INTRODUCTION

Excess deaths are the deaths occurring above and beyond the expected number of deaths for an area during the same time frame, in this case, in the absence of the COVID-19 pandemic (U.S. Centers for Disease Control and Prevention, 2021). In one estimate of excess deaths, Ackley et al. (2021) discovered that the proportion of excess deaths associated with COVID-19 was higher in counties in the Midwest and Northeast of the United States vs. the South and West. What accounts for these regional differences? For one, communities were possibly impacted on different scales by state and/or county policies, hospital capacity, differential access to healthcare, and more (Stokes et al., 2021). Thus it's important to elucidate the role of these contextual factors in impacting excess deaths across the United States.

I aim to understand which variables describing community characteristics (infrastructure, health care system, the built environment-related), along with location, serve as explanatory variables for excess COVID-19 deaths through multilevel modeling. One model will analyze the variables at the county and state level; the second model will analyze the variables at the county and metropolitan statistical area (MSA) level.

BACKGROUND

Considering the underreporting of COVID-19 cases in the early stages of the pandemic (Weinberger et al., 2020; Woolf, Chapman, Sabo, Weinberger, & Hill, 2020; Woolf, Chapman, Sabo, Weinberger, Hill, et al., 2020), excess deaths directly and indirectly associated with COVID-19 are more likely better able to capture the true magnitude of the early pandemic. For example, in an analysis of excess deaths from March-July 2020, only 67% of deaths were officially documented to be due to COVID-19 (Woolf, Chapman, Sabo, Weinberger, Hill, et al., 2020).

Researchers have also aimed to characterize the spatial distribution of excess deaths. From March-July 2020, according to one study, the following states had the highest per capita excess death rates: “New York, New Jersey, Massachusetts, Louisiana, Arizona, Mississippi, Maryland, Delaware, Rhode Island, and Michigan” (Woolf, Chapman, Sabo, Weinberger, Hill, et al., 2020). Researchers have also discovered that in the Southern and Western regions of the United States, there were less excess deaths directly attributed to COVID-19 compared to the excess deaths not directly assigned to COVID-19 (Stokes et al., 2021). Furthermore, counties with a greater prevalence of comorbidities and lower SES reported less excess deaths directly attributed to COVID-19 (Stokes et al., 2021). With these demographic and regional factors causing the COVID-19 pandemic to play out across localities differently, understanding any patterns is important for managing disease risk.

DATA SOURCES

The three primary data sources were the 2021 County Health Rankings, COVID-19 Excess Deaths dataset, and Google Street View images. The 2021 County Health Rankings “measures the health” of counties in the United States and ranks them in comparison to other counties in the same state (University of Wisconsin Population Health Institute, n.d.). The dataset captures various community health indicators. With 3194 observations, the 2021 County Health Rankings draws upon the 2015-2019 American Community Survey, 2018 Small Area Health Insurance Estimates, and 2018 Area Health Resource Files. The Google Street View dataset captures built environment characteristics of a county such as the proportion of greenery and sidewalks. With 2980 observations, these data were constructed by Nguyen et al. (2019) by processing Google Street View images. The Excess Deaths dataset was constructed by Rahman and Panozzo (2020) from the University of Toledo for the time period of February 1st, 2020-October 17th, 2020. With 485 observations, the dataset was constructed by creating county-level estimates of excess deaths by drawing from CDC National Center for Health Statistics' Provisional Mortality Data and Provisional COVID-19 Death Counts by Week for 2012-2018. One limitation is that in counties with less than 10 cases, the numbers are suppressed and reported as zero. Thus, there are significantly less observations in the Excess Deaths dataset when compared with the other two datasets (Figure 1).

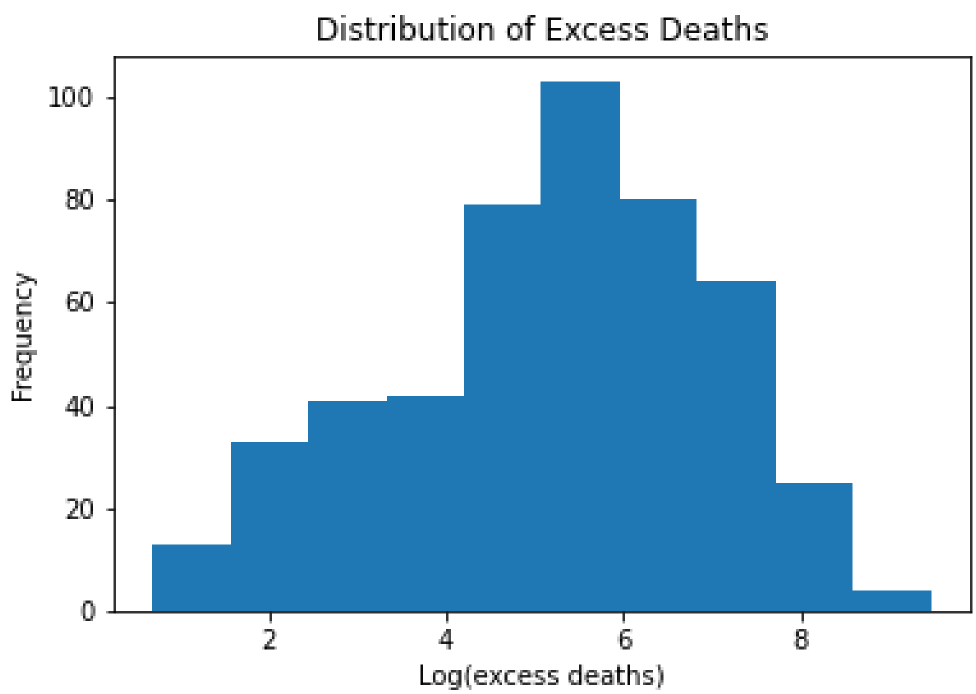

Figure 1. Distribution of the Log of Excess Death Counts.

METHODS

Methods Employed

Multilevel models take into account the nested nature of data within levels (Python for Data Science, LLC, n.d.). For the first model created, the first level is county and the second level is the state. Considering that using different boundaries for aggregation produces different results due to MAUP (Openshaw & Taylor, 1979; Symanzik, 2014), a second model was also created to compare the results with the first model. In the second model, the first level is county, and the second level is MSA. Other studies have also utilized hierarchical models in studying COVID-19 excess deaths (Woolf, Chapman, Sabo, Weinberger, Hill, et al., 2020).

Specifically within multilevel models, fixed effects were utilized. Fixed effects allow one to control for "unobserved effects" introduced by a certain geographic unit or boundary (Rey et al., 2020). In this case, it is assumed that the location (state and MSA) has an effect on excess deaths (especially policy-wise) and is of interest to capture.

Process

After joining the datasets and cleaning the data, variables that had variance inflation factors (VIF) below five (Figure 2) and Pearson's correlation coefficients below 0.60 were selected (Figure 3).

	Variable	VIF
3	mental_hlth	2.368950
4	HIV_prev	2.514517
0	prop_crosswalk	3.012217
2	uninsured_adults	3.242040
1	prop_not_single_family_house	3.628056

Figure 2. Variance Inflation Factors

	excess_deaths	prop_crosswalk	prop_not_single_family_house	uninsured_adults	mental_hlth	HIV_prev
excess_deaths	1.000000	0.572983	0.147826	-0.027634	0.244150	0.354098
prop_crosswalk	0.572983	1.000000	0.430949	-0.196280	0.423093	0.314401
prop_not_single_family_house	0.147826	0.430949	1.000000	-0.161230	0.182435	-0.040716
uninsured_adults	-0.027634	-0.196280	-0.161230	1.000000	-0.329927	0.260106
mental_hlth	0.244150	0.423093	0.182435	-0.329927	1.000000	0.135605
HIV_prev	0.354098	0.314401	-0.040716	0.260106	0.135605	1.000000

Figure 3. Pearson's Correlation Coefficients For Selected Variables

Resultantly, the final selected variables were: percent of adults without health insurance, percent of mental health providers in a county, rate of HIV cases per 100,000 people, proportion of Google Street View images that were composed of crosswalks, and proportion of Google Street View images that were not composed of single family houses.

Based on the distribution of the data, a Poisson regression was utilized. For the county/state model, to include the effects of state location, the state variable was included as a dummy variable in the regression. Similarly, for the county/MSA model, the MSA variable was included as a dummy variable in the regression.

RESULTS

For the county/state model, the state coefficients are shown in Figure 4. Specific coefficient values are listed in Appendix A.

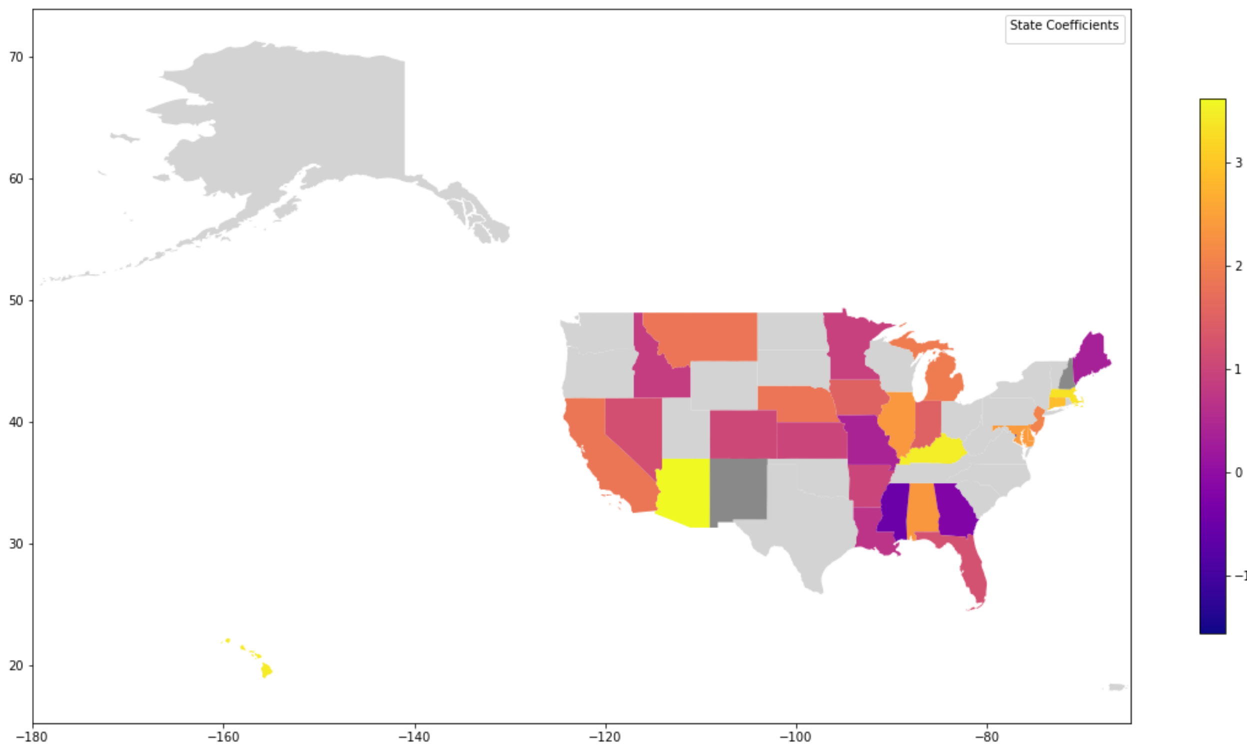

Figure 4. Multilevel Model State-Associated Coefficient Values. States in light grey have no available excess deaths data, and states in dark grey had coefficients that were not significant. Coefficients shown in color are all significant.

Of the states with excess deaths data, all states (except New Mexico and New Hampshire) had significant coefficients. All states had positive coefficients (and thus increased log of excess death counts) when compared to Alabama, with the exception of Mississippi, Georgia, and Washington DC. For example, when controlling for the proportion of crosswalk, uninsured adults, and the other predictor variables, the log of excess deaths is 0.2216 lower in Georgia than Alabama (Appendix A). In terms of spatial patterning of the coefficient distribution across the states, many of the mid-western states have coefficients ranging somewhere between 1-2.5. Some of the Mid-Atlantic/North Eastern states on the coast also have positive coefficients on the higher end of the scale. The states with the highest positive coefficients in comparison to Alabama were Arizona, Hawaii, Kentucky, and Massachusetts.

For the County/MSA Model, the MSA coefficients are shown in Figure 5. Specific coefficient values are listed in Appendix B.

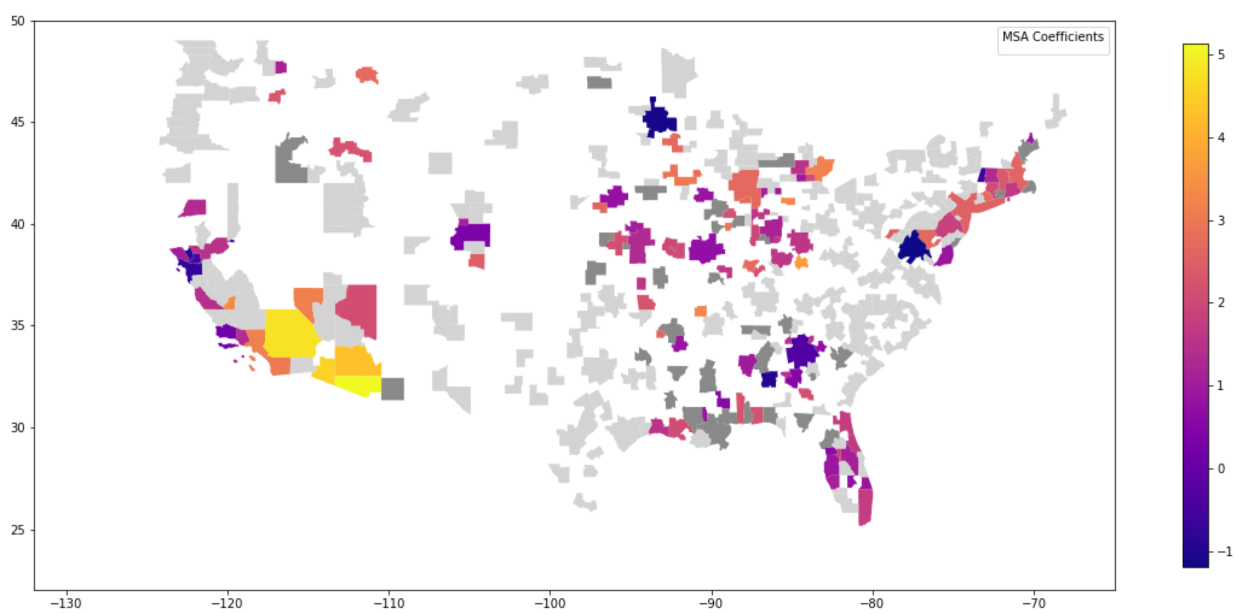

Figure 5. MSA Coefficients for the Contiguous USA. MSAs in light grey have no available excess deaths data, and MSAs in dark grey had coefficients that were not significant. Coefficients shown in color are all significant. Appendix C includes all MSAs, including those in Hawaii and Alaska.

Of the MSAs with excess deaths data, most MSAs had significant coefficients. The coefficient range in the state model is from about -1.5 to 3.5 (Figure 4), whereas for the MSA model the range is about -1 to 5 (Figure 5). In terms of spatial clustering, there are groups of MSAs in the Southwest, Mid-Atlantic, and North Eastern region that all have high, positive coefficients; whereas MSAs in the South generally have coefficients on the lower end of the scale, somewhere around -1 to 1.5. Specifically, MSAs with the highest positive coefficients in comparison to Albany, GA were Yuma, AZ; Tucson, AZ; Phoenix-Mesa-Chandler, AZ; and Riverside-San Bernardino-Ontario, CA.

With regards to the non-state variables, all variables were significant across both models (Table 1).

Table 1. Mixed Model Output for Non-State Independent Variables.

	Variable	coef	std err	z	P>|z|	[0.025	0.975]
County/ state model	**Prop crosswalk**	68.7239	0.259	265.367	0.000	68.216	69.231
	Prop not single family houses	-6.3300	0.036	-173.868	0.000	-6.401	-6.259
	Uninsured adults	12.7812	0.087	146.452	0.000	12.610	12.952
	Mental health providers	-44.7222	2.622	-17.057	0.000	-49.861	-39.58 3
	HIV prev	0.0007	1.57e-05	46.466	0.000	0.001	0.001
	Prop crosswalk	60.6365	0.503	120.459	0.000	59.650	61.623
	Prop not single	-7.3584	0.072	-101.742	0.000	-7.500	-7.217

	family houses						
County/ MSA model	**Uninsured adults**	13.4363	0.250	53.640	0.000	12.945	13.927
	Mental health providers	228.2574	5.268	43.329	0.000	217.932	238.583
	HIV prev	0.0009	2.18e-05	39.814	0.000	0.001	0.00

For the proportion of crosswalk, proportion of not single family houses, percentage of uninsured adults, and HIV prevalence variables, the coefficients remained similar in value and sign across both models. However, the coefficients for percentage of mental health providers were quite different for the two models: -44.7222 for the state model and 228.2574 for the MSA model.

DISCUSSION

With regards to the effects of states on excess deaths, the results are mostly in line with the spatial distribution noted by Ackley et al. (2020) and Woolf, Chapman, Sabo, Weinberger, Hill, et al. (2020). However, there are some differences when looking at the MSA level. In one study, the MSAs with the highest number of COVID-19 deaths from March-May 2020 were the ones associated with New York, “Detroit, Boston, Chicago, Philadelphia, Los Angeles, Washington DC, and New Orleans” (Zhang & Schwartz, 2020). While Zhang and Schwartz’s study was not looking at excess deaths, interesting to note is that MSAs in Arizona and California produced the largest impact on the log of excess deaths in this analysis. However, the COVID-19 data utilized measured excess deaths from February-October 2020. The discrepancy can be explained by the fact that the spatial pattern of COVID-19’s spread in the United States rapidly changed in the early phase of the pandemic, contributing to one area having high death rates during one time period and then another area having high death rates during another time period.

In terms of the other predictors, an increase in the proportion of crosswalks leads to an increase in the log of excess deaths. Considering that the proportion of crosswalks is a measure for the walkability of an area and thus an indicator of the infrastructure in an area, areas with a higher proportion of crosswalks are more likely to be developed suburban and/or urban areas. The relationship is in line with the fact that the early pandemic primarily impacted cities (Zhang & Schwartz, 2020), leading to higher COVID-19 deaths.

For HIV prevalence rates, people with comorbidities are at a greater risk of facing severe effects from COVID-19 infection (Ejaz et al., 2020). Thus, counties with greater HIV rates are likely to experience a greater burden from the COVID-19 pandemic. Similarly, people who are uninsured are less likely to seek health treatment and experience comorbidities, consequently also being greatly impacted by the pandemic.

For the proportion of areas not composed of single family houses and mental health providers, it is not clear what the underlying relationship is between these indicators and excess deaths.

LIMITATIONS

A multilevel model assumes that the coefficient estimates for non-location variables are the same across the study area, with the location variable adding the impact of location to customize the formula that calculates the log of excess deaths. However, the relationship between the predictors and excess deaths are likely to vary by location.

Another limitation is that multilevel models assume that the data points listed in level one are independent from each other. This means that counties that share a boundary are assumed to be independent (Dong et al., 2015). However, there still may be unaccounted spatial autocorrelation because adjacent counties can be impacted by each other's COVID-19 policies.

CONCLUSION

While the state multilevel model proved useful in potentially understanding broad regional trends, the MSA multilevel model demonstrates how locally, aspects of the pandemic may have rapidly changed in the early stages of the pandemic. Additional work is needed to elucidate relationships between certain predictors and excess deaths and to identify why certain states had specific effects on the log of excess deaths, along with potential policies of interest. Ultimately though, understanding historic disease distribution patterns will ideally allow for the improved and proactive management of disease spread.

REFERENCES

Ackley, C. A., Lundberg, D. J., Ma, L., Elo, I. T., Preston, S. H., & Stokes, A. C. (2021). *County-Level Estimates of Excess Mortality Associated with COVID-19 in the United States*. https://doi.org/10.1101/2021.04.23.21255564

Dong, G., Harris, R., Jones, K., & Yu, J. (2015). Multilevel Modelling with Spatial Interaction Effects with Application to an Emerging Land Market in Beijing, China. *PLOS ONE*, *10*(6), e0130761. https://doi.org/10.1371/journal.pone.0130761

Ejaz, H., Alsrhani, A., Zafar, A., Javed, H., Junaid, K., Abdalla, A. E., Abosalif, K. O. A., Ahmed, Z., & Younas, S. (2020). COVID-19 and comorbidities: Deleterious impact on infected patients. *Journal of Infection and Public Health*. https://doi.org/10.1016/j.jiph.2020.07.014

Nguyen, Q. C., Khanna, S., Dwivedi, P., Huang, D., Huang, Y., Tasdizen, T., Brunisholz, K. D., Li, F., Gorman, W., Nguyen, T. T., & Jiang, C. (2019). Google Street View Features by County [Data file].

Openshaw, S., & Taylor, P. J. (1979). A million or so correlation coefficients : three experiments on the modifiable areal unit problem. In N. Wrigley (Ed.), *Statistical Applications in the Spatial Sciences* (pp. 127–144). Pion Limited.

Python for Data Science, LLC. (n.d.). *Mixed Effect Regression*. Www.pythonfordatascience.org; Python for Data Science, LLC. Retrieved December 15, 2021, from https://www.pythonfordatascience.org/mixed-effects-regression-python/

Rahman, Md. Ishfaq Ur., Panozzo, Kimberly A. (2020). Excess Deaths by County [Data file].

Rey, S. J., Arribas-Bel, D., & Wolf, L. J. (2020). Geographic Data Science with Python. In *geographicdata.science*. https://geographicdata.science/book/notebooks/11_regression.html

Stokes, A. C., Lundberg, D. J., Elo, I. T., Hempstead, K., Bor, J., & Preston, S. H. (2021). COVID-19 and excess mortality in the United States: A county-level analysis. *PLOS Medicine*, *18*(5), e1003571. https://doi.org/10.1371/journal.pmed.1003571

Symanzik, J. (2014). Exploratory Spatial Data Analysis. In M. M. Fischer & P. Nijkamp (Eds.), *Handbook of Regional Science* (pp. 1295–1310). Springer, Cop.

University of Wisconsin Population Health Institute. (n.d.). *Explore Health Rankings | Our Methods*. County Health Rankings & Roadmaps; University of Wisconsin Population Health Institute. https://www.countyhealthrankings.org/explore-health-rankings/our-methods

U.S. Centers for Disease Control and Prevention. (2021, October 13). Excess Deaths Associated with COVID-19. Centers for Disease Control and Prevention; U.S. Department of Health & Human Services. https://www.cdc.gov/nchs/nvss/vsrr/covid19/excess_deaths.htm

Weinberger, D. M., Chen, J., Cohen, T., Crawford, F. W., Mostashari, F., Olson, D., Pitzer, V. E., Reich, N. G., Russi, M., Simonsen, L., Watkins, A., & Viboud, C. (2020). Estimation of Excess Deaths Associated With the COVID-19 Pandemic in the United States, March to May 2020. *JAMA Internal Medicine*. https://doi.org/10.1001/jamainternmed.2020.3391

Woolf, S. H., Chapman, D. A., Sabo, R. T., Weinberger, D. M., & Hill, L. (2020). Excess Deaths From COVID-19 and Other Causes, March-April 2020. *JAMA*. https://doi.org/10.1001/jama.2020.11787

Woolf, S. H., Chapman, D. A., Sabo, R. T., Weinberger, D. M., Hill, L., & Taylor, D. D. H. (2020). Excess Deaths From COVID-19 and Other Causes, March-July 2020. *JAMA*, *324*(15), 1562. https://doi.org/10.1001/jama.2020.19545

Zhang, C. H., & Schwartz, G. G. (2020). Spatial Disparities in Coronavirus Incidence and Mortality in the United States: An Ecological Analysis as of May 2020. *The Journal of Rural Health*, *36*(3), 433–445. https://doi.org/10.1111/jrh.12476

APPENDICES

Appendix A. Results of Poisson Regression for County/State Multilevel Fixed Effects Model. The intercept represents Alabama.

Generalized Linear Model Regression Results

Dep. Variable:	excess_deaths	**No. Observations:**	547
Model:	GLM	**Df Residuals:**	511
Model Family:	Poisson	**Df Model:**	35
Link Function:	log	**Scale:**	1.0000
Method:	IRLS	**Log-Likelihood:**	-1.1459e+05
Date:	Mon, 13 Dec 2021	**Deviance:**	2.2771e+05
Time:	22:29:01	**Pearson chi2:**	3.19e+05
No. Iterations:	27		
Covariance Type:	nonrobust		

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	2.3481	0.026	90.326	0.000	2.297	2.399
C(state)[T.AR]	1.0079	0.029	34.427	0.000	0.951	1.065
C(state)[T.AZ]	3.6179	0.026	140.625	0.000	3.568	3.668
C(state)[T.CA]	1.8488	0.027	69.759	0.000	1.797	1.901
C(state)[T.CO]	1.0692	0.029	37.152	0.000	1.013	1.126
C(state)[T.CT]	2.8777	0.030	97.264	0.000	2.820	2.936
C(state)[T.DC]	-1.5575	0.037	-41.990	0.000	-1.630	-1.485
C(state)[T.DE]	2.4265	0.043	56.454	0.000	2.342	2.511
C(state)[T.FL]	1.1984	0.023	52.112	0.000	1.153	1.243
C(state)[T.GA]	-0.2216	0.025	-8.776	0.000	-0.271	-0.172
C(state)[T.HI]	3.4409	0.044	77.915	0.000	3.354	3.527
C(state)[T.IA]	1.5128	0.040	38.258	0.000	1.435	1.590
C(state)[T.ID]	0.8681	0.048	18.275	0.000	0.775	0.961
C(state)[T.IL]	2.3793	0.024	97.289	0.000	2.331	2.427
C(state)[T.IN]	1.4913	0.026	58.330	0.000	1.441	1.541
C(state)[T.KS]	1.0089	0.033	30.276	0.000	0.944	1.074
C(state)[T.KY]	3.4942	0.030	116.297	0.000	3.435	3.553
C(state)[T.LA]	0.6902	0.033	20.800	0.000	0.625	0.755
C(state)[T.MA]	3.3479	0.030	113.362	0.000	3.290	3.406
C(state)[T.MD]	2.4188	0.026	92.109	0.000	2.367	2.470
C(state)[T.ME]	0.3419	0.072	4.751	0.000	0.201	0.483
C(state)[T.MI]	1.9589	0.026	76.122	0.000	1.908	2.009
C(state)[T.MN]	0.9092	0.042	21.862	0.000	0.828	0.991
C(state)[T.MO]	0.3842	0.030	12.663	0.000	0.325	0.444
C(state)[T.MS]	-0.4940	0.032	-15.652	0.000	-0.556	-0.432
C(state)[T.MT]	1.8280	0.053	34.666	0.000	1.725	1.931
C(state)[T.NE]	1.8201	0.046	39.948	0.000	1.731	1.909
C(state)[T.NH]	-25.3099	1.88e+04	-0.001	0.999	-3.68e+04	3.68e+04
C(state)[T.NJ]	2.0593	0.026	78.494	0.000	2.008	2.111
C(state)[T.NM]	-22.7720	2.13e+04	-0.001	0.999	-4.18e+04	4.18e+04
C(state)[T.NV]	1.1792	0.030	39.670	0.000	1.121	1.238
prop_crosswalk	68.7239	0.259	265.367	0.000	68.216	69.231
prop_not_single_family_house	-6.3300	0.036	-173.868	0.000	-6.401	-6.259
uninsured_adults	12.7812	0.087	146.452	0.000	12.610	12.952
mental_hlth	-44.7222	2.622	-17.057	0.000	-49.861	-39.583
HIV_prev	0.0007	1.57e-05	46.466	0.000	0.001	0.001

Appendix B. Results of Poisson Regression for County/MSAMultilevel Fixed Effects Model. The intercept represents Albany, GA.

Generalized Linear Model Regression Results

Dep. Variable:	excess_deaths	**No. Observations:**	251
Model:	GLM	**Df Residuals:**	104
Model Family:	Poisson	**Df Model:**	146
Link Function:	log	**Scale:**	1.0000
Method:	IRLS	**Log-Likelihood:**	-22307.
Date:	Tue, 07 Dec 2021	**Deviance:**	43431.
Time:	23:45:51	**Pearson chi2:**	5.26e+04
No. Iterations:	30		
Covariance Type:	nonrobust		

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	2.1487	0.066	32.575	0.000	2.019	2.278
C(MSA_short)[T.Alexandria, LA]	-57.1772	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Ann Arbor, MI]	2.1427	0.065	33.005	0.000	2.015	2.270
C(MSA_short)[T.Athens-Clarke County, GA]	0.7921	0.059	13.530	0.000	0.677	0.907
C(MSA_short)[T.Atlanta-Sandy Springs-Alpharetta, GA]	-0.3293	0.049	-6.658	0.000	-0.426	-0.232
C(MSA_short)[T.Auburn-Opelika, AL]	1.4317	0.083	17.164	0.000	1.268	1.595
C(MSA_short)[T.Augusta-Richmond County, GA-SC]	-28.4967	6.66e+04	-0.000	1.000	-1.31e+05	1.3e+05
C(MSA_short)[T.Baltimore-Columbia-Towson, MD]	2.6840	0.058	46.238	0.000	2.570	2.798
C(MSA_short)[T.Barnstable Town, MA]	-0.2312	0.149	-1.556	0.120	-0.522	0.060
C(MSA_short)[T.Baton Rouge, LA]	-28.7028	6.43e+04	-0.000	1.000	-1.26e+05	1.26e+05
C(MSA_short)[T.Birmingham-Hoover, AL]	-28.0719	8.14e+04	-0.000	1.000	-1.6e+05	1.59e+05
C(MSA_short)[T.Bloomington, IL]	2.1864	0.104	20.954	0.000	1.982	2.391
C(MSA_short)[T.Bloomington, IN]	-28.0013	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Boise City, ID]	-26.9343	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Boston-Cambridge-Newton, MA-NH]	2.6281	0.072	36.519	0.000	2.487	2.769
C(MSA_short)[T.Boulder, CO]	1.1341	0.077	14.793	0.000	0.984	1.284
C(MSA_short)[T.Cape Girardeau, MO-IL]	-28.6128	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Carbondale-Marion, IL]	1.6253	0.091	17.813	0.000	1.446	1.804
C(MSA_short)[T.Carson City, NV]	-0.8239	0.080	-10.334	0.000	-0.980	-0.668
C(MSA_short)[T.Cedar Rapids, IA]	3.0230	0.077	39.455	0.000	2.873	3.173
C(MSA_short)[T.Champaign-Urbana, IL]	-25.8273	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Chattanooga, TN-GA]	-28.7771	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Chicago-Naperville-Elgin, IL-IN-WI]	2.6960	0.052	51.706	0.000	2.594	2.798
C(MSA_short)[T.Cincinnati, OH-KY-IN]	1.5817	0.084	18.814	0.000	1.417	1.746

C(MSA_short)[T.Coeur d'Alene, ID]	1.1656	0.083	14.110	0.000	1.004	1.328
C(MSA_short)[T.Columbia, MO]	2.0140	0.061	33.063	0.000	1.895	2.133
C(MSA_short)[T.Columbus, GA-AL]	0.5203	0.056	9.250	0.000	0.410	0.631
C(MSA_short)[T.Columbus, IN]	1.6323	0.086	19.033	0.000	1.464	1.800
C(MSA_short)[T.Crestview-Fort Walton Beach-Destin, FL]	-28.8647	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Cumberland, MD-WV]	2.4460	0.094	25.979	0.000	2.261	2.631
C(MSA_short)[T.Daphne-Fairhope-Foley, AL]	-28.7242	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Davenport-Moline-Rock Island, IA-IL]	0.8694	0.100	8.667	0.000	0.673	1.066
C(MSA_short)[T.Decatur, IL]	2.9599	0.091	32.477	0.000	2.781	3.139
C(MSA_short)[T.Deltona-Daytona Beach-Ormond Beach, FL]	1.7231	0.055	31.460	0.000	1.616	1.830
C(MSA_short)[T.Denver-Aurora-Lakewood, CO]	0.3755	0.057	6.565	0.000	0.263	0.488
C(MSA_short)[T.Des Moines-West Des Moines, IA]	-26.5474	6.68e+04	-0.000	1.000	-1.31e+05	1.31e+05
C(MSA_short)[T.Detroit-Warren-Dearborn, MI]	3.1835	0.056	56.831	0.000	3.074	3.293
C(MSA_short)[T.Dubuque, IA]	2.8574	0.101	28.231	0.000	2.659	3.056
C(MSA_short)[T.Elkhart-Goshen, IN]	0.9775	0.075	13.077	0.000	0.831	1.124
C(MSA_short)[T.Evansville, IN-KY]	2.7378	0.059	46.108	0.000	2.621	2.854
C(MSA_short)[T.Fargo, ND-MN]	-25.8817	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Fayetteville-Springdale-Rogers, AR]	2.2596	0.062	36.467	0.000	2.138	2.381
C(MSA_short)[T.Flagstaff, AZ]	2.1308	0.075	28.553	0.000	1.985	2.277
C(MSA_short)[T.Florence-Muscle Shoals, AL]	-28.1660	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Fort Wayne, IN]	3.3480	0.058	57.727	0.000	3.234	3.462
C(MSA_short)[T.Gainesville, FL]	-29.1197	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Gainesville, GA]	1.4806	0.057	26.143	0.000	1.370	1.592
C(MSA_short)[T.Grand Rapids-Kentwood, MI]	-28.0794	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Great Falls, MT]	2.7201	0.097	28.180	0.000	2.531	2.909
C(MSA_short)[T.Gulfport-Biloxi, MS]	-29.0128	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05

C(MSA_short)[T.Hammond, LA]	0.8295	0.097	8.569	0.000	0.640	1.019
C(MSA_short)[T.Hanford-Corcoran, CA]	3.4010	0.100	33.903	0.000	3.204	3.598
C(MSA_short)[T.Hartford-East Hartford-Middletown, CT]	2.0477	0.062	32.824	0.000	1.925	2.170
C(MSA_short)[T.Hattiesburg, MS]	0.5699	0.056	10.119	0.000	0.460	0.680
C(MSA_short)[T.Homosassa Springs, FL]	0.5960	0.086	6.899	0.000	0.427	0.765
C(MSA_short)[T.Hot Springs, AR]	2.6251	0.070	37.610	0.000	2.488	2.762
C(MSA_short)[T.Huntsville, AL]	-27.4609	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Idaho Falls, ID]	2.2433	0.081	27.593	0.000	2.084	2.403
C(MSA_short)[T.Indianapolis-Carmel-Anderson, IN]	1.1909	0.085	13.964	0.000	1.024	1.358
C(MSA_short)[T.Jackson, MI]	0.9359	0.086	10.850	0.000	0.767	1.105
C(MSA_short)[T.Jackson, MS]	-28.8840	7.98e+04	-0.000	1.000	-1.56e+05	1.56e+05
C(MSA_short)[T.Jacksonville, FL]	1.7579	0.049	35.851	0.000	1.662	1.854
C(MSA_short)[T.Jefferson City, MO]	2.0751	0.079	26.117	0.000	1.919	2.231
C(MSA_short)[T.Jonesboro, AR]	3.2944	0.061	53.702	0.000	3.174	3.415
C(MSA_short)[T.Joplin, MO]	1.5826	0.059	26.785	0.000	1.467	1.698
C(MSA_short)[T.Kankakee, IL]	2.7547	0.090	30.574	0.000	2.578	2.931
C(MSA_short)[T.Kansas City, MO-KS]	1.3495	0.055	24.703	0.000	1.242	1.457
C(MSA_short)[T.Lafayette, LA]	2.1144	0.059	35.607	0.000	1.998	2.231
C(MSA_short)[T.Lafayette-West Lafayette, IN]	1.6040	0.077	20.826	0.000	1.453	1.755
C(MSA_short)[T.Lake Charles, LA]	1.5275	0.074	20.662	0.000	1.383	1.672
C(MSA_short)[T.Lansing-East Lansing, MI]	1.5067	0.065	23.065	0.000	1.379	1.635
C(MSA_short)[T.Las Vegas-Henderson-Paradise, NV]	3.1630	0.058	54.934	0.000	3.050	3.276
C(MSA_short)[T.Lawrence, KS]	-27.7497	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Lewiston, ID-WA]	2.3362	0.124	18.813	0.000	2.093	2.580
C(MSA_short)[T.Lewiston-Auburn, ME]	0.8474	0.086	9.803	0.000	0.678	1.017
C(MSA_short)[T.Lexington-Fayette, KY]	3.6880	0.058	63.987	0.000	3.575	3.801

C(MSA_short)[T.Lawrence, KS]	-27.7497	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Lewiston, ID-WA]	2.3362	0.124	18.813	0.000	2.093	2.580
C(MSA_short)[T.Lewiston-Auburn, ME]	0.8474	0.086	9.803	0.000	0.678	1.017
C(MSA_short)[T.Lexington-Fayette, KY]	3.6880	0.058	63.987	0.000	3.575	3.801
C(MSA_short)[T.Lincoln, NE]	2.6240	0.069	38.010	0.000	2.489	2.759
C(MSA_short)[T.Little Rock-North Little Rock-Conway, AR]	-26.5770	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Los Angeles-Long Beach-Anaheim, CA]	3.1620	0.055	57.224	0.000	3.054	3.270
C(MSA_short)[T.Louisville/Jefferson County, KY-IN]	1.6187	0.080	20.303	0.000	1.462	1.775
C(MSA_short)[T.Manhattan, KS]	-26.7078	5.93e+04	-0.000	1.000	-1.16e+05	1.16e+05
C(MSA_short)[T.Miami-Fort Lauderdale-Pompano Beach, FL]	1.7733	0.044	40.321	0.000	1.687	1.859
C(MSA_short)[T.Michigan City-La Porte, IN]	1.1524	0.108	10.640	0.000	0.940	1.365
C(MSA_short)[T.Minneapolis-St. Paul-Bloomington, MN-WI]	-1.0987	0.237	-4.644	0.000	-1.562	-0.635
C(MSA_short)[T.Mobile, AL]	2.2894	0.052	43.876	0.000	2.187	2.392
C(MSA_short)[T.Monroe, LA]	-28.0815	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Montgomery, AL]	-0.9920	0.247	-4.014	0.000	-1.476	-0.508
C(MSA_short)[T.Napa, CA]	-0.8695	0.133	-6.534	0.000	-1.130	-0.609
C(MSA_short)[T.New Haven-Milford, CT]	2.7079	0.061	44.268	0.000	2.588	2.828
C(MSA_short)[T.New Orleans-Metairie, LA]	-28.6766	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.New York-Newark-Jersey City, NY-NJ-PA]	2.5169	0.052	48.178	0.000	2.415	2.619
C(MSA_short)[T.North Port-Sarasota-Bradenton, FL]	1.1090	0.059	18.652	0.000	0.992	1.226
C(MSA_short)[T.Norwich-New London, CT]	-28.2272	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Ocean City, NJ]	-27.7716	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05

C(MSA_short)[T.Omaha-Council Bluffs, NE-IA]	0.7967	0.243	3.279	0.001	0.320	1.273
C(MSA_short)[T.Orlando-Kissimmee-Sanford, FL]	1.1302	0.049	23.169	0.000	1.035	1.226
C(MSA_short)[T.Owensboro, KY]	2.2339	0.083	26.829	0.000	2.071	2.397
C(MSA_short)[T.Oxnard-Thousand Oaks-Ventura, CA]	1.4027	0.070	19.947	0.000	1.265	1.541
C(MSA_short)[T.Pensacola-Ferry Pass-Brent, FL]	2.2018	0.052	42.157	0.000	2.099	2.304
C(MSA_short)[T.Peoria, IL]	-27.1231	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Philadelphia-Camden-Wilmington, PA-NJ-DE-MD]	1.8377	0.060	30.629	0.000	1.720	1.955
C(MSA_short)[T.Phoenix-Mesa-Chandler, AZ]	4.3116	0.054	79.694	0.000	4.206	4.418
C(MSA_short)[T.Pine Bluff, AR]	0.8450	0.089	9.463	0.000	0.670	1.020
C(MSA_short)[T.Pittsfield, MA]	-0.6410	0.130	-4.920	0.000	-0.896	-0.386
C(MSA_short)[T.Port St. Lucie, FL]	0.8643	0.072	11.995	0.000	0.723	1.006
C(MSA_short)[T.Portland-South Portland, ME]	-28.1782	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Providence-Warwick, RI-MA]	1.6985	0.082	20.721	0.000	1.538	1.859
C(MSA_short)[T.Pueblo, CO]	2.4730	0.084	29.597	0.000	2.309	2.637
C(MSA_short)[T.Redding, CA]	1.3669	0.082	16.595	0.000	1.205	1.528
C(MSA_short)[T.Riverside-San Bernardino-Ontario, CA]	4.8071	0.062	78.053	0.000	4.686	4.928
C(MSA_short)[T.Rochester, MN]	2.6920	0.069	38.781	0.000	2.556	2.828
C(MSA_short)[T.Rome, GA]	1.4823	0.062	23.907	0.000	1.361	1.604
C(MSA_short)[T.Sacramento-Roseville-Folsom, CA]	1.5020	0.062	24.175	0.000	1.380	1.624
C(MSA_short)[T.Salinas, CA]	1.4640	0.084	17.400	0.000	1.299	1.629
C(MSA_short)[T.Salisbury, MD-DE]	0.8782	0.090	9.798	0.000	0.703	1.054
C(MSA_short)[T.San Diego-Chula Vista-Carlsbad, CA]	3.0369	0.057	53.383	0.000	2.925	3.148
C(MSA_short)[T.San Francisco-Oakland-Berkeley, CA]	-0.7739	0.075	-10.302	0.000	-0.921	-0.627
C(MSA_short)[T.Santa Maria-Santa Barbara, CA]	0.2139	0.077	2.781	0.005	0.063	0.365
C(MSA_short)[T.Santa Rosa-Petaluma, CA]	1.0341	0.071	14.647	0.000	0.896	1.173
C(MSA_short)[T.Sebring-Avon Park, FL]	0.7276	0.073	10.015	0.000	0.585	0.870
C(MSA_short)[T.Sierra Vista-Douglas, AZ]	-25.9445	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Springfield, IL]	-27.0567	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Springfield, MA]	1.3091	0.075	17.471	0.000	1.162	1.456
C(MSA_short)[T.Springfield, MO]	-28.1479	6.7e+04	-0.000	1.000	-1.31e+05	1.31e+05
C(MSA_short)[T.St. Joseph, MO-KS]	1.0618	0.084	12.612	0.000	0.897	1.227
C(MSA_short)[T.St. Louis, MO-IL]	0.7382	0.094	7.874	0.000	0.554	0.922
C(MSA_short)[T.Tallahassee, FL]	-28.6188	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.Tampa-St. Petersburg-Clearwater, FL]	0.9015	0.049	18.223	0.000	0.805	0.998
C(MSA_short)[T.Terre Haute, IN]	1.9670	0.071	27.880	0.000	1.829	2.105
C(MSA_short)[T.Texarkana, TX-AR]	-27.8888	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05
C(MSA_short)[T.The Villages, FL]	1.8679	0.071	26.451	0.000	1.730	2.006
C(MSA_short)[T.Topeka, KS]	2.1610	0.077	28.199	0.000	2.011	2.311
C(MSA_short)[T.Tucson, AZ]	5.1364	0.058	88.340	0.000	5.022	5.250
C(MSA_short)[T.Tuscaloosa, AL]	0.9870	0.062	15.914	0.000	0.865	1.109
C(MSA_short)[T.Urban Honolulu, HI]	3.3762	0.071	47.711	0.000	3.238	3.515
C(MSA_short)[T.Vallejo, CA]	-0.5165	0.112	-4.618	0.000	-0.736	-0.297
C(MSA_short)[T.Warner Robins, GA]	-29.3356	1.16e+05	-0.000	1.000	-2.28e+05	2.28e+05

C(MSA_short)[T.Washington-Arlington-Alexandria, DC-VA-MD-WV]	-1.1932	0.074	-16.033	0.000	-1.339	-1.047
C(MSA_short)[T.Waterloo-Cedar Falls, IA]	2.9097	0.083	35.252	0.000	2.748	3.072
C(MSA_short)[T.Wichita, KS]	-26.2714	8.23e+04	-0.000	1.000	-1.61e+05	1.61e+05
C(MSA_short)[T.Worcester, MA-CT]	2.3621	0.067	35.279	0.000	2.231	2.493
C(MSA_short)[T.Yuma, AZ]	4.5872	0.075	61.467	0.000	4.441	4.733
prop_crosswalk	60.6365	0.503	120.459	0.000	59.650	61.623
prop_not_single_family_house	-7.3584	0.072	-101.742	0.000	-7.500	-7.217
uninsured_adults	13.4363	0.250	53.640	0.000	12.945	13.927
mental_hlth	228.2574	5.268	43.329	0.000	217.932	238.583
HIV_prev	0.0009	2.18e-05	39.814	0.000	0.001	0.001

Appendix C. MSA Model Coefficients. MSAs in light grey have no available excess deaths data, and MSAs in dark grey had coefficients that were not significant. Coefficients shown in color are all significant. Hawaii's MSAs are shown in the large box all the way to the left, and Alaska's MSAs and in the box to the right of the box for Hawaii.