

Spatiotemporal Impacts of Ideology and Social Vulnerability on COVID-19: Supplemental Appendix

Erich Seamon, Jennifer-Johnson Leung, Craig Miller, Ben Ridenhour

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Appendix Overview

Summary

Below are examinations of COVID-19 cumulative deaths adjusted by population, at a county level. We look at spatial and temporal variations for the entire United States, as well by region.

Part 1: Study Area and Regionalization

Regionalization is based on United States(US) Health and Human Services (HHS) health regions.

- Region 1 and 2 (combined): NorthEast: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New York and New Jersey
- Region 3: MidEast: Pennsylvania, West Virginia, Maryland, Delaware and the District of Columbia
- Region 4: SouthEast: Florida, Georgia, South Carolina, and North Carolina, Alabama, Mississippi, Tennessee, and Kentucky
- Region 5: Midwest: Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota
- Region 6: MidSouth: Texas, Louisiana, Arkansas, and New Mexico, Oklahoma
- Region 7: Middle West: Iowa, Missouri, Nebraska, and Kansas
- Region 8: MidNorth: Montana, Wyoming, Utah, Colorado, North Dakota, and South Dakota
- Region 9: West: California, Nevada, and Arizona
- Region 10: Pacific Northwest: Idaho, Oregon, and Washington

Part 2: Datasets and Modeling Framework

Part 2 of our analysis documents the datasets and modeling methodology employed as part of this effort.

Part 3: Exploratory Data Analysis and Regression Modeling

Our regional analysis examines COVID-19 parameters for the entire United States, as well as for each of the nine (9) regions listed above.

- The first plot (1) shows fatality rates vs. logarithmic population density, categorized by voting ideology summarized by the 2020 Presidential Election. 100-75% vote for Biden = very liberal, 75-50% for Biden = moderately liberal, 100-75% for Trump = very conservative, and 75-50% for Trump = moderately conservative. Each observation represents one county.
- The second plot (2) shows cumulative cases, adjusted for population, vs. cumulative deaths, adjusted for population, categorized by voting ideology - as noted above.
- The third (3) and fourth (4) plots show the relationship of the four ideology groupings across the specified region, over time - examining deaths for a rolling window, as well as cumulative deaths. These plots provide a summary view of the change in ideological and regional associations with cases and deaths.

For each region, we have outputs for three linear linear models, with population adjusted deaths (by county) as the dependent variable - for each of the three time windows (alpha, delta, and omicron variant). In addition, we have standardized coefficients graphs, that indicates the effect for each variable, for each model.

Part 4: Spatial Autocorrelation

The second portion of this analysis evaluates the spatial autocorrelation of population adjusted county deaths, for all three time periods examined.

Part 5: Geographically Weighted Random Forest (GWRF) Modeling

The third portion of this analysis attempts to model spatial variation for the entire United States, using geographically weighted random forest modeling (GWRF). Our model incorporates the same independent variables that are used as part of our regionalized linear models.

Geographical Weighted Random Forest (GWRF) is a spatial analysis method using a local version of the Random Forest Regression Model. It allows for the investigation of spatial non-stationarity, and the relationship between a dependent and a set of independent variables. The latter is possible by fitting a sub-model for each observation in space, taking into account the neighboring observations. This technique adopts the idea of the Geographically Weighted Regression Kalogirou (2003). The main difference between a tradition (linear) GWR and GRF is that we can model non-stationarity coupled with a flexible non-linear model which is very hard to overfit due to its bootstrapping nature, thus relaxing the assumptions of traditional Gaussian statistics. Essentially it was designed to be a bridge between machine learning and geographical models, combining inferential and explanatory power. Additionally, it is suited for datasets with numerous predictors, due to the robust nature of the random forest algorithm with regards to high dimensionality.

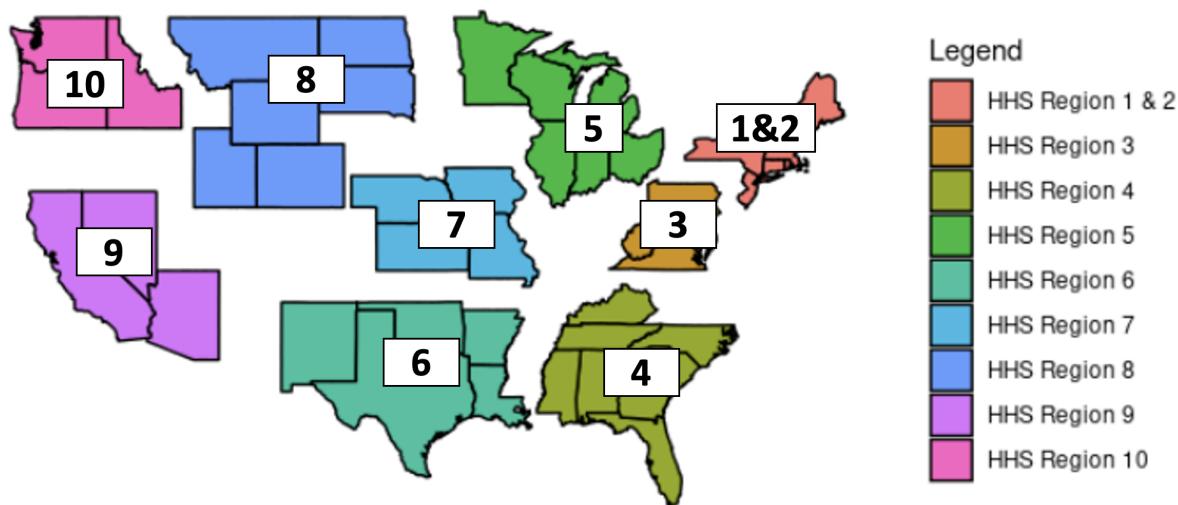
For this analysis, We generate GWRF localized model fits and feature importances (IncMSE). The feature importance algorithmic process is:

1. Compute model MSE
2. For each variable in the model:
 - a. Permute variable
 - b. Calculate new model MSE according to variable permutation
 - c. Take the difference between model MSE and new model MSE
3. Collect the results in a list

Part 1: Study Area and Regionalization

For the initial portion of our analysis, we examine COVID-19 cases and deaths for the entire United States, as well as by U.S. Human Health Services (HHS) regions, as noted in Figure S1 below.

Figure S1: Study Area



Part 2: Datasets and Modeling Framework

We utilize fifteen (15) independent variables and one (1) dependent variable for our analysis, which are as follows:

Table S1: Variable Descriptions

Table 1: Table S1: Variable Descriptions

Type	Variables	Description
Independent	Socioeconomic Status	Index which represents income, poverty, employment, and education.
Independent	Household Composition and Disability	Index with represents age, single parenting, and disability.
Independent	Minority Status	Index which represents race and ethnicity.
Independent	Housing Type and Transportation	Index which represents housing structure, crowding and vehicle access.
Independent	Democratic Voting Percentage	Represents voting outcomes from the 2020 presidential general election.
Independent	Vaccination Rate	CDC data for two dose vaccination rates at a county level, ending in April 1, 2022.
Independent	Population Density	Population density at a county level.
Independent	Obesity	Number of people who are obese, at a county level.
Independent	Unemployment	Number of unemployed adults per county.
Independent	Uninsured Adults	Number of uninsured adults per county.
Independent	Social Associations	Number of people who are members of a social organization (churches, clubs, etc).
Independent	Diabetes	Number of people with diabetes at a county level.
Independent	Food Insecurity	Index indicating the relative level of food insecurity in a county.
Independent	Broadband Access	Number of people without broadband access.
Independent	Population Age 65+	Number of people age 65 or older in a county.
Dependent	Population adjusted COVID-19 deaths	Population-adjusted COVID-19 deaths per county.

Using this framework, we constructed three (3) temporal model time frames:

1. Alpha variant time window (deaths calculated from December 1, 2019 to May 1, 2021)
2. Delta variant time window (deaths calculated from May 1, 2021, to December 1, 2021)
3. Omicron variant time window (deaths calculated from December 1, 2021 to April 1, 2022)

Figure S2: Model Framework

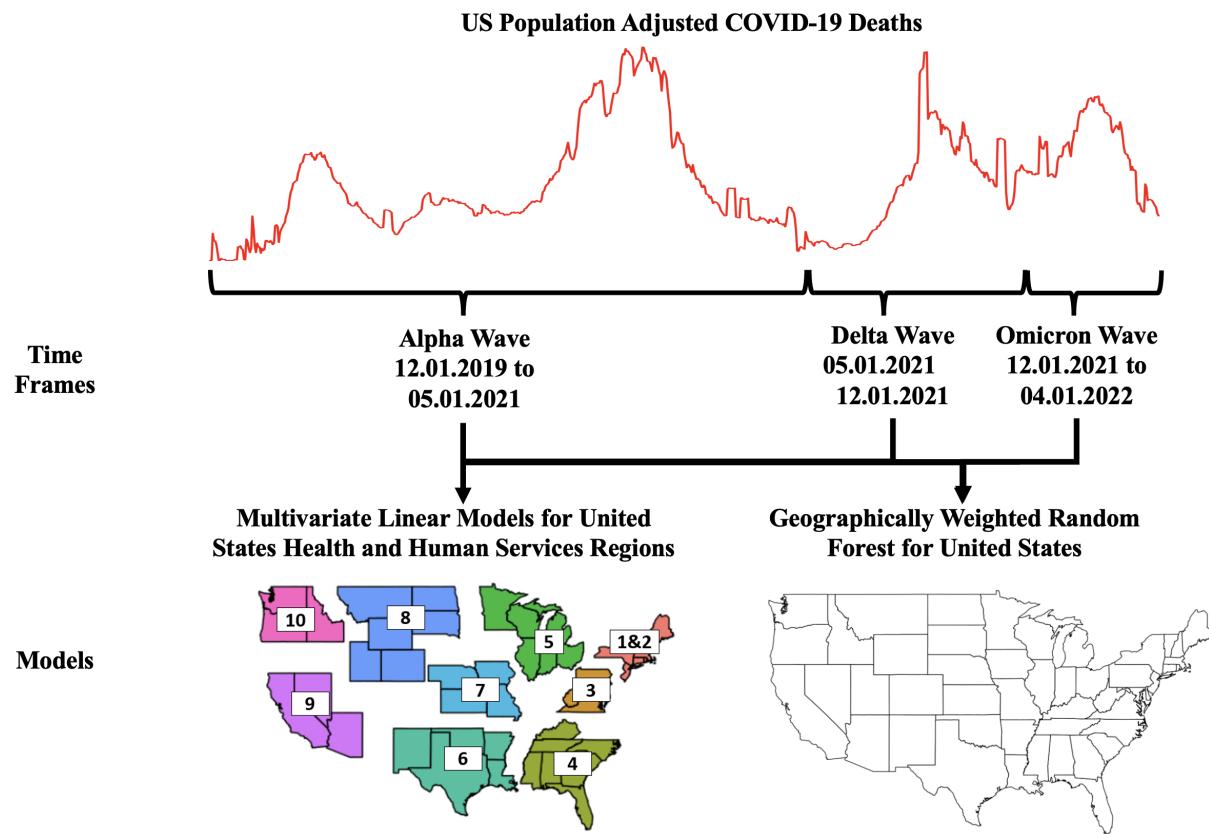
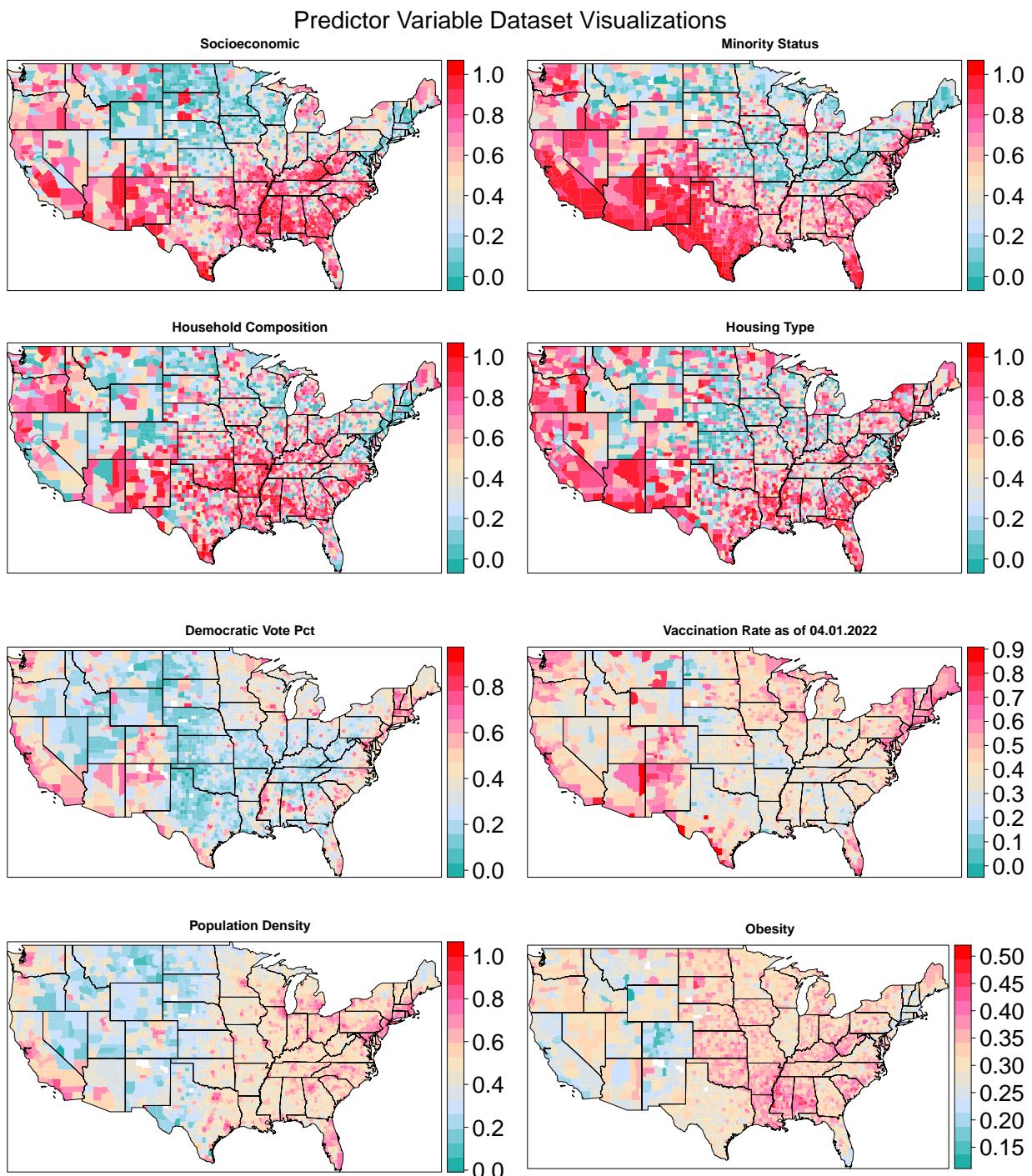
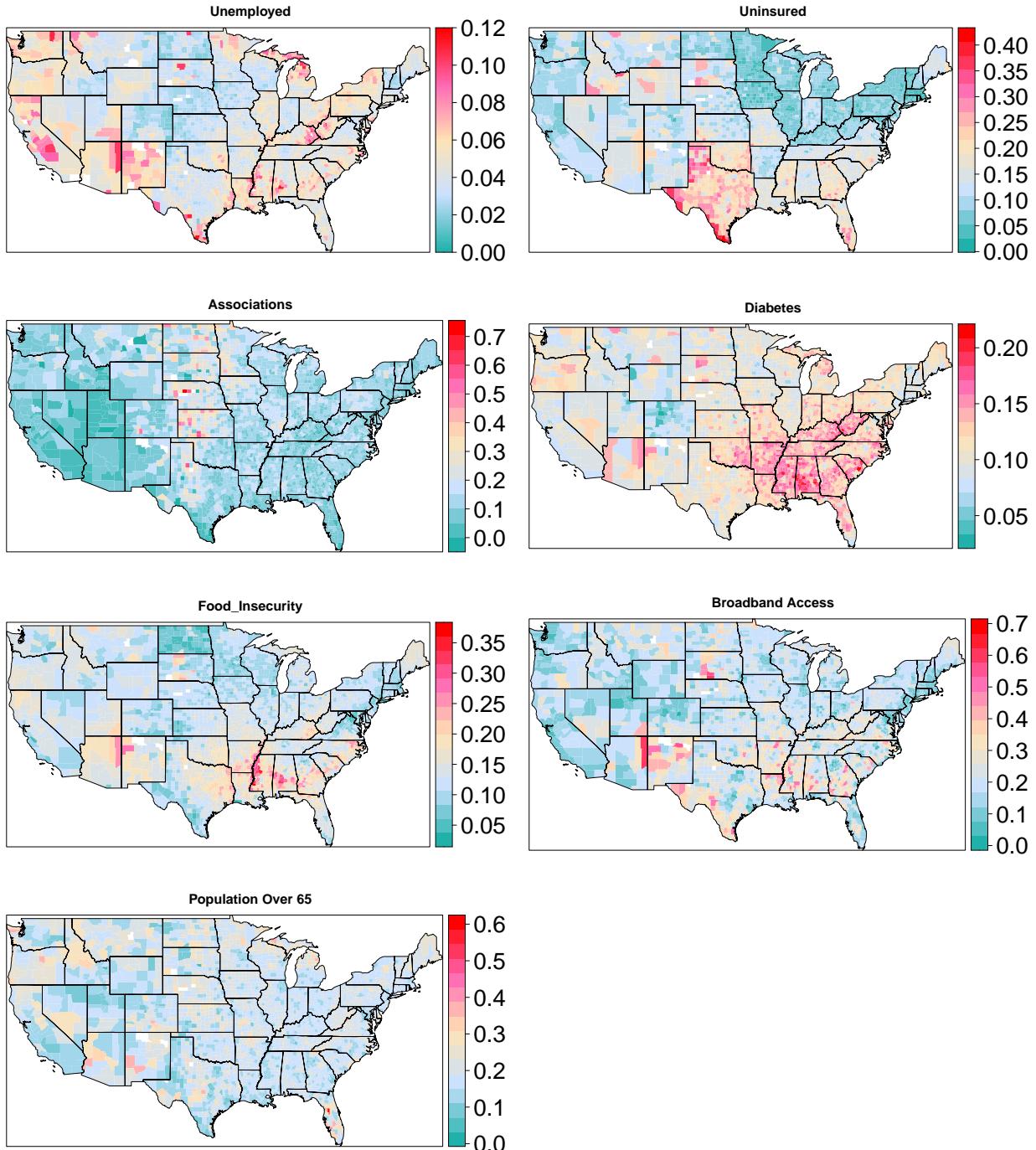


Figure S3: Dataset Visualizations





Response Variable Dataset Visualizations

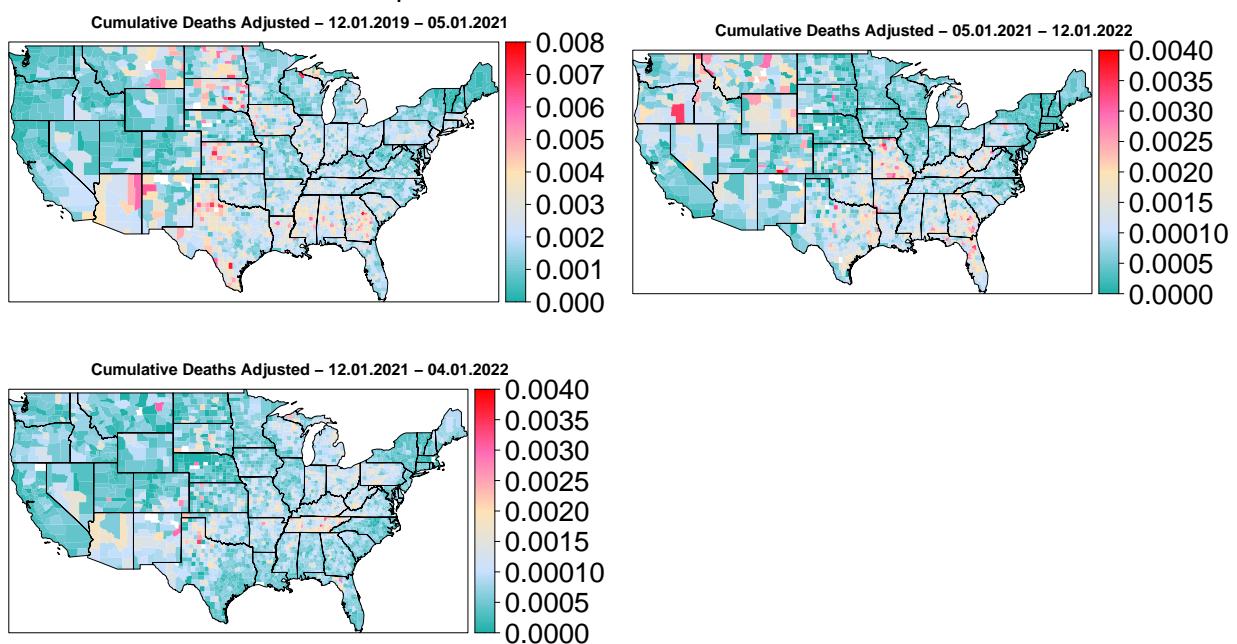
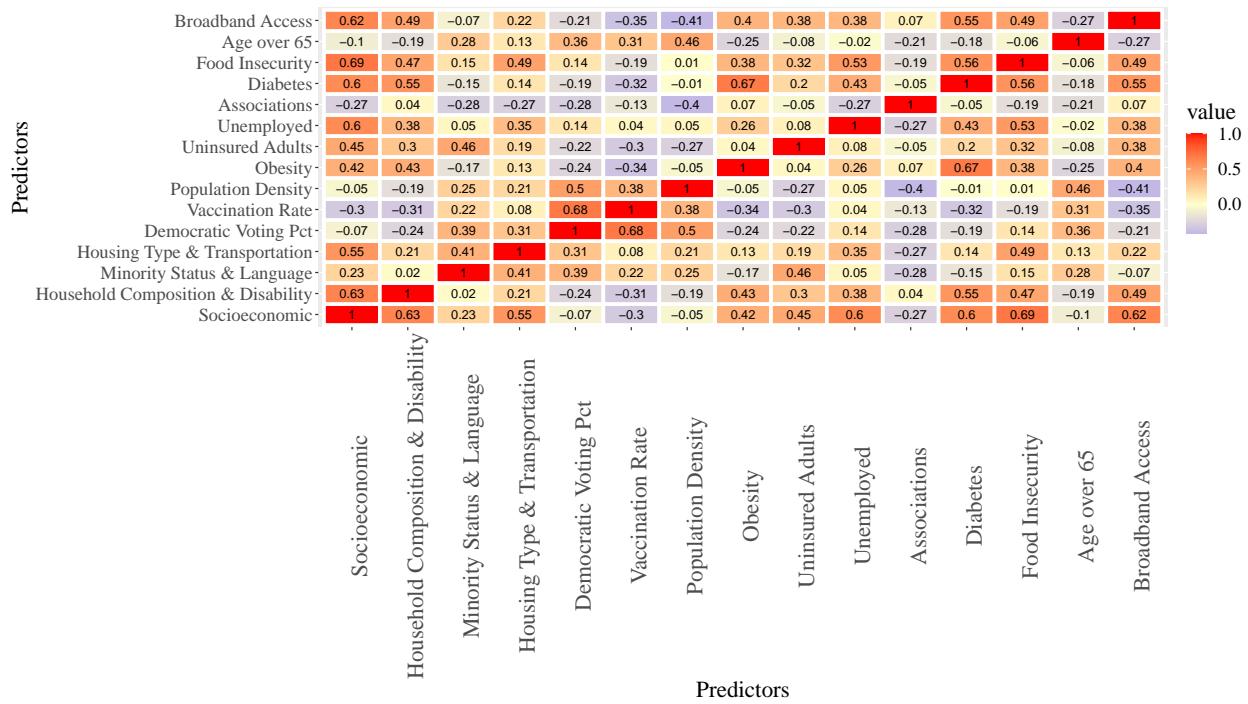


Figure S4: Correlation HeatMap



Part 3: Data Analysis and Regression: United States

Figure S5: Fatality Rate vs. Population Density

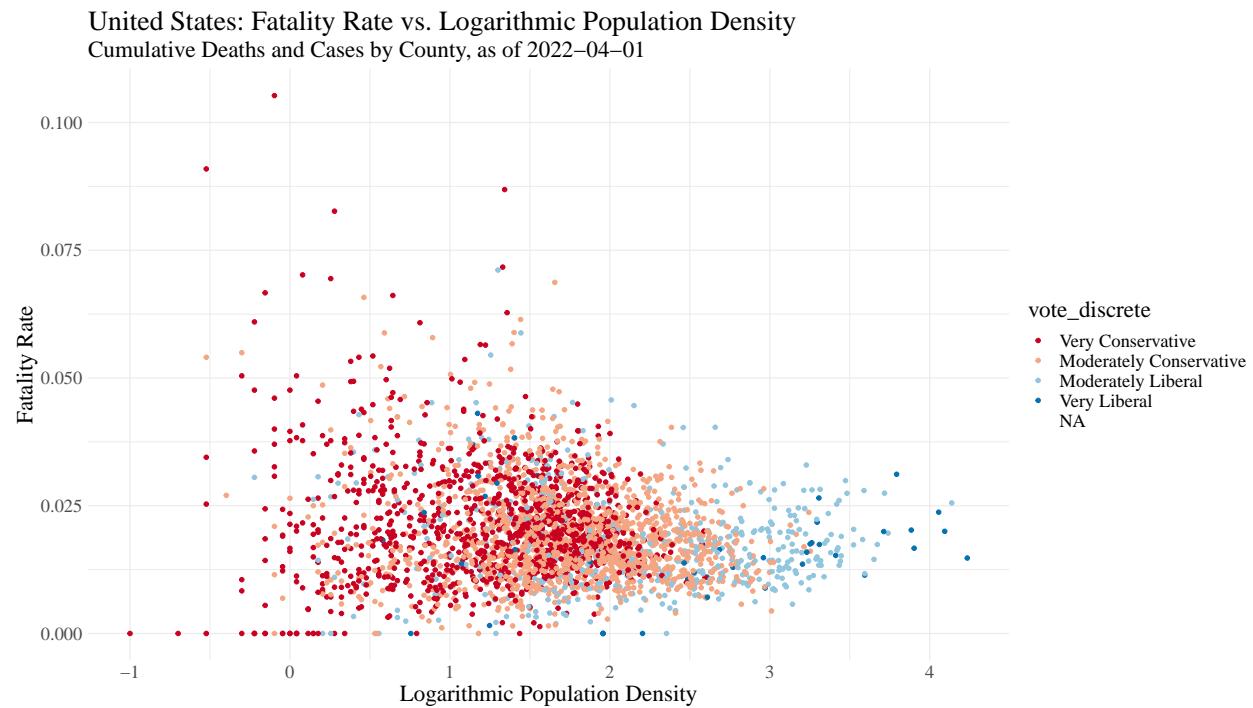


Figure S6: County Level Cumulative Cases vs. Cumulative Deaths

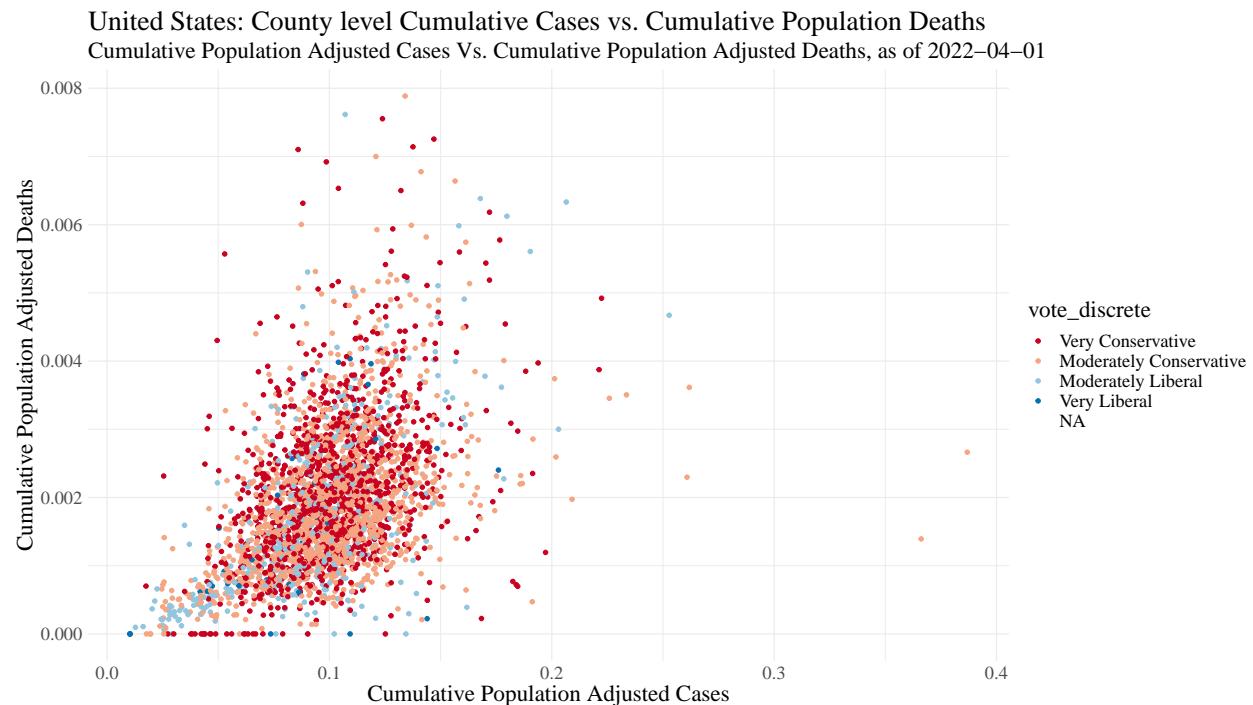


Figure S7: Population Adjusted Cumulative Deaths vs Ideology over time

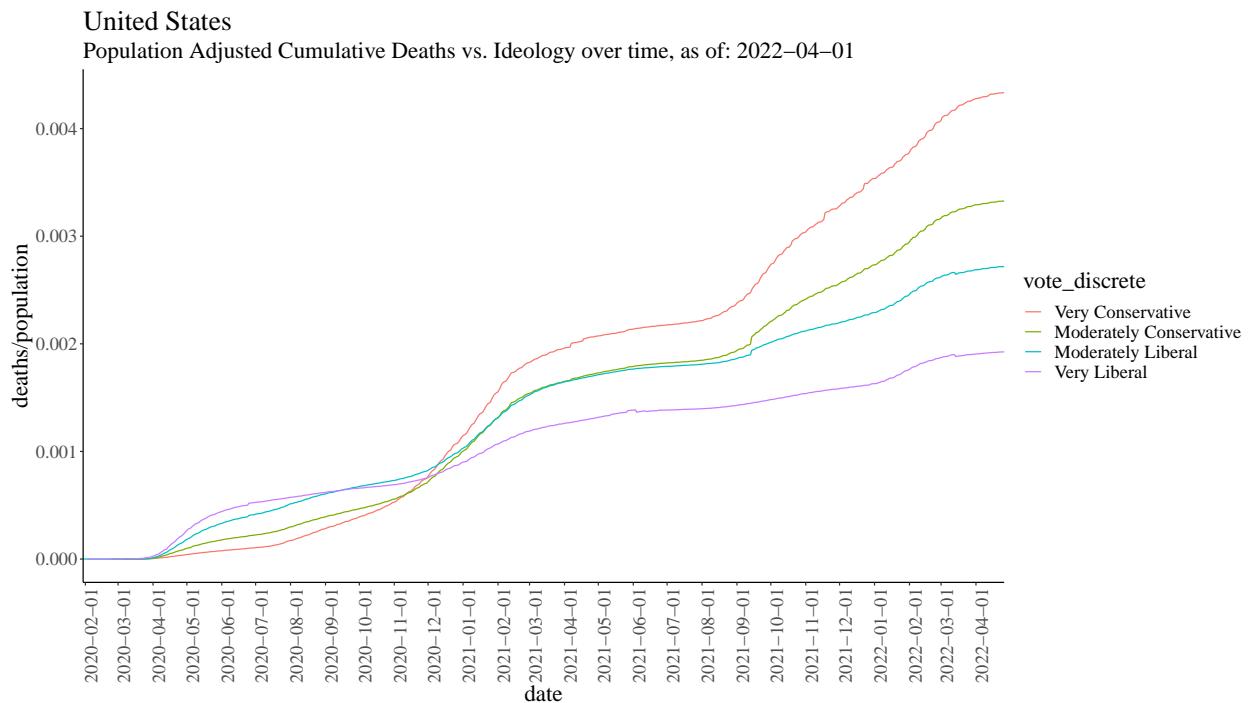


Table S2: United States: Regression Model Results

Predictors	Alpha Wave Deaths		Delta Wave Deaths		Omicron Wave Deaths	
	Estimates	p	Estimates	p	Estimates	p
Intercept	-0.000070	<0.001	0.00115	<0.001	0.00053	<0.001
Socioeconomic	-0.000000	0.984	0.00017	0.010	0.00041	<0.001
Household Composition & Disability	0.00026	0.002	0.00022	<0.001	0.00019	<0.001
Minority Status & Language	0.00038	<0.001	-0.00019	<0.001	-0.00029	<0.001
Housing Type & Transportation	0.00011	0.185	0.00015	<0.001	-0.00004	0.304
Democratic Voting Pct	-0.00066	<0.001	-0.00097	<0.001	-0.00079	<0.001
Vaccination Rate	0.00036	0.104	-0.00059	<0.001	0.00015	0.106
Population Density	0.00005	0.003	0.00001	0.292	0.00005	<0.001
Obesity	0.00075	<0.001	-0.00074	<0.001	-0.00041	<0.001
Uninsured Adults	0.00108	<0.001	0.00049	<0.001	-0.00011	0.124
Unemployed	0.00047	0.074	0.00059	<0.001	0.00018	0.109
Diabetes	0.00050	0.016	0.00075	<0.001	0.00054	<0.001
Food Insecurity	-0.00041	0.064	0.00040	<0.001	-0.00030	0.001
Social Associations	0.00280	<0.001	-0.00044	<0.001	0.00034	<0.001
Age over 65	0.00000	0.001	0.00000	0.580	0.00000	0.542
Broadband Access	0.00328	<0.001	-0.00031	0.061	0.00046	0.001
Observations	3093		3093		3093	
R ² / R ² adjusted	0.256 / 0.253		0.358 / 0.355		0.282 / 0.278	

Part 3: Data Analysis and Regression: Regions 1 and 2 (Northeast)

Figure S8: Fatality Rate vs. Population Density

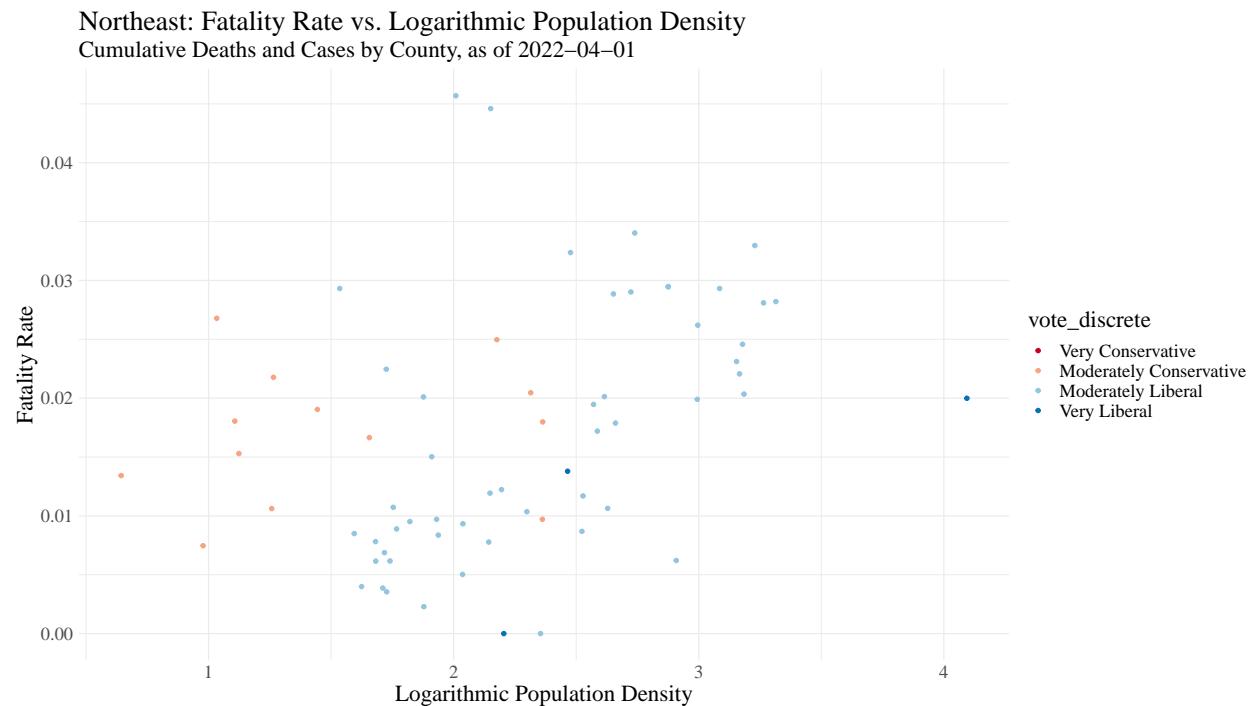


Figure S9: County Level Cumulative Cases vs. Cumulative Deaths

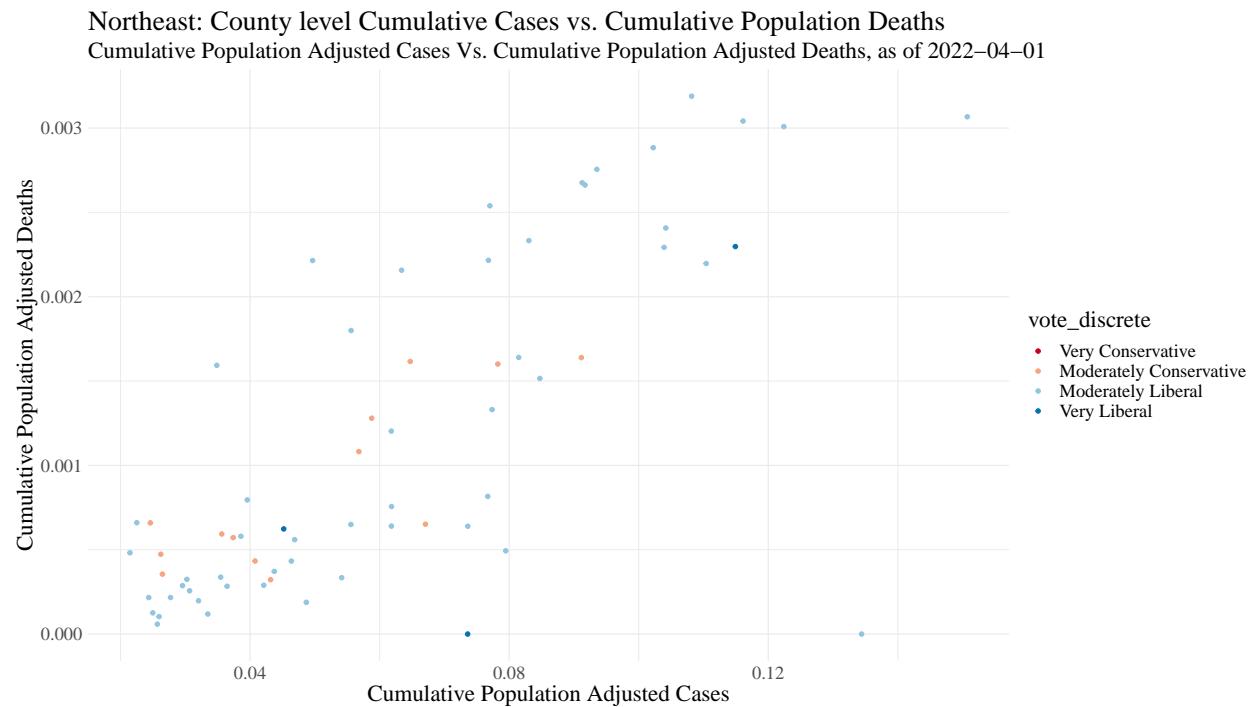


Figure S10: Population Adjusted Cumulative Deaths vs Ideology over time ->

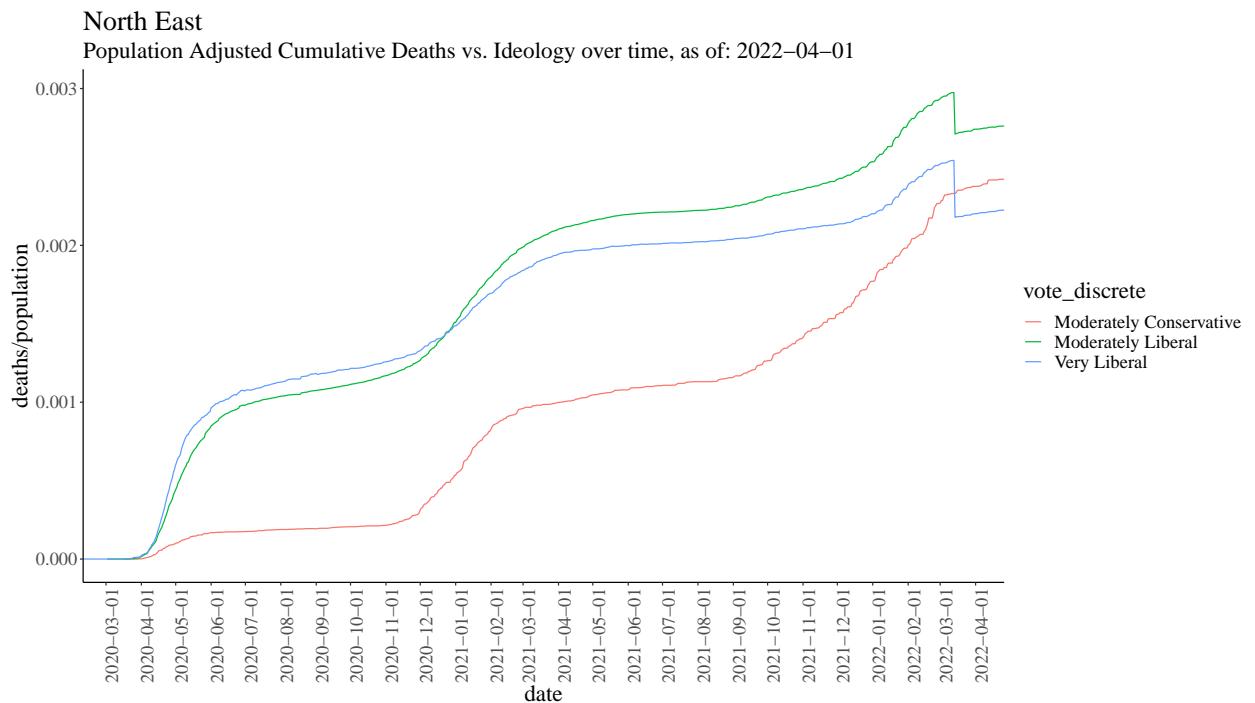


Table S3: Region 1 & 2: Regression Model Results

Predictors	Alpha Wave Deaths		Delta Wave Deaths		Omicron Wave Deaths	
	Estimates	p	Estimates	p	Estimates	p
Intercept	-0.00093	0.243	0.00026	0.253	0.00031	0.271
Socioeconomic	0.00086	0.112	-0.00010	0.512	-0.00034	0.076
Household Composition & Disability	0.00062	0.051	0.00031	0.001	0.00032	0.004
Minority Status & Language	0.00092	0.006	-0.00006	0.500	0.00013	0.260
Housing Type & Transportation	-0.00047	0.029	0.00010	0.104	-0.00006	0.454
Democratic Voting Pct	-0.00056	0.372	-0.00032	0.076	-0.00107	<0.001
Vaccination Rate	-0.00038	0.480	-0.00021	0.168	0.00023	0.224
Population Density	0.00041	<0.001	0.00002	0.283	0.00004	0.055
Obesity	-0.00024	0.733	0.00030	0.146	0.00060	0.020
Uninsured Adults	0.00045	0.443	0.00025	0.132	0.00082	<0.001
Unemployed	0.00087	0.393	-0.00013	0.662	-0.00081	0.028
Diabetes	0.00066	0.414	0.00001	0.961	-0.00051	0.080
Food Insecurity	-0.00234	0.033	0.00031	0.323	0.00104	0.008
Social Associations	-0.00088	0.477	0.00012	0.724	0.00014	0.751
Age over 65	0.00000	0.312	0.00000	0.588	-0.00000	0.532
Broadband Access	0.00230	0.187	-0.00028	0.565	0.00026	0.675
Observations	145		145		145	
R ² / R ² adjusted	0.769 / 0.742		0.474 / 0.413		0.540 / 0.486	

Part 3: Data Analysis and Regression: Region 3 (Mideast)

Figure S11: Fatality Rate vs. Population Density

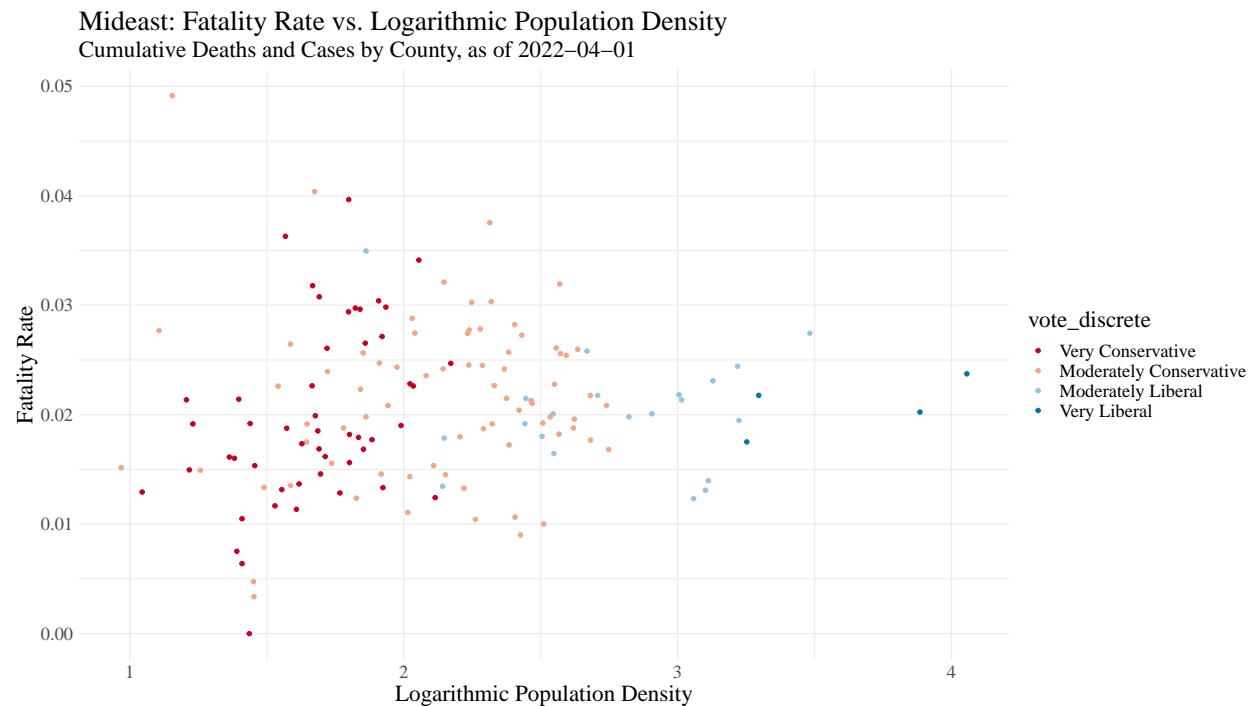


Figure S12: County Level Cumulative Cases vs. Cumulative Deaths

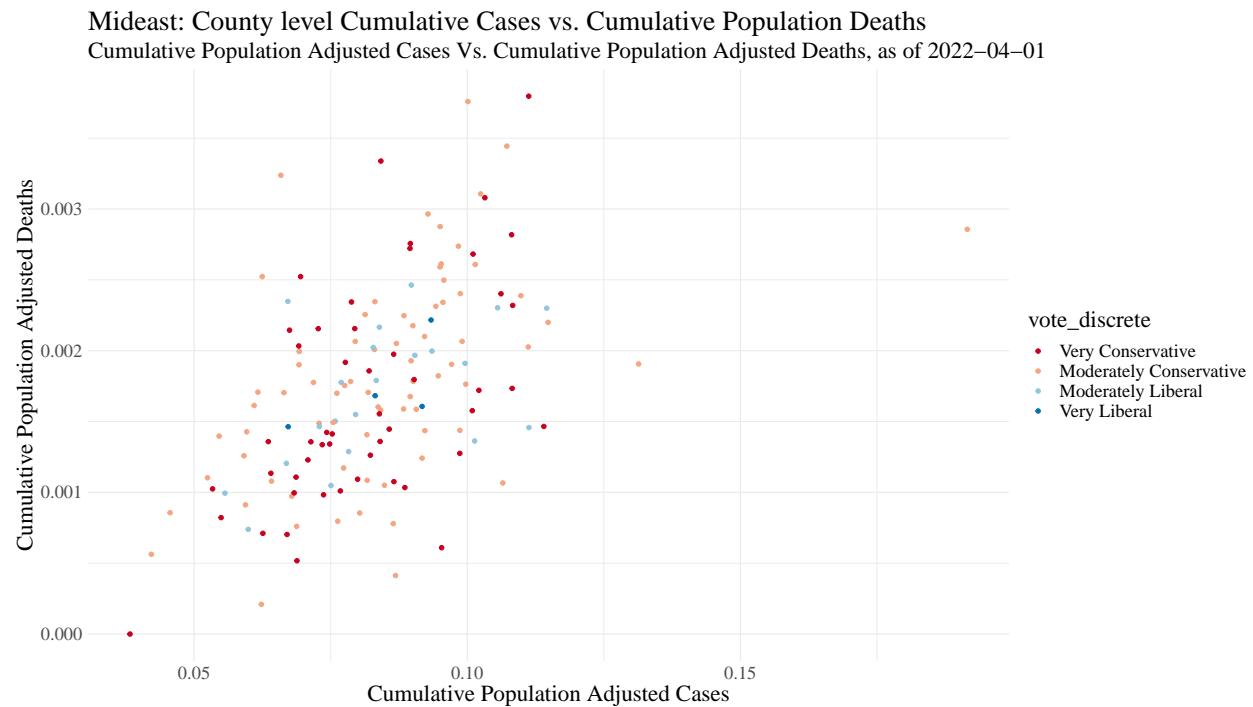


Figure S13: Population Adjusted Cumulative Deaths vs Ideology over time

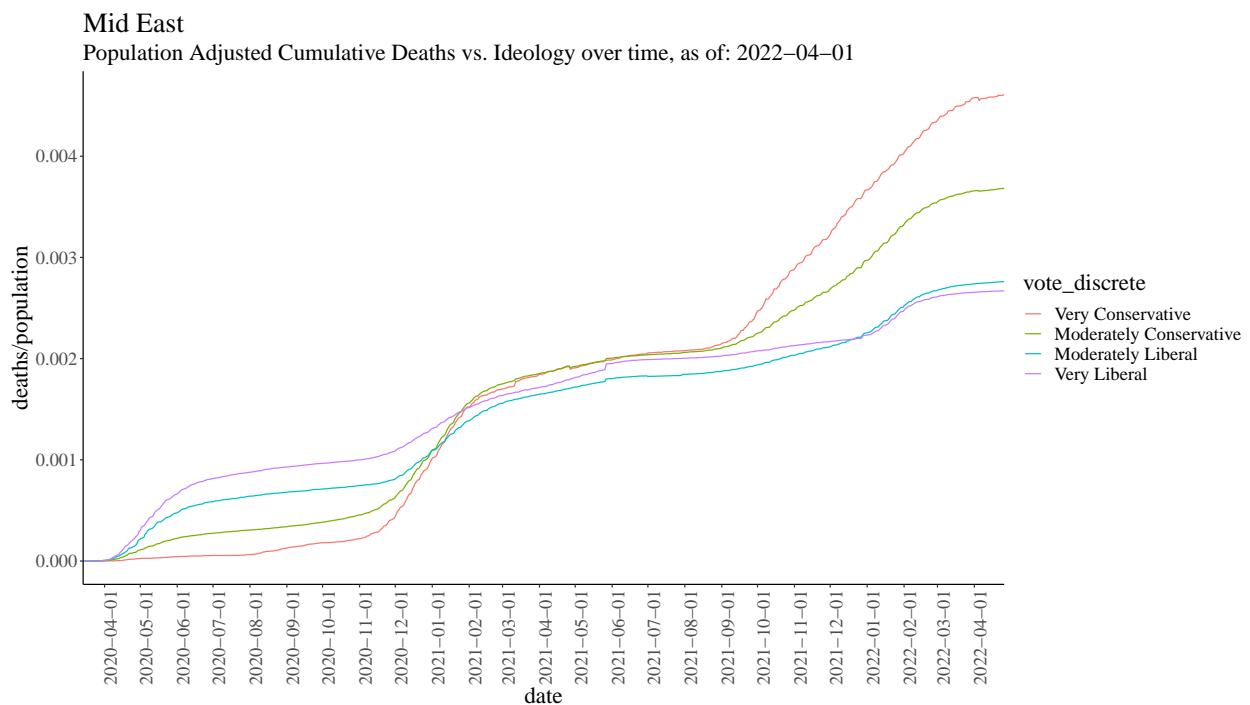


Table S4: Region 3: Regression Model Results

Predictors	Alpha Wave Deaths		Delta Wave Deaths		Omicron Wave Deaths	
	Estimates	p	Estimates	p	Estimates	p
Intercept	-0.00130	0.202	0.00198	0.022	0.00022	0.757
Socioeconomic	-0.00117	0.046	0.00031	0.520	0.00045	0.267
Household Composition & Disability	0.00034	0.283	0.00034	0.195	0.00026	0.233
Minority Status & Language	0.00056	0.129	-0.00057	0.066	0.00006	0.800
Housing Type & Transportation	0.00059	0.041	0.00011	0.639	0.00014	0.486
Democratic Voting Pct	-0.00222	0.022	0.00014	0.862	-0.00129	0.055
Vaccination Rate	0.00048	0.639	-0.00009	0.919	-0.00009	0.900
Population Density	0.00021	0.050	-0.00023	0.011	0.00012	0.112
Obesity	0.00024	0.773	0.00038	0.581	0.00016	0.786
Uninsured Adults	0.00070	0.756	-0.00332	0.081	-0.00008	0.959
Unemployed	0.00013	0.891	0.00050	0.536	0.00017	0.798
Diabetes	0.00255	<0.001	0.00006	0.915	0.00039	0.412
Food Insecurity	-0.00010	0.946	0.00126	0.310	-0.00101	0.328
Social Associations	0.00295	0.014	0.00092	0.351	0.00014	0.863
Age over 65	0.00000	0.418	0.00000	0.128	0.00000	0.867
Broadband Access	-0.00042	0.766	-0.00240	0.045	0.00059	0.547
Observations	82		82		82	
R ² / R ² adjusted	0.500 / 0.386		0.608 / 0.518		0.466 / 0.344	

Part 3: Data Analysis and Regression: Region 4 (Southeast)

Figure S14: Fatality Rate vs. Population Density

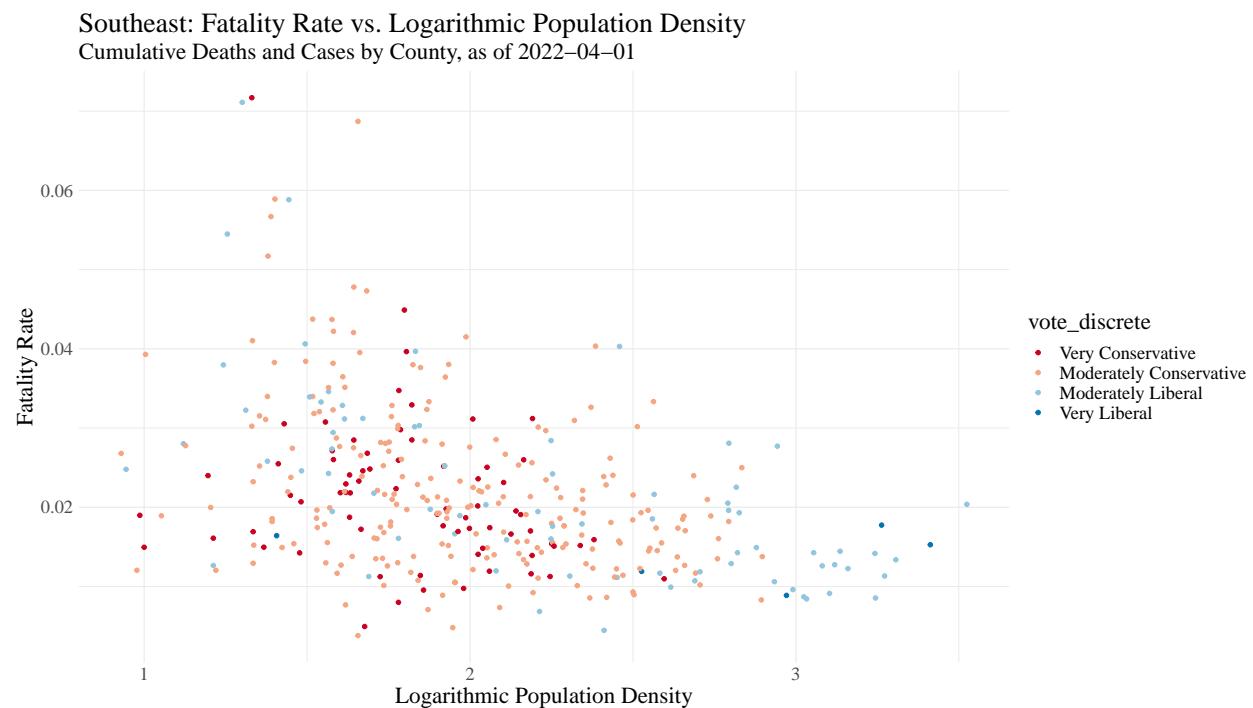


Figure S15: County Level Cumulative Cases vs. Cumulative Deaths

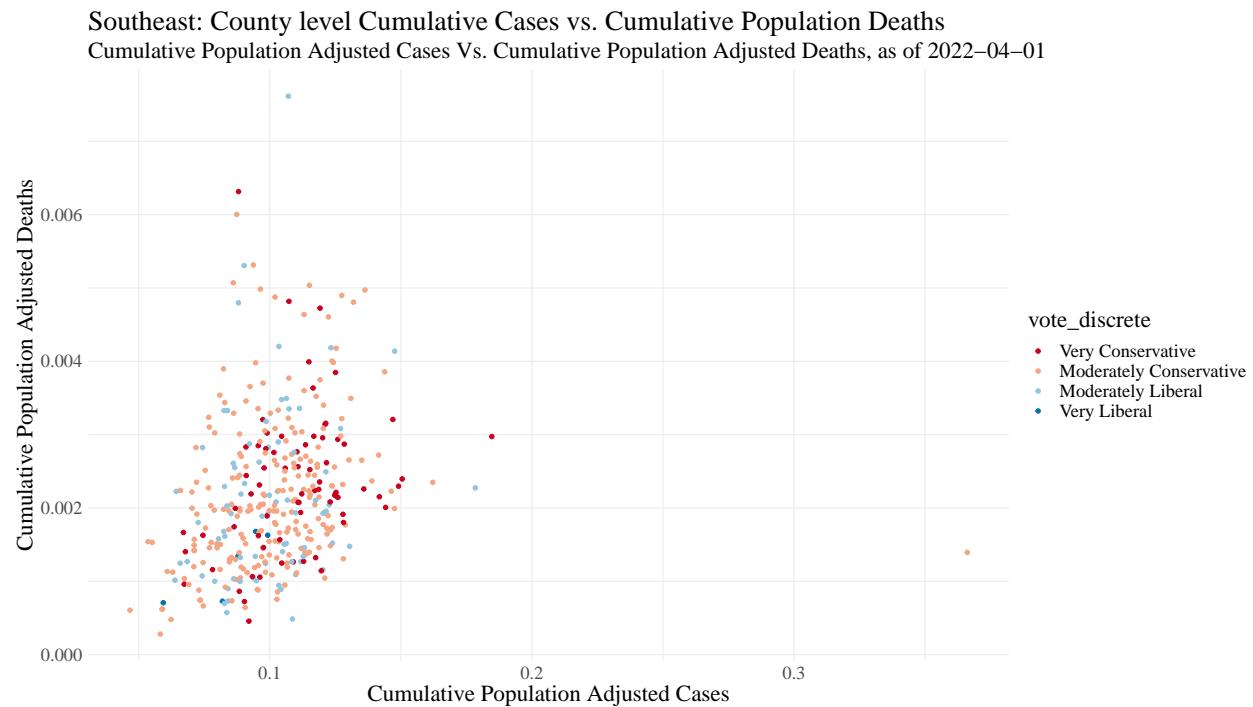


Figure S16: Population Adjusted Cumulative Deaths vs Ideology over time

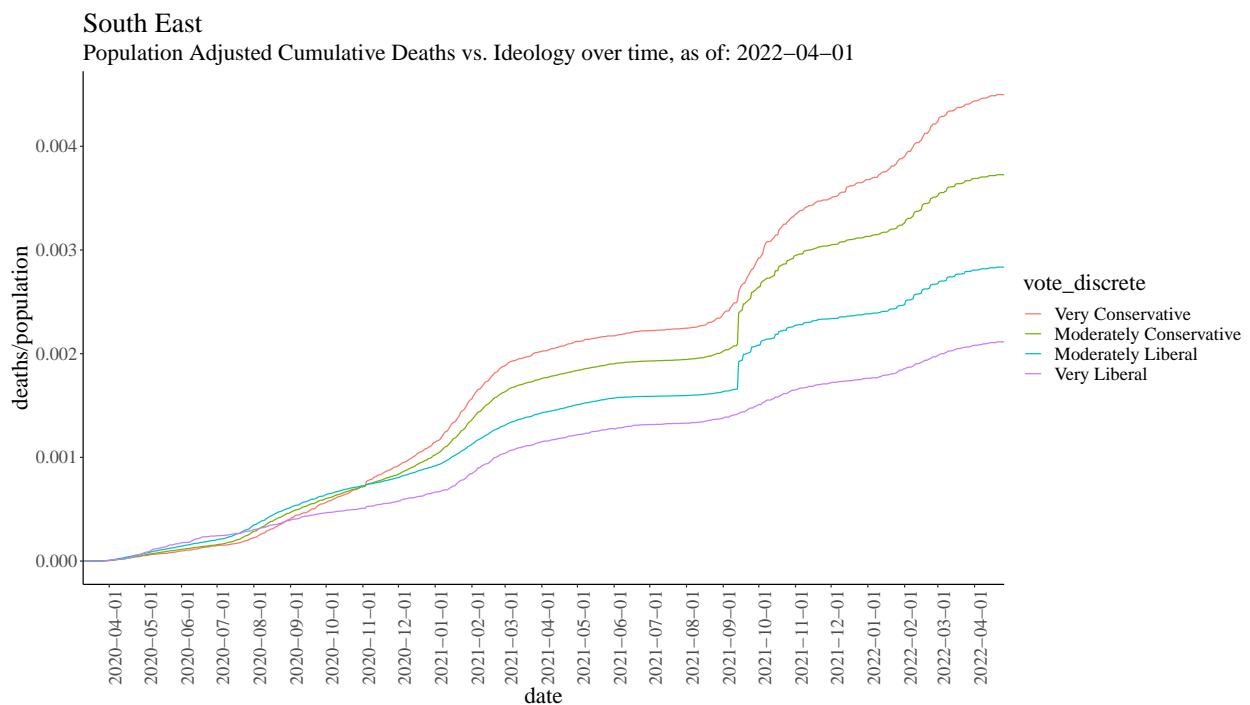


Table S5: Region 4: Regression Model Results

Predictors	Alpha Wave Deaths		Delta Wave Deaths		Omicron Wave Deaths	
	Estimates	p	Estimates	p	Estimates	p
Intercept	0.00119	0.131	0.00084	0.163	0.00014	0.638
Socioeconomic	-0.00056	0.202	0.00008	0.802	0.00028	0.083
Household Composition & Disability	-0.00003	0.888	0.00001	0.960	0.00004	0.645
Minority Status & Language	-0.00011	0.763	-0.00041	0.124	-0.00022	0.085
Housing Type & Transportation	0.00073	0.001	0.00046	0.009	0.00007	0.425
Democratic Voting Pct	-0.00124	0.038	-0.00328	<0.001	-0.00097	<0.001
Vaccination Rate	-0.00260	<0.001	-0.00097	0.055	-0.00033	0.168
Population Density	0.00003	0.730	0.00014	0.018	0.00009	0.002
Obesity	-0.00076	0.257	0.00018	0.720	-0.00008	0.746
Uninsured Adults	0.00048	0.506	0.00116	0.037	0.00018	0.507
Unemployed	0.00214	0.041	0.00080	0.318	-0.00025	0.519
Diabetes	0.00204	<0.001	0.00181	<0.001	0.00075	<0.001
Food Insecurity	0.00159	0.053	0.00145	0.021	0.00024	0.430
Social Associations	0.00059	0.539	-0.00091	0.216	0.00057	0.106
Age over 65	0.00000	0.050	0.00000	0.004	0.00000	0.142
Broadband Access	0.00203	0.017	-0.00078	0.231	-0.00011	0.724
Observations	383		383		383	
R ² / R ² adjusted	0.408 / 0.384		0.424 / 0.400		0.288 / 0.259	

Part 3: Data Analysis and Regression: Region 5 (Midwest)

Figure S17: Fatality Rate vs. Population Density

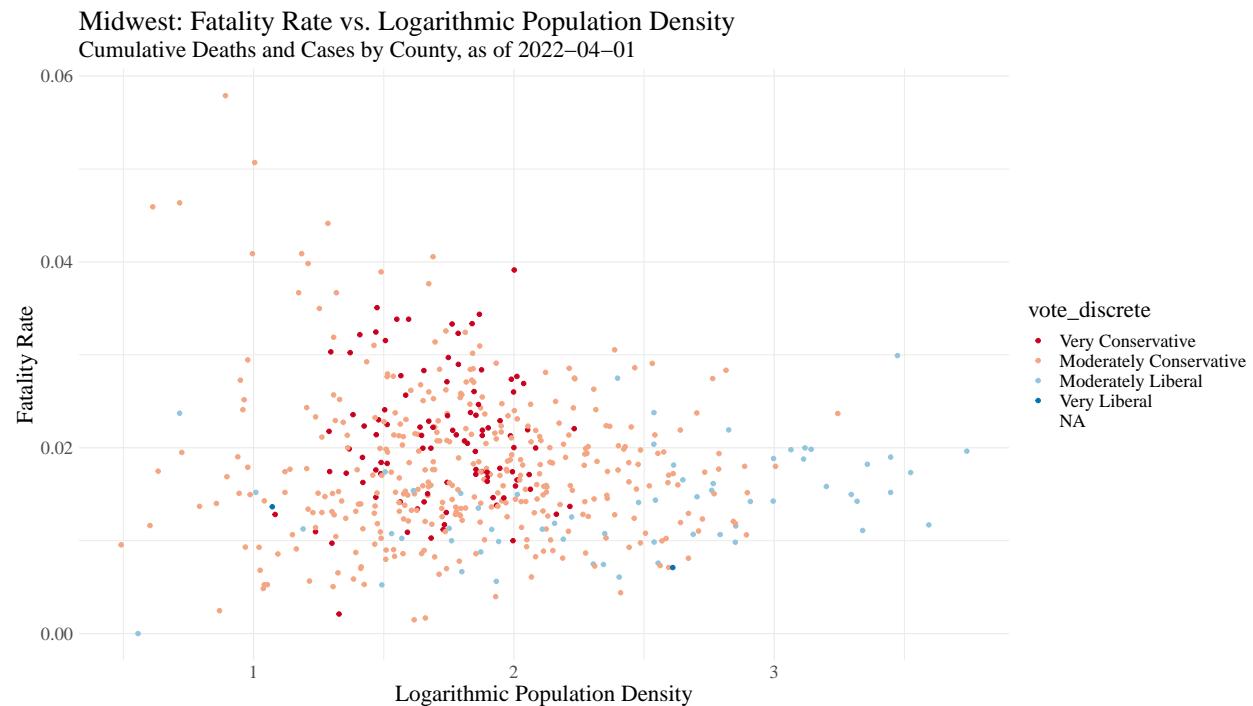


Figure S18: County Level Cumulative Cases vs. Cumulative Deaths

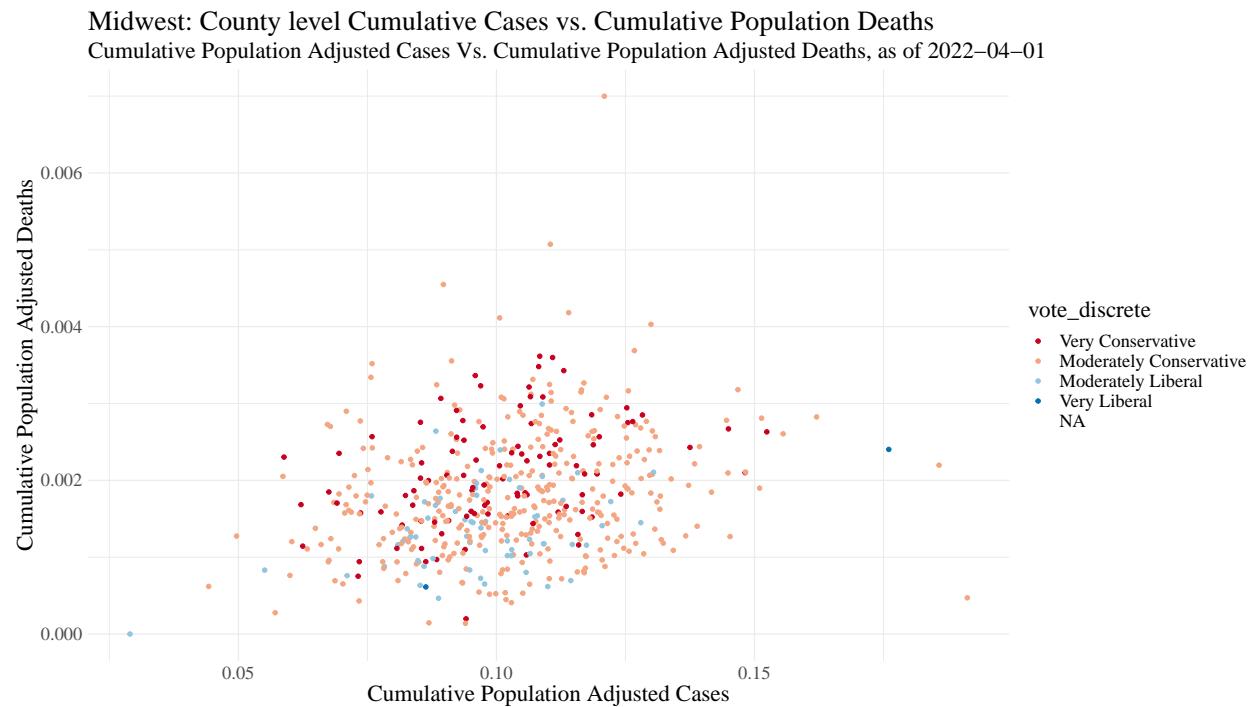


Figure S19: Population Adjusted Cumulative Deaths vs Ideology over time

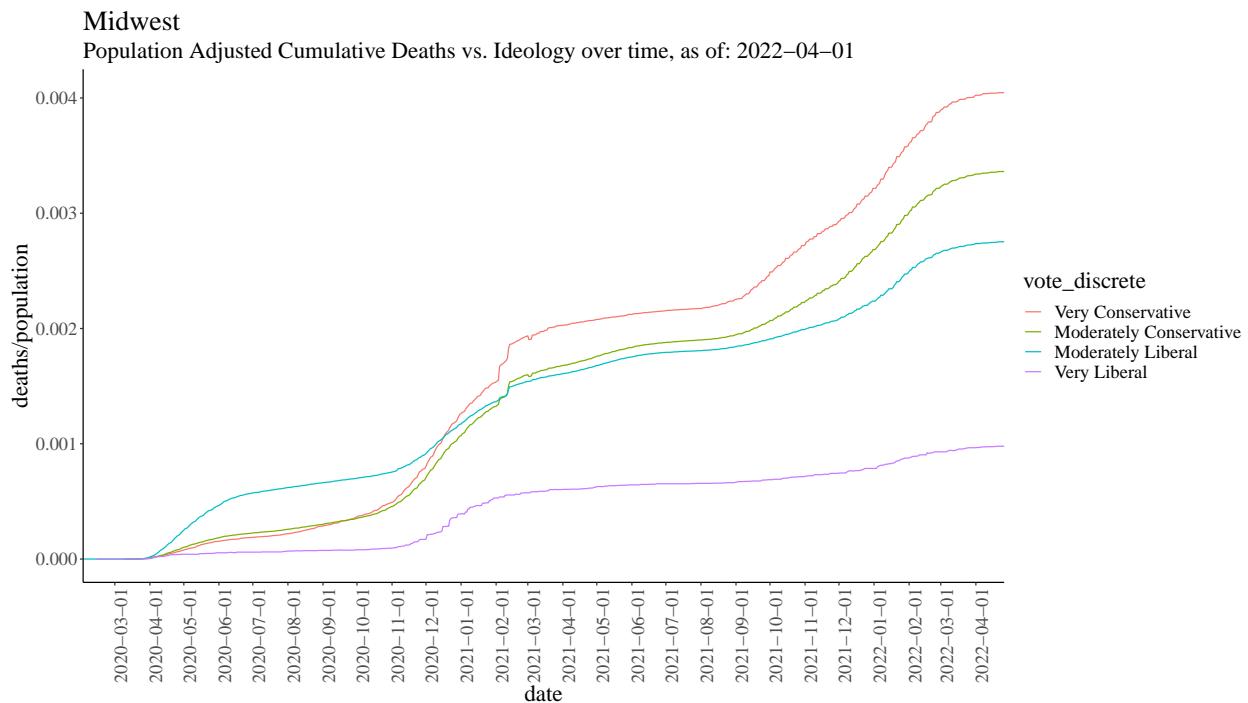


Table S6: Region 5: Regression Model Results

Predictors	Alpha Wave Deaths		Delta Wave Deaths		Omicron Wave Deaths	
	Estimates	p	Estimates	p	Estimates	p
Intercept	0.00127	0.009	0.00062	0.001	0.00045	0.031
Socioeconomic	0.00048	0.178	0.00027	0.057	0.00023	0.128
Household Composition & Disability	0.00042	0.015	0.00011	0.099	0.00013	0.079
Minority Status & Language	-0.00010	0.669	-0.00029	0.002	-0.00022	0.028
Housing Type & Transportation	-0.00002	0.925	0.00003	0.656	-0.00007	0.338
Democratic Voting Pct	-0.00213	<0.001	-0.00019	0.408	-0.00025	0.296
Vaccination Rate	0.00076	0.195	-0.00061	0.009	-0.00044	0.079
Population Density	0.00006	0.232	0.00002	0.266	0.00003	0.090
Obesity	-0.00069	0.125	-0.00005	0.765	0.00040	0.034
Uninsured Adults	0.00082	0.295	0.00014	0.650	0.00025	0.454
Unemployed	-0.00037	0.530	0.00102	<0.001	0.00057	0.023
Diabetes	0.00077	0.136	0.00076	<0.001	0.00115	<0.001
Food Insecurity	0.00046	0.577	-0.00042	0.197	0.00005	0.889
Social Associations	0.00178	0.001	-0.00021	0.333	0.00002	0.915
Age over 65	0.00000	0.073	-0.00000	0.750	0.00000	0.967
Broadband Access	-0.00121	0.201	-0.00016	0.665	-0.00142	<0.001
Observations	523		523		523	
R ² / R ² adjusted	0.204 / 0.181		0.427 / 0.410		0.421 / 0.404	

Part 3: Data Analysis and Regression: Region 6 (MidSouth)

Figure S20: Fatality Rate vs. Population Density

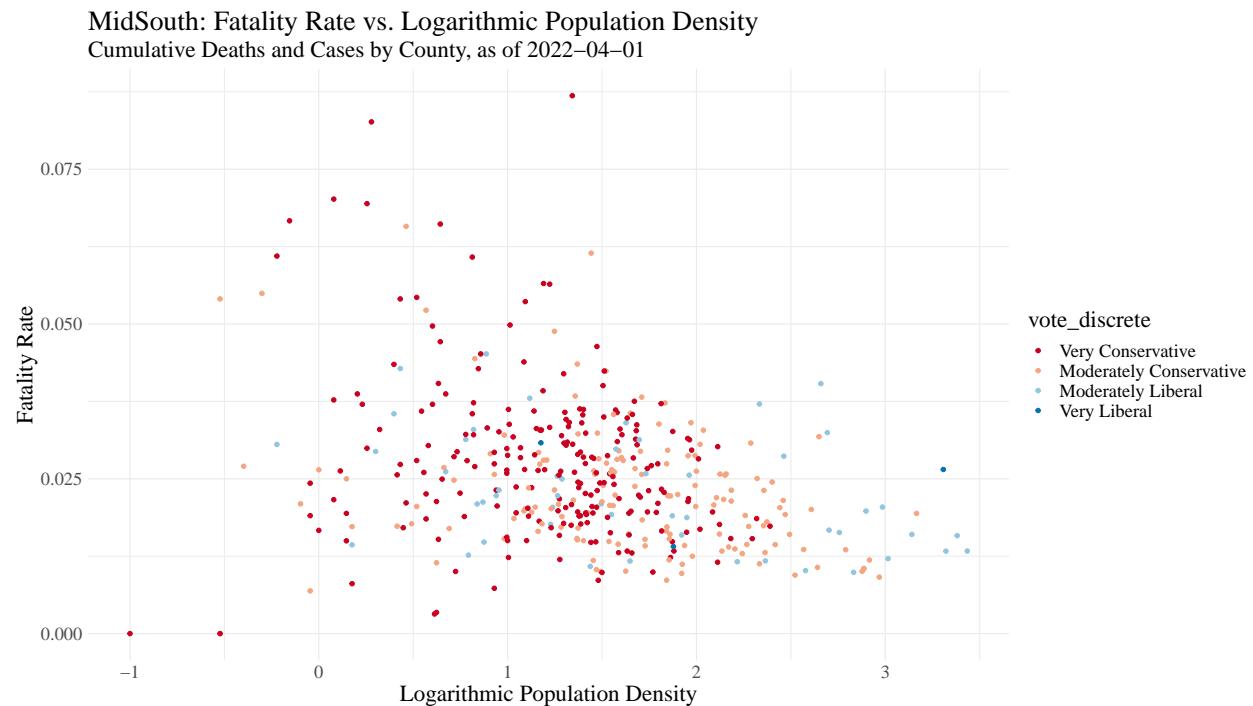


Figure S21: County Level Cumulative Cases vs. Cumulative Deaths

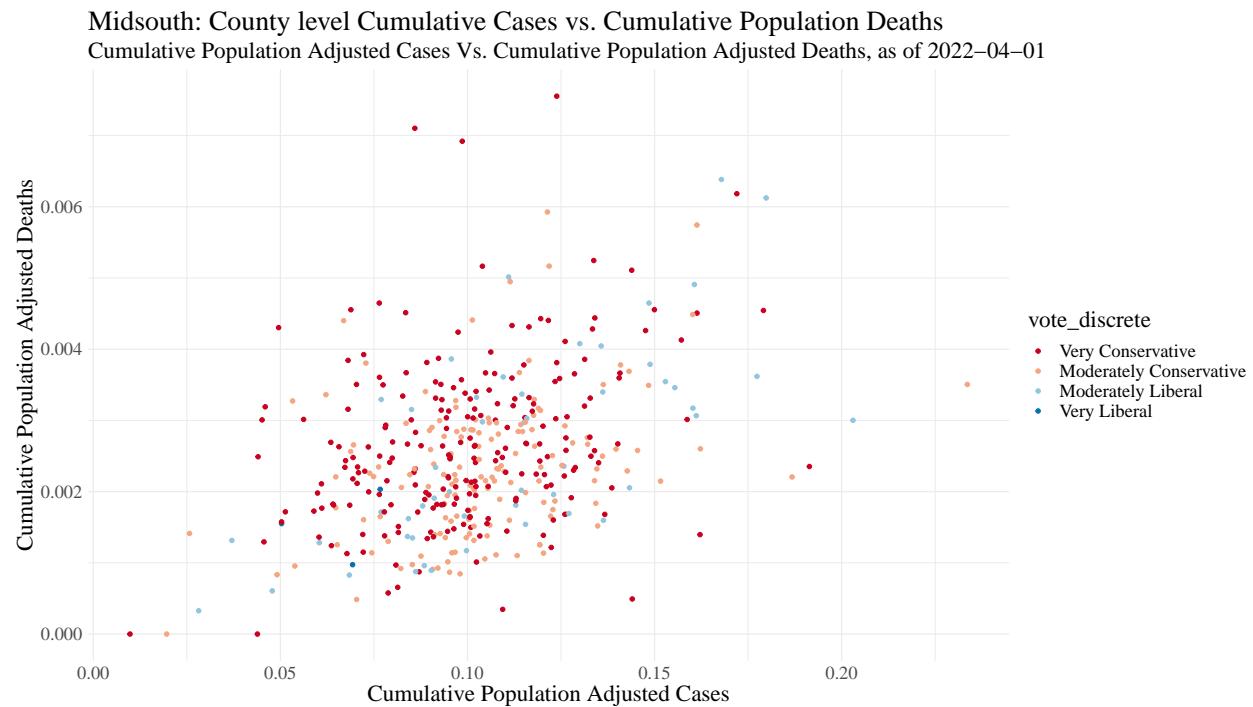


Figure S22: Population Adjusted Cumulative Deaths vs Ideology over time

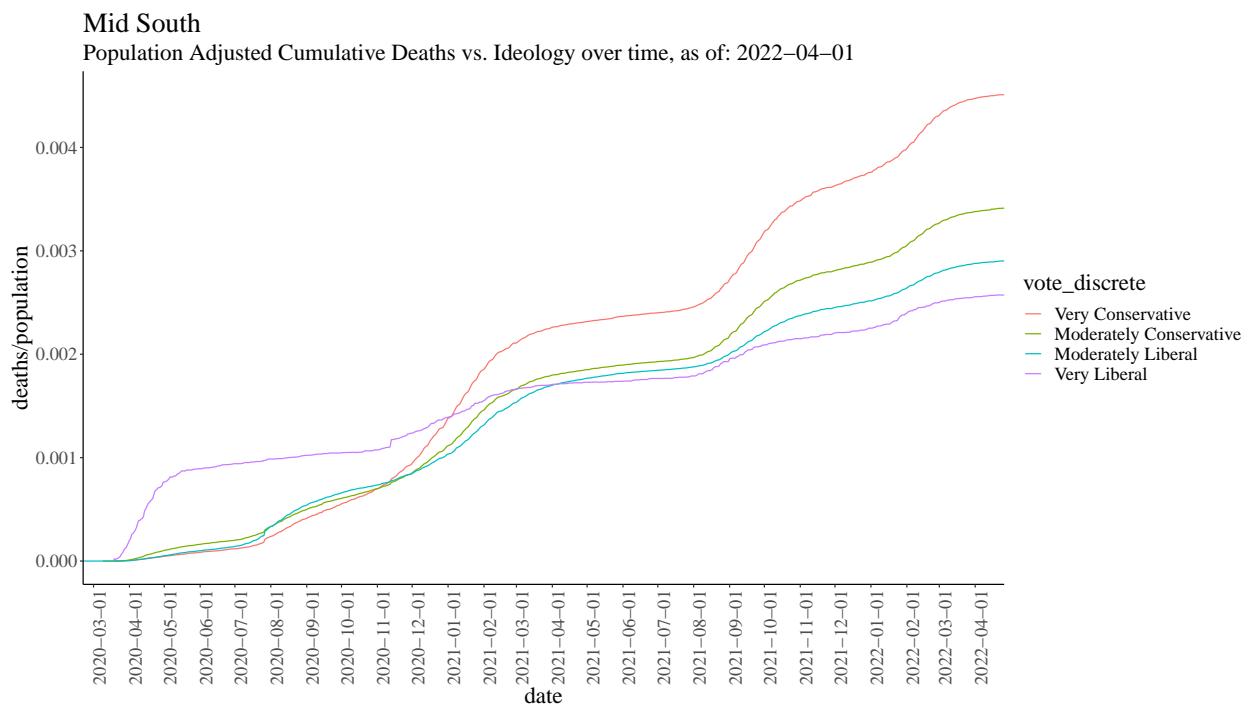


Table S7: Region 6: Regression Model Results

Predictors	Alpha Wave Deaths		Delta Wave Deaths		Omicron Wave Deaths	
	Estimates	p	Estimates	p	Estimates	p
Intercept	0.00041	0.424	0.00108	<0.001	0.00075	0.001
Socioeconomic	0.00034	0.334	-0.00007	0.708	0.00039	0.009
Household Composition & Disability	0.00059	0.004	0.00032	0.003	0.00028	0.001
Minority Status & Language	-0.00049	0.117	-0.00006	0.705	-0.00032	0.018
Housing Type & Transportation	0.00042	0.063	0.00005	0.675	-0.00007	0.461
Democratic Voting Pct	0.00054	0.324	-0.00077	0.010	-0.00041	0.083
Vaccination Rate	-0.00058	0.317	-0.00096	0.003	-0.00009	0.723
Population Density	-0.00009	0.085	0.00007	0.008	0.00003	0.141
Obesity	0.00059	0.335	-0.00044	0.184	-0.00053	0.042
Uninsured Adults	0.00237	<0.001	0.00031	0.117	-0.00014	0.358
Unemployed	0.00125	0.062	0.00062	0.087	0.00002	0.950
Diabetes	0.00025	0.713	0.00057	0.135	-0.00039	0.192
Food Insecurity	-0.00097	0.039	0.00012	0.641	-0.00017	0.397
Social Associations	0.00261	<0.001	-0.00049	0.159	0.00211	<0.001
Age over 65	-0.00000	0.960	-0.00000	0.177	-0.00000	0.872
Broadband Access	0.00093	0.230	0.00045	0.288	0.00072	0.032
Observations	428		428		428	
R ² / R ² adjusted	0.358 / 0.334		0.196 / 0.167		0.322 / 0.298	

Part 3: Data Analysis and Regression: Region 7 (Middle West)

Figure S23: Fatality Rate vs. Population Density

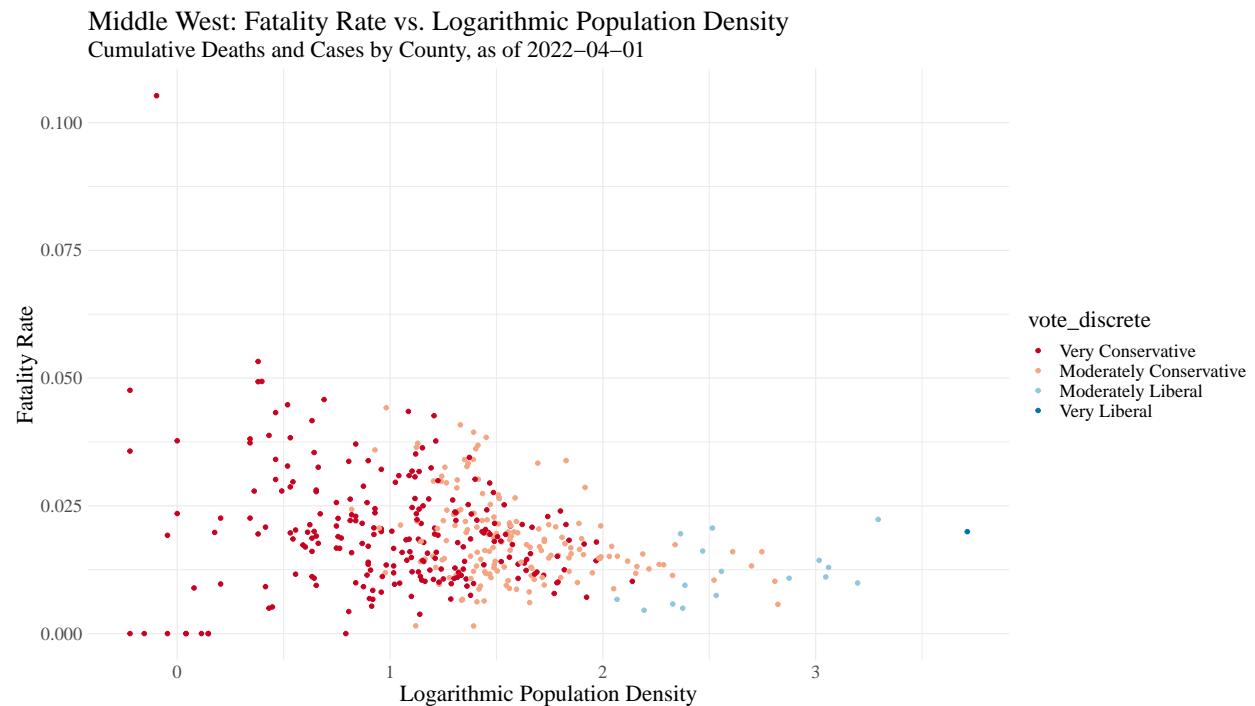


Figure S24: County Level Cumulative Cases vs. Cumulative Deaths

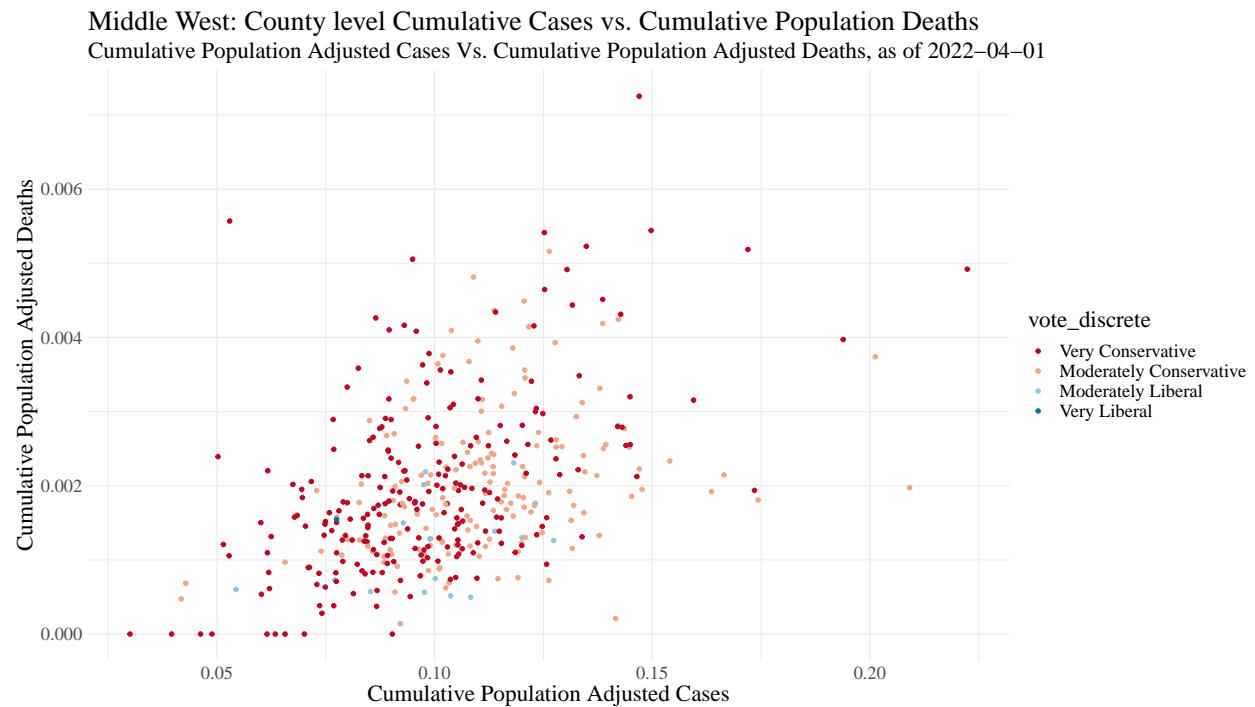


Figure S25: Population Adjusted Cumulative Deaths vs Ideology over time

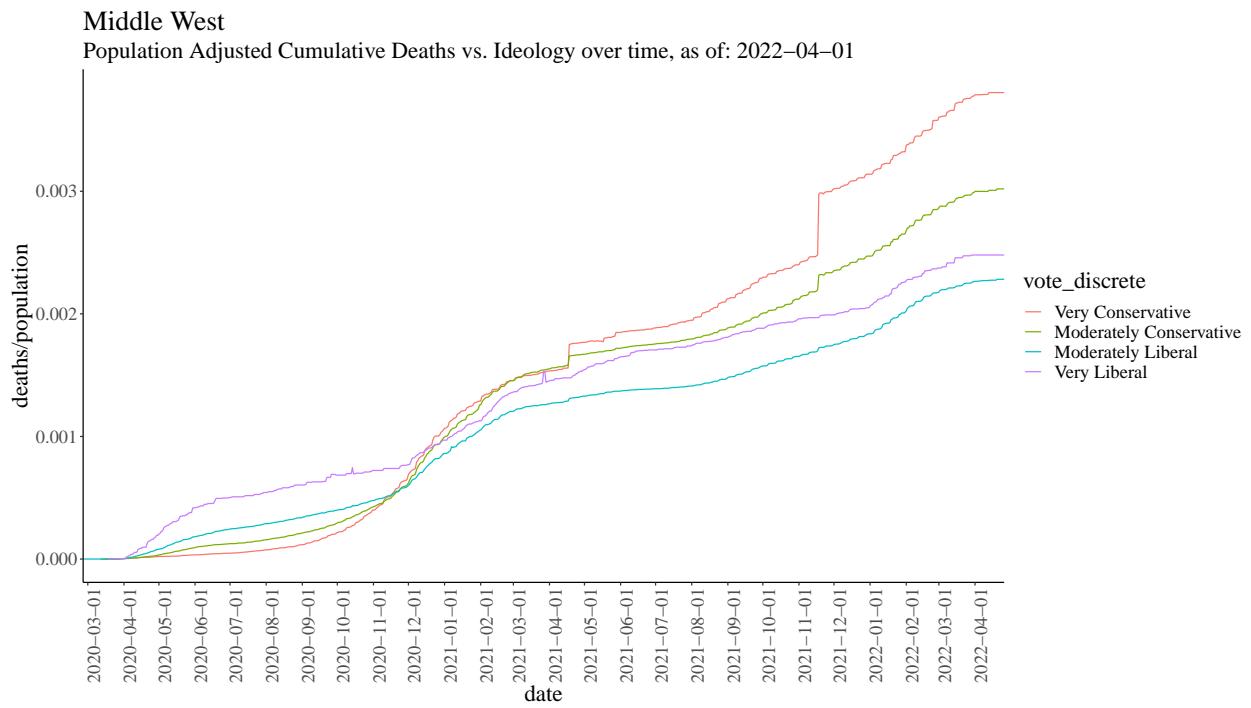


Table S8: Region 7: Regression Model Results

Predictors	Alpha Wave Deaths		Delta Wave Deaths		Omicron Wave Deaths	
	Estimates	p	Estimates	p	Estimates	p
Intercept	0.00107	0.095	-0.00008	0.799	0.00015	0.556
Socioeconomic	0.00108	0.017	0.00061	0.007	0.00087	<0.001
Household Composition & Disability	0.00034	0.162	-0.00010	0.399	0.00010	0.299
Minority Status & Language	0.00030	0.310	-0.00046	0.002	-0.00048	<0.001
Housing Type & Transportation	0.00041	0.155	0.00002	0.906	0.00001	0.960
Democratic Voting Pct	-0.00225	0.023	-0.00098	0.045	0.00010	0.795
Vaccination Rate	0.00269	0.001	0.00025	0.554	0.00038	0.247
Population Density	-0.00004	0.606	0.00013	0.002	0.00002	0.537
Obesity	-0.00022	0.764	-0.00150	<0.001	-0.00041	0.146
Uninsured Adults	-0.00313	<0.001	0.00064	0.083	-0.00083	0.005
Unemployed	-0.00068	0.678	0.00336	<0.001	0.00117	0.068
Diabetes	0.00098	0.158	0.00201	<0.001	0.00098	<0.001
Food Insecurity	-0.00249	0.016	-0.00087	0.089	-0.00097	0.016
Social Associations	0.00259	<0.001	0.00030	0.223	0.00056	0.004
Age over 65	0.00000	0.589	-0.00000	0.460	0.00000	0.368
Broadband Access	0.00021	0.854	0.00133	0.022	0.00028	0.534
Observations	409		409		409	
R ² / R ² adjusted	0.250 / 0.222		0.530 / 0.512		0.322 / 0.296	

Part 3: Data Analysis and Regression: Region 8 (Midnorth)

Figure S26: Fatality Rate vs. Population Density

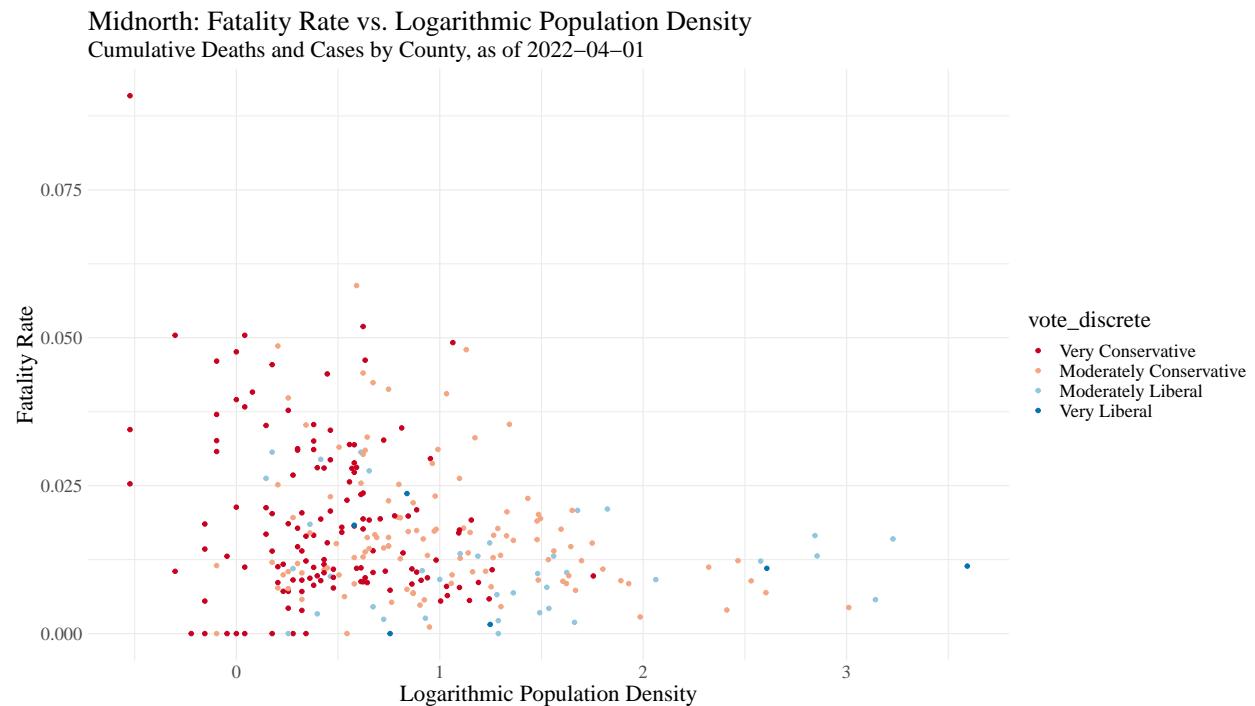


Figure S27: County Level Cumulative Cases vs. Cumulative Deaths

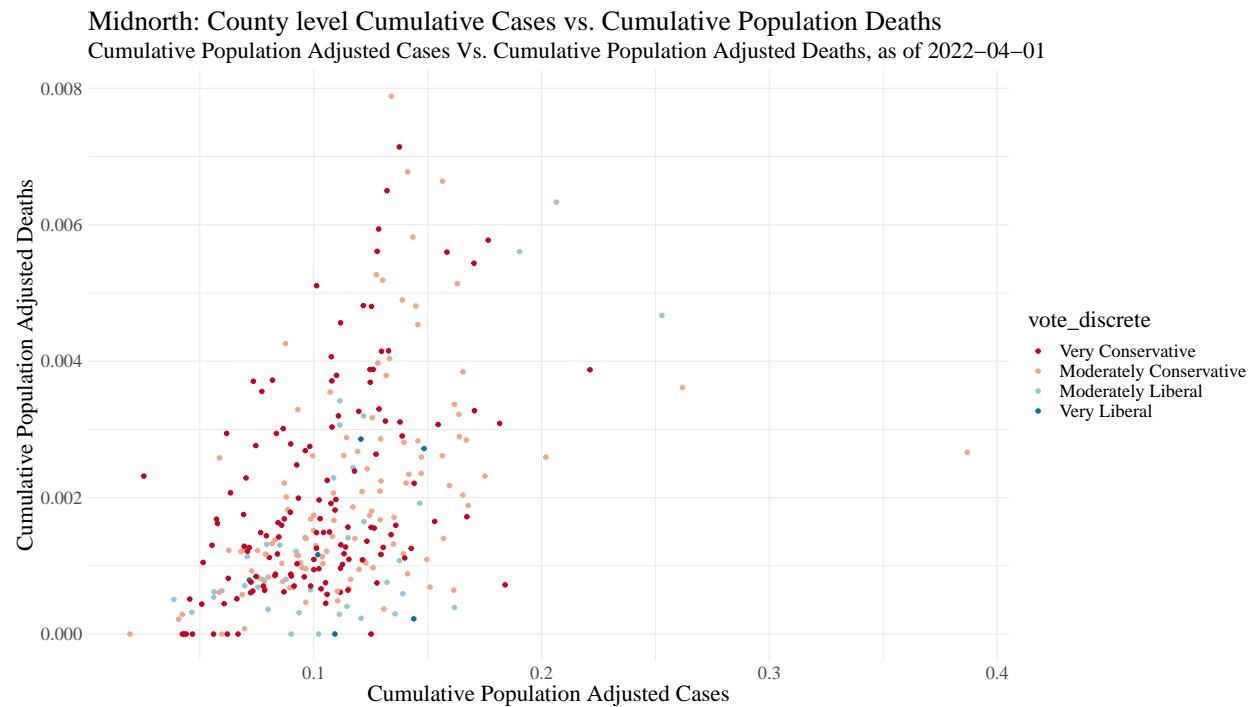


Figure S28: Population Adjusted Cumulative Deaths vs Ideology over time

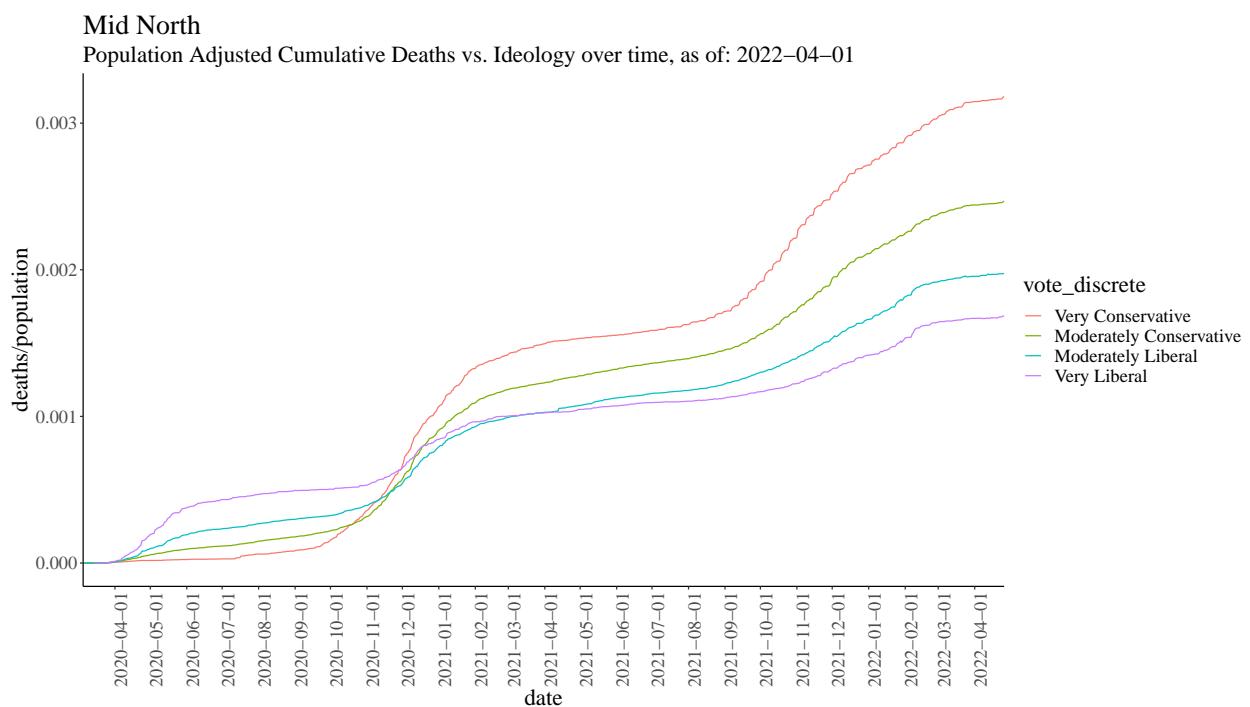


Table S9: Region 8: Regression Model Results

Predictors	Alpha Wave Deaths		Delta Wave Deaths		Omicron Wave Deaths	
	Estimates	p	Estimates	p	Estimates	p
Intercept	-0.00122	0.022	0.00198	<0.001	0.00011	0.571
Socioeconomic	0.00037	0.513	0.00081	0.004	0.00004	0.861
Household Composition & Disability	0.00044	0.256	0.00023	0.220	0.00020	0.162
Minority Status & Language	-0.00053	0.239	-0.00029	0.195	0.00006	0.710
Housing Type & Transportation	-0.00008	0.821	0.00030	0.090	0.00001	0.939
Democratic Voting Pct	-0.00106	0.196	-0.00060	0.138	-0.00063	0.038
Vaccination Rate	0.00180	0.038	-0.00126	0.003	-0.00034	0.287
Population Density	0.00014	0.135	-0.00003	0.483	0.00010	0.004
Obesity	0.00268	0.002	-0.00145	0.001	-0.00046	0.155
Uninsured Adults	0.00089	0.464	-0.00038	0.529	0.00057	0.207
Unemployed	-0.00116	0.378	0.00203	0.002	0.00004	0.937
Diabetes	0.00102	0.445	-0.00021	0.749	0.00060	0.218
Food Insecurity	-0.00204	0.125	-0.00073	0.264	0.00007	0.886
Social Associations	0.00123	0.085	0.00006	0.858	0.00053	0.044
Age over 65	-0.00000	0.923	0.00000	0.339	-0.00000	0.505
Broadband Access	0.00472	0.002	0.00055	0.460	0.00148	0.008
Observations	292		292		292	
R ² / R ² adjusted	0.343 / 0.307		0.274 / 0.234		0.182 / 0.137	

Part 3: Data Analysis and Regression: Region 9 (West)

Figure S29: Fatality Rate vs. Population Density

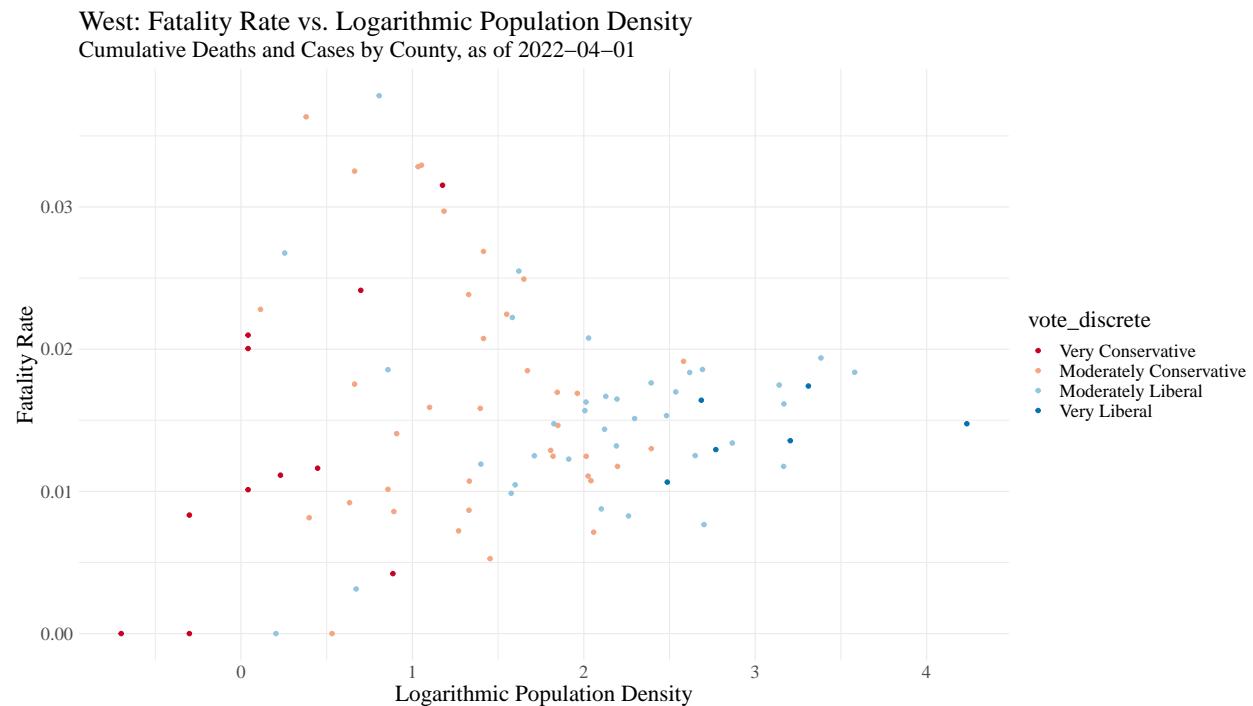


Figure S30: County Level Cumulative Cases vs. Cumulative Deaths

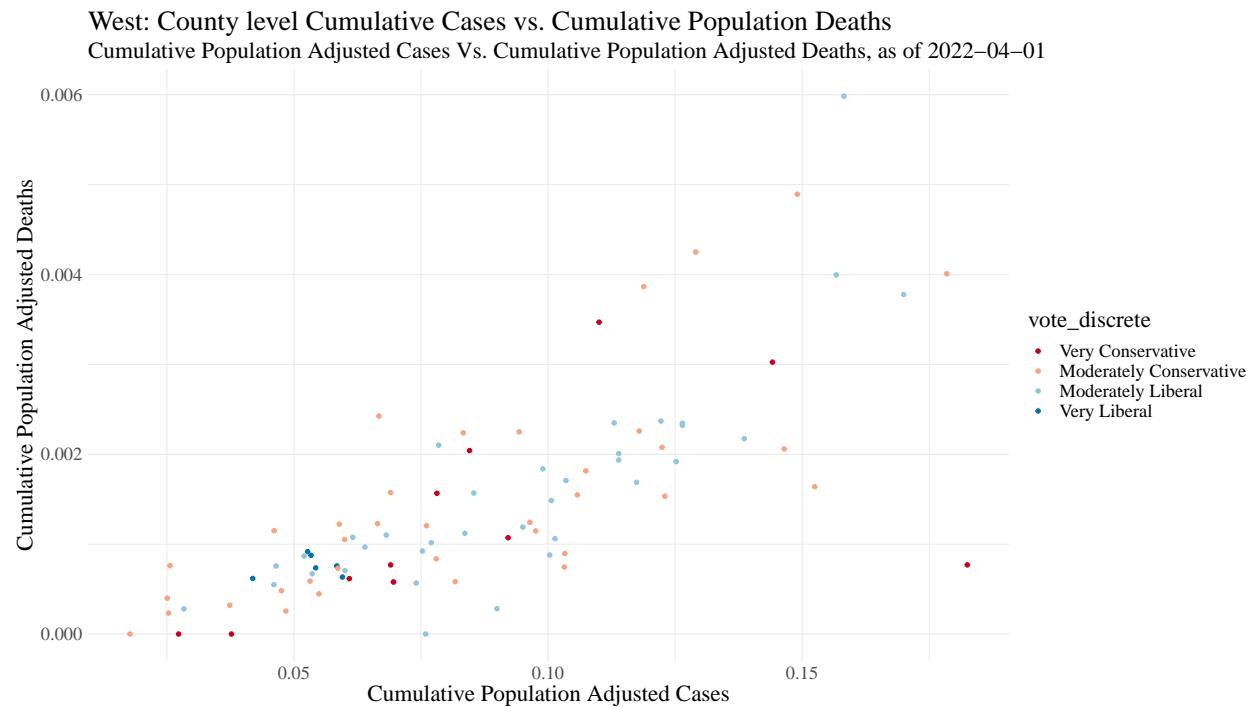


Figure S31: Population Adjusted Cumulative Deaths vs Ideology over time

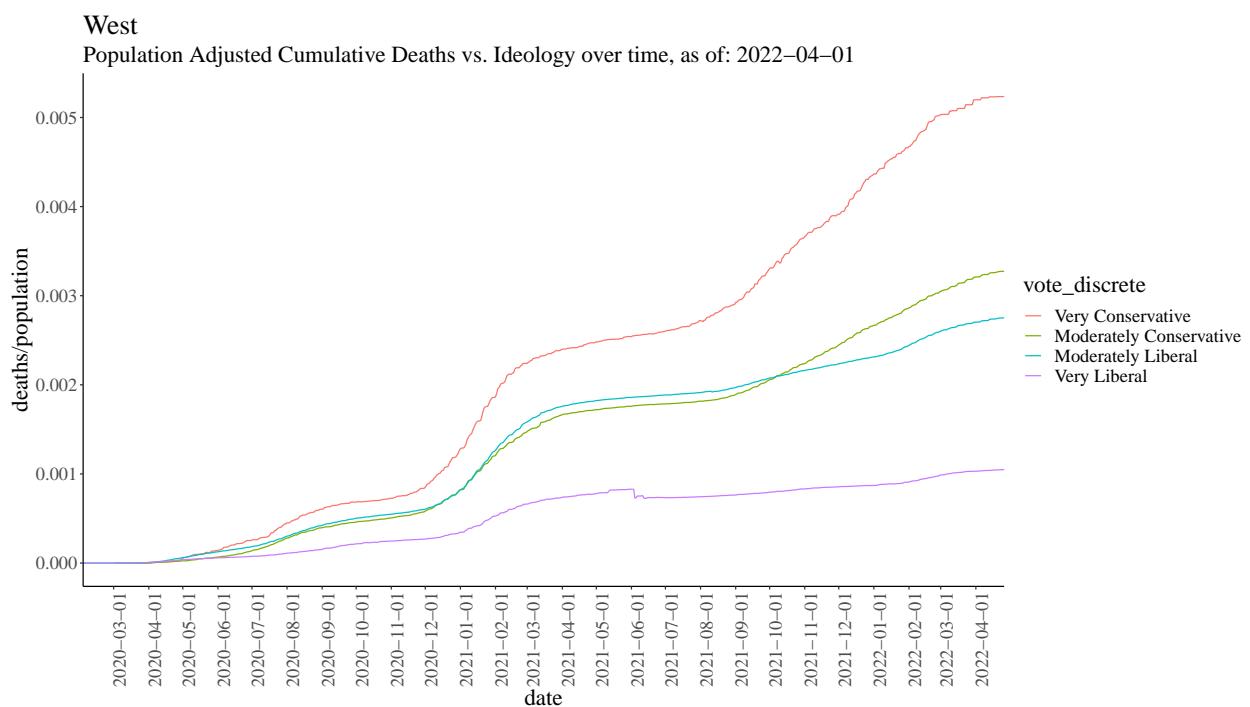


Table S10: Region 9: Regression Model Results

<i>Predictors</i>	Alpha Wave Deaths	Delta Wave Deaths	Omicron Wave Deaths
	<i>p</i>	<i>p</i>	<i>p</i>
Intercept	<0.001	0.046	0.087
Socioeconomic	0.031	0.176	0.757
Household Composition & Disability	0.079	<0.001	0.366
Minority Status & Language	0.918	0.086	0.552
Housing Type & Transportation	0.557	0.096	0.503
Democratic Voting Pct	0.020	<0.001	0.014
Vaccination Rate	<0.001	0.886	0.347
Population Density	0.373	0.961	0.184
Obesity	0.868	0.624	0.864
Uninsured Adults	0.001	0.298	0.013
Unemployed	0.259	<0.001	0.514
Diabetes	<0.001	0.386	0.001
Food Insecurity	0.663	0.047	0.435
Social Associations	0.755	0.820	0.293
Age over 65	0.332	0.765	0.945
Broadband Access	0.280	0.394	0.617
Observations	90	90	90
R ² / R ² adjusted	0.745 / 0.693	0.747 / 0.695	0.618 / 0.541

Part 3: Data Analysis and Regression: Region 10 (Pacific NW)

Figure S32: Fatality Rate vs. Population Density

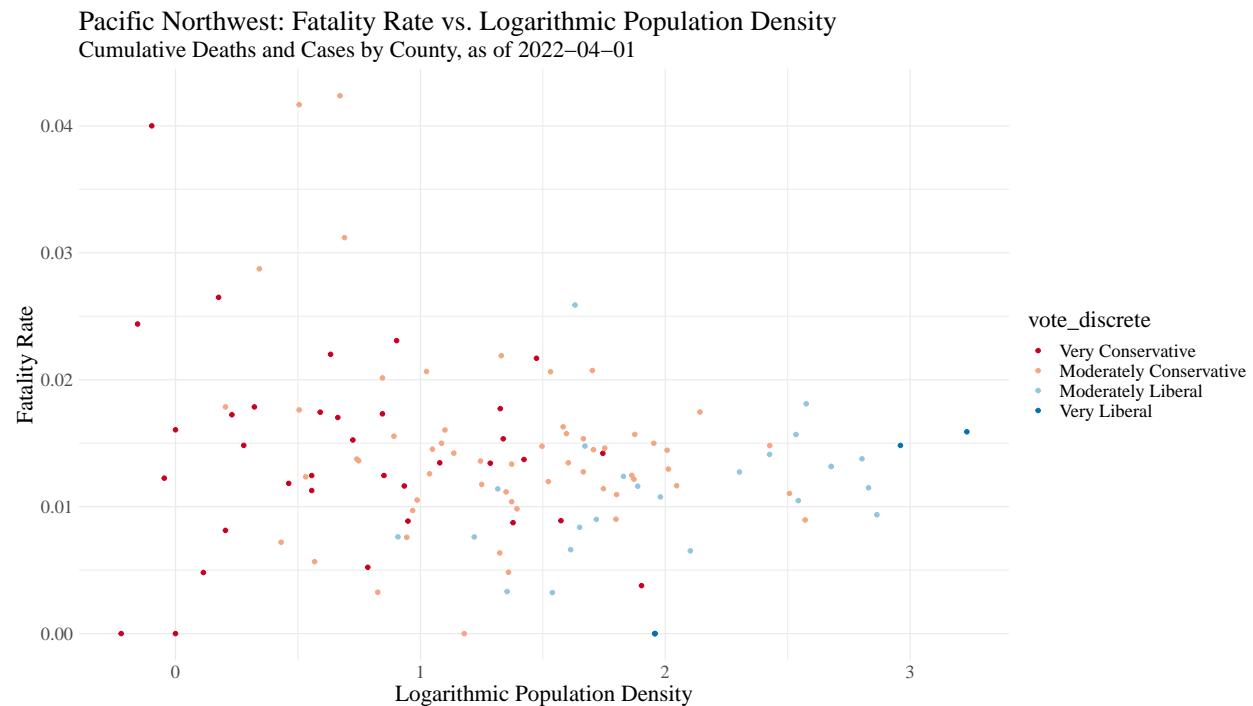


Figure S33: County Level Cumulative Cases vs. Cumulative Deaths

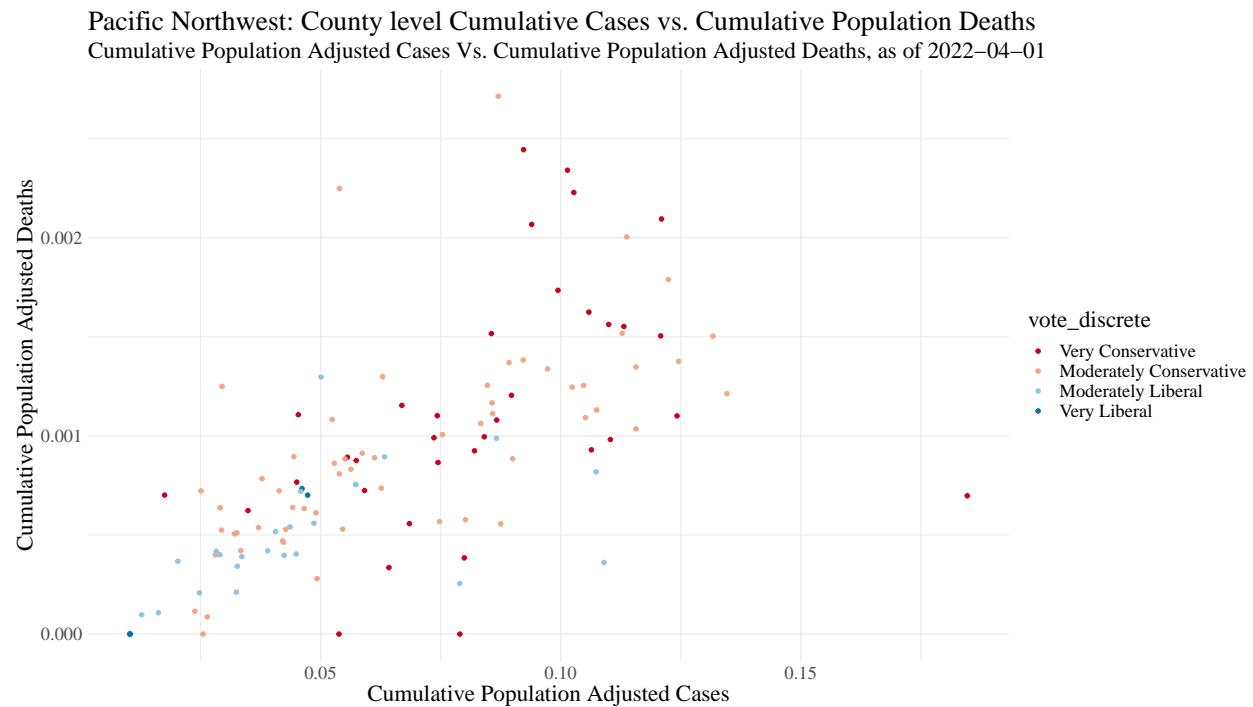


Figure S34: Population Adjusted Cumulative Deaths vs Ideology over time

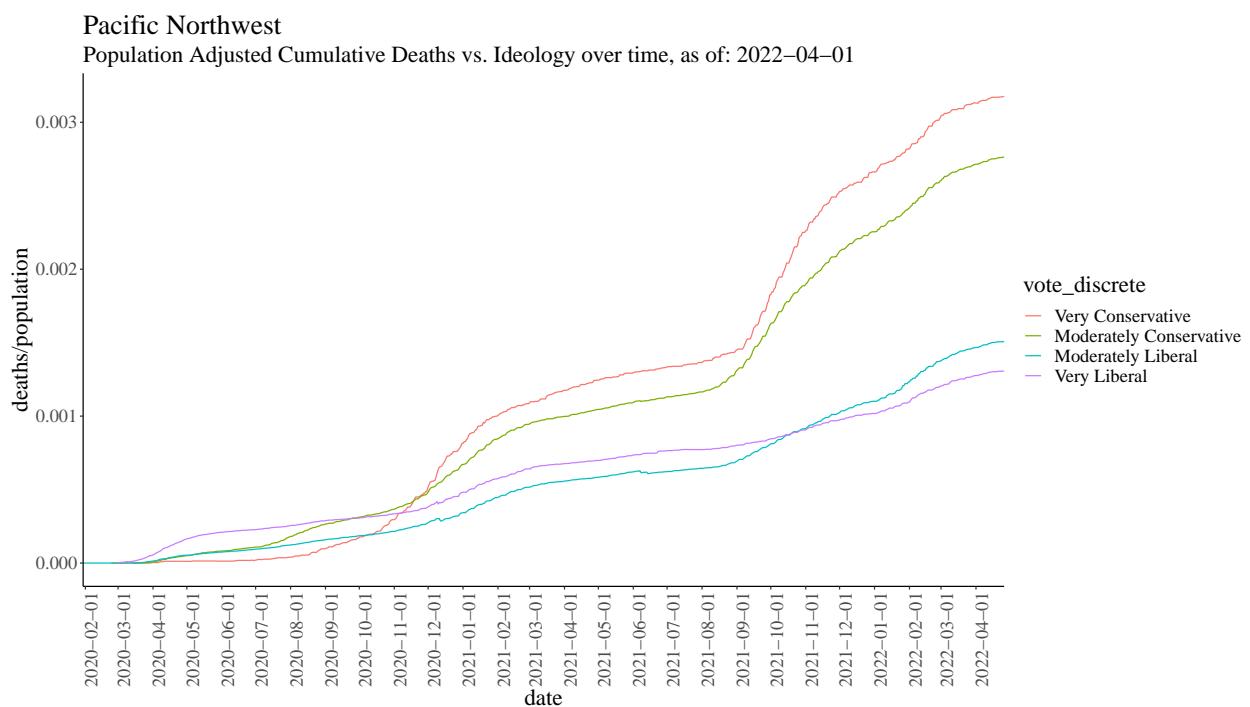


Table S11: Region 10: Regression Model Results

Predictors	Alpha Wave Deaths		Delta Wave Deaths		Omicron Wave Deaths	
	Estimates	p	Estimates	p	Estimates	p
Intercept	0.00116	0.084	0.00083	0.210	-0.00094	0.013
Socioeconomic	-0.00012	0.761	-0.00029	0.475	-0.00053	0.022
Household Composition & Disability	0.00039	0.117	0.00076	0.003	0.00026	0.067
Minority Status & Language	0.00045	0.163	-0.00045	0.165	0.00024	0.194
Housing Type & Transportation	0.00024	0.305	0.00031	0.192	0.00016	0.218
Democratic Voting Pct	-0.00114	0.067	-0.00184	0.003	-0.00093	0.008
Vaccination Rate	-0.00122	0.085	-0.00120	0.089	0.00064	0.108
Population Density	0.00008	0.082	0.00011	0.016	0.00002	0.502
Obesity	-0.00023	0.718	-0.00097	0.132	-0.00007	0.842
Uninsured Adults	0.00046	0.428	0.00159	0.007	0.00079	0.017
Unemployed	-0.00049	0.502	0.00219	0.003	0.00051	0.212
Diabetes	0.00000	0.999	0.00044	0.549	0.00070	0.096
Food Insecurity	-0.00060	0.505	0.00166	0.065	0.00176	0.001
Social Associations	0.00026	0.753	0.00178	0.033	-0.00016	0.739
Age over 65	0.00000	0.515	0.00000	0.839	0.00000	0.322
Broadband Access	0.00147	0.283	-0.00130	0.337	0.00211	0.007
Observations	130		130		130	
R ² / R ² adjusted	0.469 / 0.400		0.640 / 0.593		0.540 / 0.479	

Part 3: Data Analysis and Regression Modeling Summarized Model Results

Table S12: Model Results: Alpha Wave (December 2019 - May 2021)

<i>Predictors</i>	NE <i>p</i>	ME <i>p</i>	SE <i>p</i>	MW <i>p</i>	MS <i>p</i>	MDW <i>p</i>	MN <i>p</i>	W <i>p</i>	PNW <i>p</i>	US <i>p</i>
Intercept	0.243	0.202	0.131	0.009	0.424	0.095	0.022	<0.001	0.084	<0.001
Socioeconomic	0.112	0.046	0.202	0.178	0.334	0.017	0.513	0.031	0.761	0.984
Household Composition & Disability	0.051	0.283	0.888	0.015	0.004	0.162	0.256	0.079	0.117	0.002
Minority Status & Language	0.006	0.129	0.763	0.669	0.117	0.310	0.239	0.918	0.163	<0.001
Housing Type & Transportation	0.029	0.041	0.001	0.925	0.063	0.155	0.821	0.557	0.305	0.185
Democratic Voting Pct	0.372	0.022	0.038	<0.001	0.324	0.023	0.196	0.020	0.067	<0.001
Vaccination Rate	0.480	0.639	<0.001	0.195	0.317	0.001	0.038	<0.001	0.085	0.104
Population Density	<0.001	0.050	0.730	0.232	0.085	0.606	0.135	0.373	0.082	0.003
Obesity	0.733	0.773	0.257	0.125	0.335	0.764	0.002	0.868	0.718	<0.001
Uninsured Adults	0.443	0.756	0.506	0.295	<0.001	<0.001	0.464	0.001	0.428	<0.001
Unemployed	0.393	0.891	0.041	0.530	0.062	0.678	0.378	0.259	0.502	0.074
Diabetes	0.414	<0.001	<0.001	0.136	0.713	0.158	0.445	<0.001	0.999	0.016
Food Insecurity	0.033	0.946	0.053	0.577	0.039	0.016	0.125	0.663	0.505	0.064
Social Associations	0.477	0.014	0.539	0.001	<0.001	<0.001	0.085	0.755	0.753	<0.001
Age over 65	0.312	0.418	0.050	0.073	0.960	0.589	0.923	0.332	0.515	0.001
Broadband Access	0.187	0.766	0.017	0.201	0.230	0.854	0.002	0.280	0.283	<0.001
Observations	145	82	383	523	428	409	292	90	130	3093
R2 / R2 adjusted	0.769 / 0.742	0.500 / 0.386	0.408 / 0.384	0.204 / 0.181	0.358 / 0.334	0.250 / 0.222	0.343 / 0.307	0.745 / 0.693	0.469 / 0.400	0.256 / 0.253

Table S13: Model Results: Delta Wave (May 2021 - December 2021)

<i>Predictors</i>	NE	ME	SE	MW	MS	MDW	MN	W	PNW	US
	<i>p</i>									
Intercept	0.253	0.022	0.163	0.001	<0.001	0.799	<0.001	0.046	0.210	<0.001
Socioeconomic	0.512	0.520	0.802	0.057	0.708	0.007	0.004	0.176	0.475	0.010
Household Composition & Disability	0.001	0.195	0.960	0.099	0.003	0.399	0.220	<0.001	0.003	<0.001
Minority Status & Language	0.500	0.066	0.124	0.002	0.705	0.002	0.195	0.086	0.165	<0.001
Housing Type & Transportation	0.104	0.639	0.009	0.656	0.675	0.906	0.090	0.096	0.192	<0.001
Democratic Voting Pct	0.076	0.862	<0.001	0.408	0.010	0.045	0.138	<0.001	0.003	<0.001
Vaccination Rate	0.168	0.919	0.055	0.009	0.003	0.554	0.003	0.886	0.089	<0.001
Population Density	0.283	0.011	0.018	0.266	0.008	0.002	0.483	0.961	0.016	0.292
Obesity	0.146	0.581	0.720	0.765	0.184	<0.001	0.001	0.624	0.132	<0.001
Uninsured Adults	0.132	0.081	0.037	0.650	0.117	0.083	0.529	0.298	0.007	<0.001
Unemployed	0.662	0.536	0.318	<0.001	0.087	<0.001	0.002	<0.001	0.003	<0.001
Diabetes	0.961	0.915	<0.001	<0.001	0.135	<0.001	0.749	0.386	0.549	<0.001
Food Insecurity	0.323	0.310	0.021	0.197	0.641	0.089	0.264	0.047	0.065	<0.001
Social Associations	0.724	0.351	0.216	0.333	0.159	0.223	0.858	0.820	0.033	<0.001
Age over 65	0.588	0.128	0.004	0.750	0.177	0.460	0.339	0.765	0.839	0.580
Broadband Access	0.565	0.045	0.231	0.665	0.288	0.022	0.460	0.394	0.337	0.061
Observations	145	82	383	523	428	409	292	90	130	3093
R2 / R2 adjusted	0.474 / 0.413	0.608 / 0.518	0.424 / 0.400	0.427 / 0.410	0.196 / 0.167	0.530 / 0.512	0.274 / 0.234	0.747 / 0.695	0.640 / 0.593	0.358 / 0.355

Table S14: Model Results: Omicron Wave (December 2021 - April 2022)

<i>Predictors</i>	NE	ME	SE	MW	MS	MDW	MN	W	PNW	US
	<i>p</i>									
Intercept	0.271	0.757	0.638	0.031	0.001	0.556	0.571	0.087	0.013	<0.001
Socioeconomic	0.076	0.267	0.083	0.128	0.009	<0.001	0.861	0.757	0.022	<0.001
Household Composition & Disability	0.004	0.233	0.645	0.079	0.001	0.299	0.162	0.366	0.067	<0.001
Minority Status & Language	0.260	0.800	0.085	0.028	0.018	<0.001	0.710	0.552	0.194	<0.001
Housing Type & Transportation	0.454	0.486	0.425	0.338	0.461	0.960	0.939	0.503	0.218	0.304
Democratic Voting Pct	<0.001	0.055	<0.001	0.296	0.083	0.795	0.038	0.014	0.008	<0.001
Vaccination Rate	0.224	0.900	0.168	0.079	0.723	0.247	0.287	0.347	0.108	0.106
Population Density	0.055	0.112	0.002	0.090	0.141	0.537	0.004	0.184	0.502	<0.001
Obesity	0.020	0.786	0.746	0.034	0.042	0.146	0.155	0.864	0.842	<0.001
Uninsured Adults	<0.001	0.959	0.507	0.454	0.358	0.005	0.207	0.013	0.017	0.124
Unemployed	0.028	0.798	0.519	0.023	0.950	0.068	0.937	0.514	0.212	0.109
Diabetes	0.080	0.412	<0.001	<0.001	0.192	<0.001	0.218	0.001	0.096	<0.001
Food Insecurity	0.008	0.328	0.430	0.889	0.397	0.016	0.886	0.435	0.001	0.001
Social Associations	0.751	0.863	0.106	0.915	<0.001	0.004	0.044	0.293	0.739	<0.001
Age over 65	0.532	0.867	0.142	0.967	0.872	0.368	0.505	0.945	0.322	0.542
Broadband Access	0.675	0.547	0.724	<0.001	0.032	0.534	0.008	0.617	0.007	0.001
Observations	145	82	383	523	428	409	292	90	130	3093
R2 / R2 adjusted	0.540 / 0.486	0.466 / 0.344	0.288 / 0.259	0.421 / 0.404	0.322 / 0.298	0.322 / 0.296	0.182 / 0.137	0.618 / 0.541	0.540 / 0.479	0.282 / 0.278

Figure S35: Model Results: Regression R² Plot

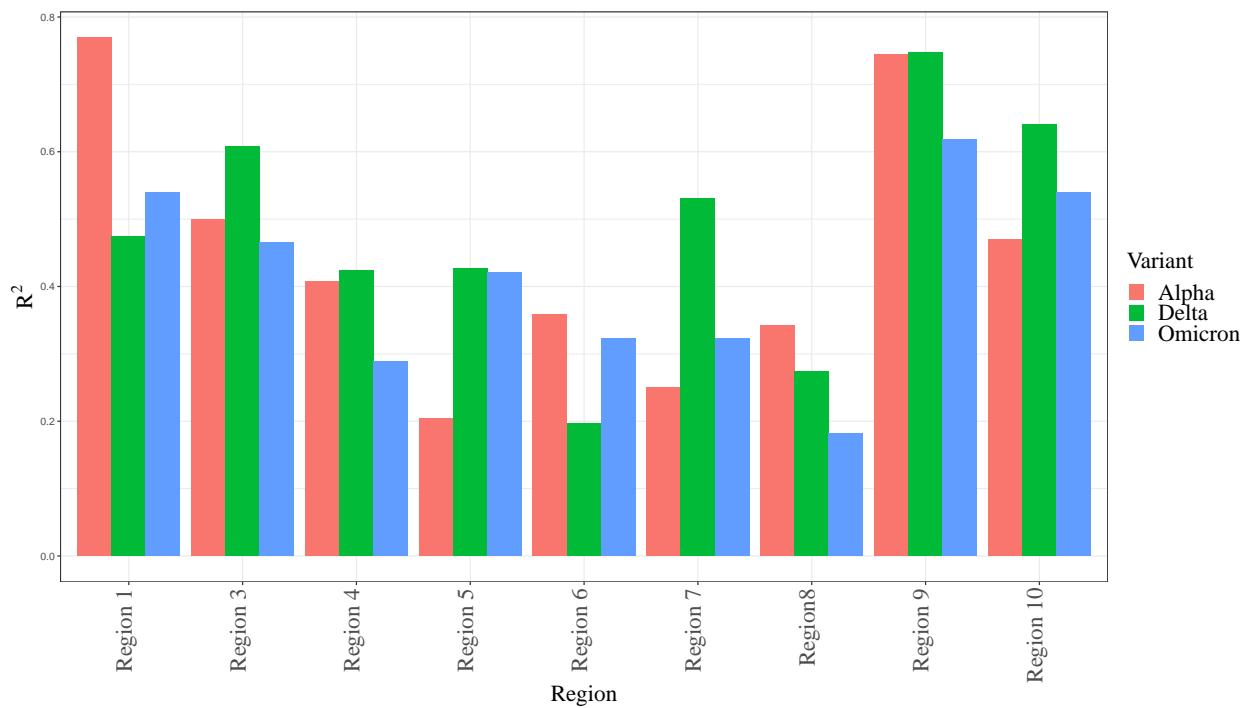
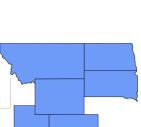


Table S15: Regionalized Regression Model Results: Significance Table

Regions	Significant Independent Variables			Map
	Alpha	Delta	Omicron	
Region 1-2		Household Composition and Disability, Democratic Voting Pct, Population Density, Unemployment, Uninsured Adults, Food Insecurity	Socioeconomic Stats, Democratic Voting Pct, Unemployment, Diabetes	
Region 3	Socioeconomic Stats, Housing Type and Transportation, Democratic Voting Pct, Social Associations, Food Insecurity	Population Density		
Region 4	Housing Type and Transportation, Democratic Voting Pct, Vaccination Rate, Uninsured Adults, Social Associations	Housing Type and Transportation, Democratic Voting Pct, Population Density, Unemployment, Social Associations, Diabetes, Lack of Broadband Access	Democratic Voting Pct, Population Density, Social Associations	
Region 5	Household Composition and Disability, Democratic Voting Pct, Food Insecurity	Minority Status and Language, Vaccination Rate, Uninsured Adults, Social Associations	Minority Status and Language, Obesity, Uninsured Adults, Social Associations	
Region 6	Household Composition and Disability, Unemployment, Diabetes, Food Insecurity	Household Composition and Disability, Democratic Voting Pct, Vaccination Rate, Population Density	Socioeconomic Stats, Household Composition and Disability, Minority Status and Language, Obesity, Food Insecurity	
Region 7	Socioeconomic Stats, Democratic Voting Pct, Vaccination Rate, Unemployment, Diabetes, Food Insecurity	Socioeconomic Stats, Minority Status and Language, Democratic Voting Pct, Population Density, Obesity, Uninsured Adults, Social Associations	Socioeconomic Stats, Minority Status and Language, Unemployment, Social Associations, Diabetes, Food Insecurity	
Region 8	Vaccination Rate, Obesity	Socioeconomic Stats, Vaccination Rate, Obesity, Uninsured Adults	Democratic Voting Pct, Population Density, Food Insecurity	
Region 9	Socioeconomic Stats, Democratic Voting Pct, Vaccination Rate, Unemployment, Social Associations	Household Composition and Disability, Democratic Voting Pct, Uninsured Adults, Diabetes	Democratic Voting Pct, Unemployment, Social Associations	
Regions 10	Minority Status and Language, Housing Type and Transportation, Population Density, Diabetes	Household Composition and Disability	Household Composition and Disability, Democratic Voting Pct, Obesity, Unemployment, Uninsured Adults, Diabetes	

Part 4: Spatial Autocorrelation

Morans I is a test of spatial autocorrelation.

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x}) (x_j - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2}$$

- N: The number of spatial units indexed by i and j
- W: The sum of all w_{ij}
- x: The variable of interest (in this instance, cumulative COVID cases, adjusted for population)
- \bar{x} : The mean of x
- w_{ij} : A matrix of spatial weights

Figure S36: Morans I results: United States - Alpha Wave, Dependent Variable

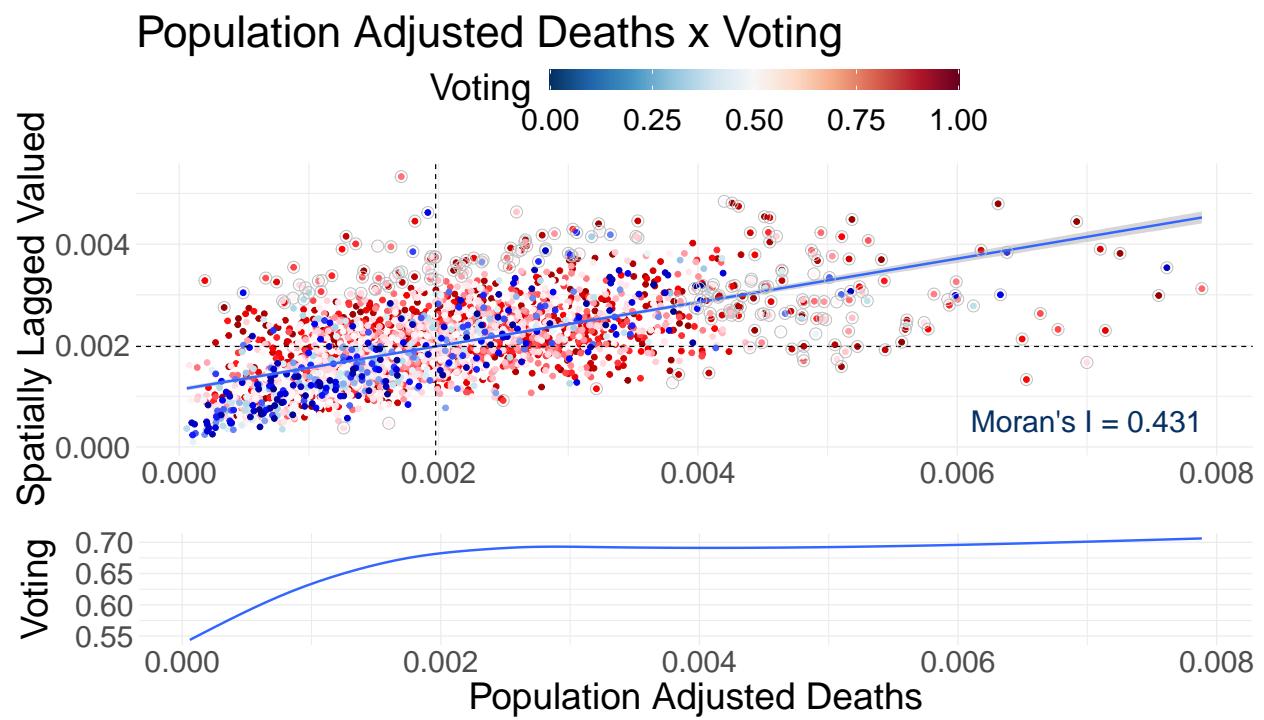
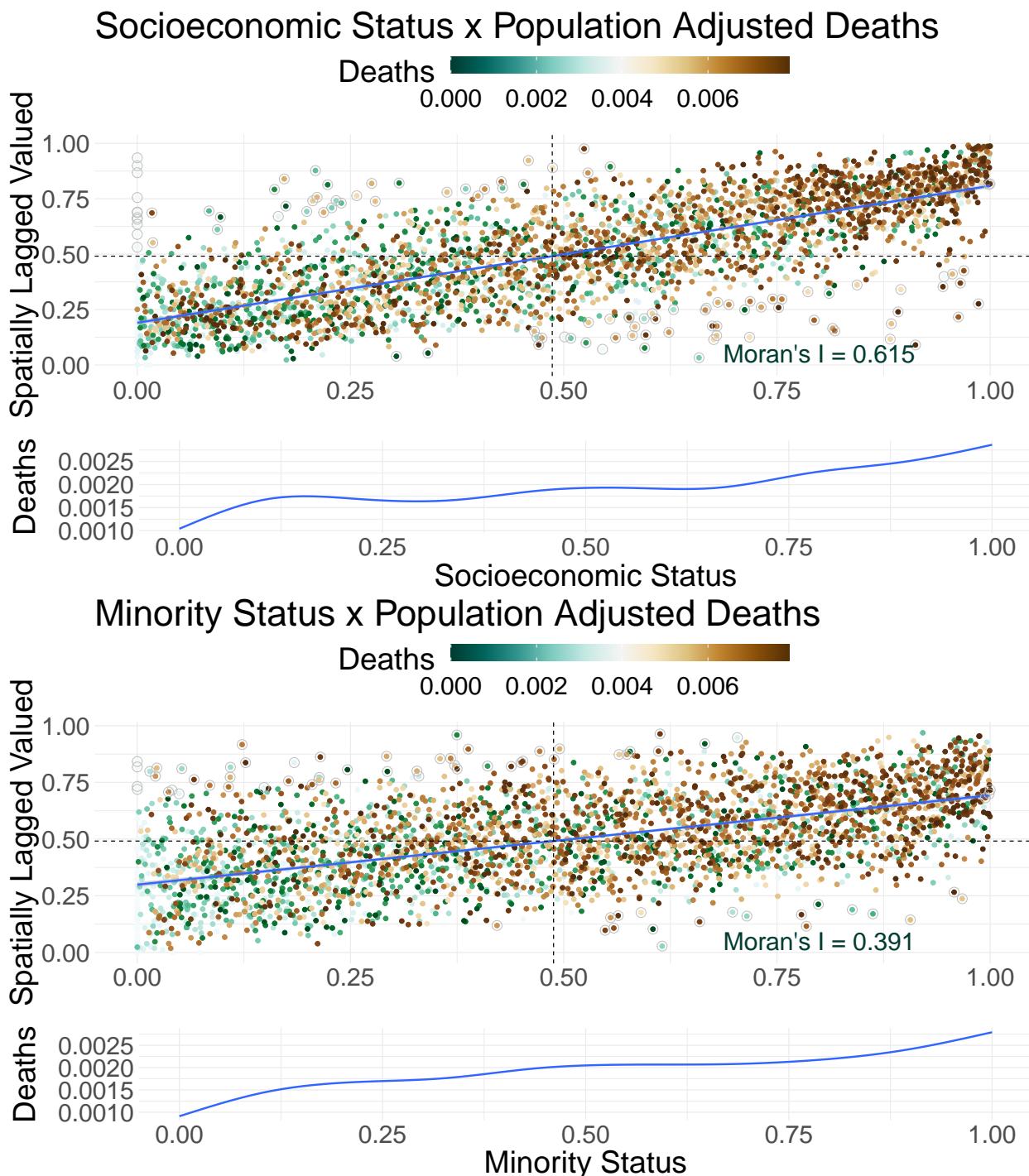
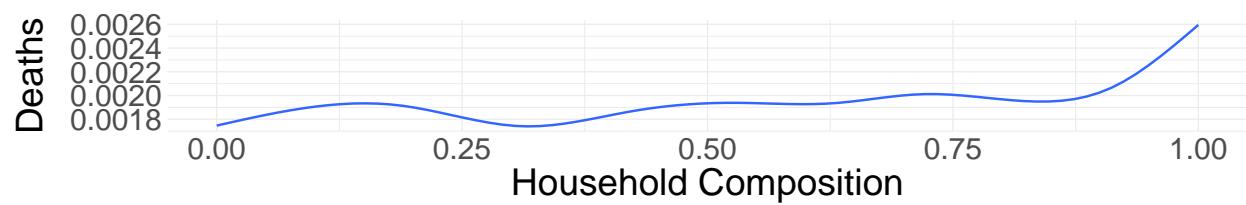
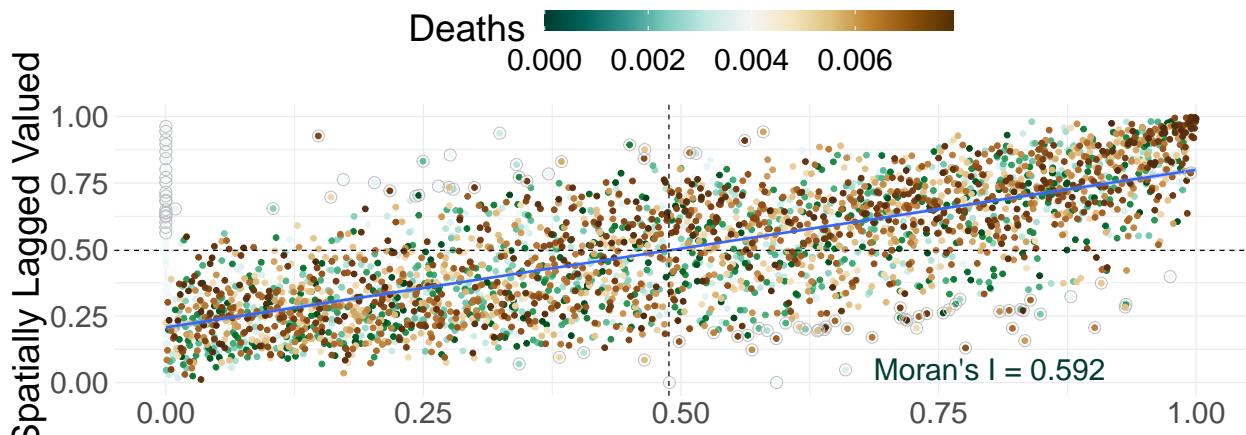


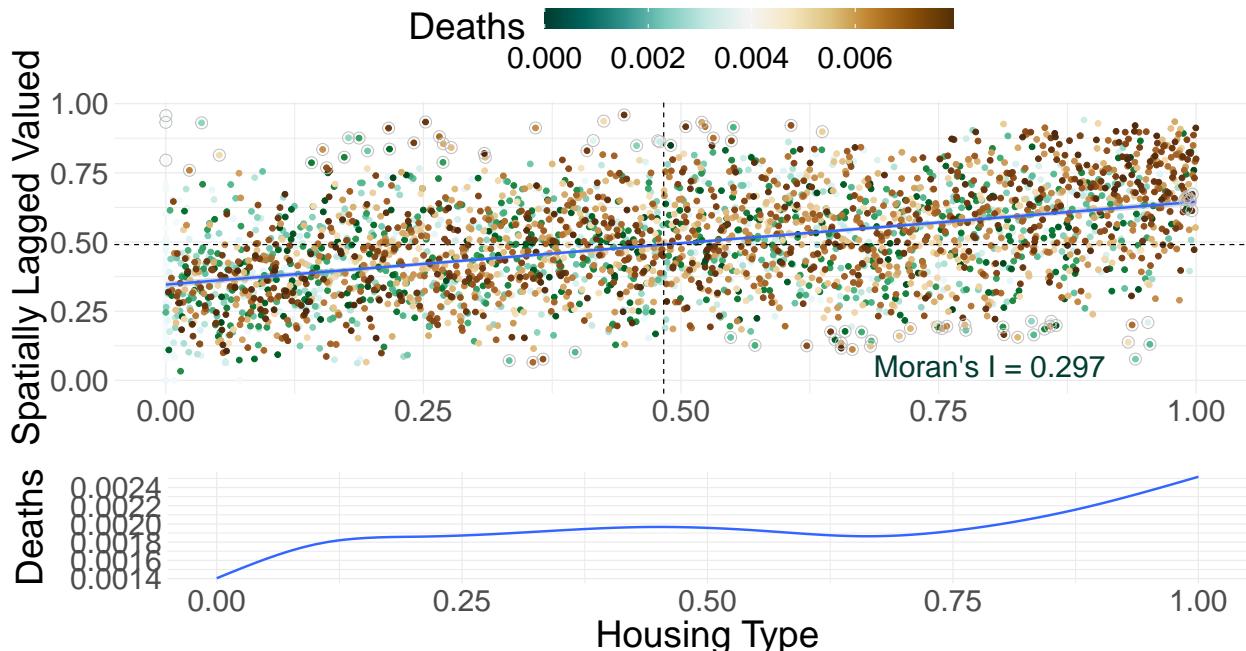
Figure S37: Morans I results: United States - Alpha Wave, Independent Variables



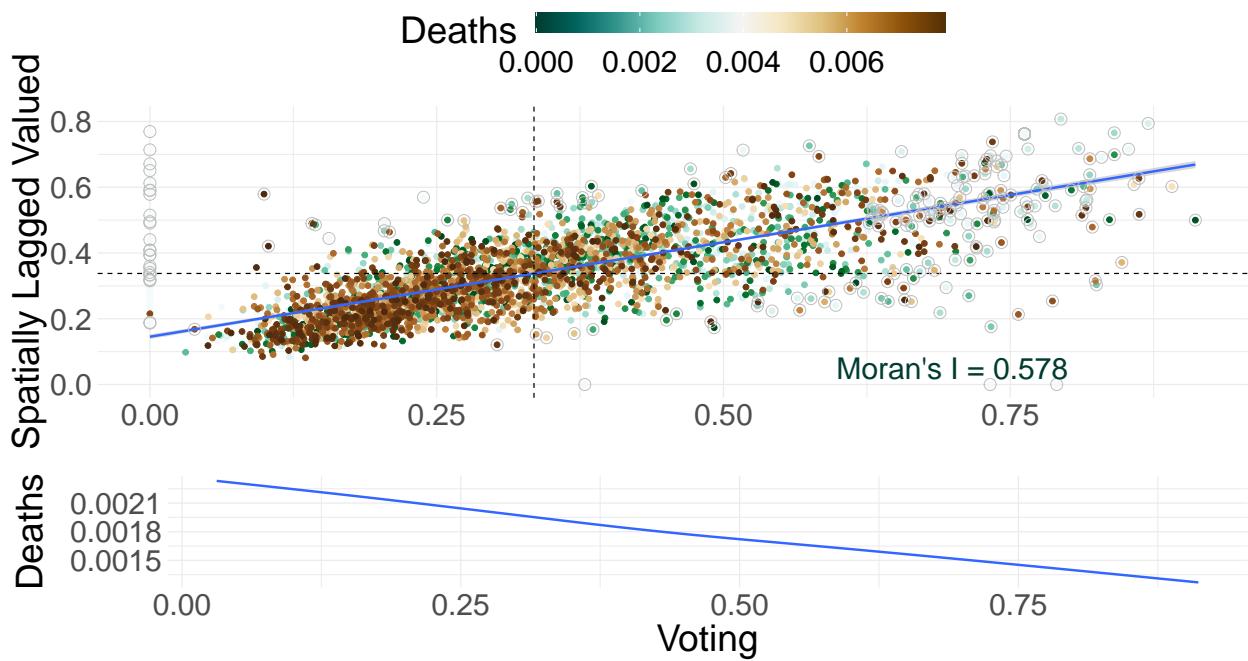
Household Composition x Population Adjusted Deaths



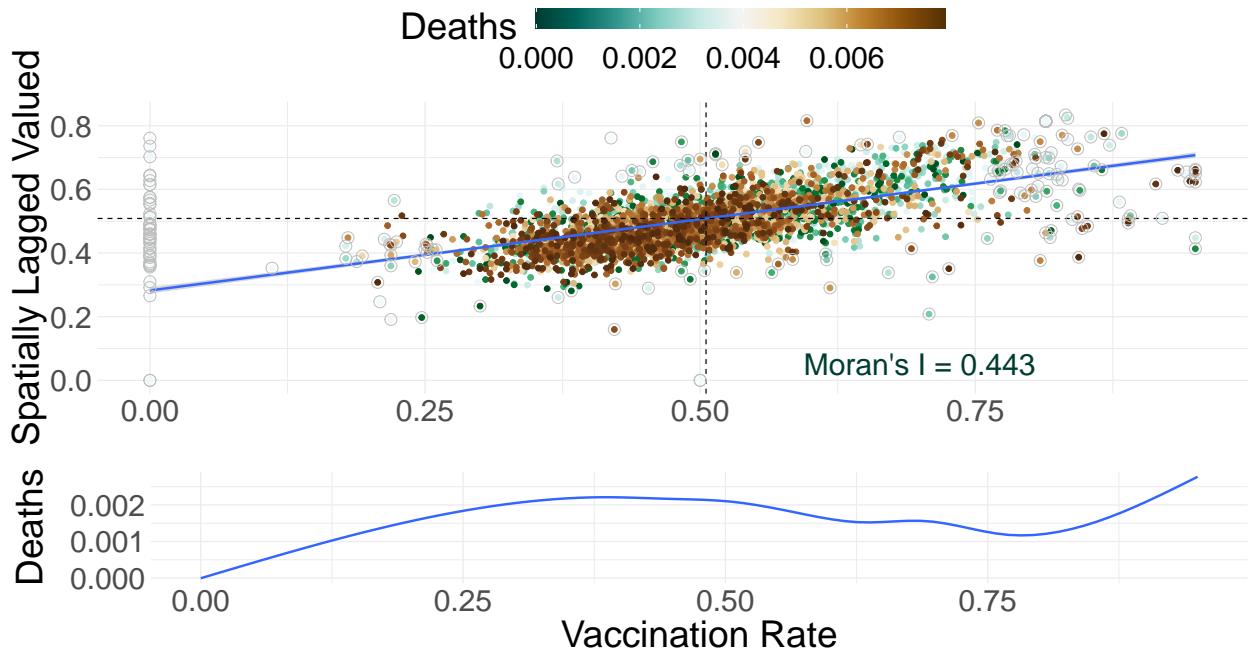
Housing Type x Population Adjusted Deaths



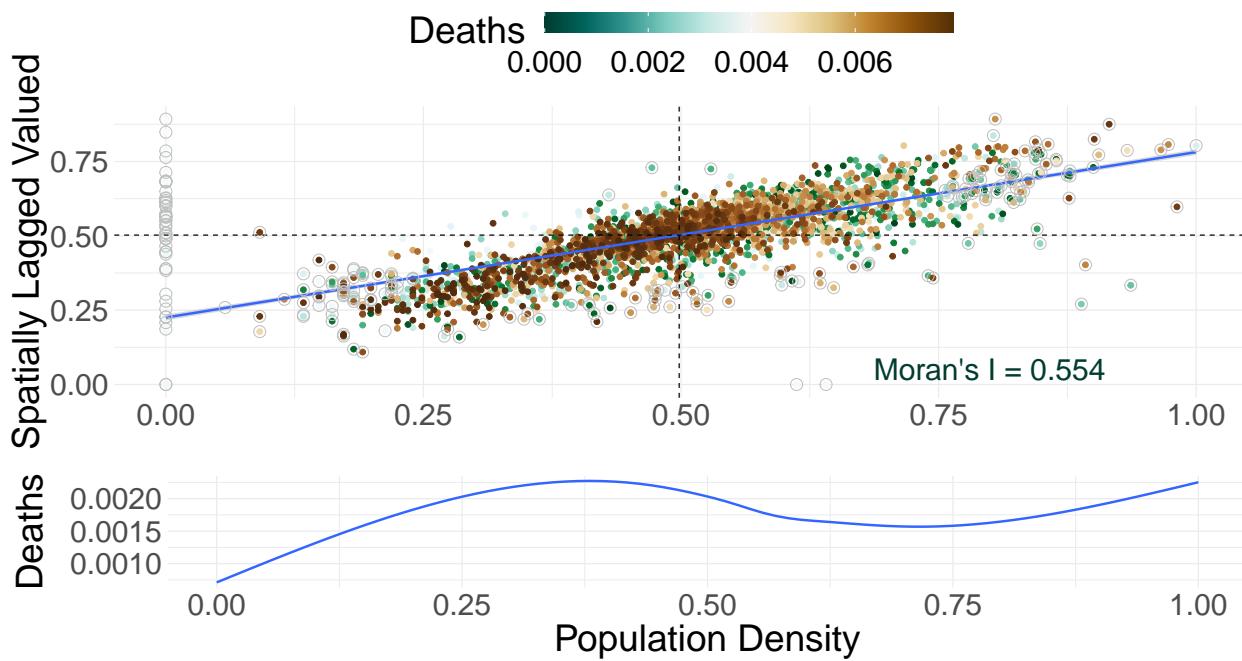
Voting x Population Adjusted Deaths



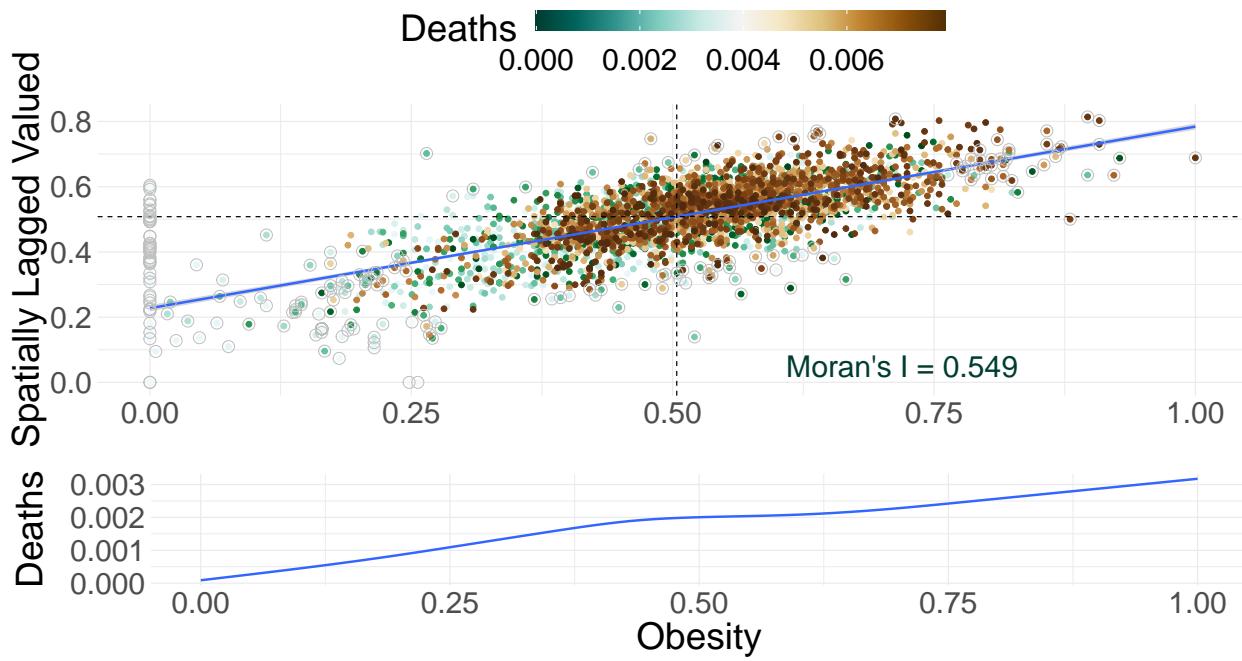
Vaccination Rate x Population Adjusted Deaths



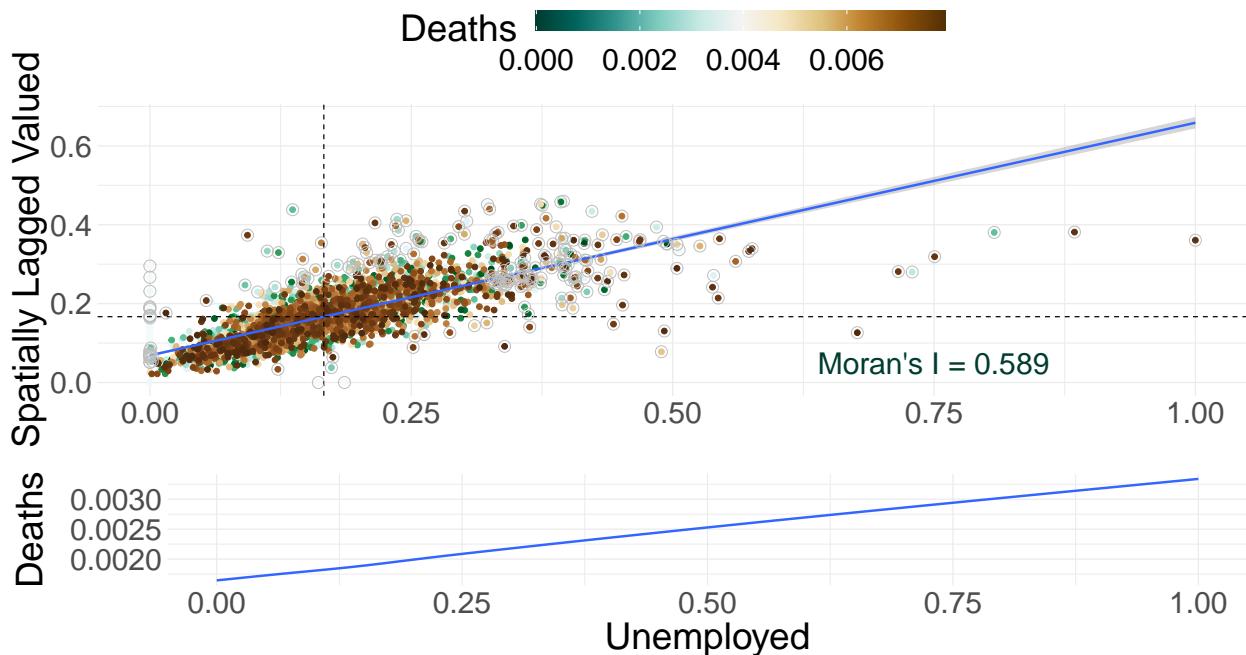
Population Density x Population Adjusted Deaths



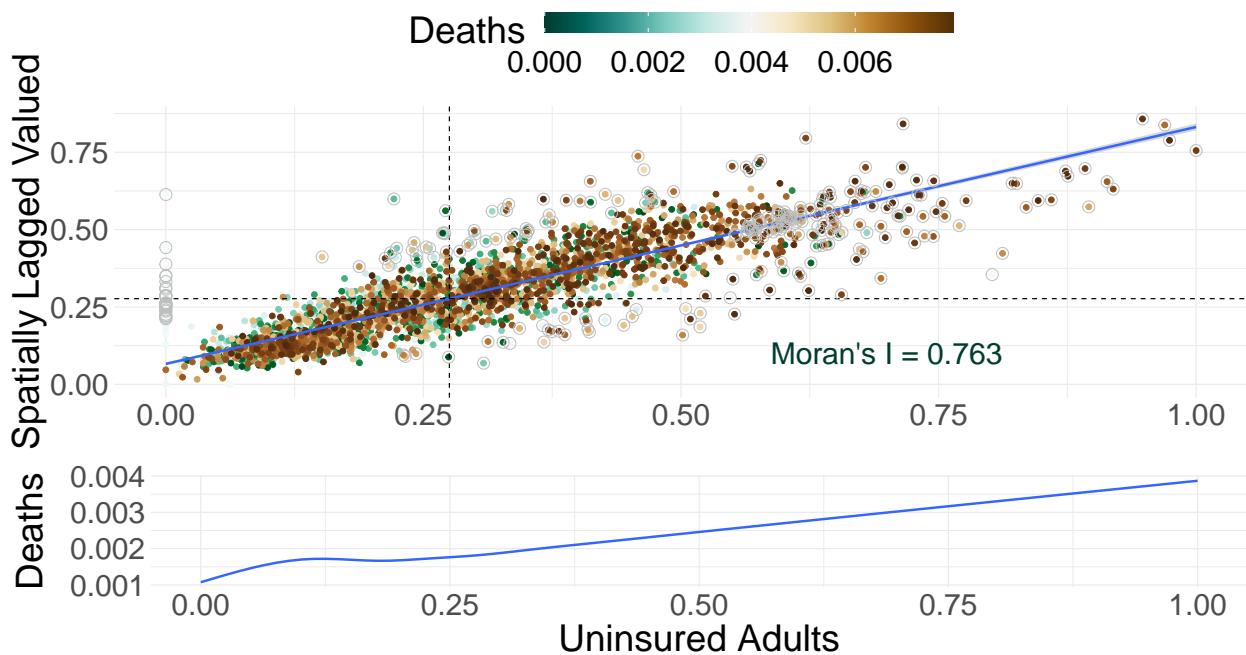
Obesity x Population Adjusted Deaths



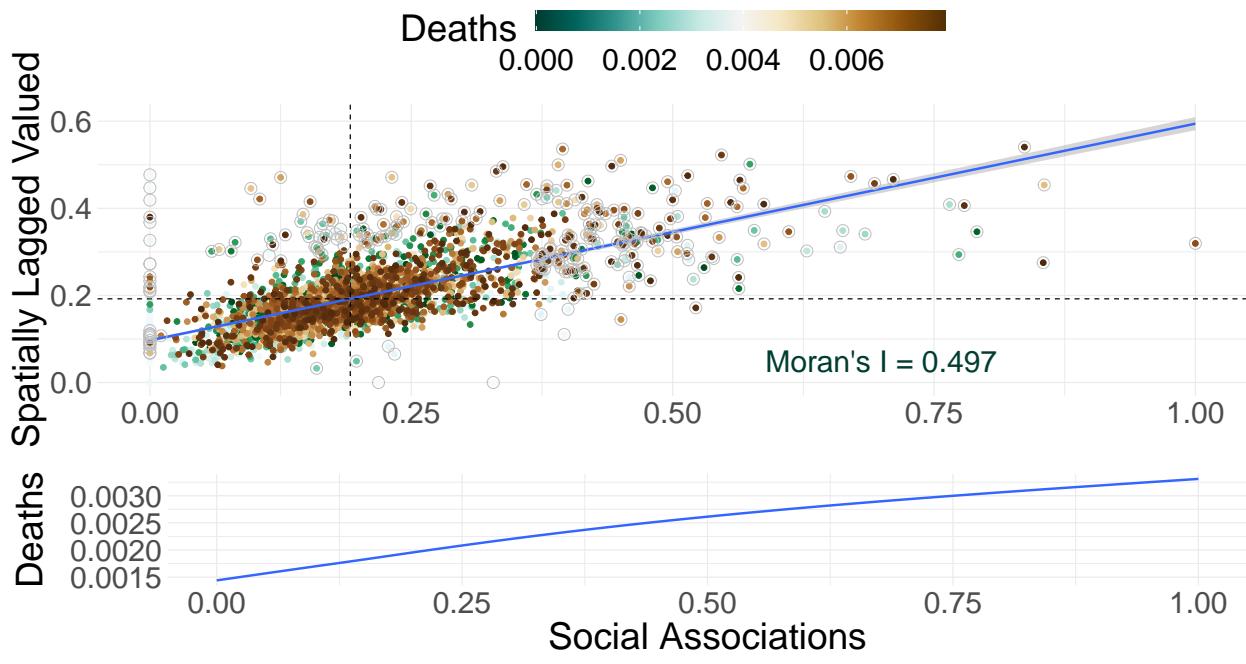
Unemployed x Population Adjusted Deaths



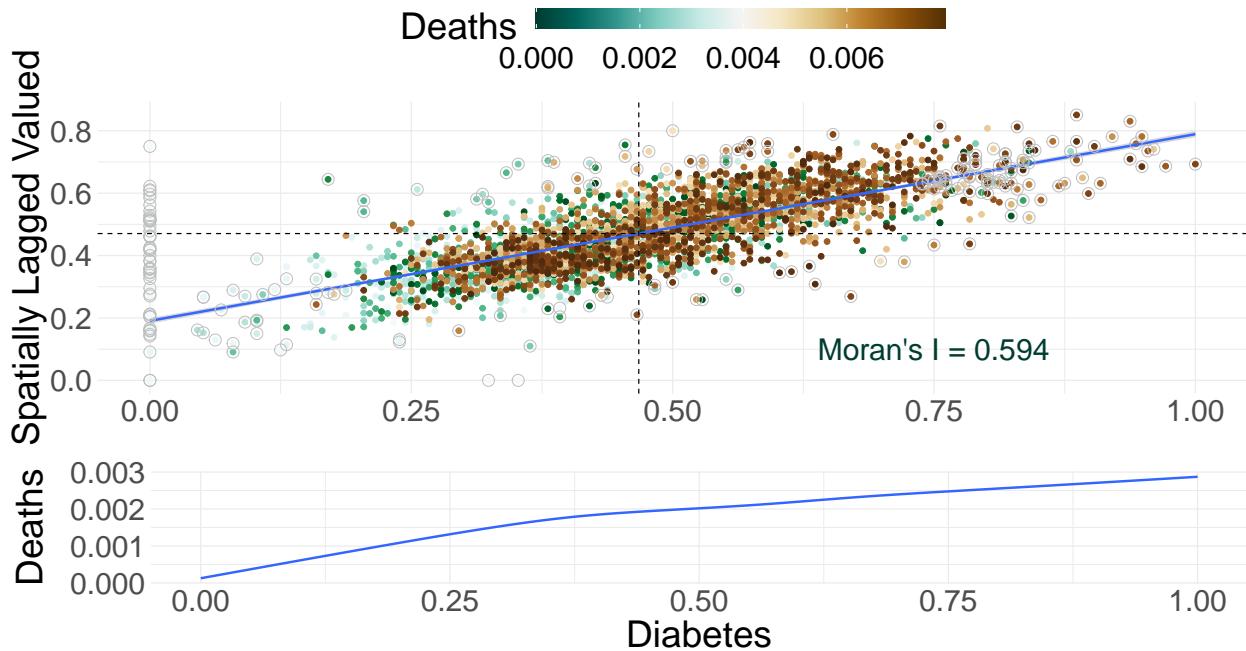
Uninsured Adults x Population Adjusted Deaths



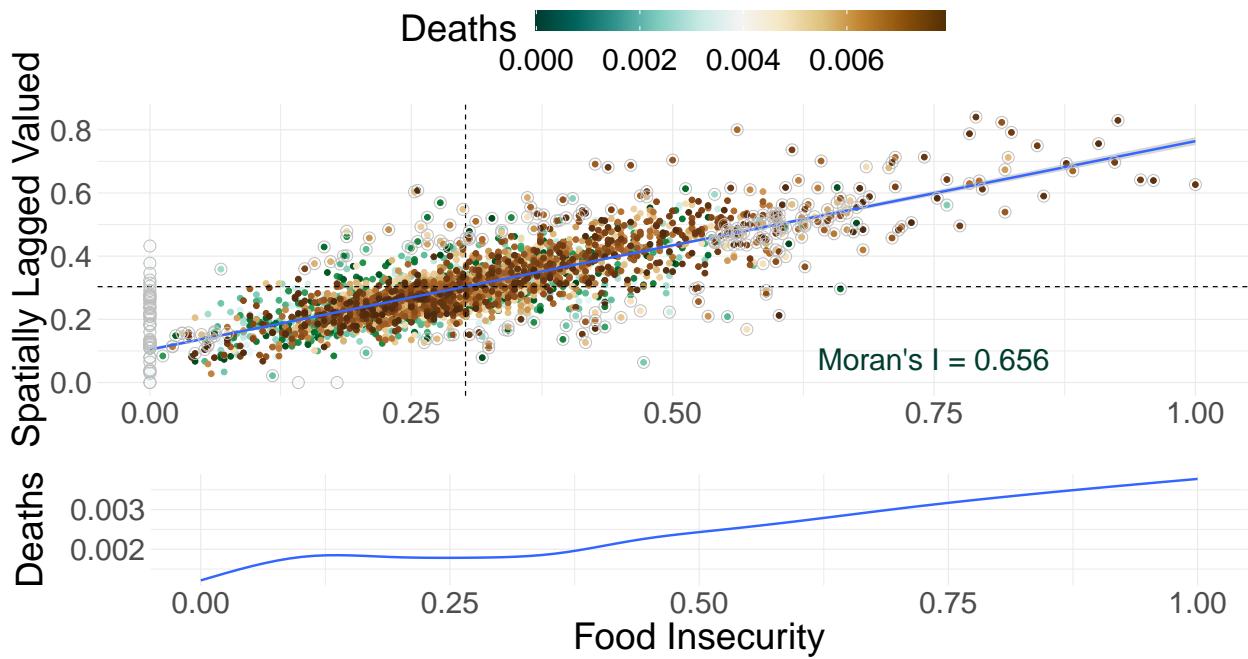
Social Associations x Population Adjusted Deaths



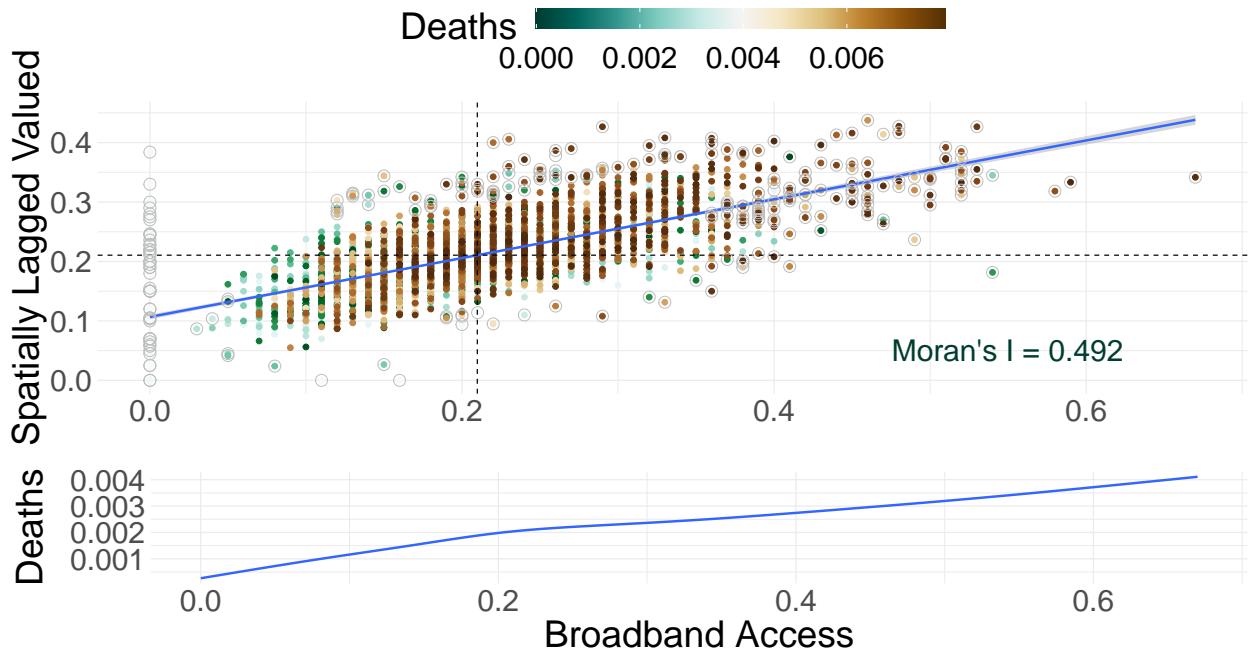
Diabetes x Population Adjusted Deaths



Food Insecurity x Population Adjusted Deaths



Broadband Access x Population Adjusted Deaths



Age Over 65 x Population Adjusted Deaths

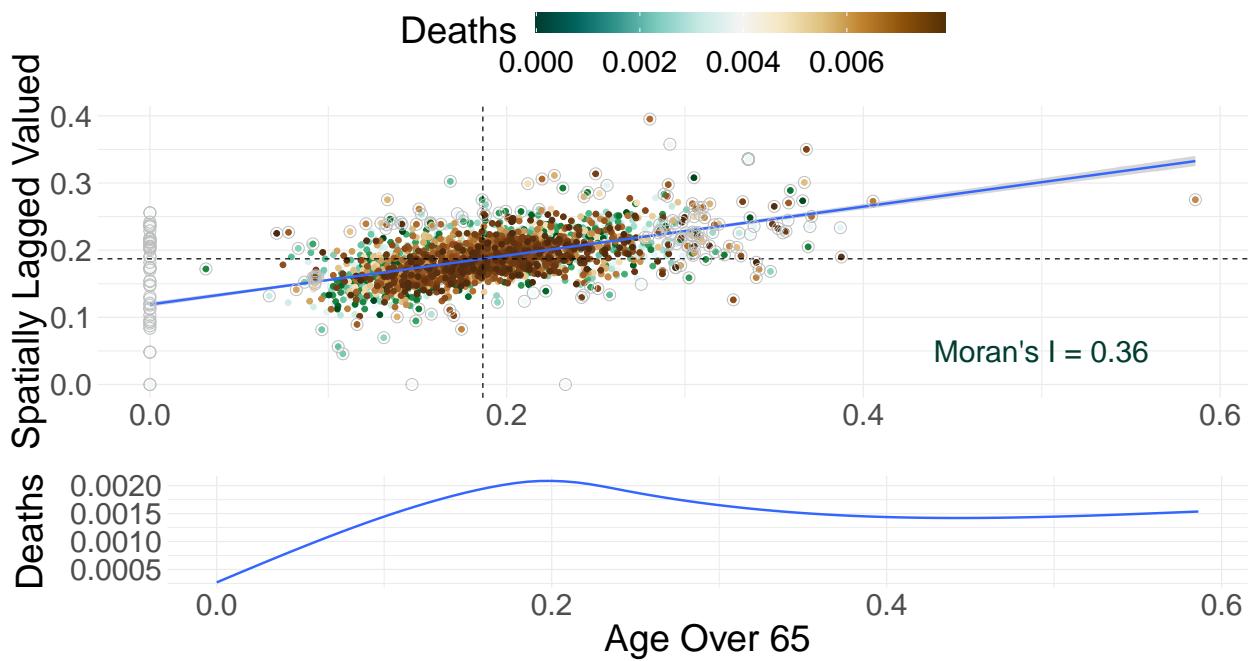


Figure S38: Morans I results: United States - Delta Wave, Dependent Variable

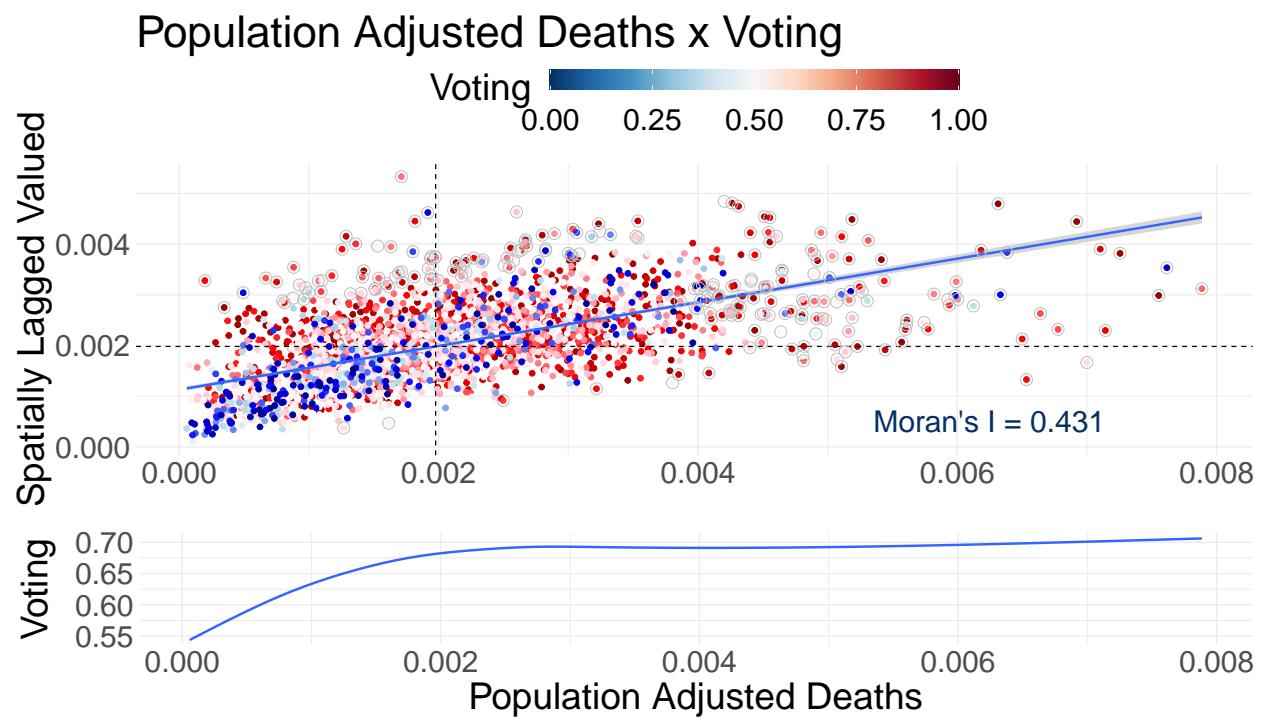
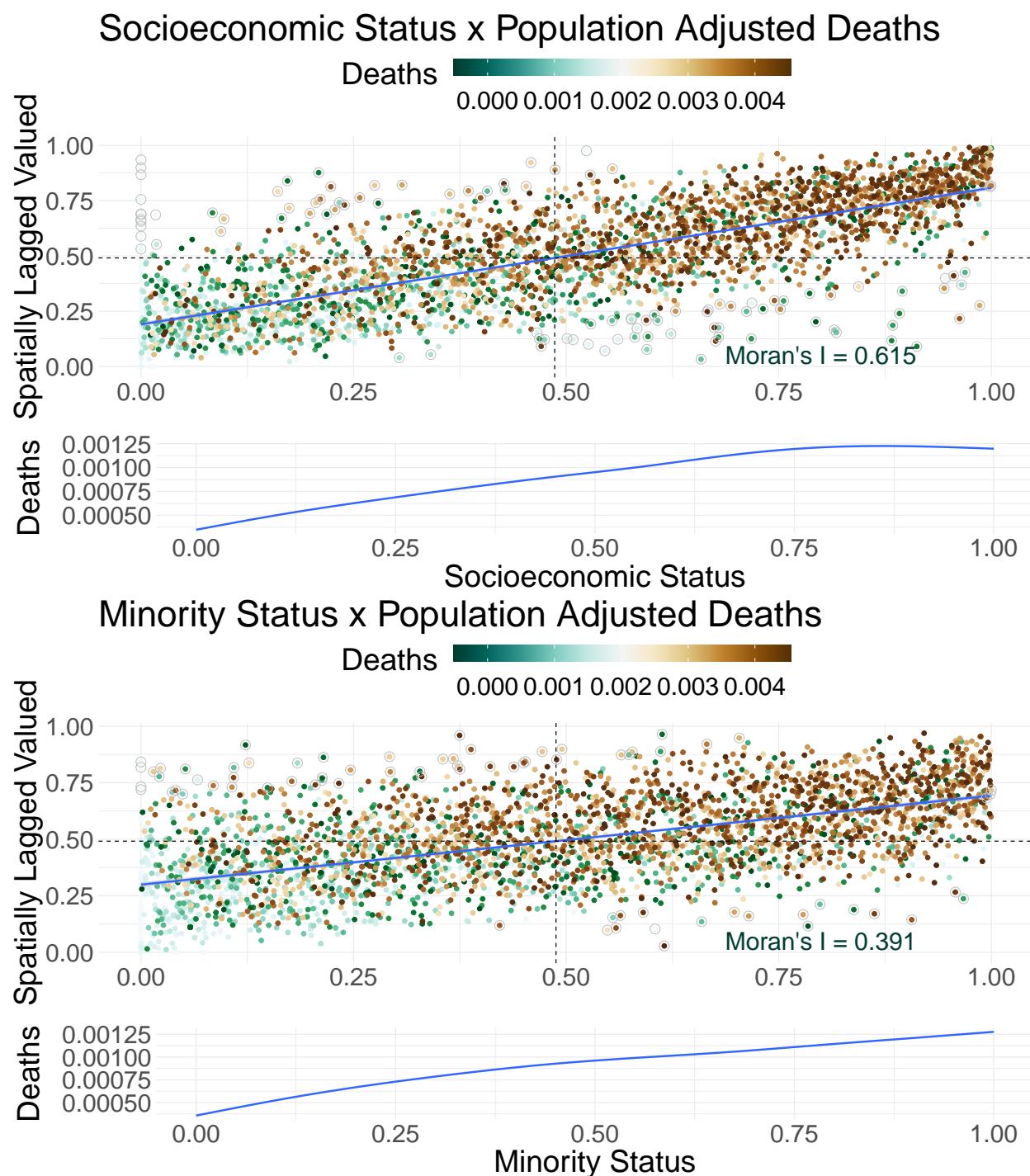
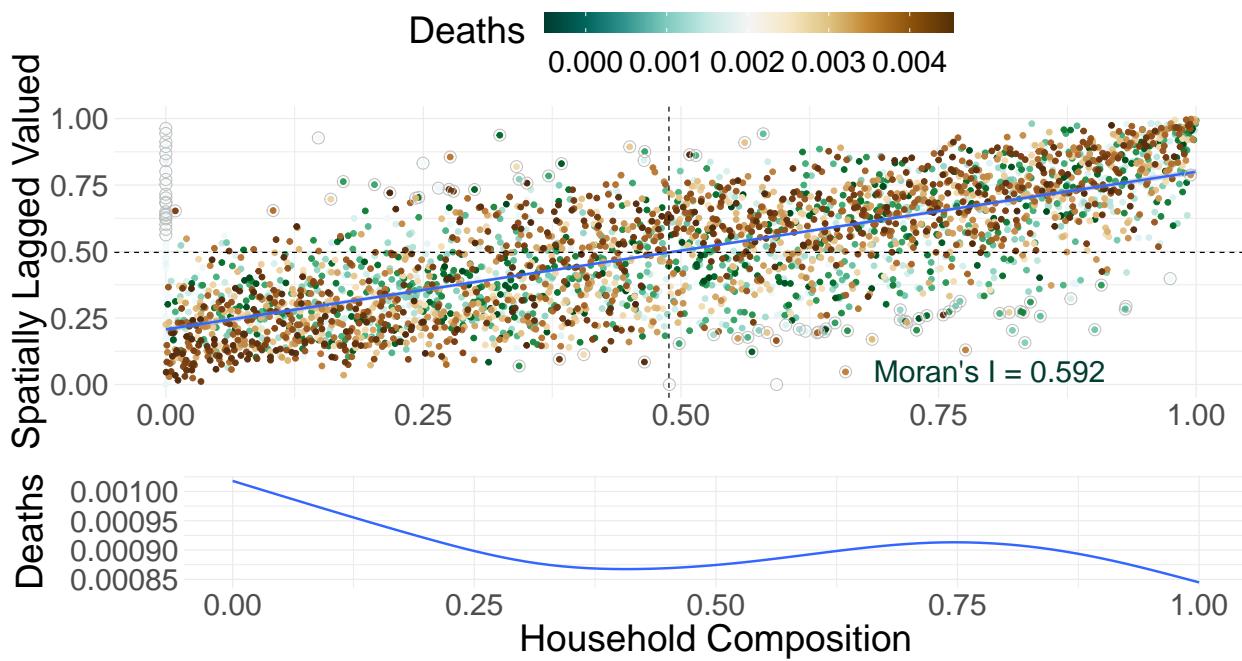


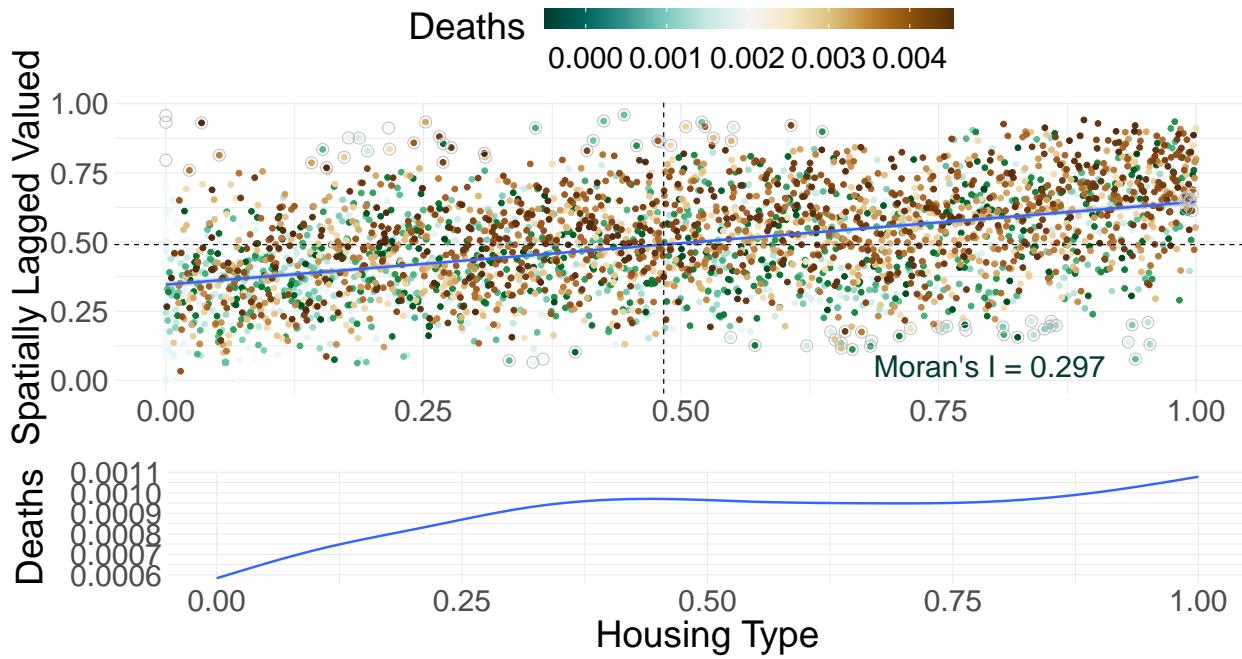
Figure S39: Morans I results: United States - Delta Wave, Independent Variables



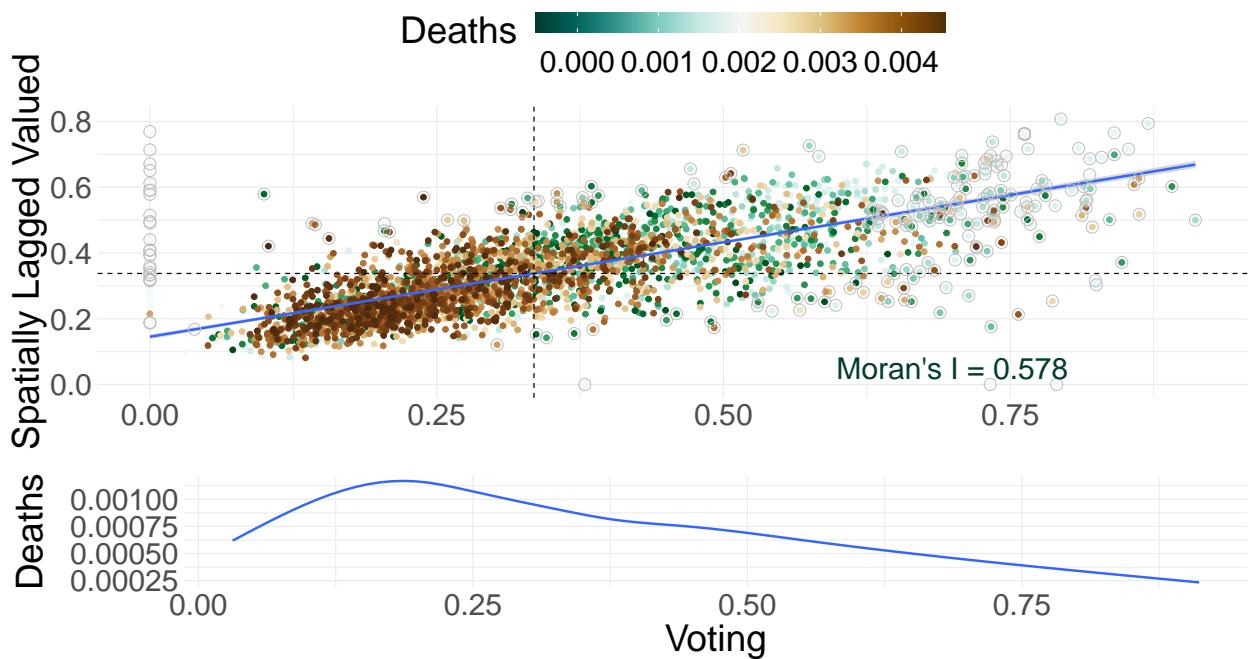
Household Composition x Population Adjusted Deaths



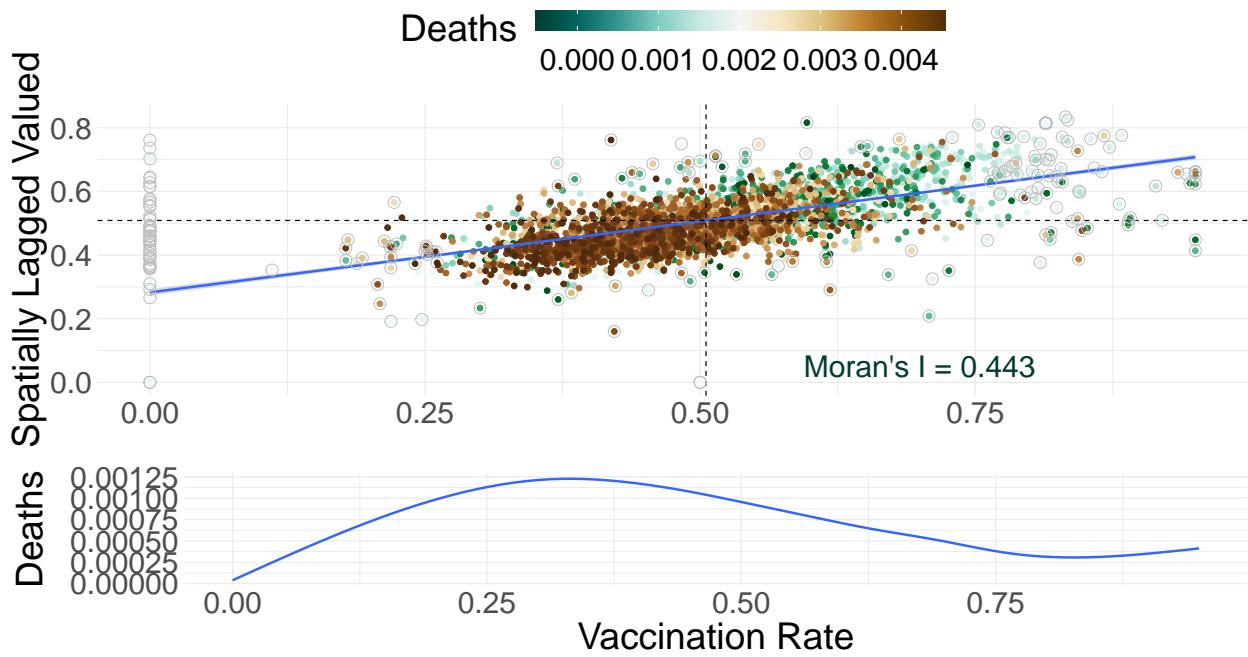
Housing Type x Population Adjusted Deaths



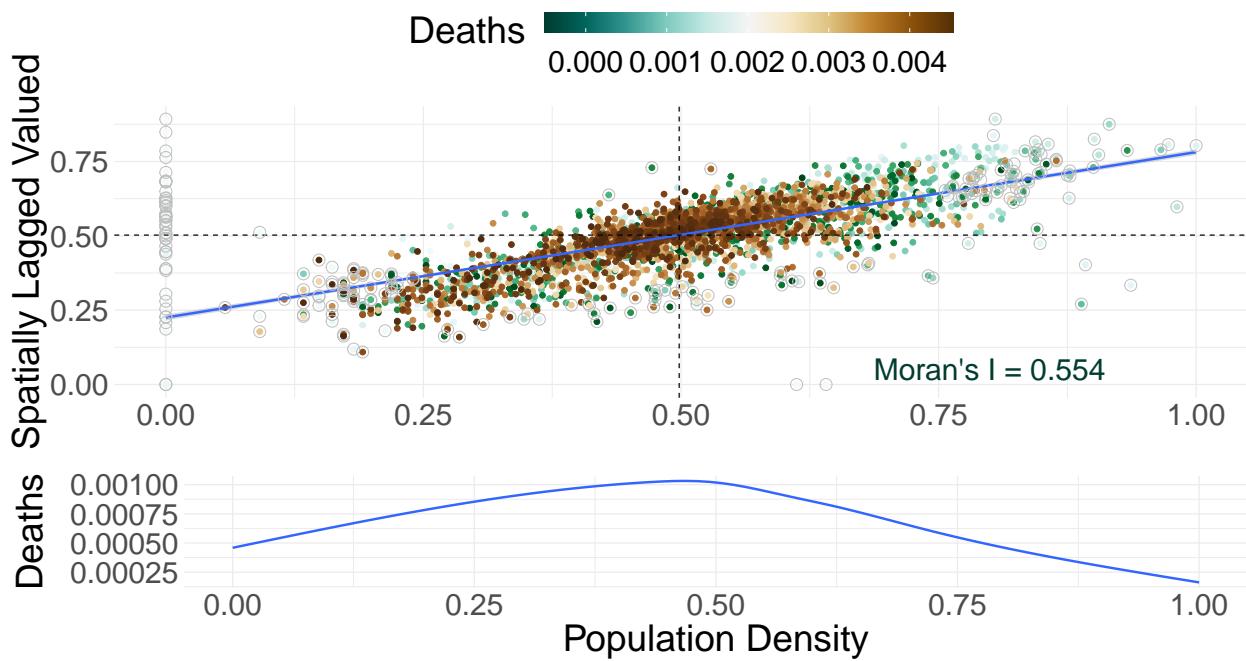
Voting x Population Adjusted Deaths



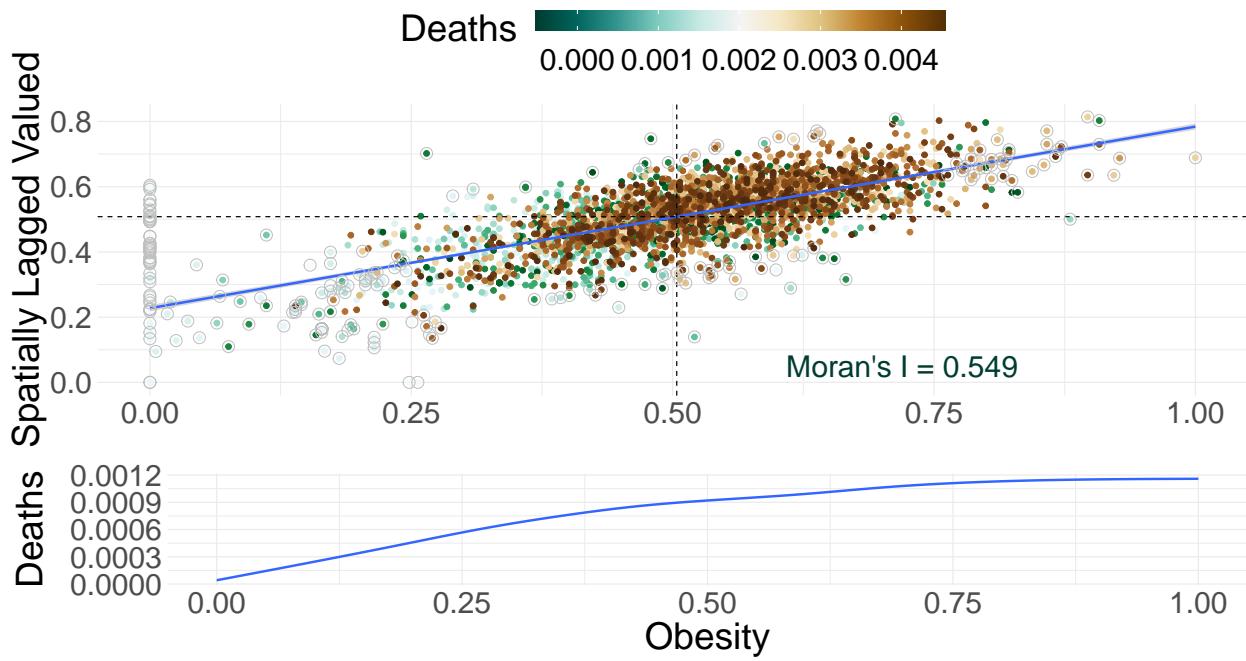
Vaccination Rate x Population Adjusted Deaths



Population Density x Population Adjusted Deaths



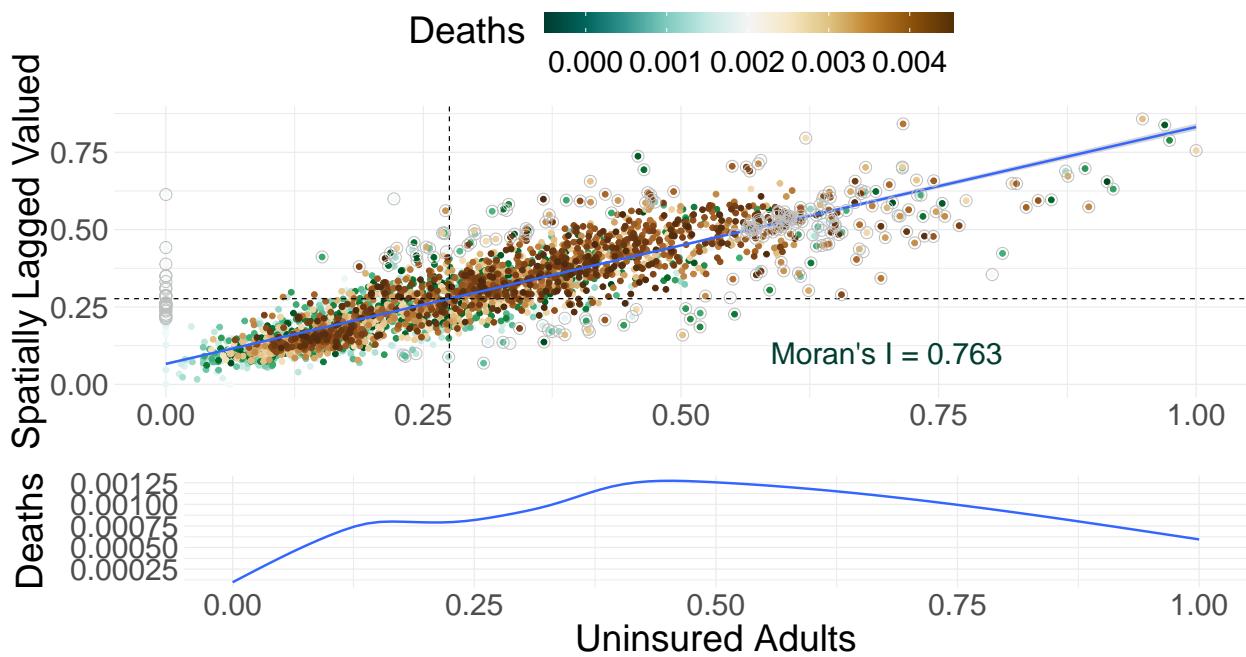
Obesity x Population Adjusted Deaths



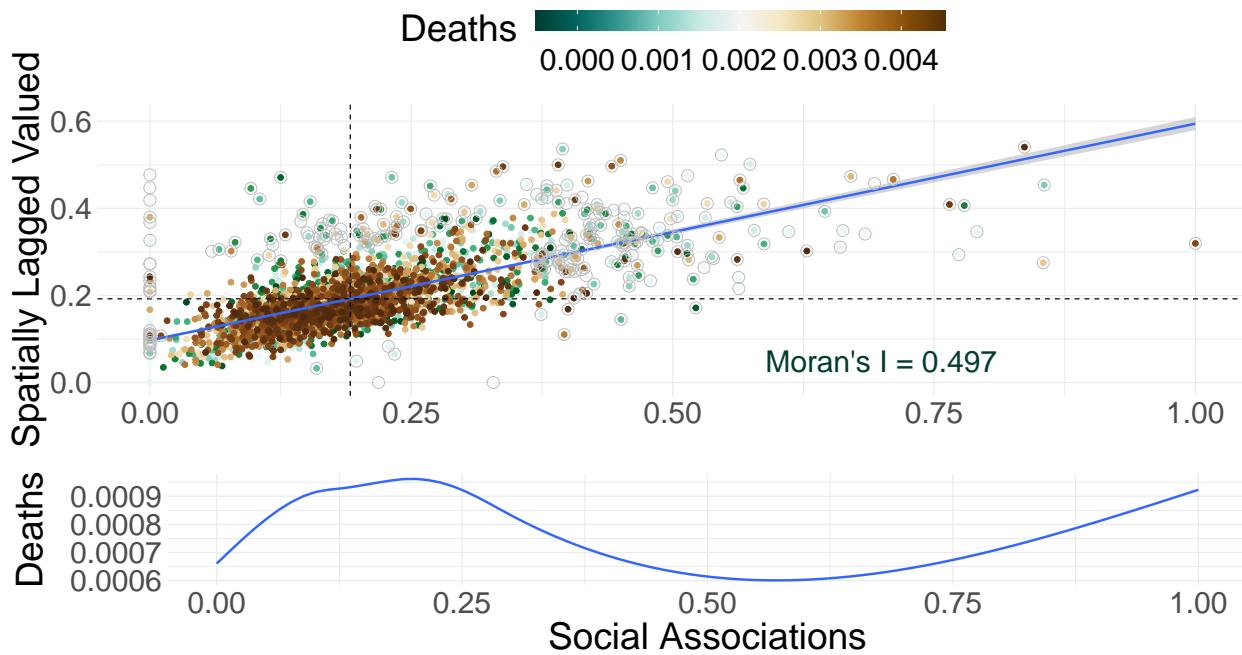
Unemployed x Population Adjusted Deaths



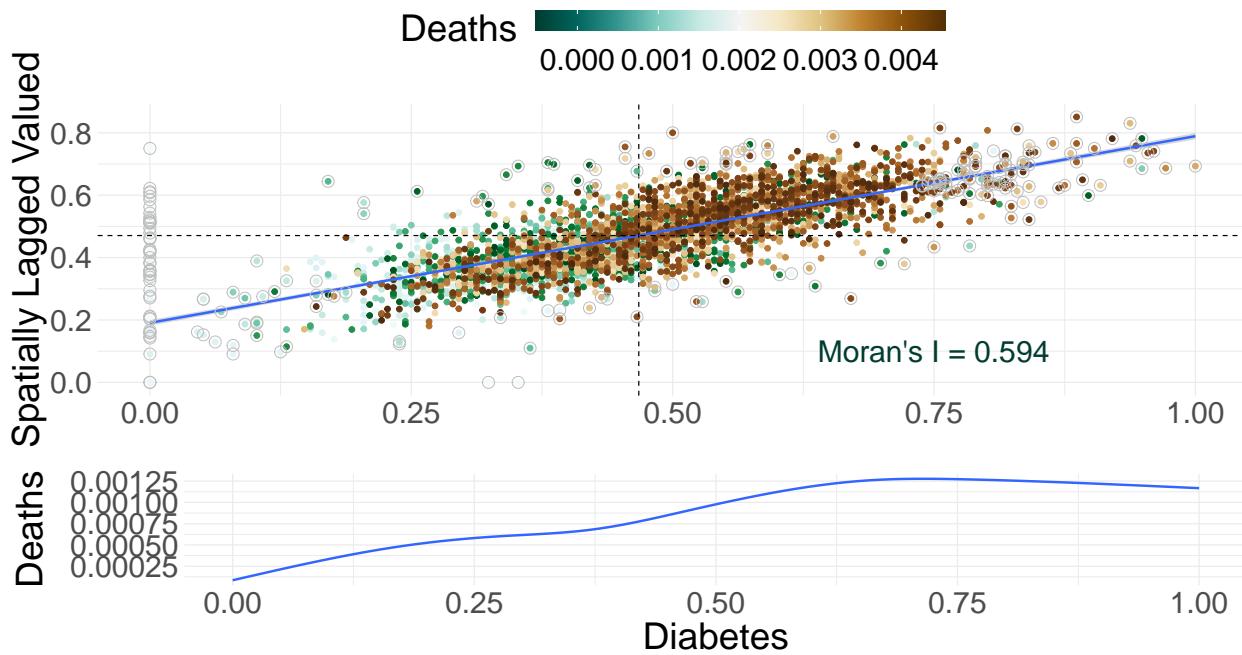
Uninsured Adults x Population Adjusted Deaths



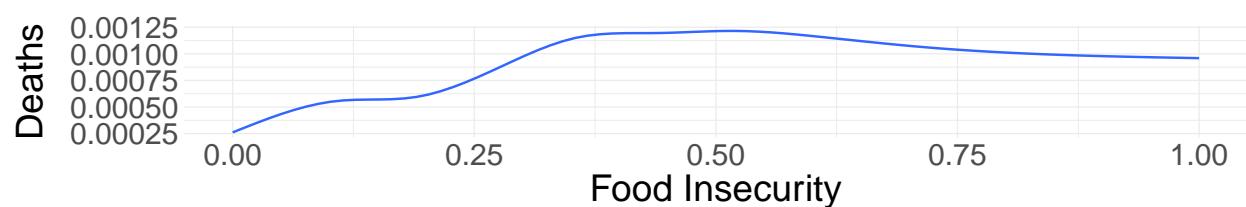
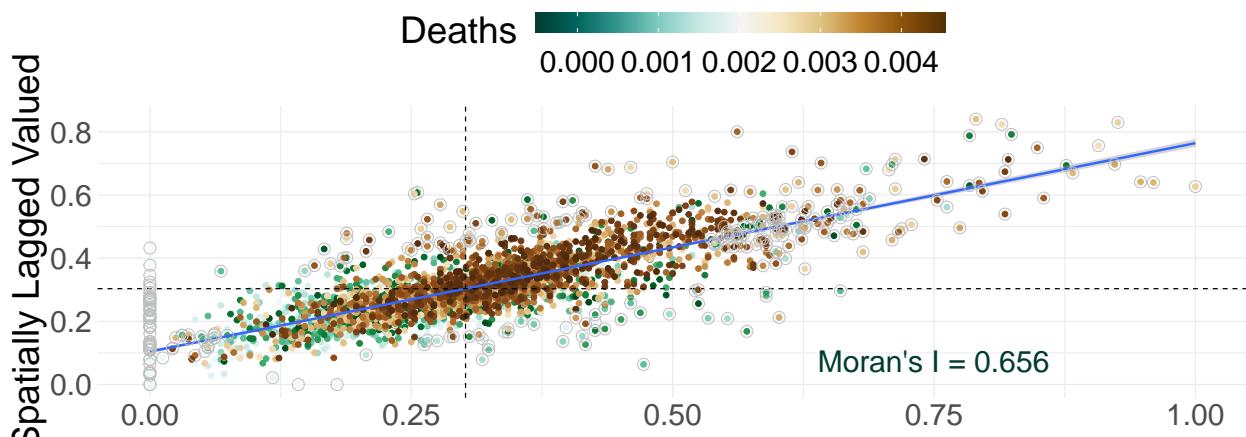
Social Associations x Population Adjusted Deaths



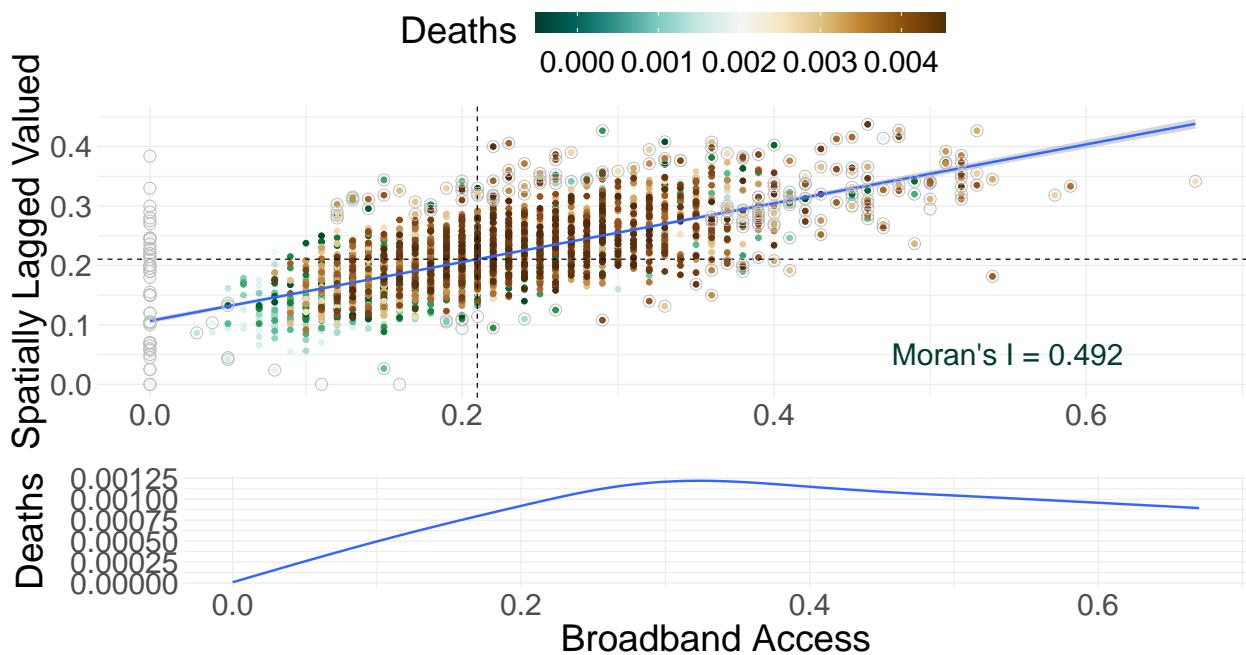
Diabetes x Population Adjusted Deaths



Food Insecurity x Population Adjusted Deaths



Broadband Access x Population Adjusted Deaths



Age Over 65 x Population Adjusted Deaths

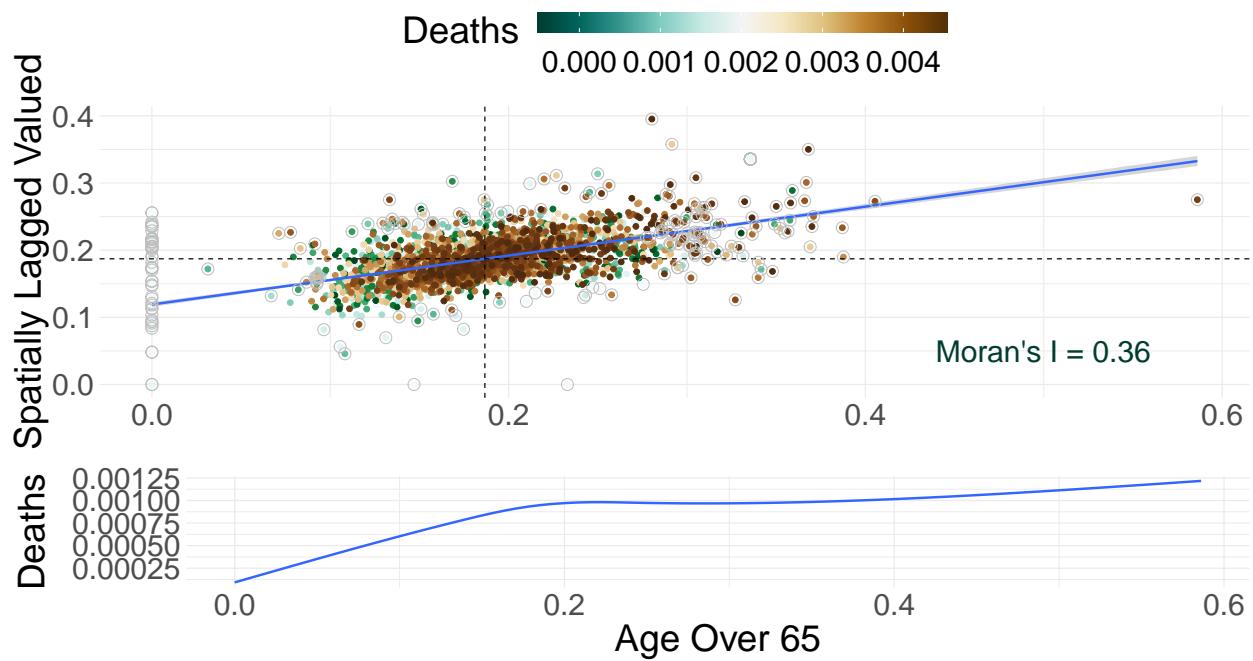


Figure S40: Morans I results: United States - Omicron Wave, Dependent Variable

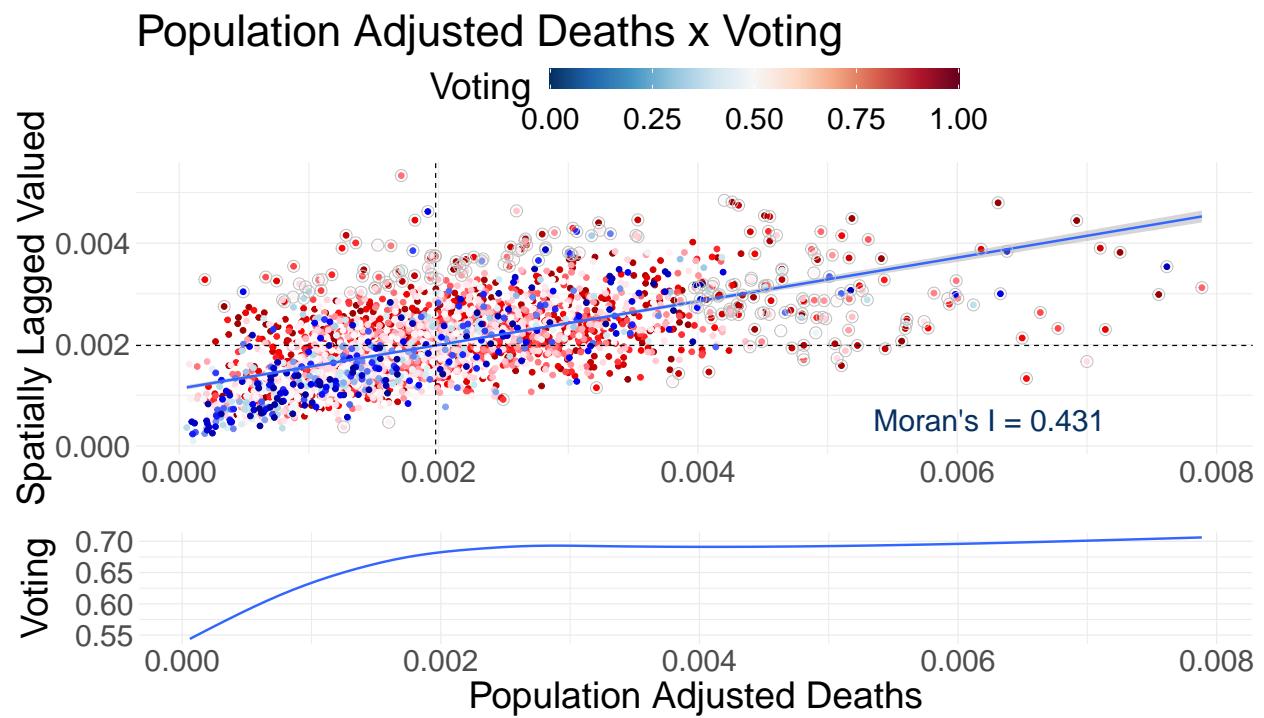
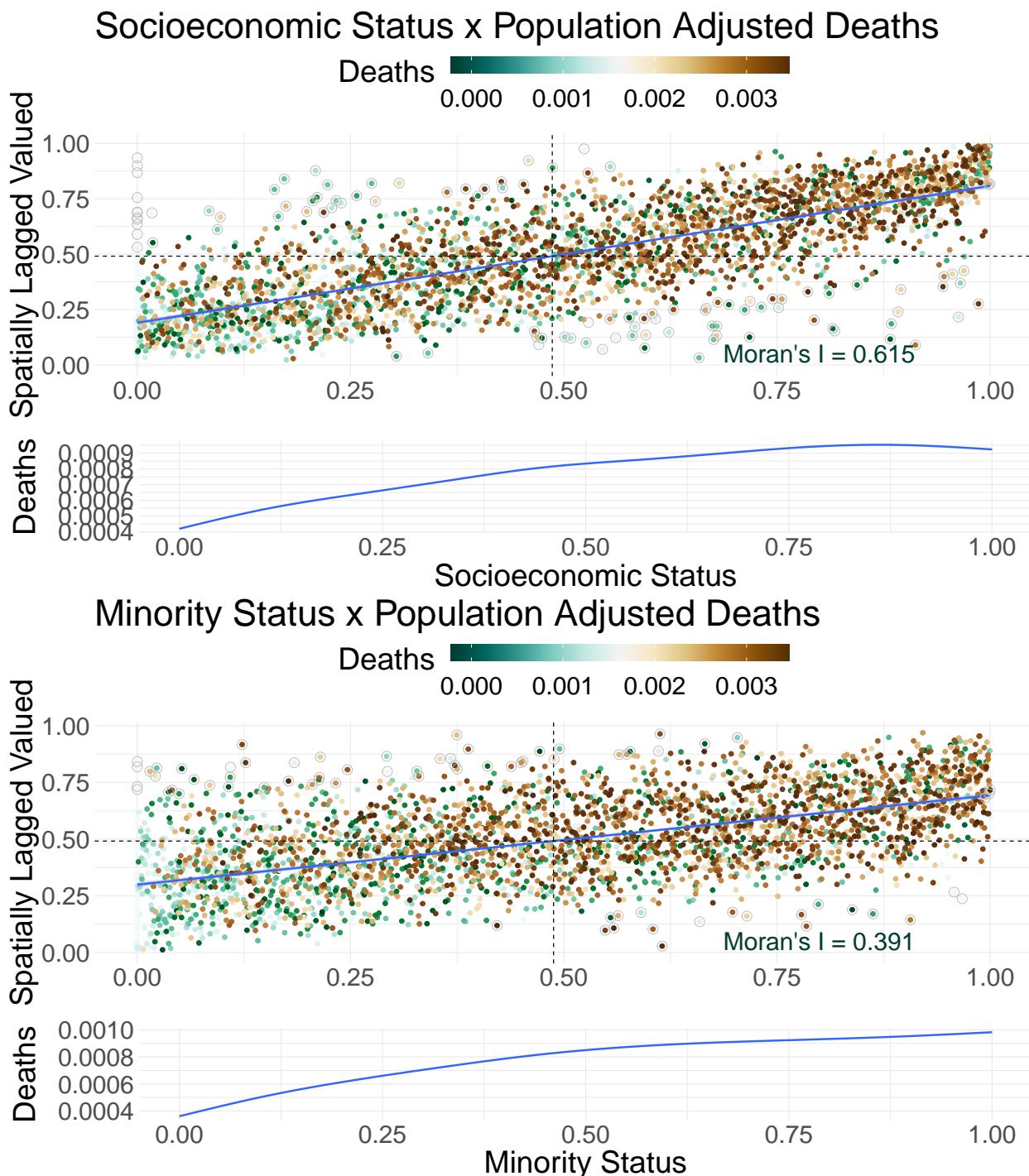
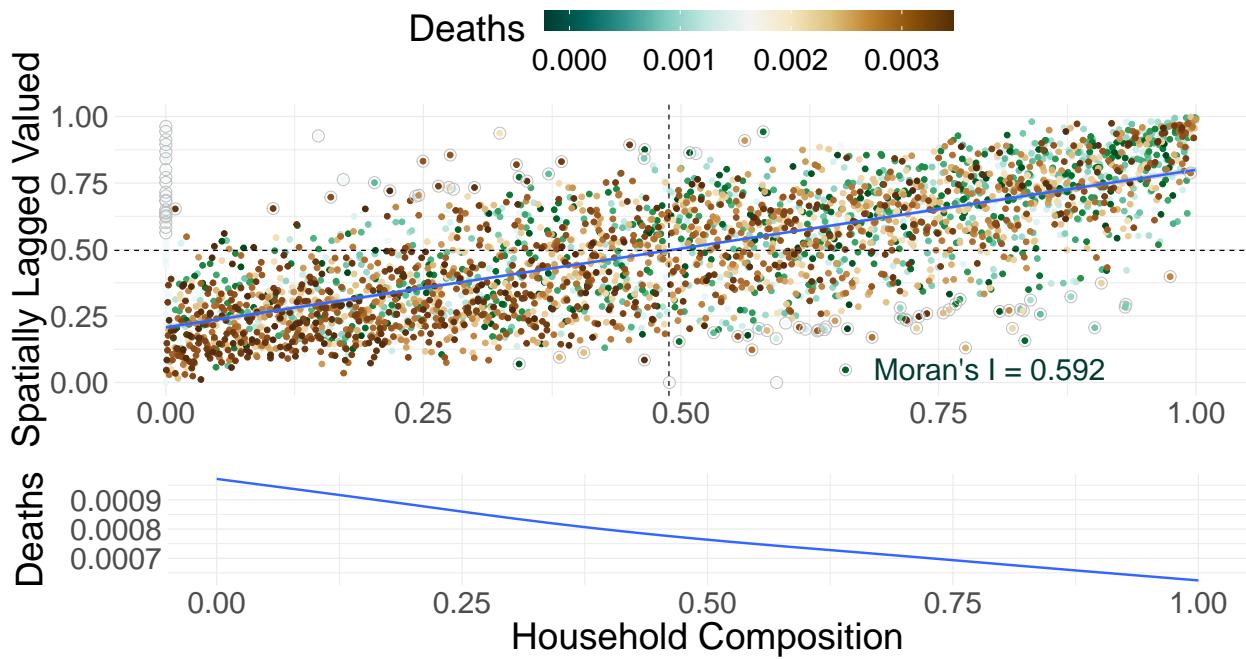


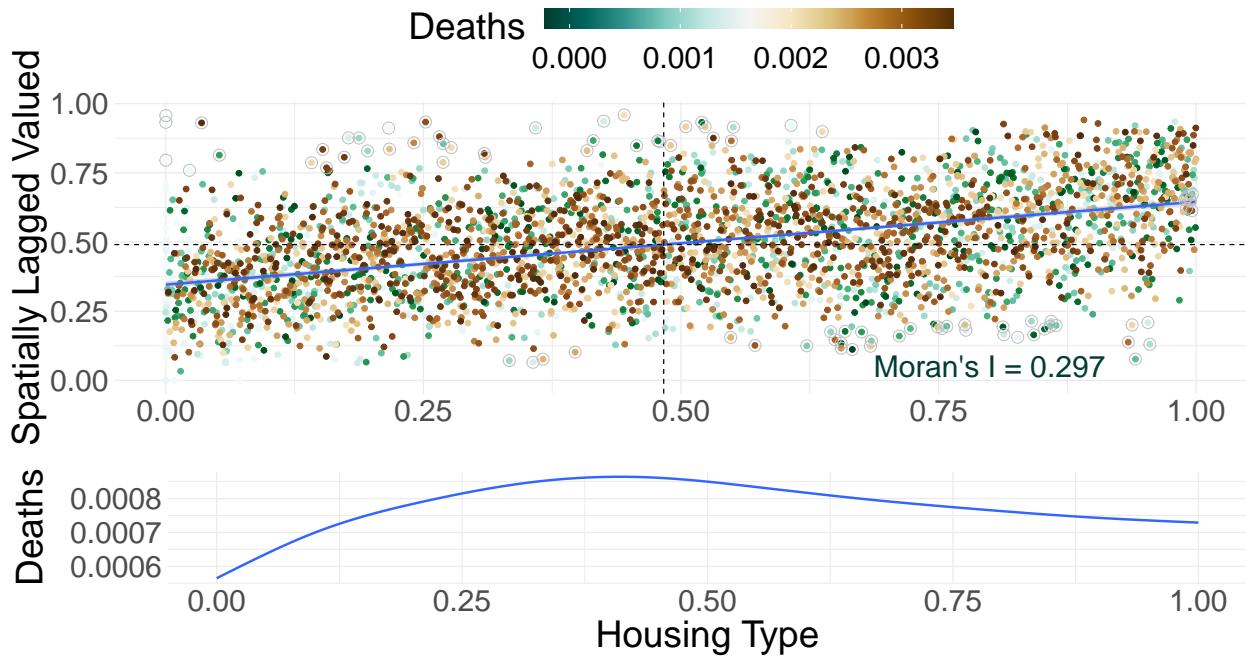
Figure S41: Morans I results: United States - Omicron Wave, Independent Variables



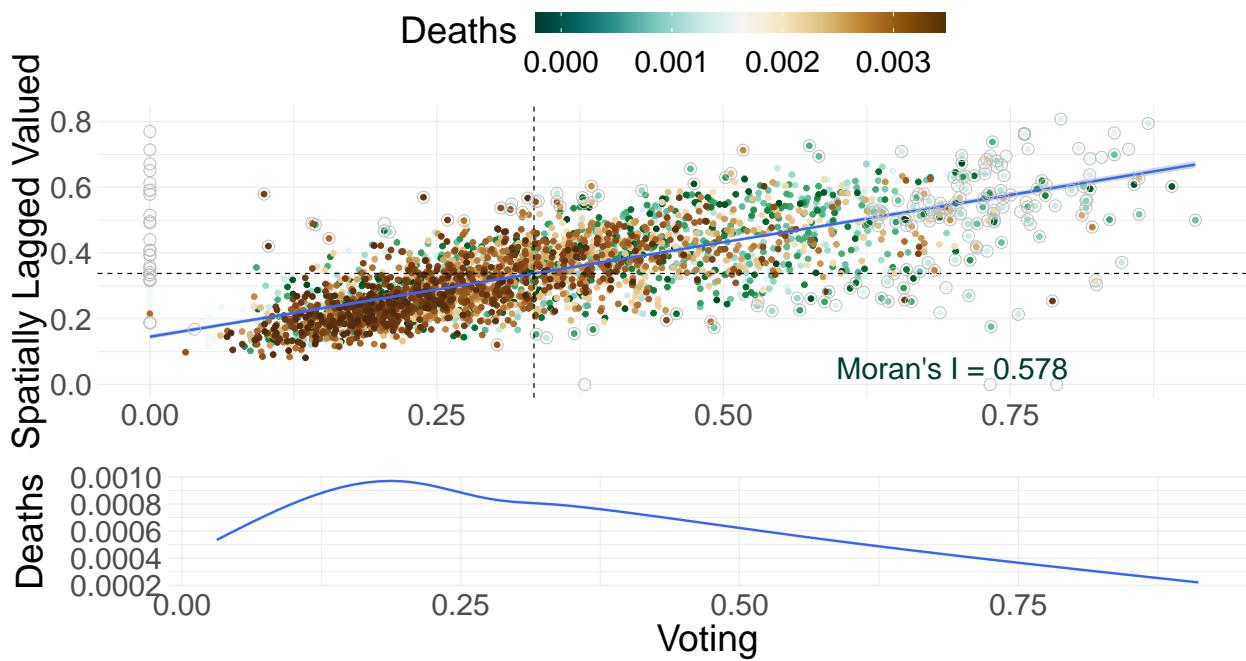
Household Composition x Population Adjusted Deaths



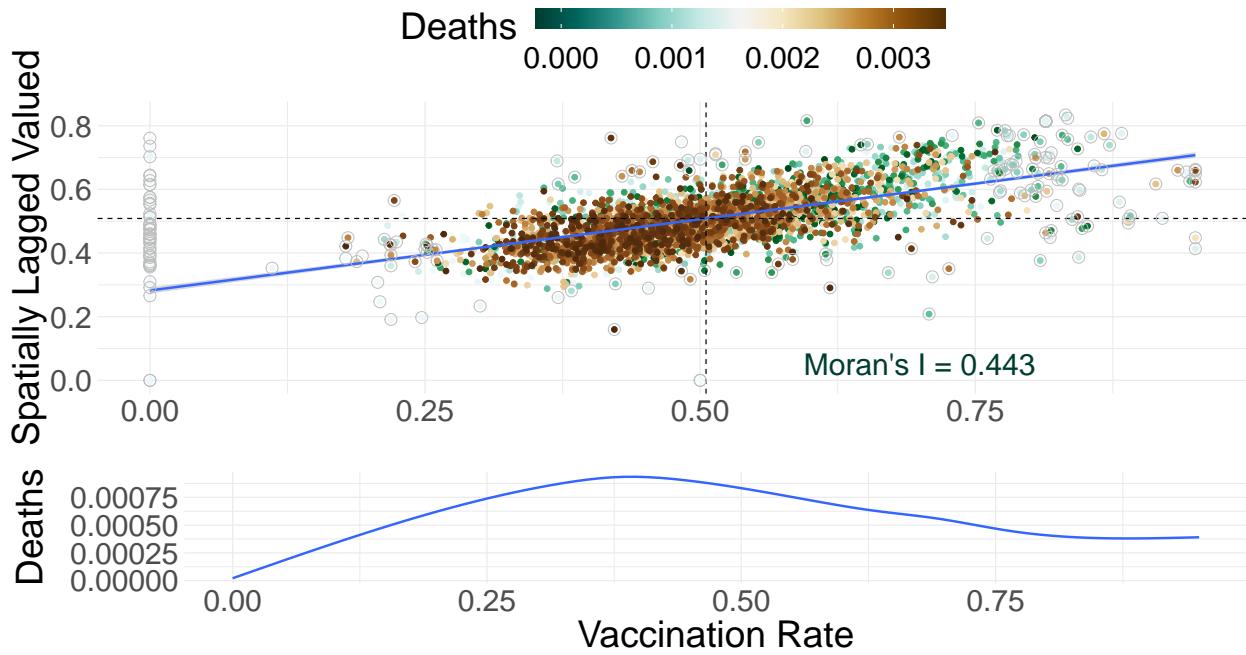
Housing Type x Population Adjusted Deaths



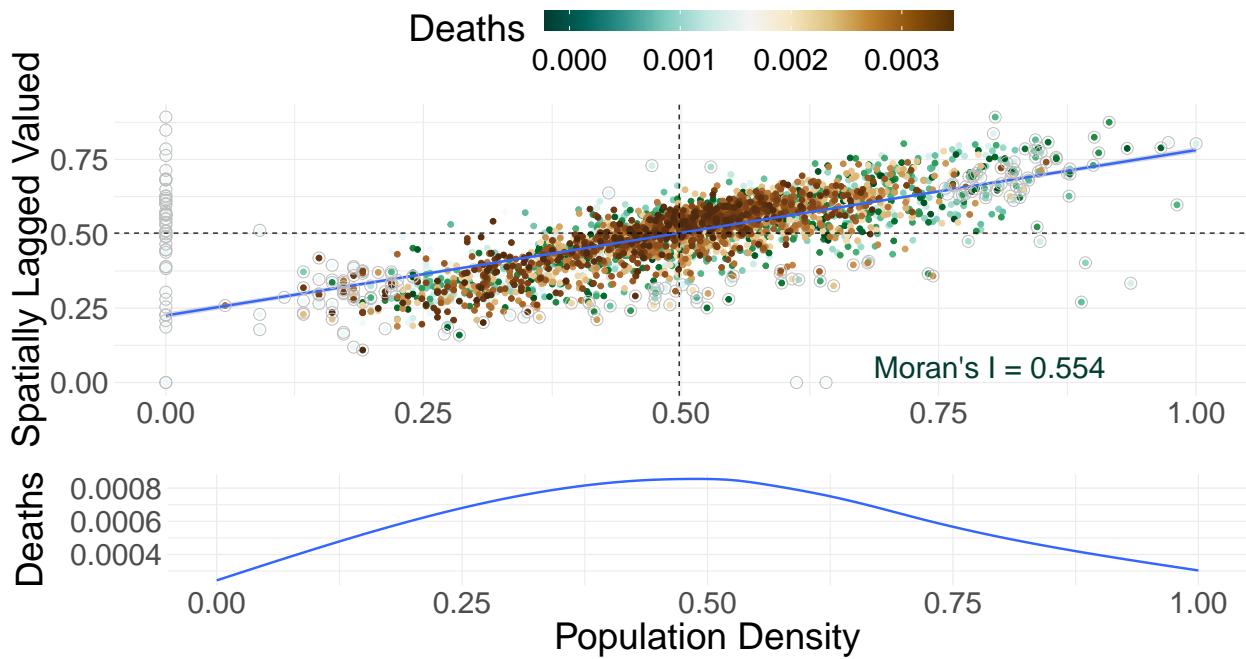
Voting x Population Adjusted Deaths



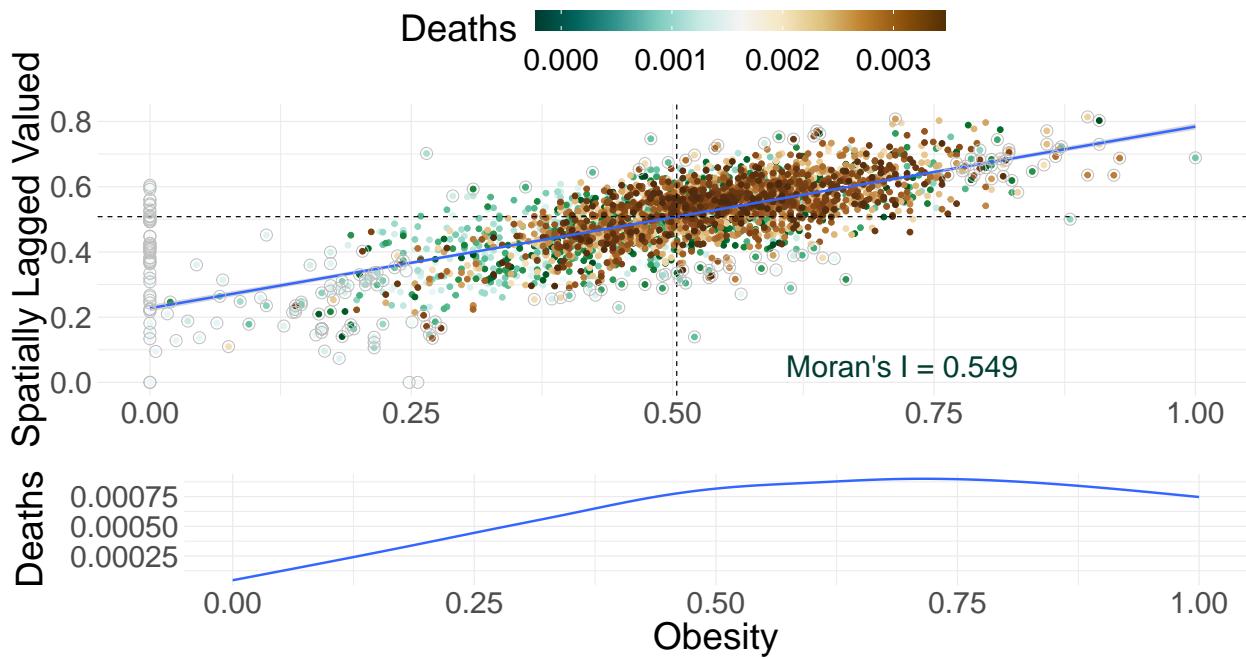
Vaccination Rate x Population Adjusted Deaths



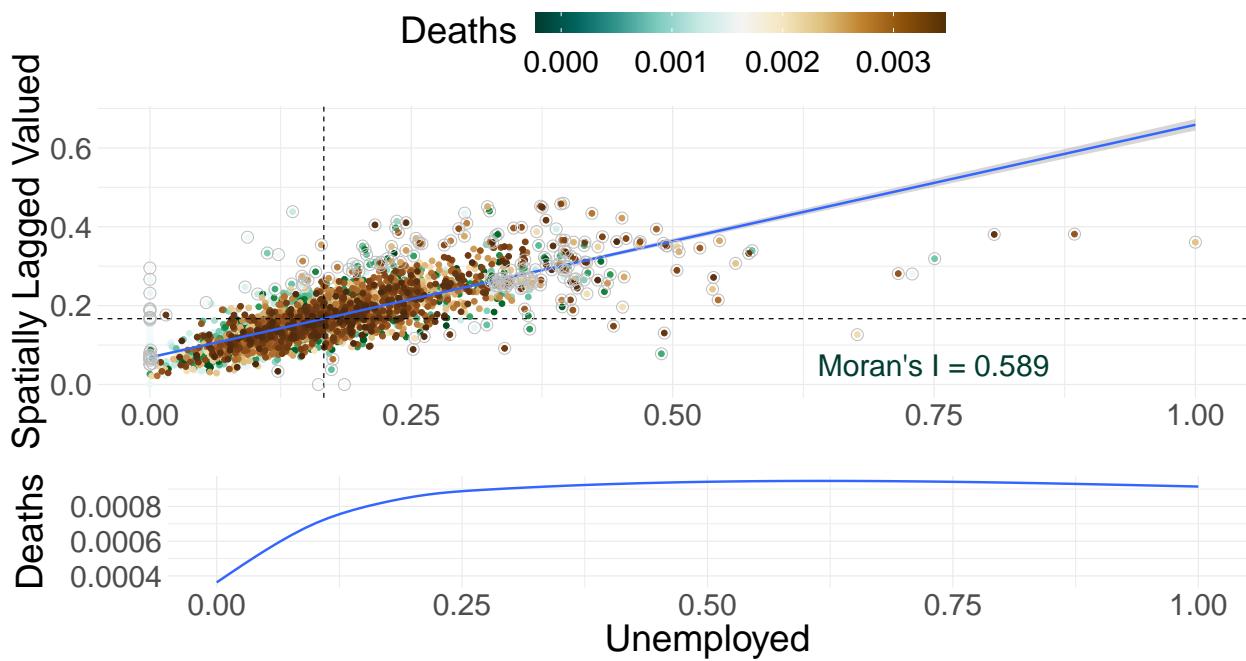
Population Density x Population Adjusted Deaths



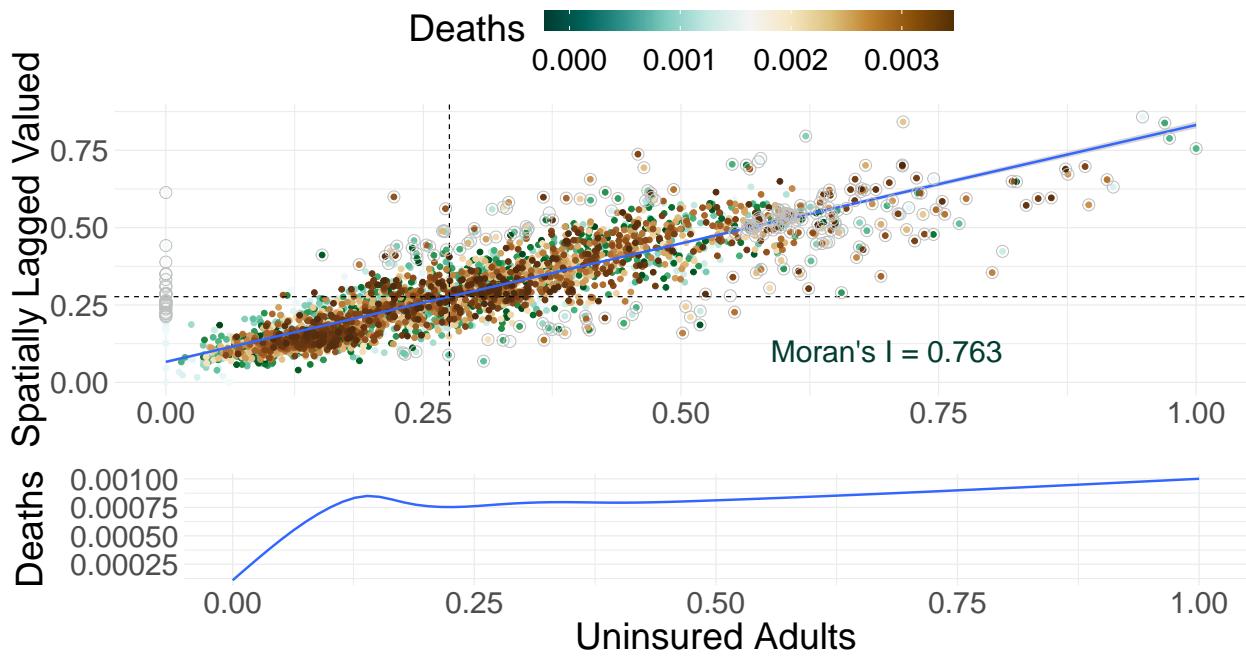
Obesity x Population Adjusted Deaths



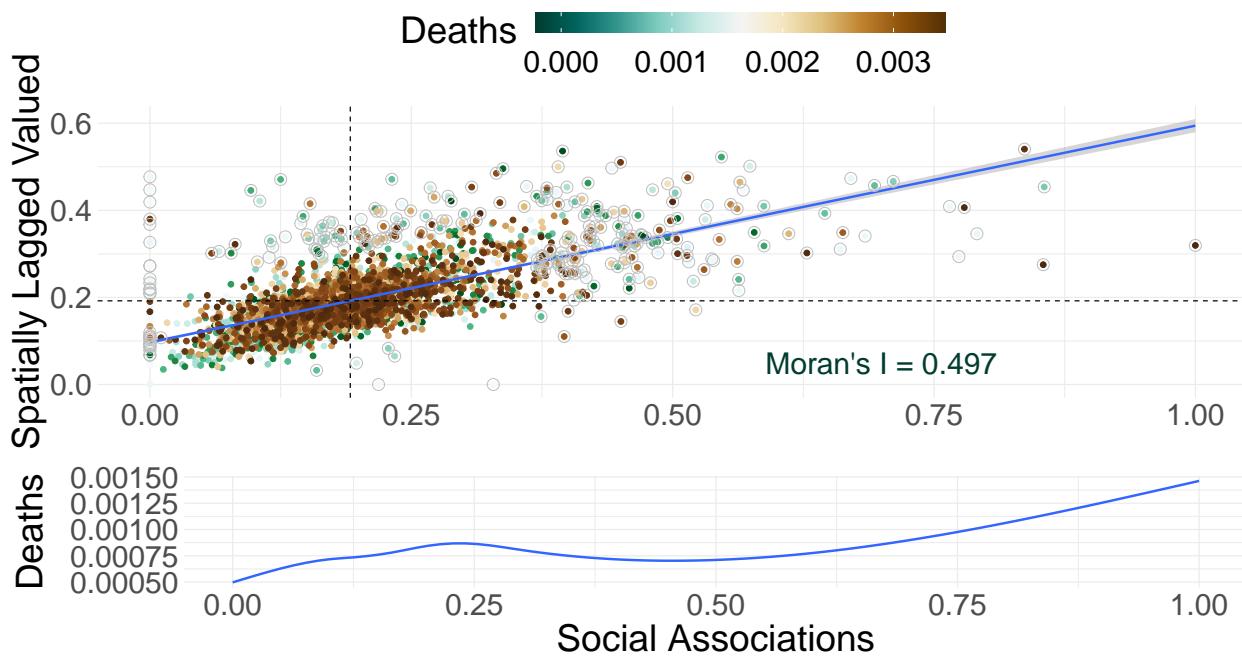
Unemployed x Population Adjusted Deaths



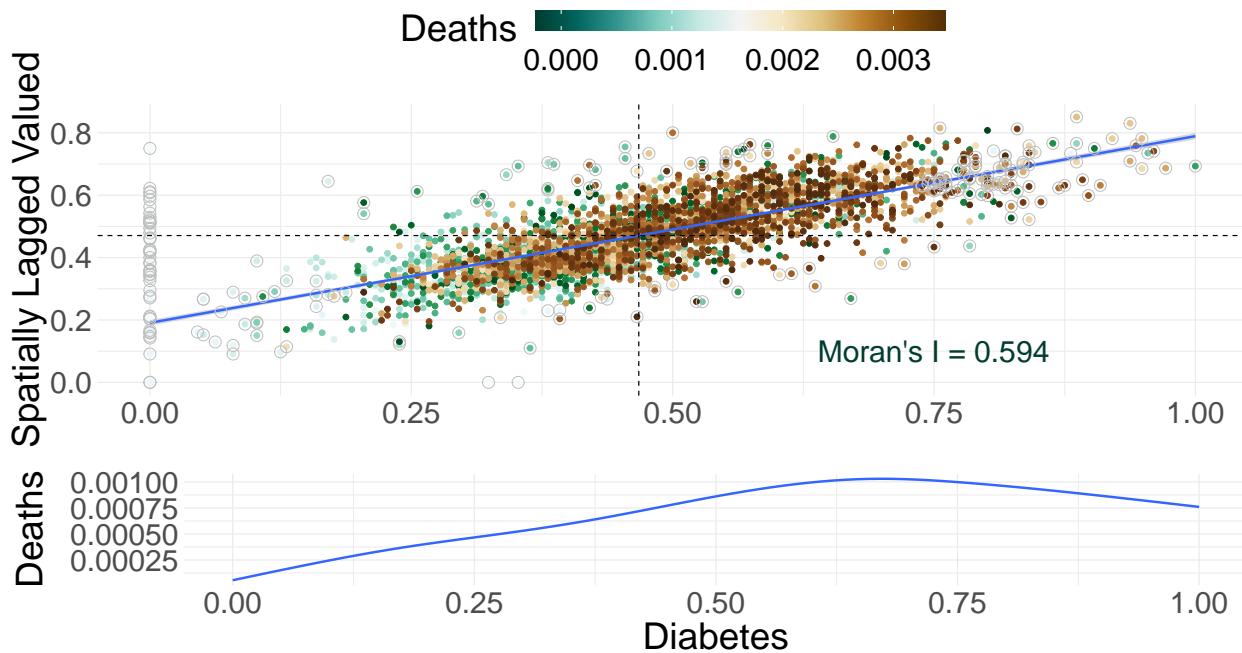
Uninsured Adults x Population Adjusted Deaths



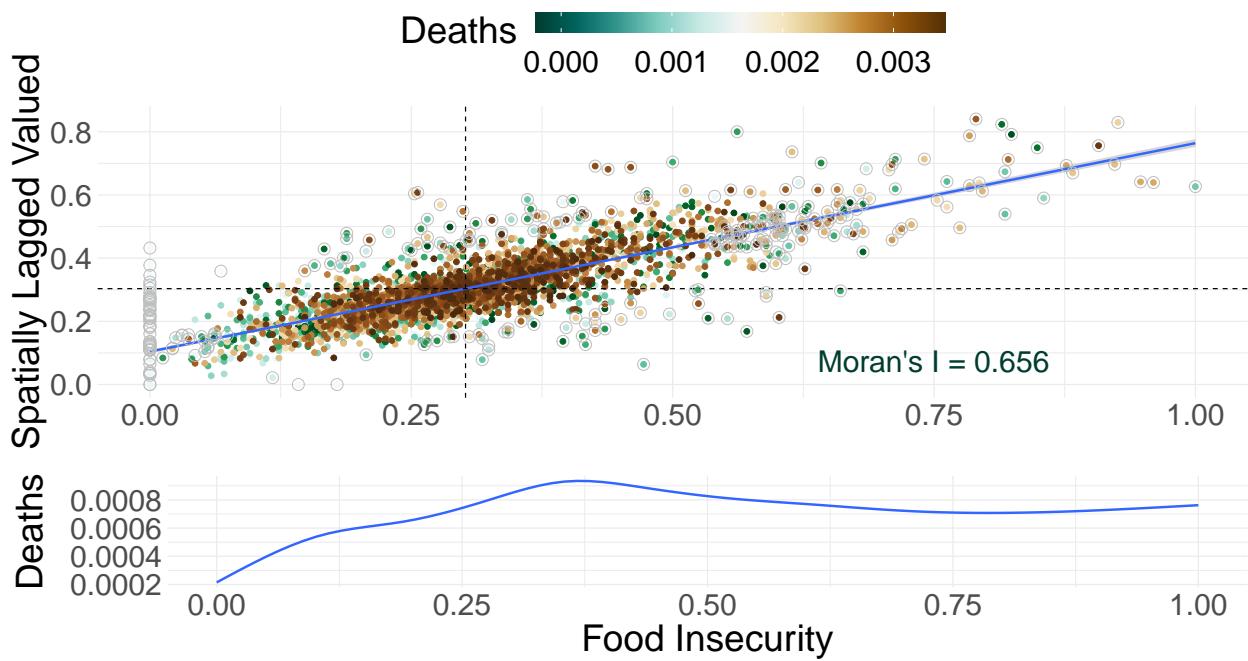
Social Associations x Population Adjusted Deaths



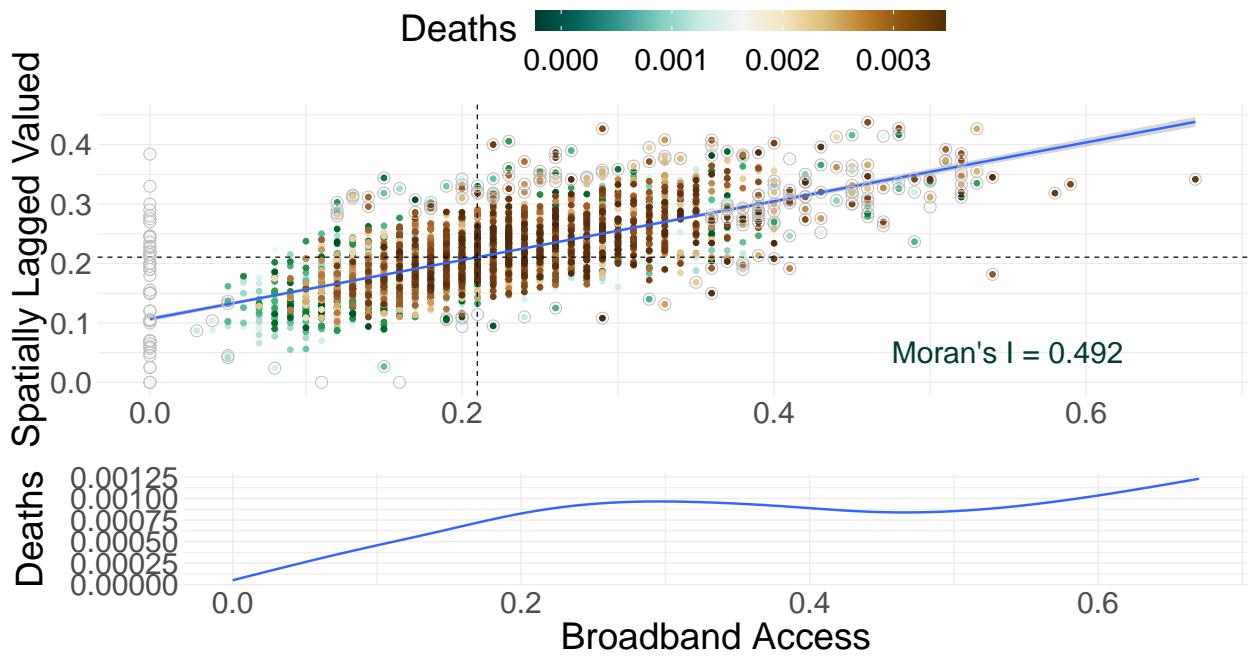
Diabetes x Population Adjusted Deaths



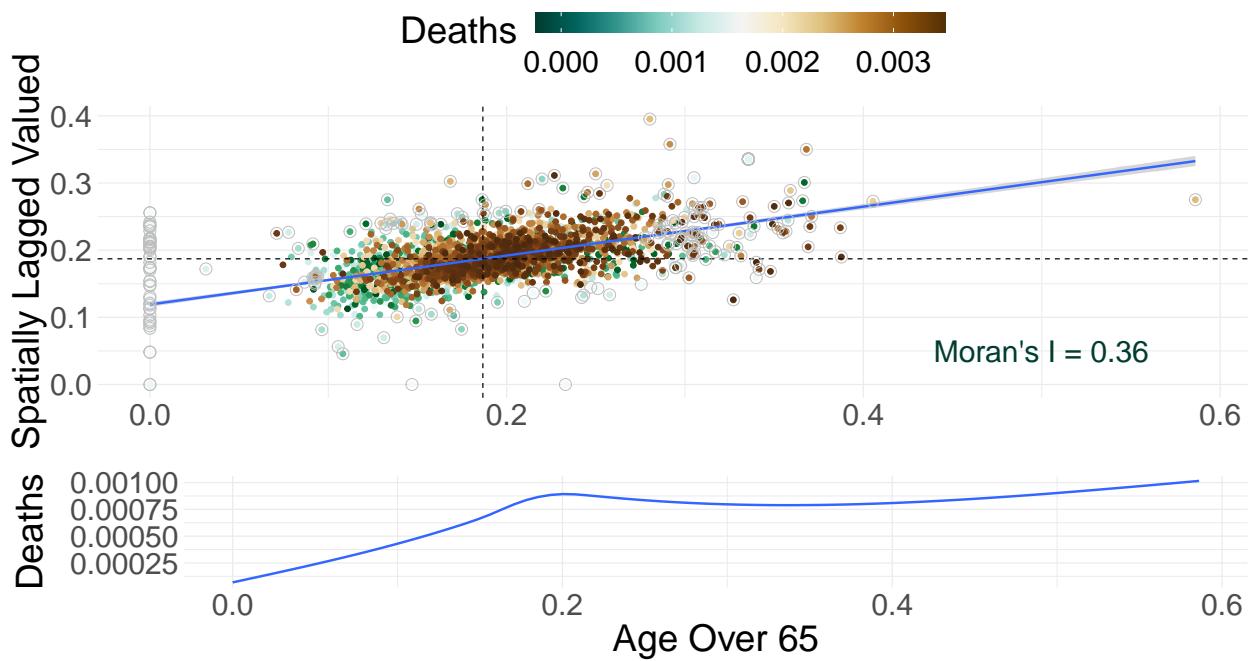
Food Insecurity x Population Adjusted Deaths



Broadband Access x Population Adjusted Deaths



Age Over 65 x Population Adjusted Deaths



Part 5: Geographically Weighted Random Forest Modeling: Model Alpha Wave

Figure S42: GWRF Alpha Wave: Model Weighting

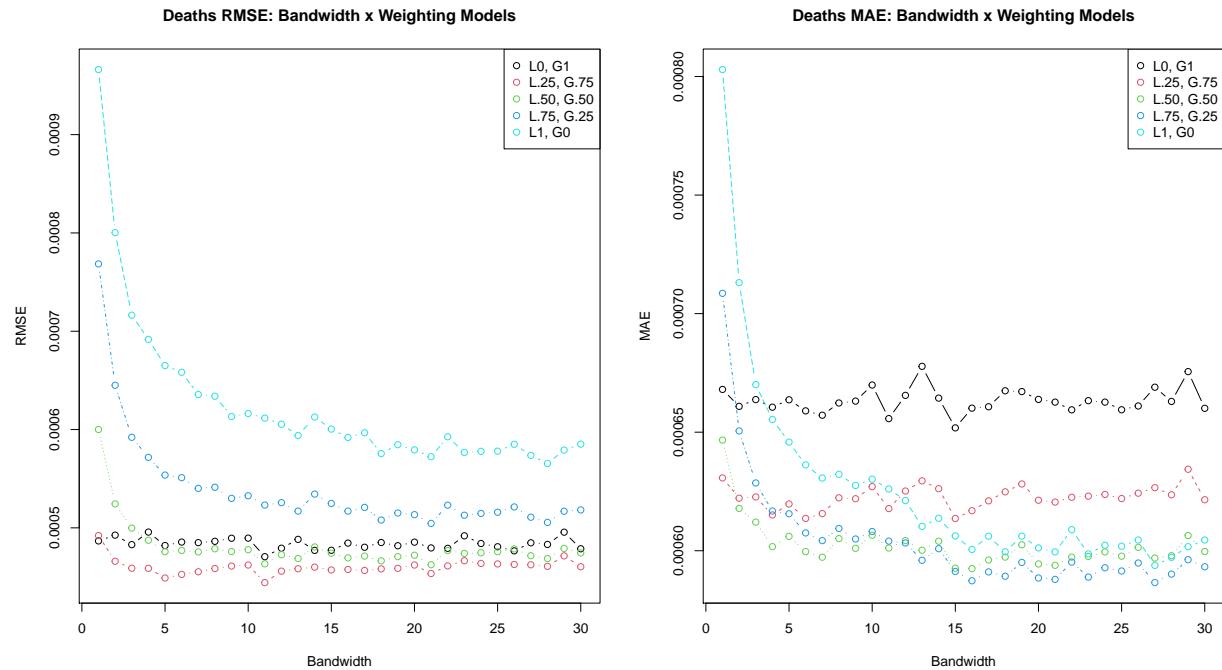
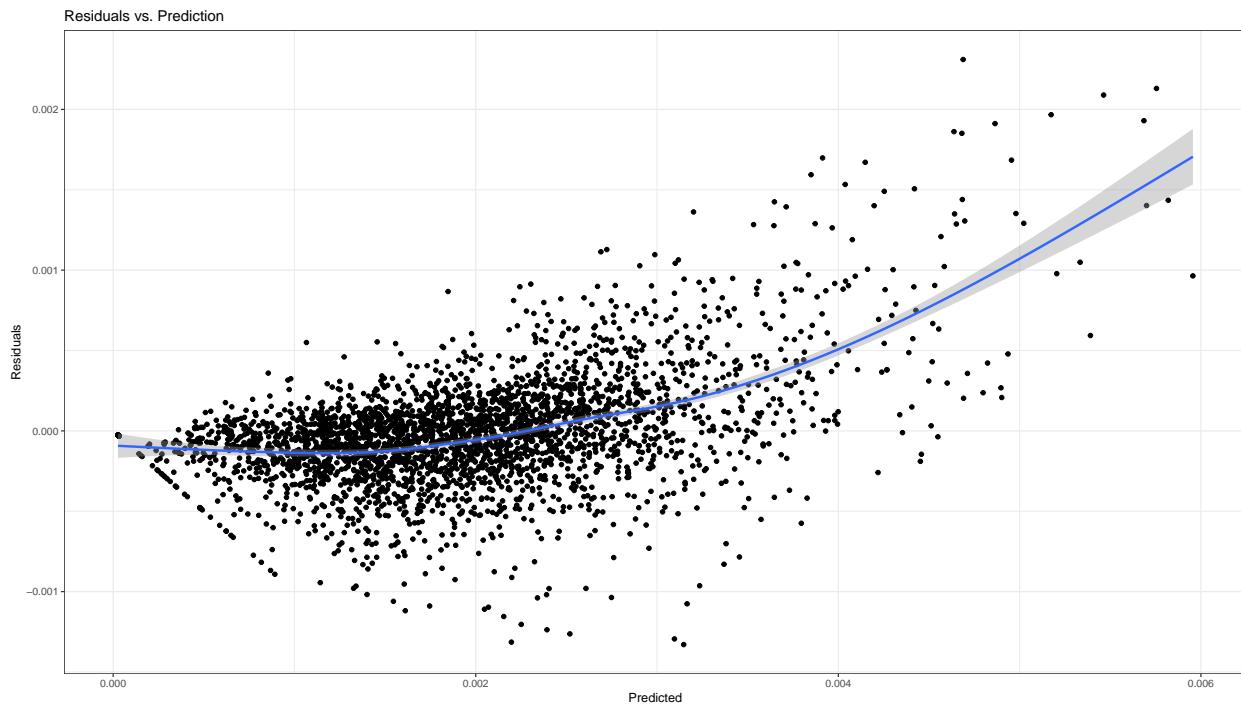


Figure S43: GWRF Alpha Wave: Residuals vs. Predicted



```
##  
## Pearson's product-moment correlation  
##  
## data: risk_final5@data$deaths_adjusted and risk_final5@data$LM_ResPred  
## t = 54.605, df = 3152, p-value < 0.0000000000000022  
## alternative hypothesis: true correlation is not equal to 0  
## 95 percent confidence interval:  
## 0.6788410 0.7147329  
## sample estimates:  
## cor  
## 0.6972236
```

Figure S44: GWRF Alpha Wave: Model Prediction Results

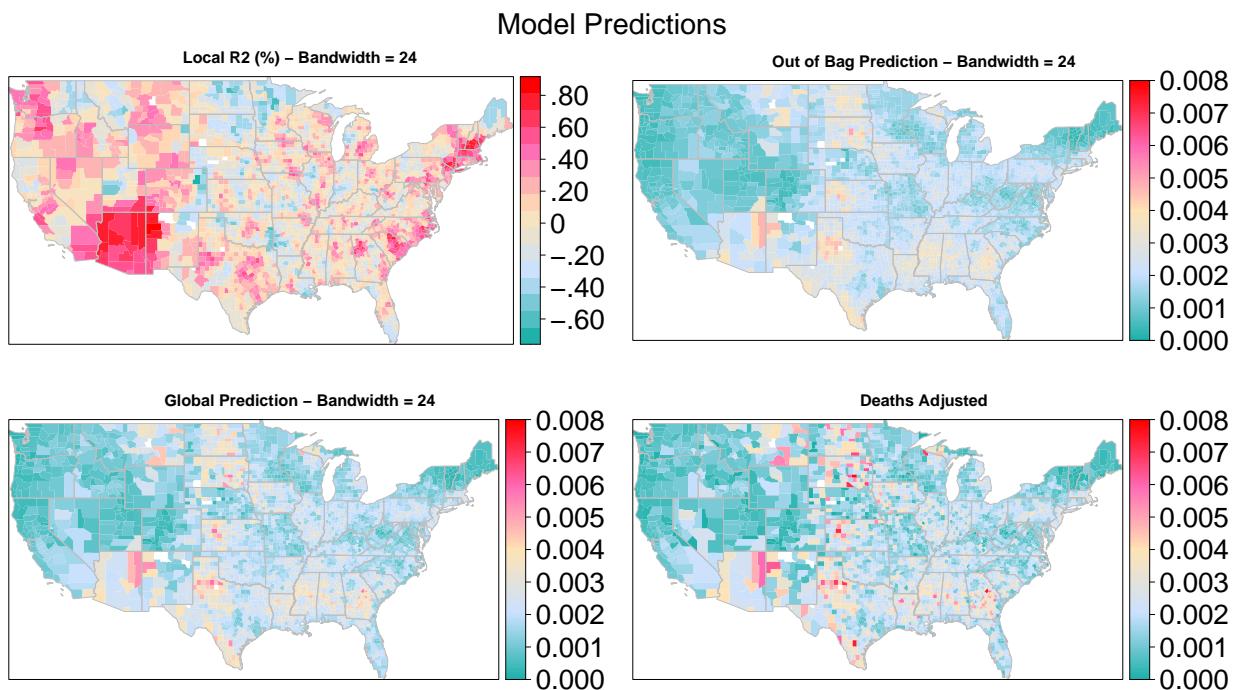
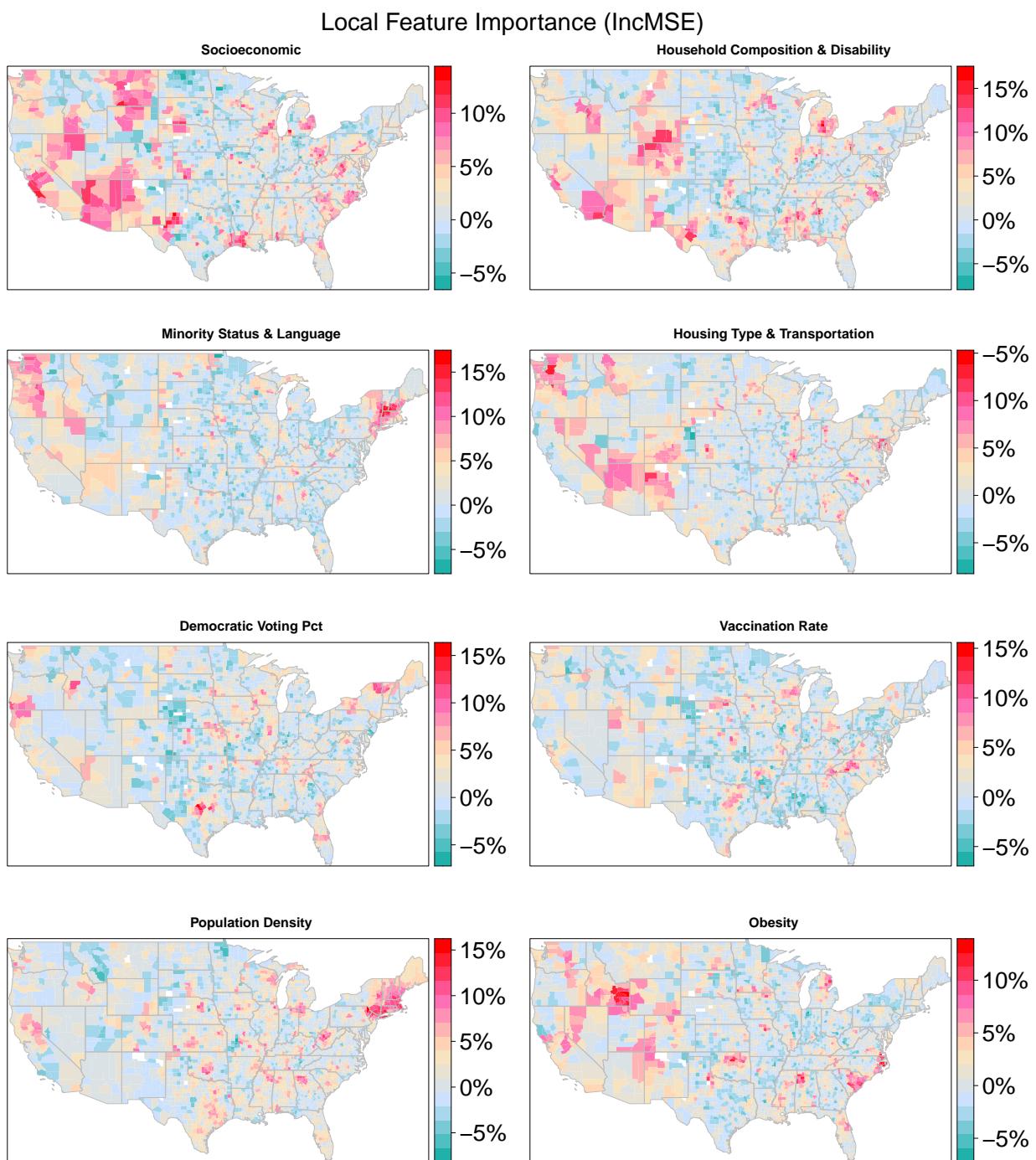


Figure S45: GWRF Alpha Wave: Feature Importance



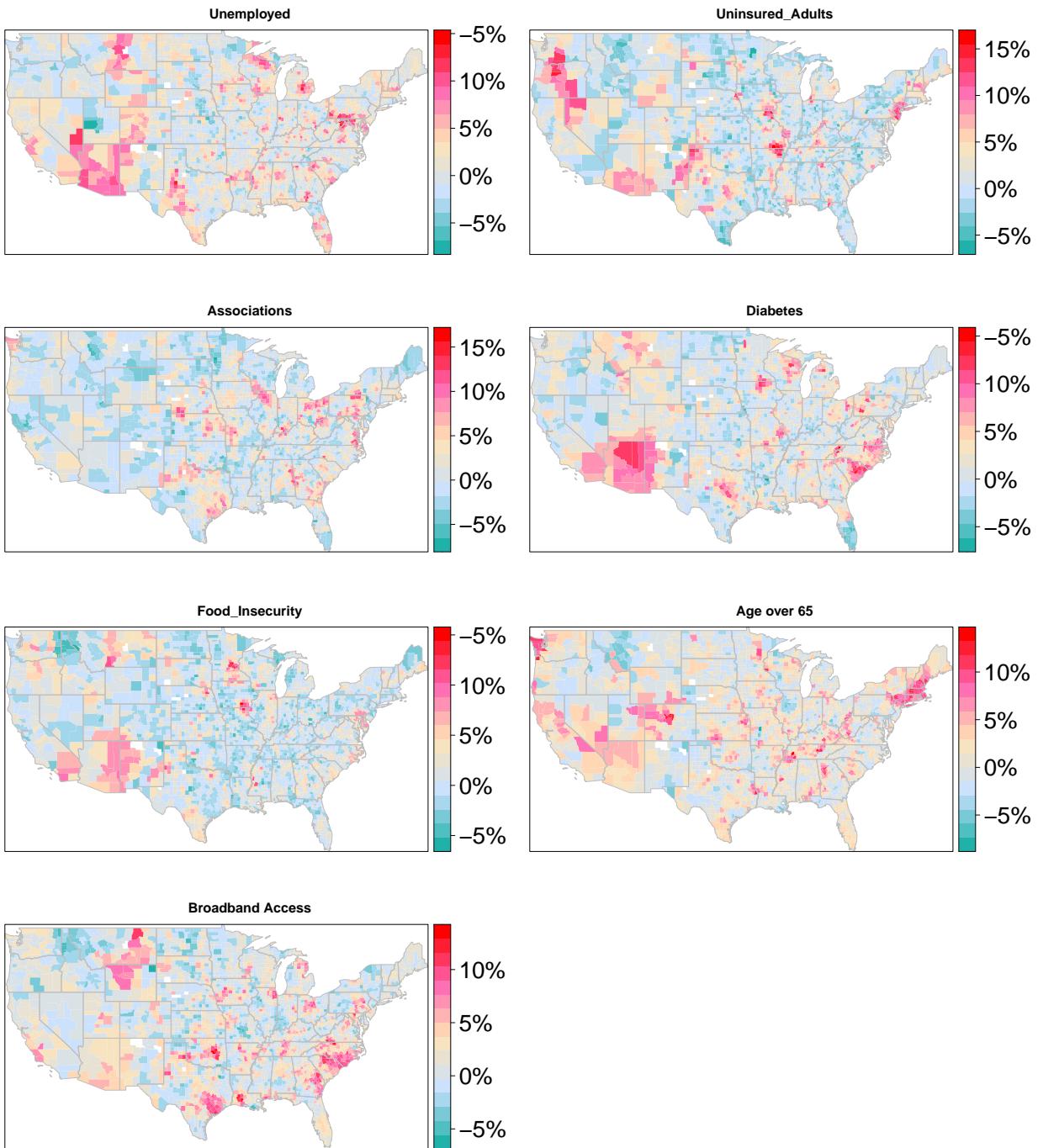


Table S16: GWRF Alpha Wave OOB vs. Global R2

Out of Bag R2	Global R2
0.4037901	0.8949985

Part 5: Geographically Weighted Random Forest Modeling: Delta Wave

Figure S46: GWRF Delta Wave: Model Weighting

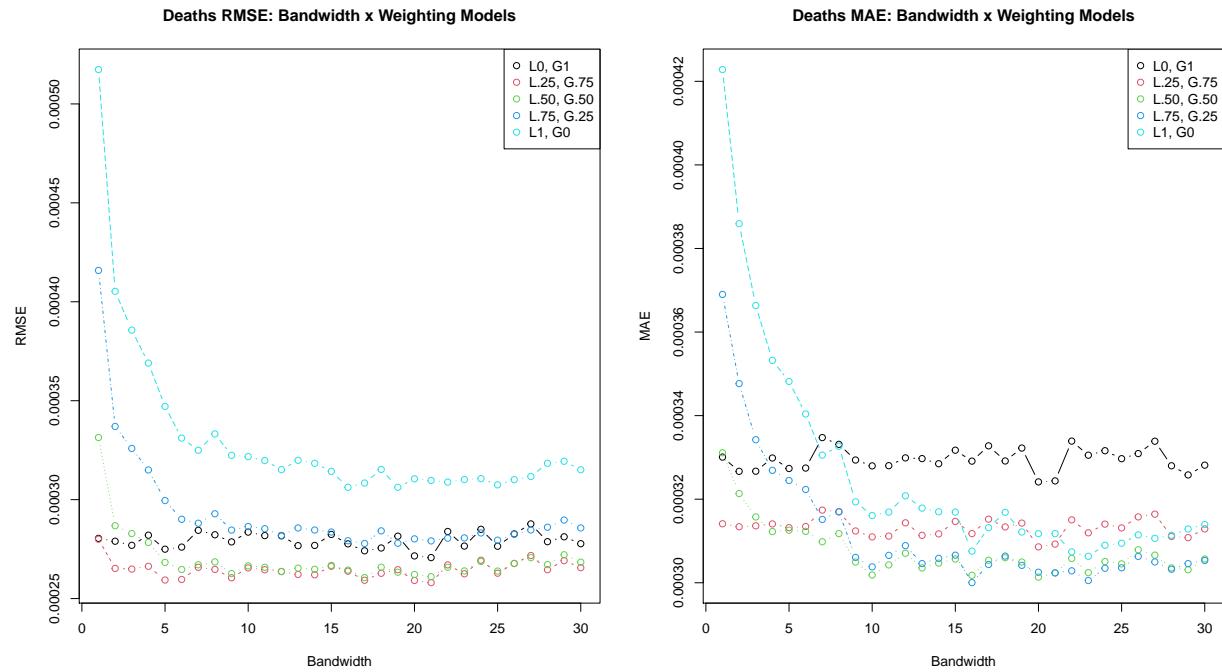
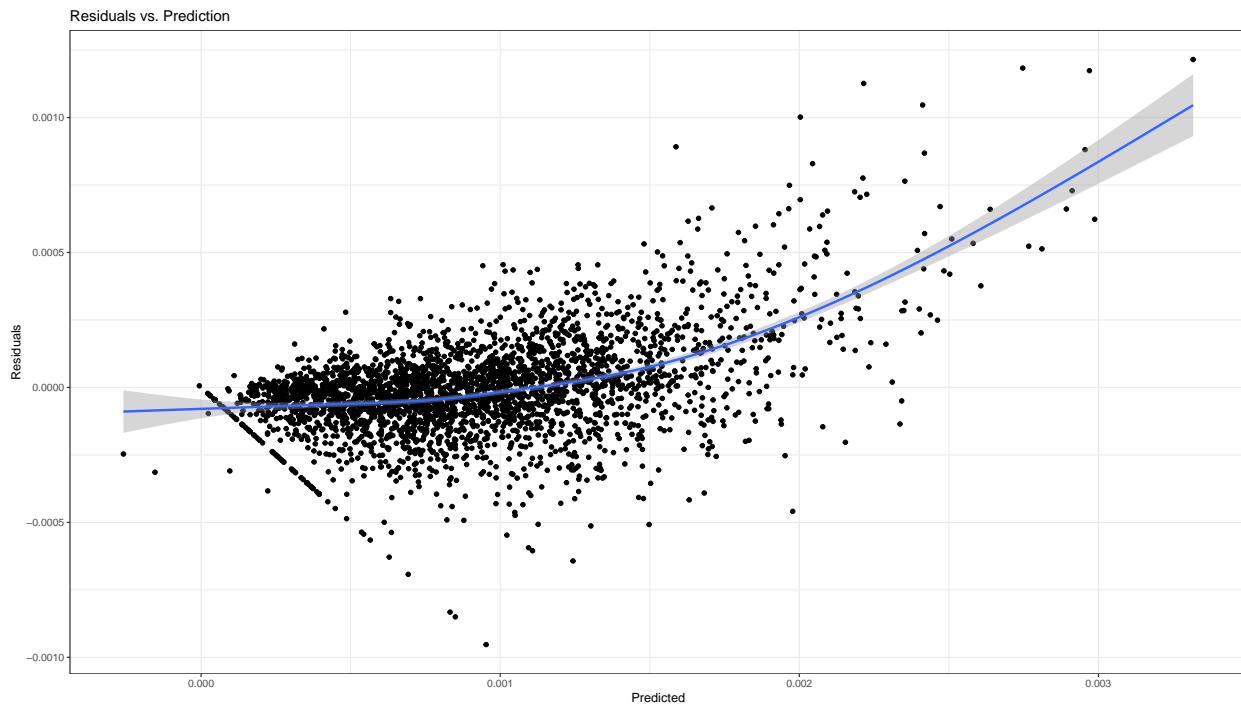


Figure S47: GWRF Delta Wave: Residuals vs. Predicted



```
##  
## Pearson's product-moment correlation  
##  
## data: risk_final5@data$deaths_adjusted and risk_final5@data$LM_ResPred  
## t = 53.402, df = 3152, p-value < 0.0000000000000022  
## alternative hypothesis: true correlation is not equal to 0  
## 95 percent confidence interval:  
## 0.6704279 0.7070959  
## sample estimates:  
## cor  
## 0.6892029
```

Figure S48: GWRF Delta Wave: Model Prediction Results

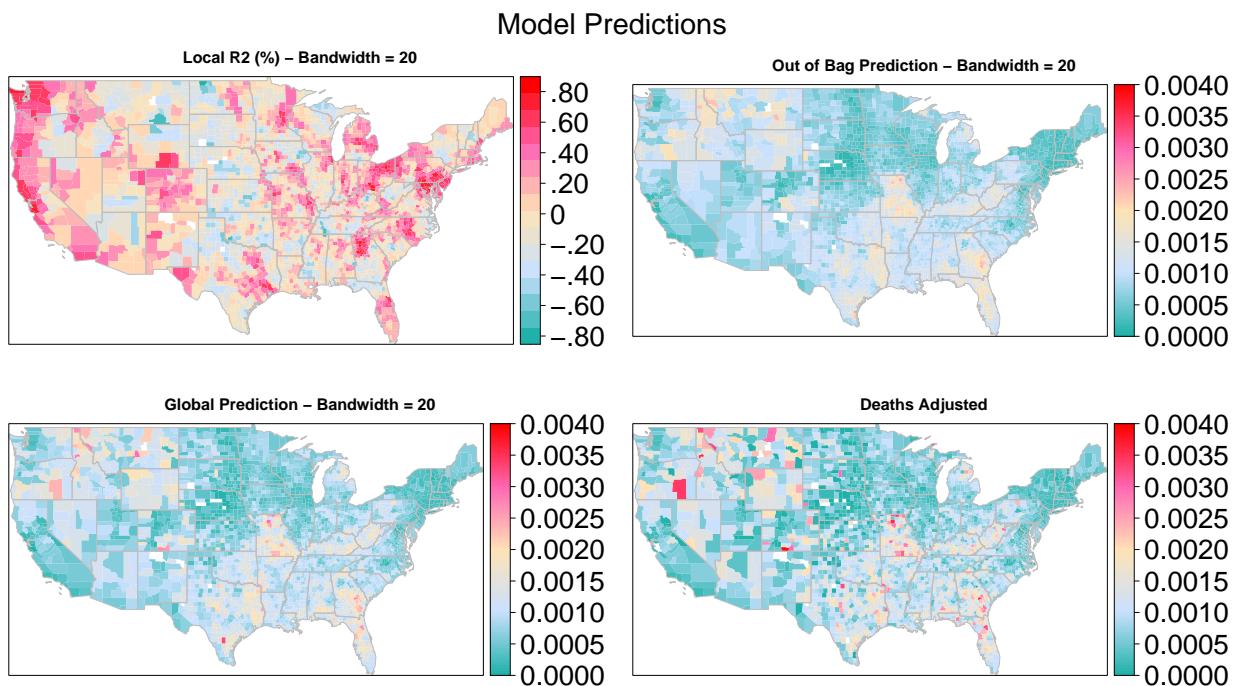
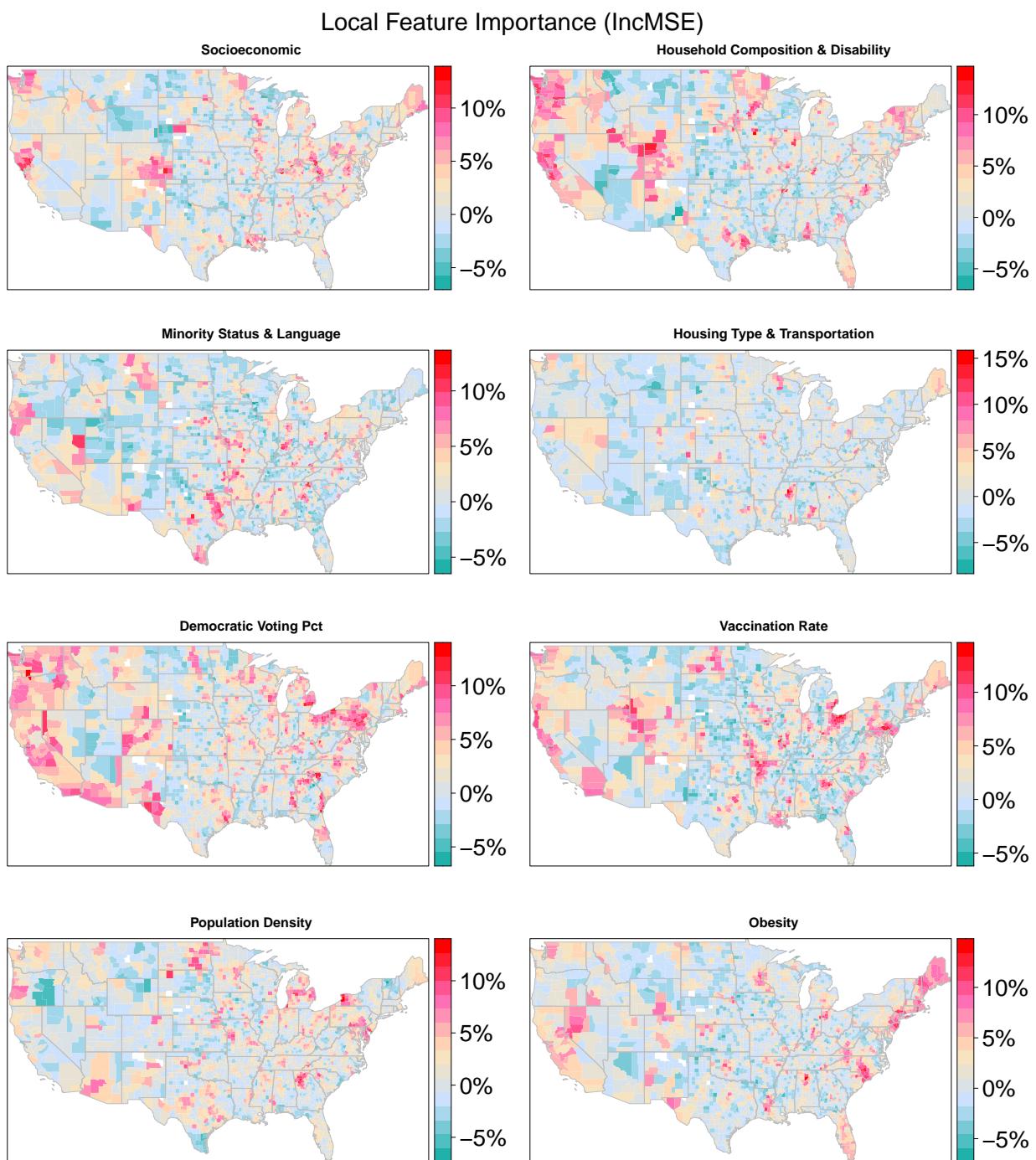


Figure S49: GWRF Delta Wave: Model Feature Importance



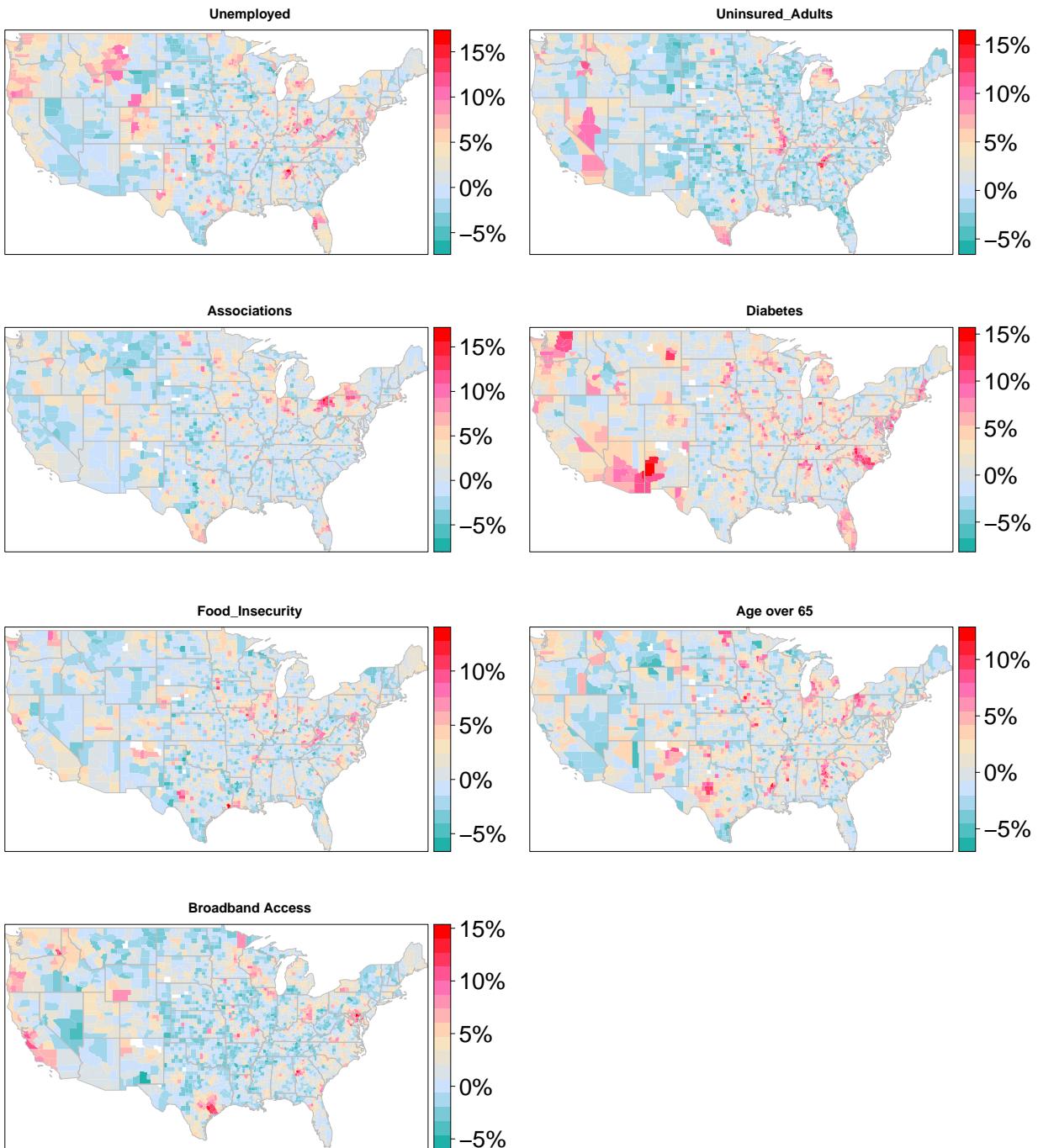


Table S17: GWRF Delta Wave: OOB vs Global R2

Out of Bag R2	Global R2
0.4452838	0.9023839

Part 5: Geographically Weighted Random Forest Modeling: Omicron Wave

Figure S50: GWRF Omicron Wave: Model Weighting

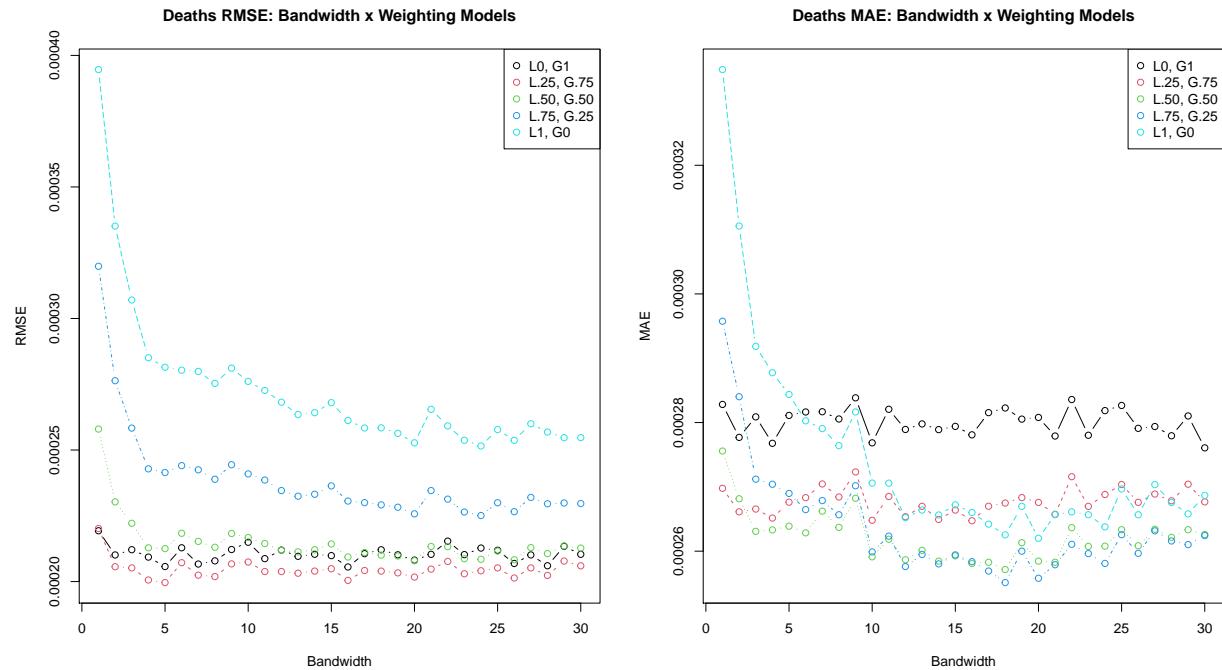
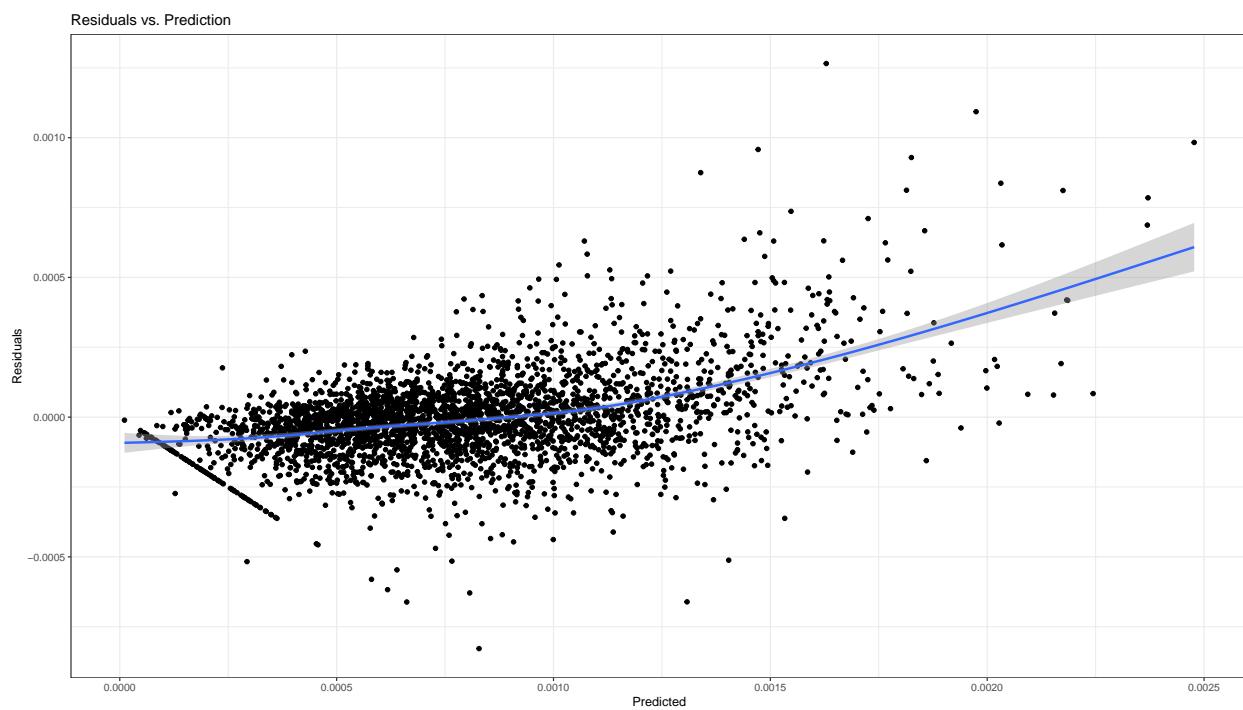


Figure S51: GWRF Omicron Wave: Residuals vs. Predicted



```
##  
## Pearson's product-moment correlation  
##  
## data: risk_final5@data$deaths_adjusted and risk_final5@data$LM_ResPred  
## t = 54.688, df = 3152, p-value < 0.0000000000000022  
## alternative hypothesis: true correlation is not equal to 0  
## 95 percent confidence interval:  
## 0.6794105 0.7152495  
## sample estimates:  
## cor  
## 0.6977664
```

Figure S52: GWRF Omicron Wave: Model Prediction Results

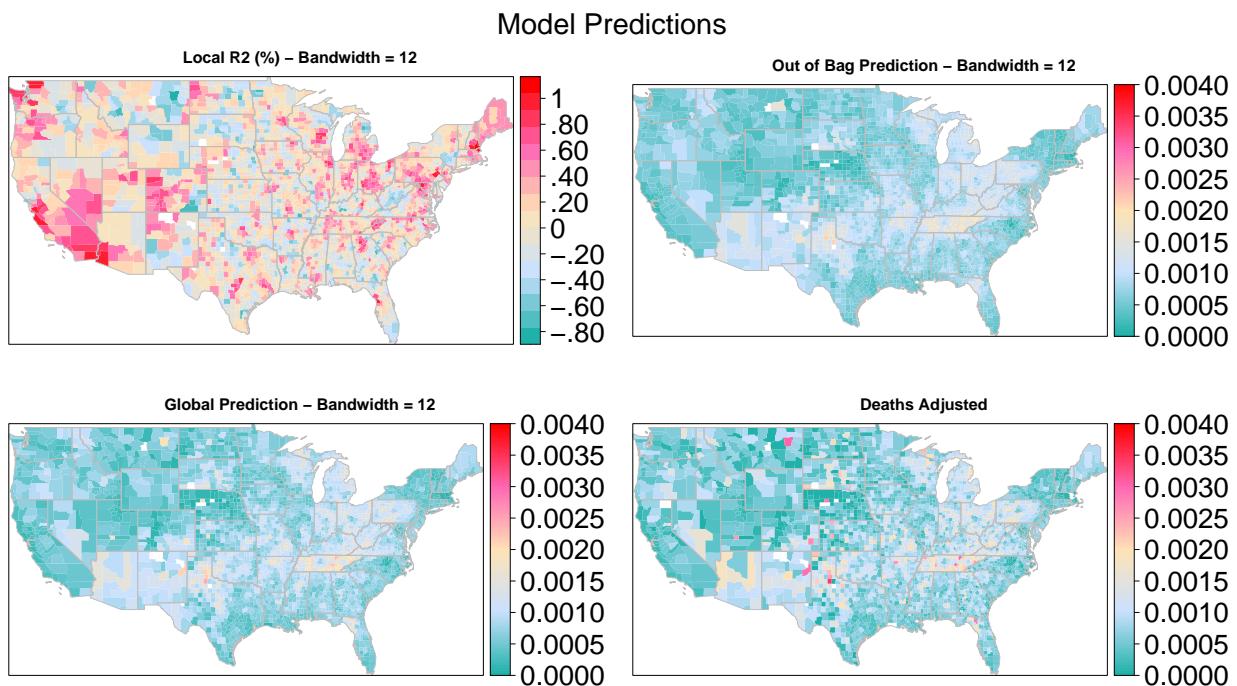
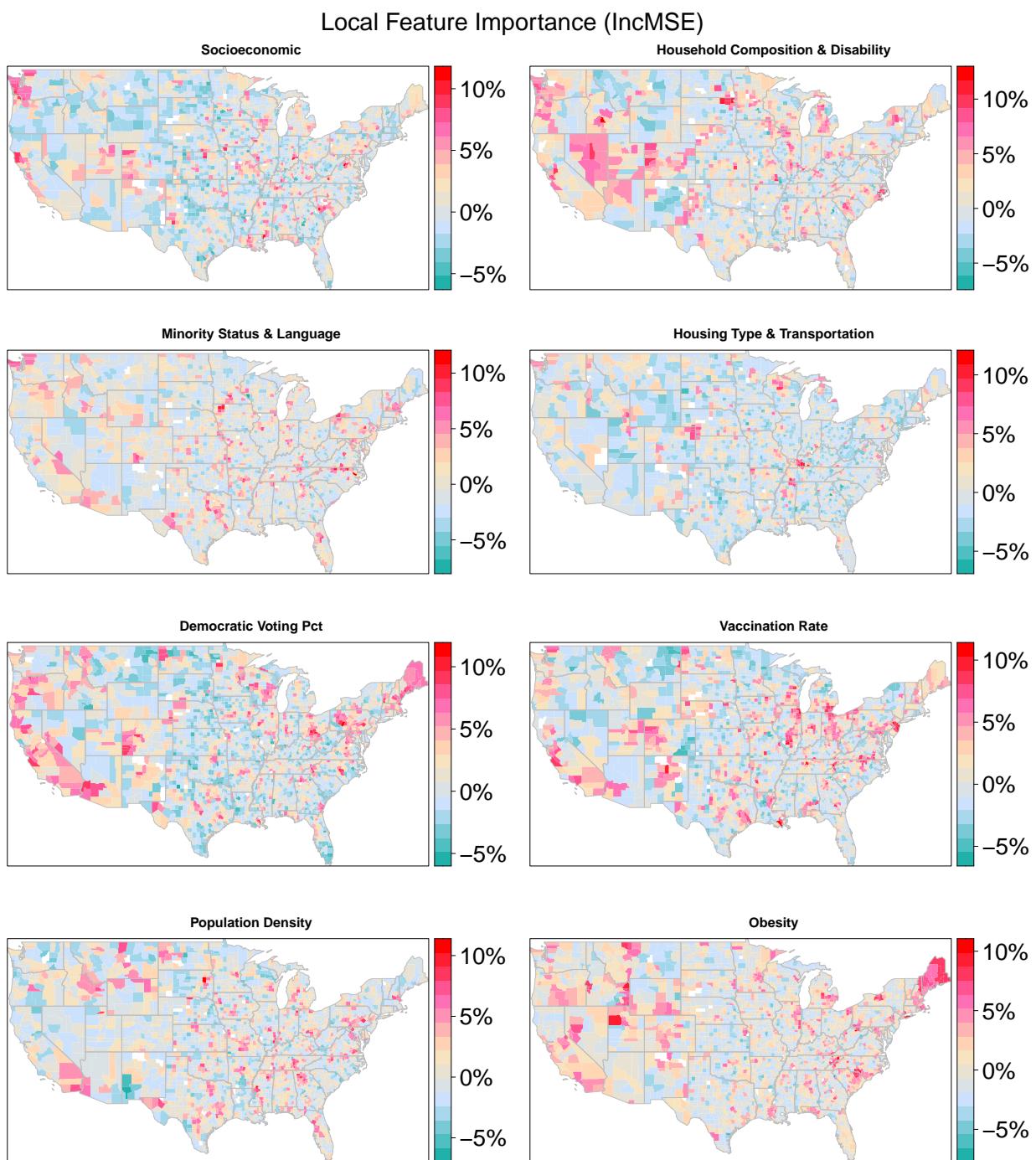


Figure S53: GWRF Omicron Wave: Model Feature Importance



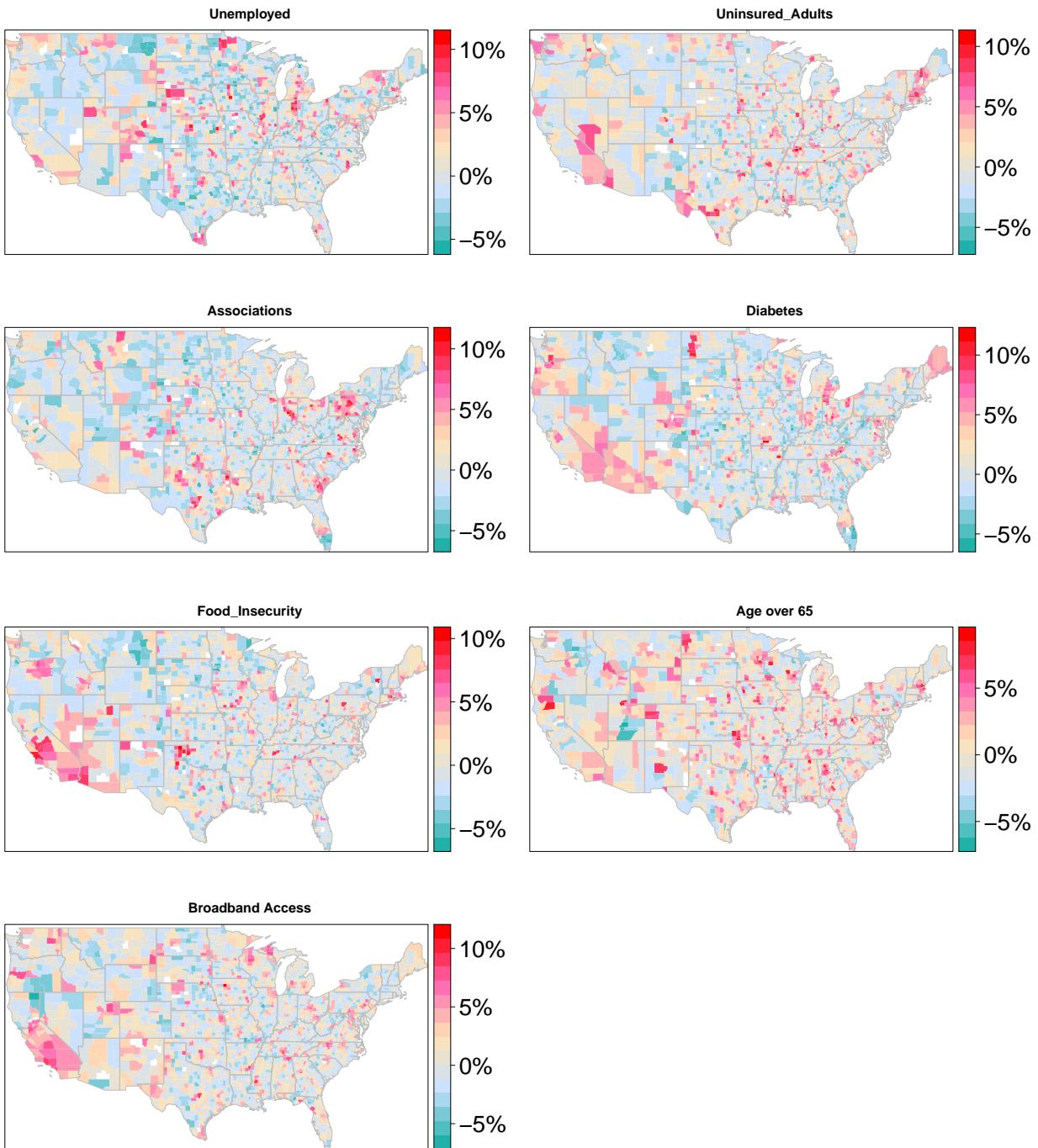


Table S18: GWRF Omicron Wave: OOB vs Global R2

Out of Bag R2	Global R2
0.3424833	0.8803354