Policy predictors of domestic-violence shooting incidence in the United States, 2014-2018

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Motivation and Goal

Domestic violence (DV) shootings are a major issue in the United States, but research on these shootings is limited. Here, we use Gun Violence Archive data and spatio-temporal generalized linear mixed models (GLMM) to study the relationship between state legislation that restricts gun access of DV offenders and the rate of DV shootings in the state during 2014-2018.

Model Specification

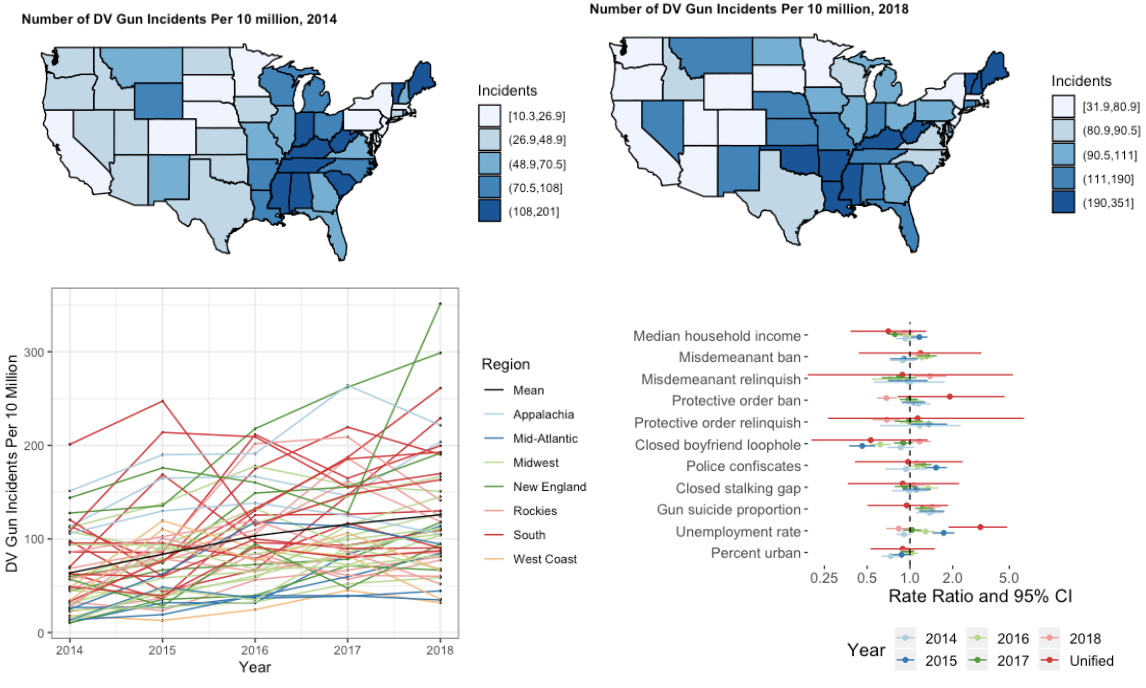
We use sparse restricted spatial Poisson GLMMs (Hughes and Haran, 2013), extended to the repeated measurements setting. Specifically, we model:

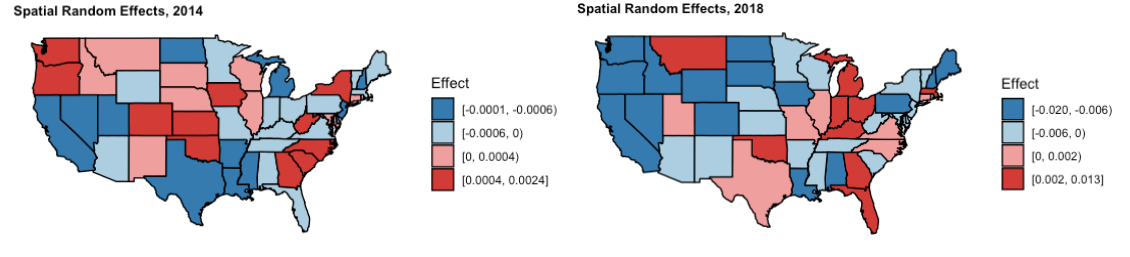
$$Y_{ij}|\lambda_{ij} \sim Poisson(E_{ij}\lambda_{ij})$$
$$ln(\lambda_{ij}|\beta, \delta_s) = \mathbf{X_{ij}}\beta + \mathbf{M_{ij}}\delta_{\mathbf{s_j}}$$

where i indicates state (i = 1, …, 48), j indicates year (j = 2014, 2015,…, 2018), and E_{ij} is an offset. $\delta_{\mathbf{s_j}}$ are unconfounded spatial random effects distributed:

$$p(\delta_{\mathbf{s_j}}|\tau) \propto \tau^{\mathbf{q/2}}\mathbf{exp}(\frac{-\tau}{2}\delta_{\mathbf{s_j}}'\mathbf{Q_{s_j}}\delta_{\mathbf{s_j}}).$$

with $\mathbf{Q_{s_j}} = \mathbf{M_j'QM_j}$ for $\mathbf{Q} = \mathbf{diag(A1)} - \mathbf{A}$. $\mathbf{X_{ij}}$ is the p-vector of predictors for the i^{th} state and j^{th} year, while $\mathbf{M_{ij}}$ is the ith row of the q positive eigenvectors of $\mathbf{M_j} = \mathbf{P_jAP_j}$, where $\mathbf{P_j} = \mathbf{I} - \mathbf{X_j}(\mathbf{X_j'X_j})^{-1}\mathbf{X_j'}$ and $\mathbf{A}$ is the adjacency matrix. This transformation of the spatial random effects reduces confounding between the random effects and the main effects, in addition to reducing the dimension of the model. We also consider a stratified model where the β, τ parameters are allowed to vary with time. All analyses were run in R.





Results & Takeaways

- Main effects were surprisingly different across years, and a unified model with a common variance across years may not be appropriate.
- Only promising policy predictors of DV gun violence incidence was closing the boyfriend loophole.
- The effects of median household income, the gun suicide proportion, the unemployment rate, and the urbanicity of the state on DV gun violence largely agree with previous findings.
- After incorporating covariates, little unexplained spatial variation remains in the data.
- Future work: compare to other spatial modeling approaches, consider different definitions for a DV gun violence endpoint.

References

1. Hughes J and M Haran, “Dimension reduction and alleviation of confounding for spatial generalized linear mixed models.” JRSS-B 75 Part 1 (2013): 139-159.
2. Gun Violence Archive, 2014-2018. https://www.gunviolencearchive.org/
3. Team R Core. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria; 2020. http://www.R-project.org/

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