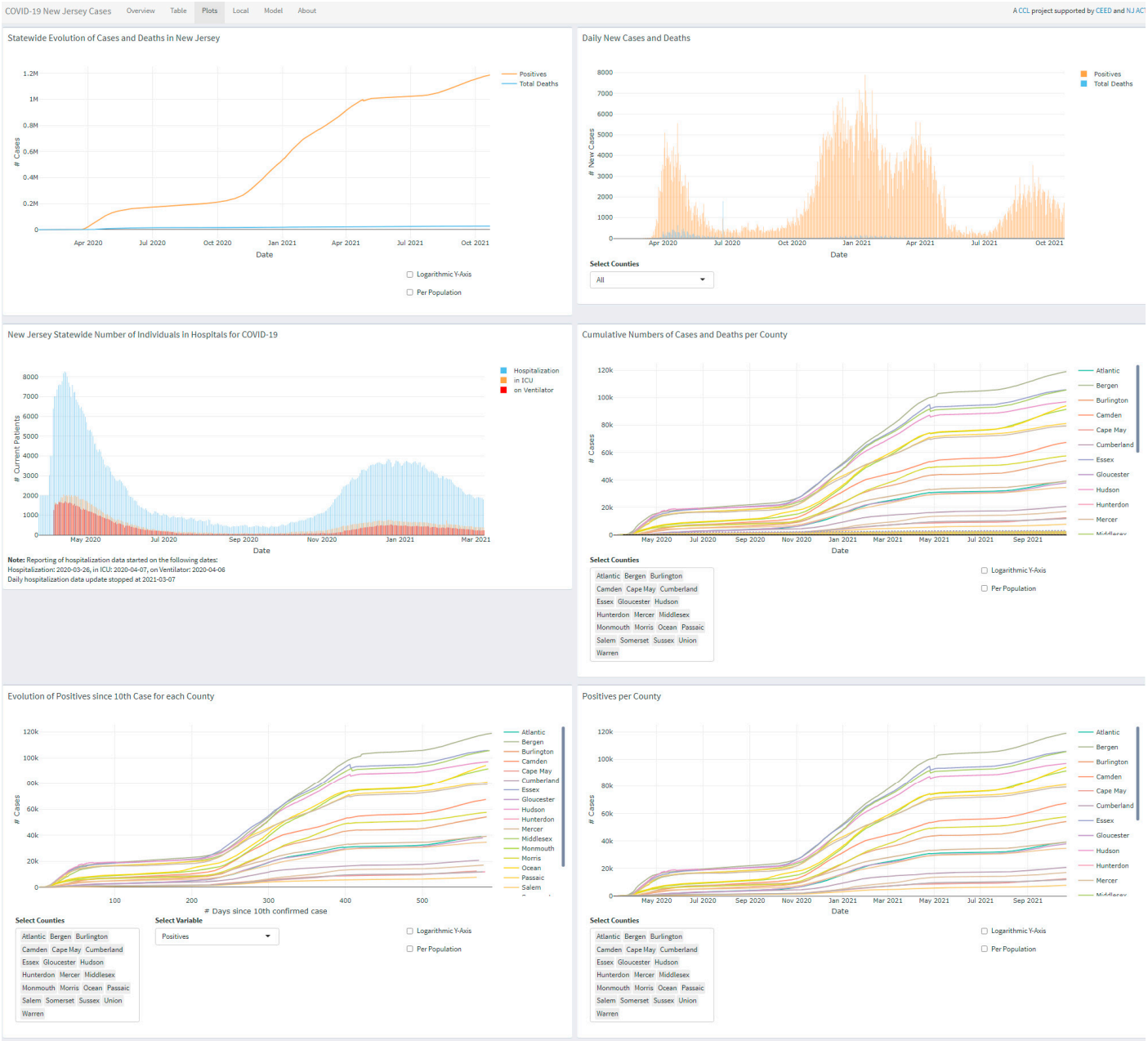



**Figure S11(d).** Local Tab

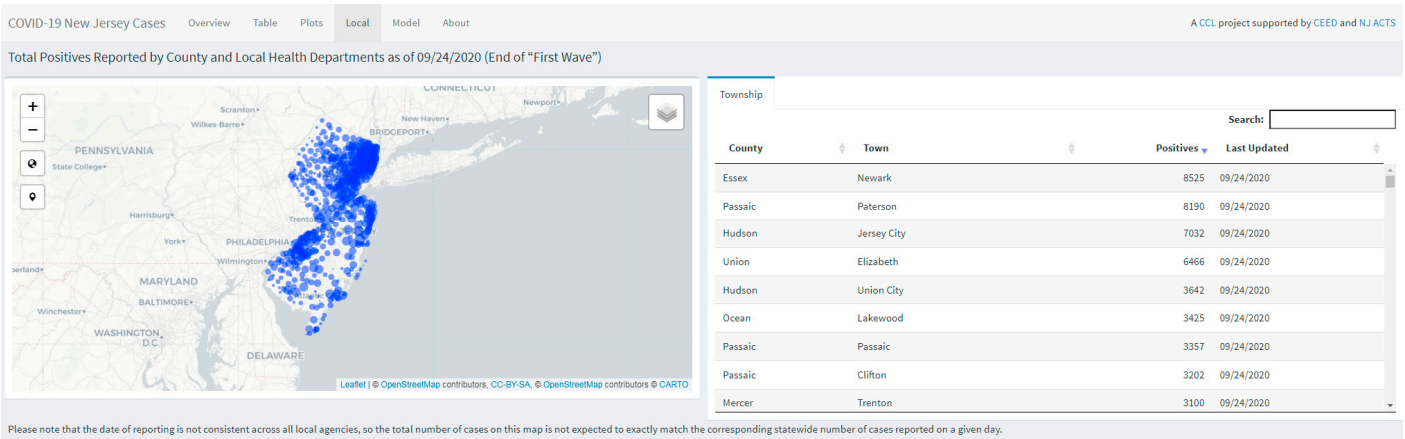
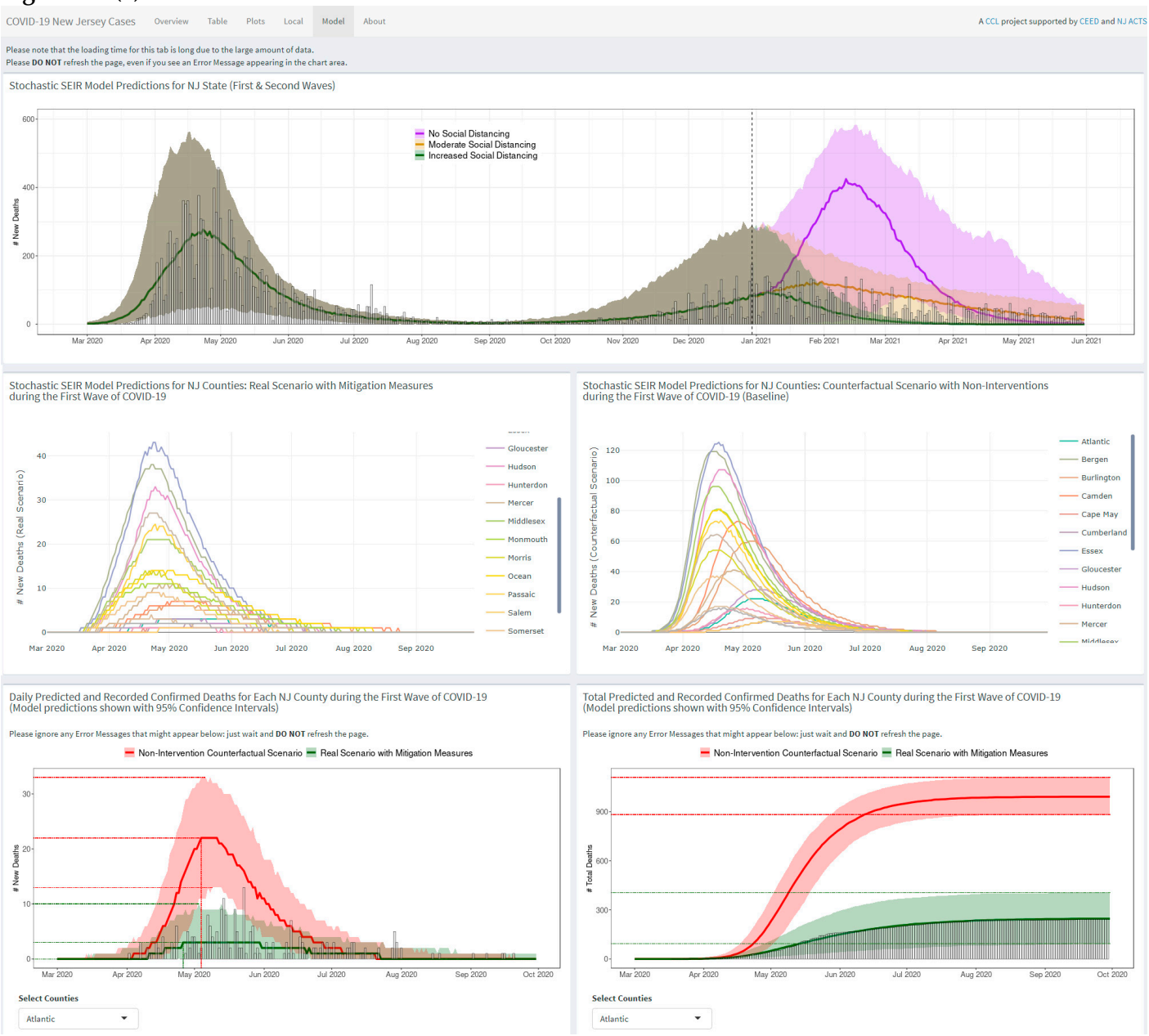


**Figure S11(e).** Model Tab



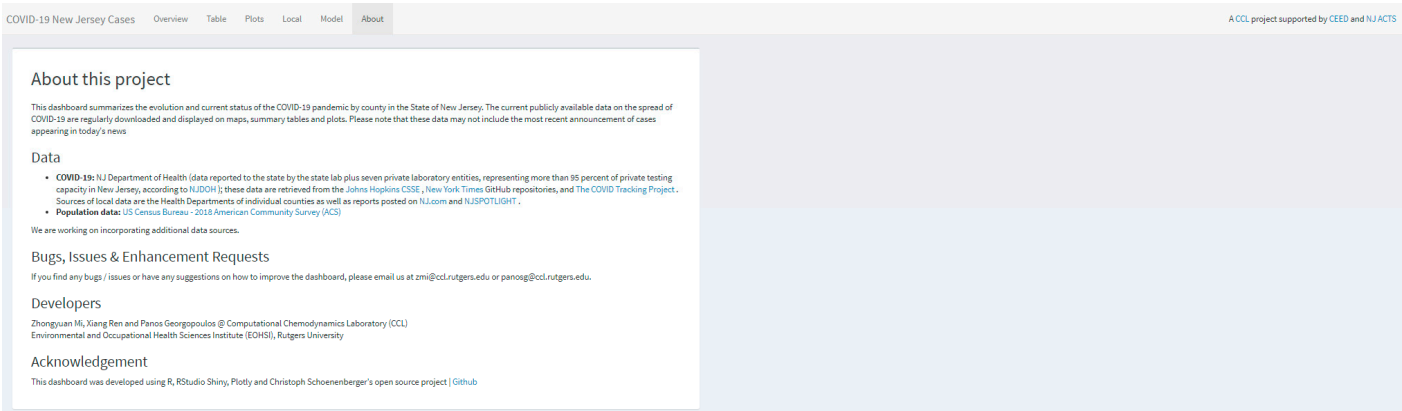


**Figure S11(f).** About Tab