RESEARCH BRIEF

No. 5: March 2024

MODELING COUNTY FIREARM SUICIDE MORTALITY RATES USING BAYESIAN SPATIAL SMOOTHING METHODS

Emma L. Gause, Austin E. Schumacher, Alice M. Ellyson, Suzanne D. Withers, Jonathan D. Mayer, Ali Rowhani-Rahbar

Brief prepared by: Erika Marts

BACKGROUND

The Centers for Disease Control and Prevention (CDC) considers rates calculated from fewer than 20 occurrences to be unreliable and prohibits the public reporting of rates calculated with fewer than 10 occurrences due to the potential identifiability risk. However, in 2019, 80.7% of US counties had fewer than 10 firearm suicide deaths, meaning they could not report a firearm suicide mortality rate. Over half of suicides, a leading cause of death, involve a firearm. In rural, small population counties, which often experience higher firearm suicide rates, small numbers are affected by these suppression rules. Using firearm suicide deaths as a motivating example, this article introduces the Bayesian spatial and space-time smoothing models, a special application of small area estimation where the full universe of data is known, but too sparse to use for reliable inference.

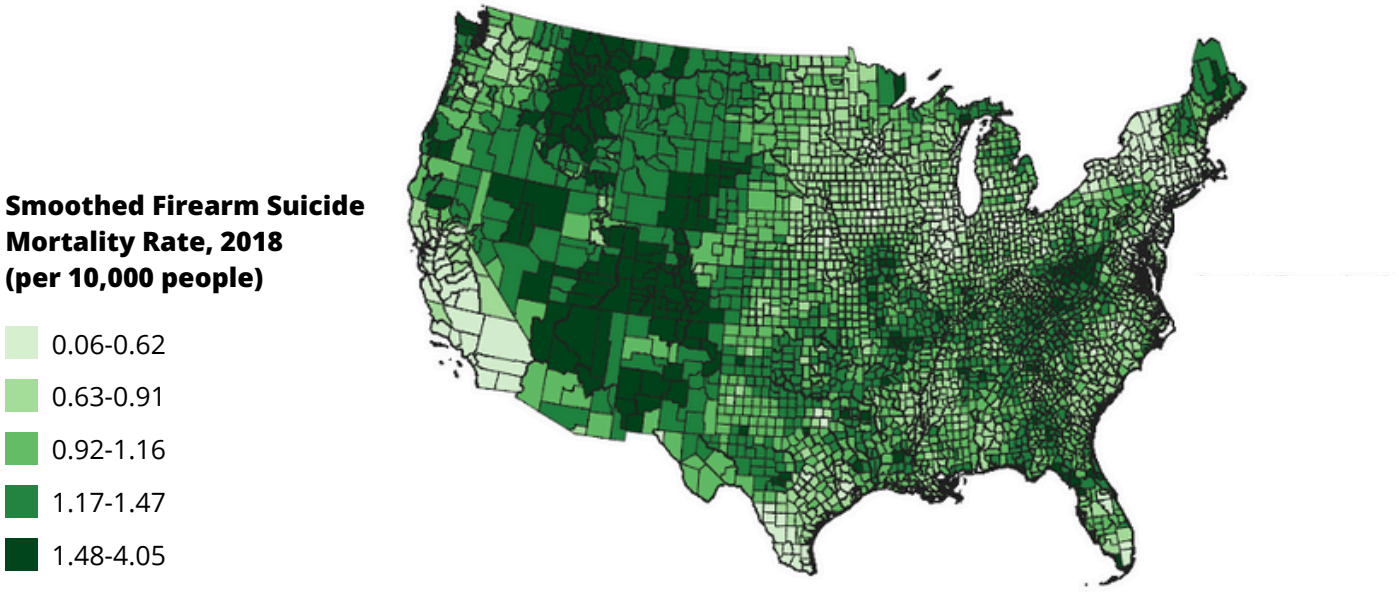
APPROACH

Using CDC National Vital Statistics System mortality data for 2014-2018, researchers at the University of Washington's Center for Firearm Injury Prevention (C-FIP) applied Bayesian spatial and space-time smoothing models to estimate more reliable county-level firearm suicide death rates to identify areas of high risk. These methods are useful for calculating risk estimates for rare outcomes or small geographies when small numbers are a concern, and new estimation techniques in R have made fitting these models more accessible than ever. The article includes a discussion of the method's theory, model specification, results interpretation, and potential caveats, and provides code examples for replication.

FINDINGS

All US contiguous counties were included in the analysis. Using CDC guidelines for reporting estimates, it would not have been possible to report a reliable firearm suicide mortality rate for 91.1% of these counties in 2018, but the use of the spatial smoothing models allowed for a precise annual risk estimate to be produced for all areas. The highest rates of firearm suicide were observed in the Mountain West, Southwest, and Appalachia (Figure 1).

Figure 1. After applying spatial and time-smoothing models, reliable firearm suicide mortality rates could be reported for every US county in 2018.



Results from this study illustrate the two primary benefits of spatial smoothing methods for disease mapping:

- More reliable comparisons of smoothed firearm suicide mortality rates across different geographic contexts.
- The ability to estimate and display precise mortality rates for areas experiencing 20 or fewer deaths, like the majority of US counties.

Since this model-based smoothing approach pools and weights data from surrounding counties, the rate estimates do not pose the same concern for identifiability in reporting. However, there is a trade-off between variance and bias, as bias is introduced by smoothing over some real local heterogeneity to increase precision and make comparisons across geographies more reliable.

IMPLICATIONS FOR POLICY AND PRACTICE

Given improvements to data storage and computation, the ability to assess local mortality trends on a wide scale has increased and the demand for sub-state estimates has grown. Using Bayesian models to leverage the spatial structure of outcomes can help to identify true underlying risks in small geographies and find geographical disparities. Spatial disease mapping is more accessible to researchers than ever, and Public Health scientists may consider adding these methodologies to their toolkit, particularly when interested in rare outcomes or sub-state areas.

FOR ADDITIONAL INFORMATION ON THIS TOPIC PLEASE REFER TO:

Gause EL, Schumacher AE, Ellyson AM, Withers SD, Mayer JD, Rowhani-Rahbar A. An Introduction to Bayesian Spatial Smoothing Methods for Disease Mapping: Modeling County Firearm Suicide Mortality Rates. *Am J Epidemiol*. Published online February 20, 2024. doi:10.1093/aje/kwae005

FUNDING INFORMATION

This work was supported by funds from the State of Washington to the Center for Firearm Injury Prevention.