Rurality & Mortality (1918 Flu & COVID in Missouri)

Aaron Bogan

"1918 Flu" Mortality

Summary

Weekly death counts attributed to the "1918 Flu" for 115 Missouri counties were recorded from the beginning of 1918 to the end of 1919. These weekly counts were standardized to account for county population differences ("standardized mortality ratio" or SMR). Two distinct 'peak' mortality time periods were visually identified. The first peak period ("wave 1") consists of 17 continuous weeks beginning in early September of 1918 and ending the final week of 1918. The second, ("wave 2") consists of 10 continuous weeks beginning the first week of 1920 to early March 1920.

Each of the 115 counties was classified by rurality into one of three mutually exclusive groups: Rural, Semirural, or Urban. These classifications were determined by the research team investigators.

Since the investigators were interested in comparing rurality's effect on 'peak' mortality, the maximum SMR for each county during each wave (1 and 2) was determined. A ratio of $\frac{Max\ SMR_{wave1}}{Max\ SMR_{wave2}}$ was used to test for differences between the two flu peak mortaltiy periods.

– **There were no statistically significant differences in maximum SMR between the two "1918 Flu" waves.**

Based on this finding, the two 'peak' periods were combined and the maximum SMR for each county across the two periods was determined.

– **Across both flu waves, "Rural" counties experienced significantly LOWER peak "1918 Flu" mortality on average than either "Semiurban" or "Urban" counties.**

COVID Mortality

Summary

COVID cumulative daily death counts were downloaded on 08/03/21 from the web site "https://usafacts.org/visualizations/coronavirus-covid-19-spread-map/state/missouri" for each of the 115 Missouri counties. Death counts for each county were aggregated across 14-day periods. These bi-weekly death counts were standardized in a manner similar to the "1918 Flu" counts. Also similar to the 1918 analysis, a 'peak' mortality period was visually identified. This peak period consists of 39, 14-day periods from the end of August 2020 to mid-April 2021. Each county was classified by rurality (Rural, Semirural, Urban) by the investigators and maximum SMR was determined for each.

– **"Rural" counties experienced significantly HIGHER peak COVID mortality on average than either "Semiurban" or "Urban" counties.**

Discussion of Methods

"1918 Flu"

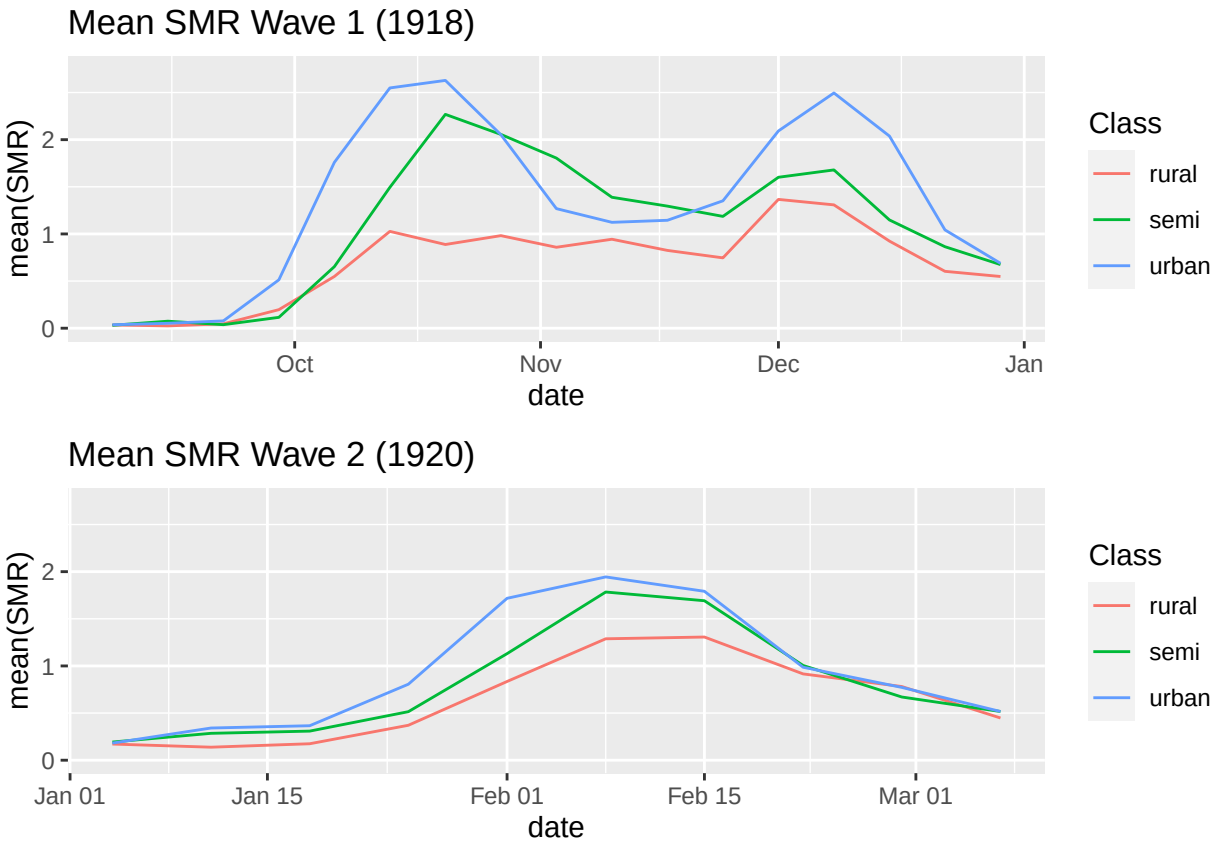
Comparison of Peak Waves (1918 and 1920)

County level weekly death counts were standardized based on the following ratio:

$$E = \frac{County\ Population * Total\ Deaths}{Number\ of\ Weeks * State\ Population}$$

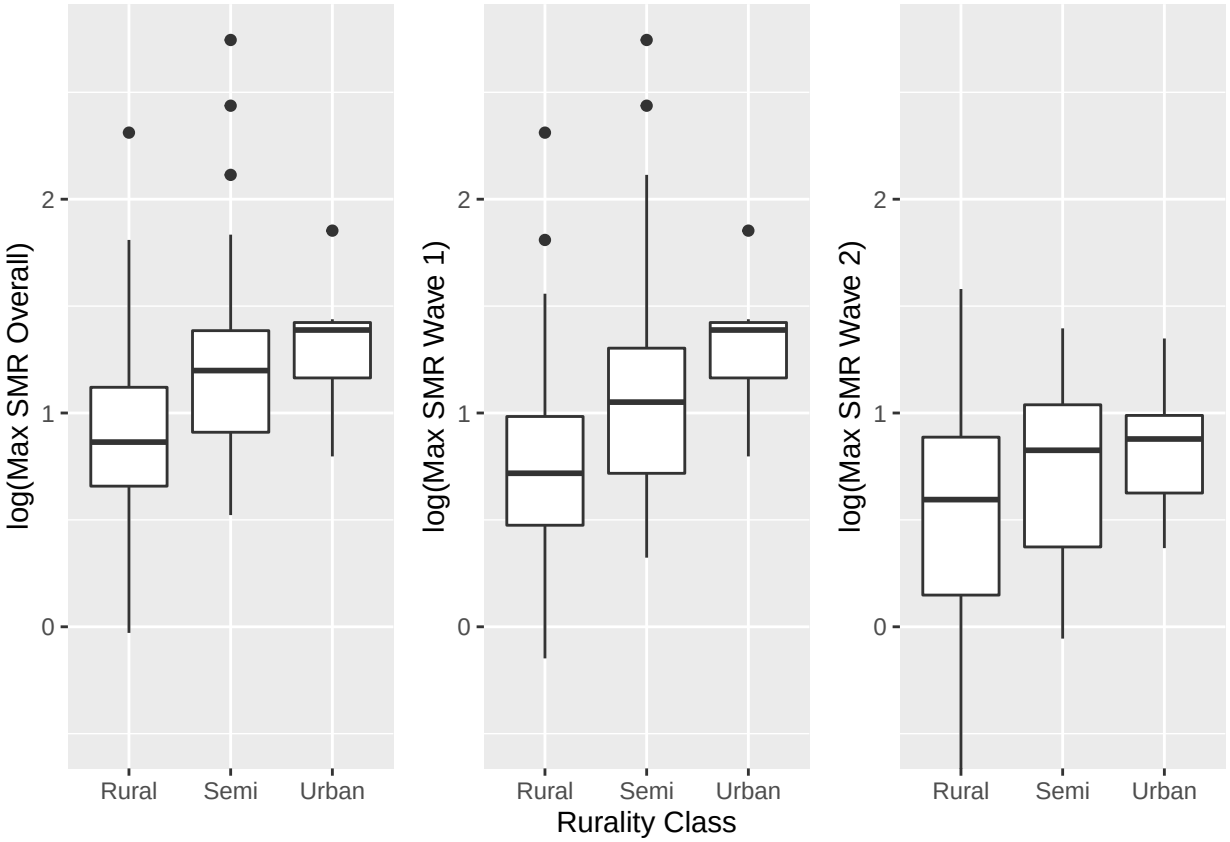
$$SMR = \frac{County\ Weekly\ Death\ Count}{E}$$

Time Series of mean SMR



The response variable (maximum county SMR) was heavily skewed so a log transform was used to aid in model diagnostics and fitting.

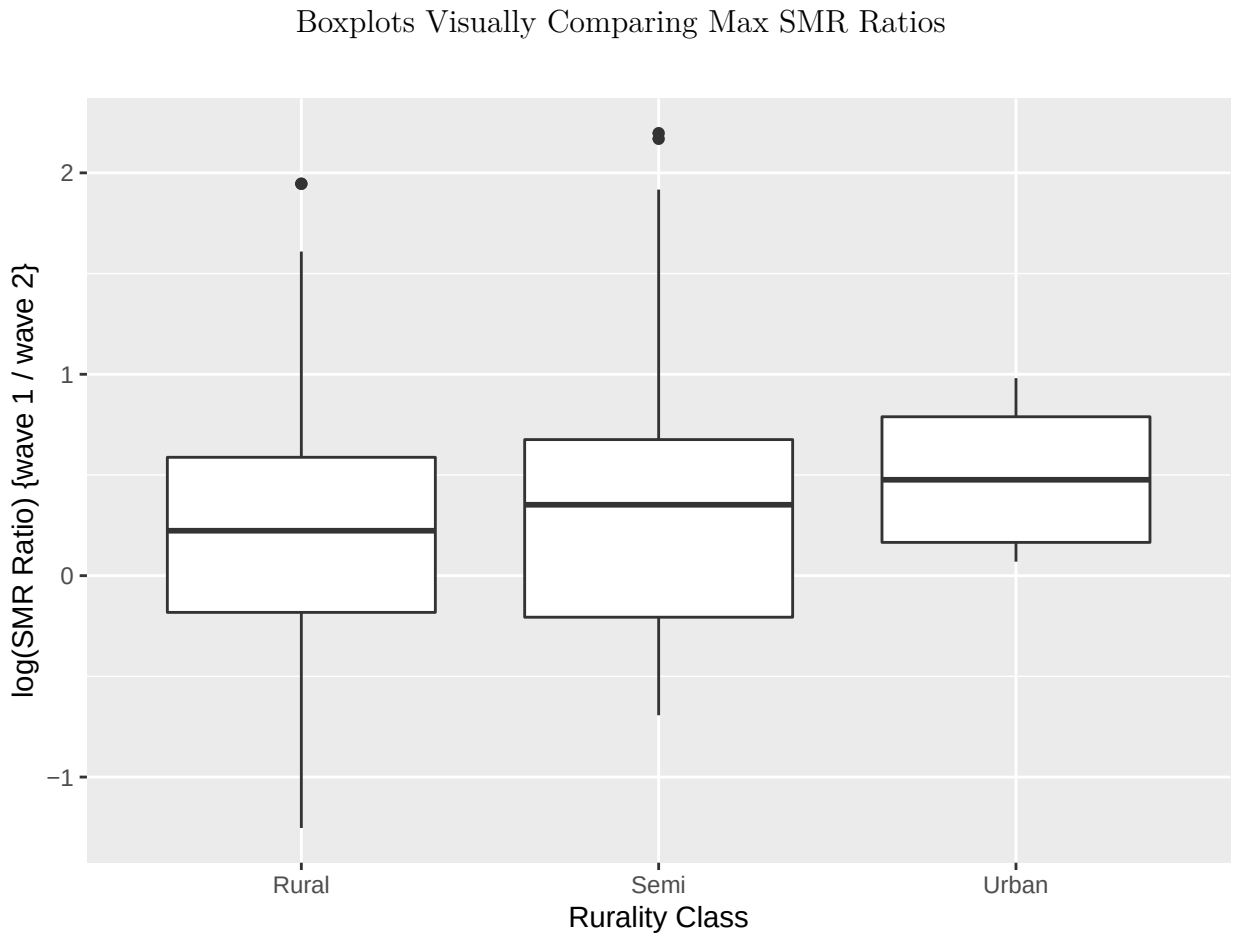
Boxplots Visually Comparing Max SMR



Maximum SMR for each county during wave 1 (late 1918) was divided by the maximum SMR for that county during wave 2 (early 1920).

$$\frac{Max\ SMR_{wave1}}{Max\ SMR_{wave2}}$$

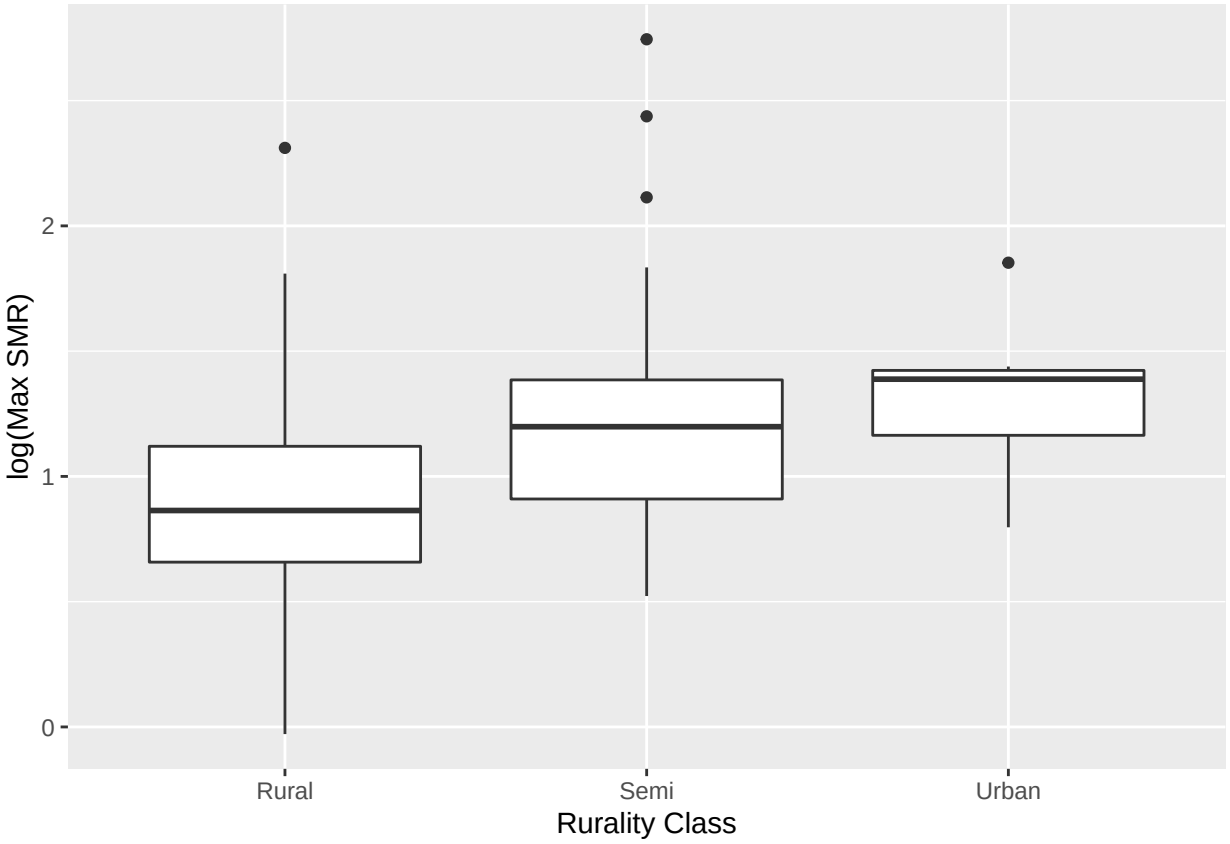
Significant aerial spatial correlation was detected using a Moran's I test. A conditional autoregressive ("CAR") model was fit using a maximum likelihood method to detect any differences in mean SMR ratio across the three groups. No significant difference was detected. **Peak SMR for the 1918 and 1920 flu seasons is NOT significantly different.**



Rurality Mortality Comparisons

Since the two "1918 Flu" waves are statistically similar, data from the two waves were combined. Again, aerial spatial correlation was detected using a Moran's I test. Two CAR models were fit using a Bayesian method as well as a maximum likelihood method. Both methods produced significant models indicating **LOWER max SMR on average for "Rural" counties than "Semiurban" or "Urban" counties.**

Boxplots Visually Comparing "1918 Flu" Max SMR



Bayesian CAR Model Summary

	Median	2.5%	97.5%
Rural	0.91	0.84	0.98
Sem - Rur	0.27	0.11	0.43
Urb - Rur	0.47	0.19	0.75

ML CAR Model Summary

	Estimate	Std. Error	z value	Pr(>|z|)
Rural	0.90	0.075	12.05	0.000
Sem - Rur	0.29	0.080	3.56	0.000
Urb - Rur	0.47	0.139	3.38	0.001

COVID

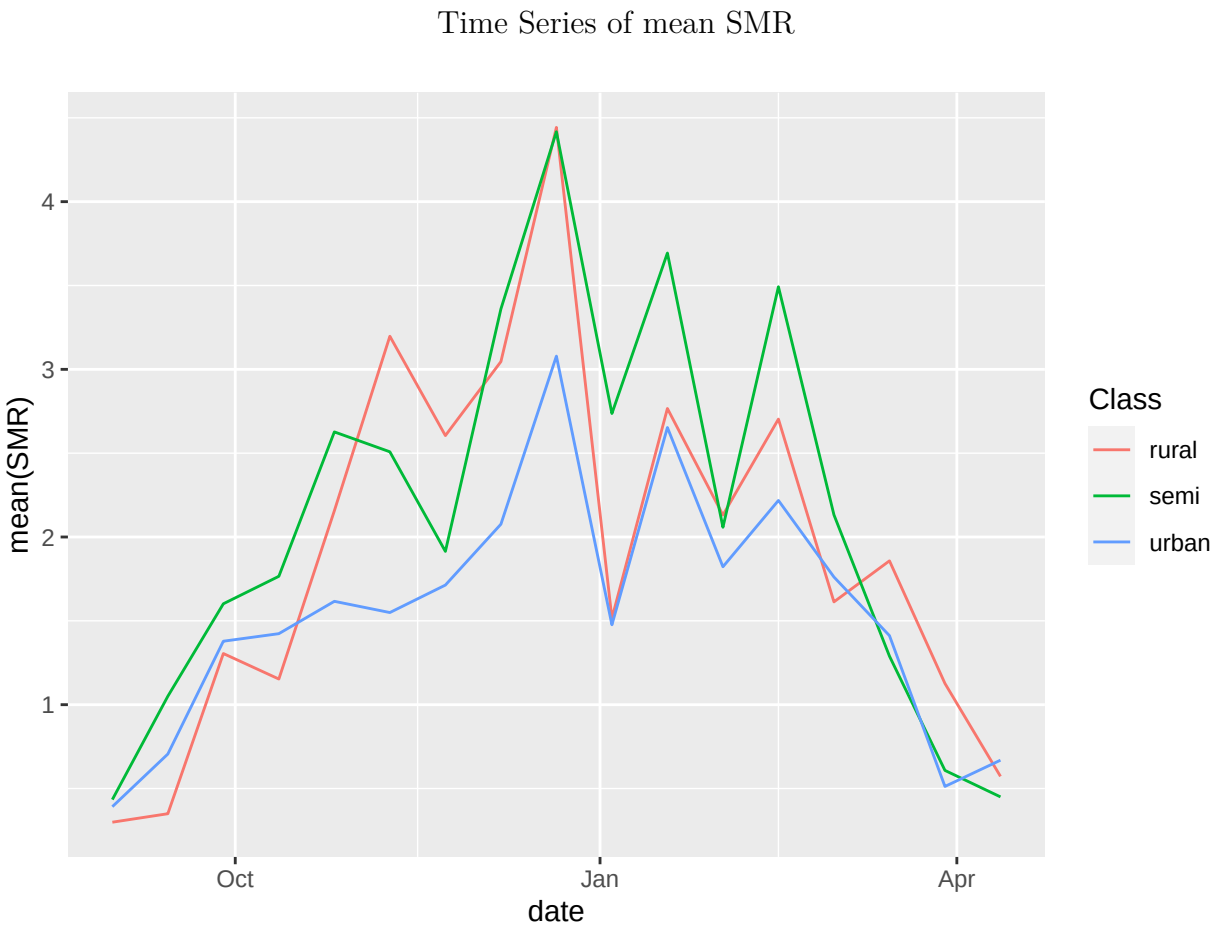
Rurality Mortality Comparisons

COVID cumulative daily death counts were downloaded on 08/03/21 from the web site "https://usafacts.org/visualizations/coronavirus-covid-19-spread-map/state/missouri" for each of the 115 Missouri counties. Weekly count aggregation resulted in roughly 1.2% erroneous negative weekly counts. These erroneous counts were assumed to be due to recording/reporting lags that were corrected in subsequent weeks. To minimize the impact of these erroneous counts, a 14-day (bi-weekly) aggregation was chosen. This resulted in 0.4% negative bi-weekly counts. The bi-weekly death counts were standardized similarly to the "1918 Flu" counts.

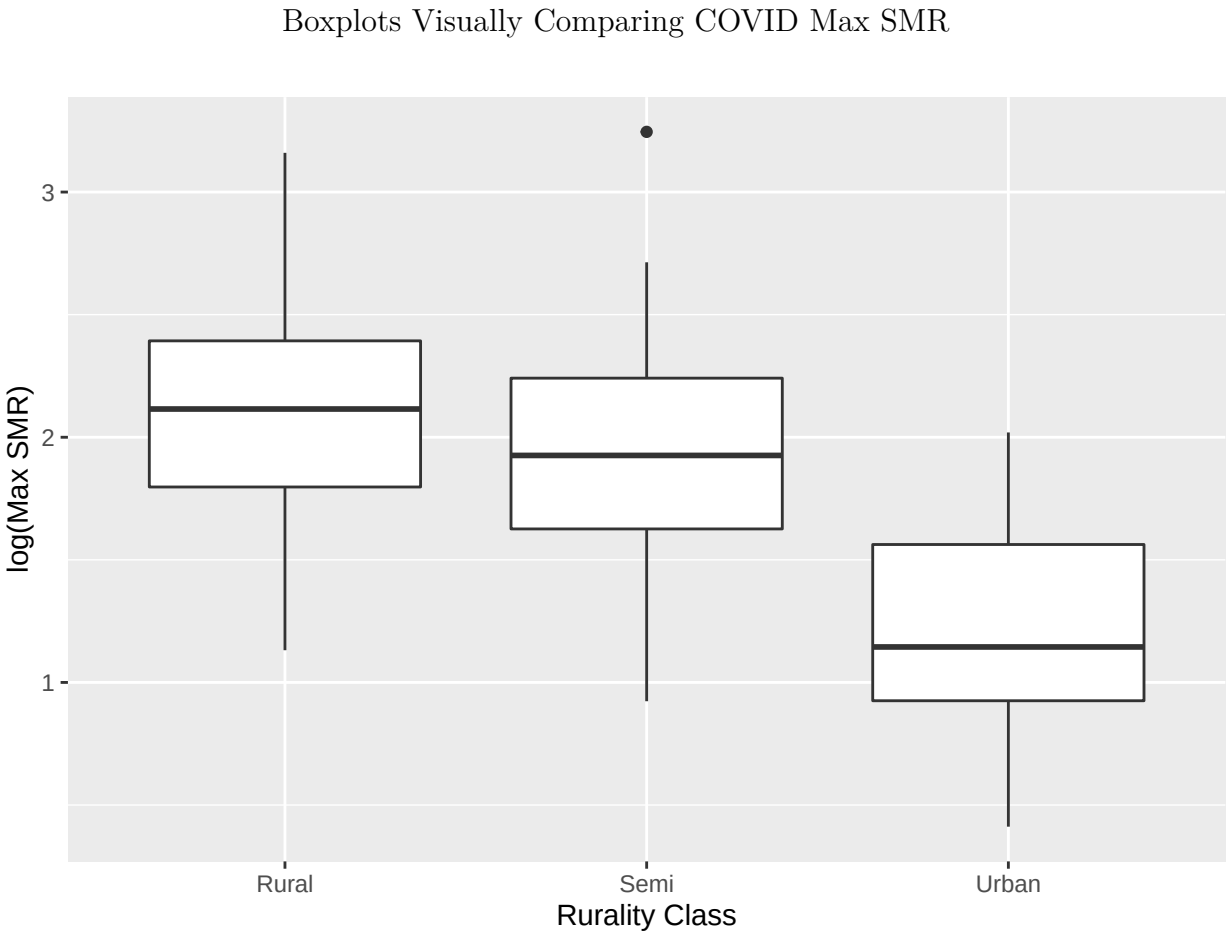
$$E = \frac{County\ Population * Total\ Deaths}{Number\ of\ 14\ day\ Periods * State\ Population}$$

$$SMR = \frac{County\ 14\ Day\ Death\ Count}{E}$$

Also similar to the 1918 analysis, a 'peak' mortality period was visually identified. This peak consists of 39, 14-day periods from the end of August 2020 to mid-April 2021. Each county was classified by rurality (Rural, Semirural, Urban) by the investigators.



Maximum SMR over the 39 bi-weekly periods was determined for each county. A log transformation was used to improve model diagnostics and fit.



Aerial spatial correlation was detected in the response variable (max SMR) using a Moran's I test. Two CAR models were fit using a Bayesian method as well as a maximum likelihood method. Both methods produced significant models indicating a **HIGHER max SMR on average for "Rural" counties than "Semiurban" or "Urban" counties.**

Bayesian CAR Model Summary

	Median	2.5%	97.5%
Rural	2.12	2.00	2.24
Sem - Rur	-0.18	-0.36	0.00
Urb - Rur	-0.90	-1.17	-0.63

ML CAR Model Summary

	Estimate	Std. Error	z value	Pr(>|z|)
Rural	2.12	0.072	29.47	0.000
Sem - Rur	-0.19	0.090	-2.06	0.039
Urb - Rur	-0.89	0.140	-6.38	0.000