

A Multivariate Conditional Autoregressive Model of the COVID-19, Opioid and Gun Violence Syndemic

A CASE STUDY OF CHICAGO, ILLINOIS



Introduction

Implementation of public health interventions to reduce incidence of COVID19 have had unintended health consequences for people who use substances and for those who are vulnerable to violent victimization

In Chicago, during the pandemic

- The use of opioid-related fatalities has dramatically increased (Angulski & Barboza, 2021)
- There has been a paradoxical trend of increased gun related violence during the covid-19 pandemic (Sutherland, McKenny & Elkbuli, 2021)

The term ‘epidemic’ is too narrow to describe the multiple epidemics that have existed simultaneously along with COVID-19, and that are directly interrelated with the COVID-19 pandemic

The Present Study

We use a syndemics framework to model the co-occurring epidemics of COVID-19, opioid-related overdoses and gun violence using multivariate spatial models to capture their overlap in a way that reflects disease burden

The syndemics framework emphasizes context where the overlap occurs

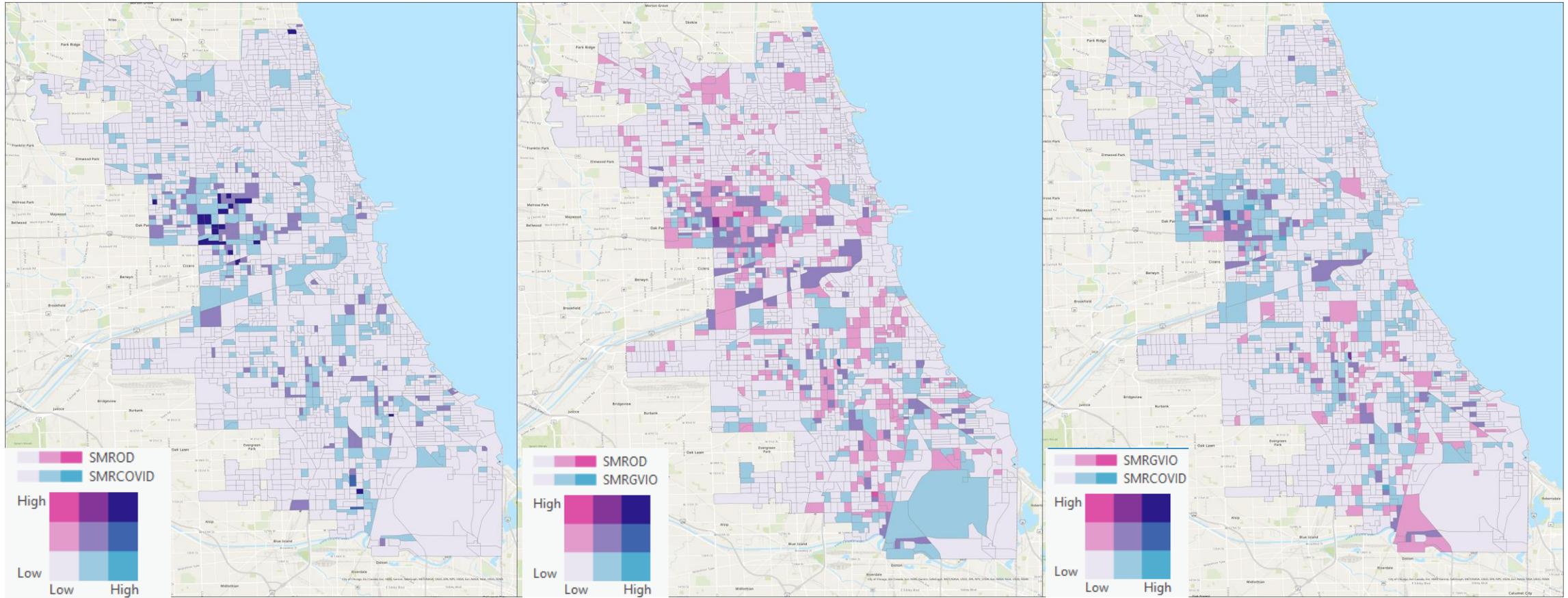
We examine the complex interaction between opioid overdose, gun violence and COVID-19 (OVIC)

- The application of syndemic theory to OVIC while accounting for trends in social distancing and area deprivation allows us to evaluate the impact of COVID-19 policy responses on the co-occurring epidemics and understand their differential impact on vulnerable individuals living in areas of high deprivation

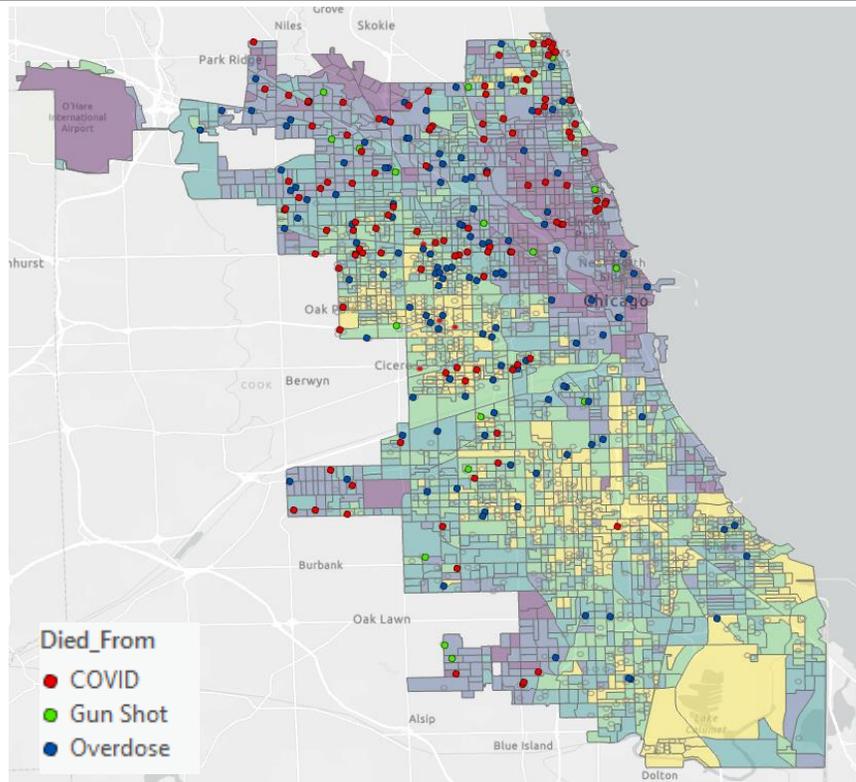
Variable	Definition	Source
OD	Opioid-Related Drug Overdose Deaths	
COVID-19	COVID-19 Deaths	Cook's County Medical Examiner
GUNVIO	Gun Violence Deaths	
Social Distancing		Safegraph, Inc.
Area Deprivation Index		

Data Sources for Current Study

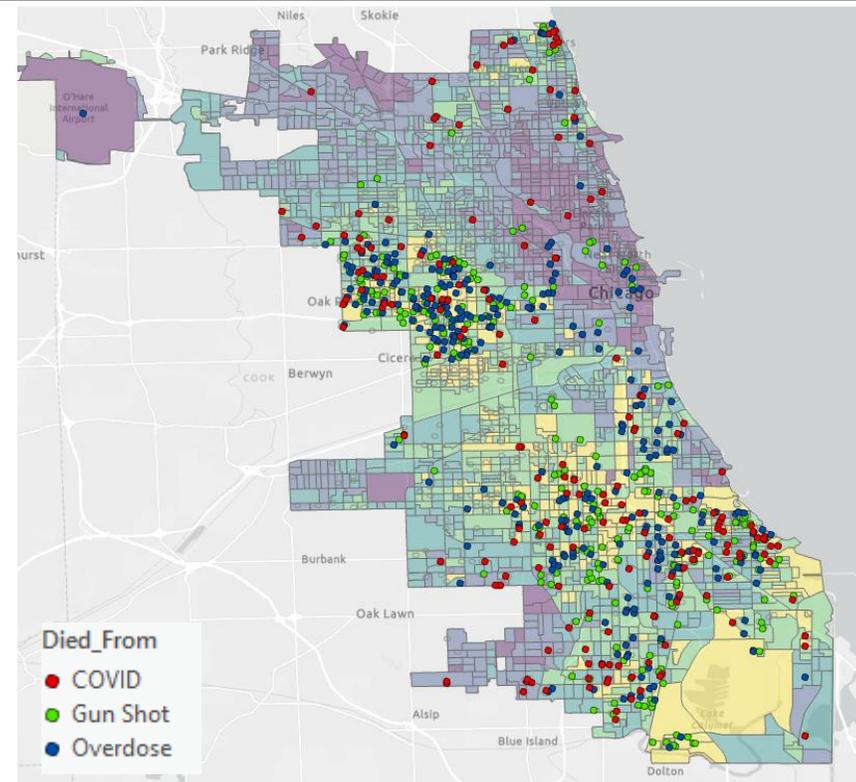
Bivariate maps representing all possible combinations of SMR's for Overdose, Gun Violence & COVID-19 fatalities during March 24, 2020 – Aug 6, 2020x



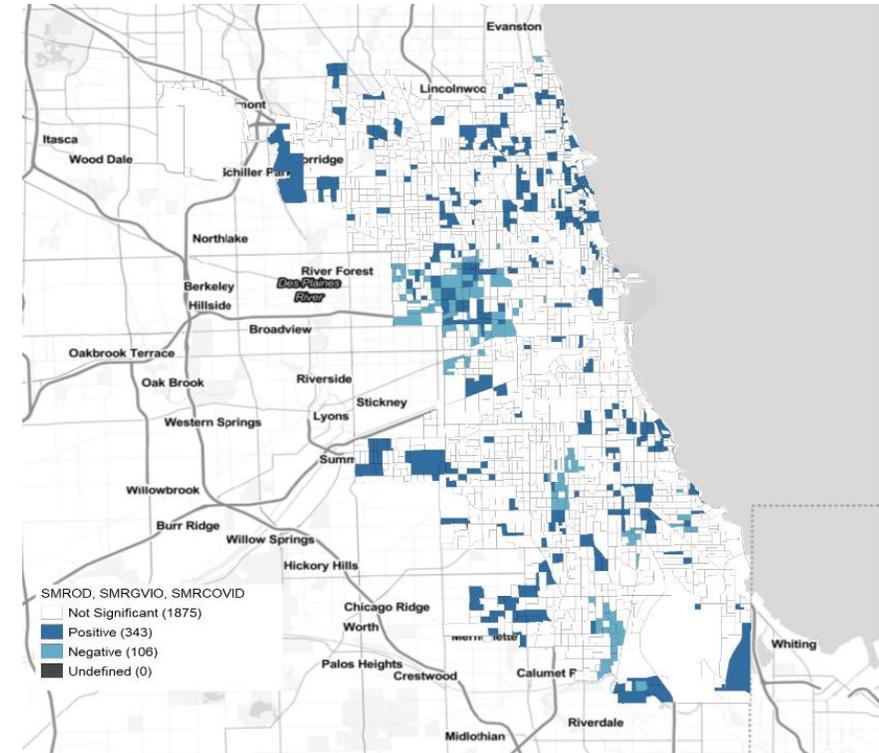
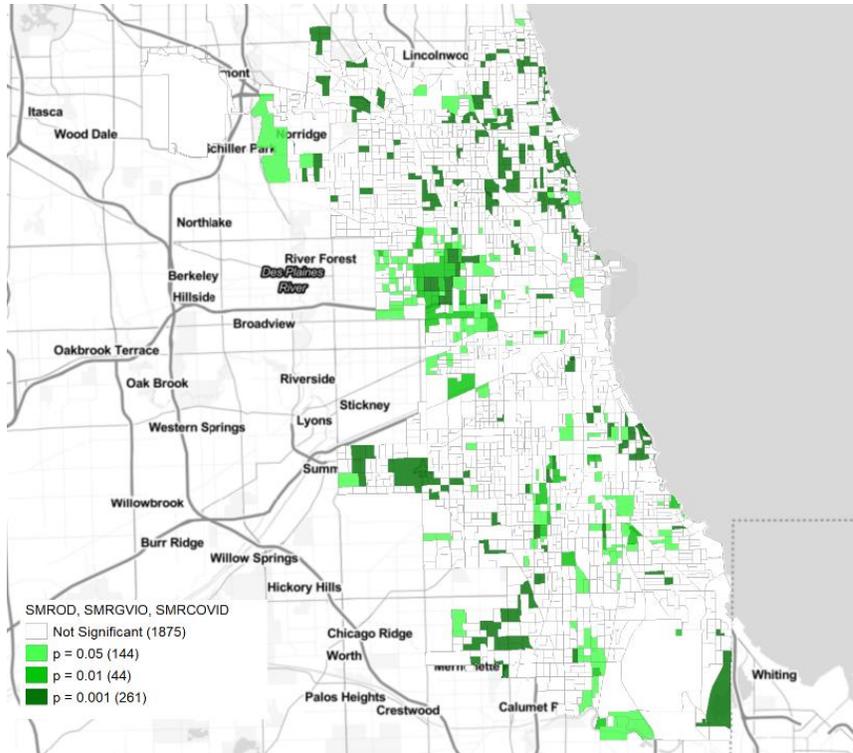
Drug Overdose, Gun Violence & COVID-19 Fatalities 3/24/2020 – 8/6/2020



NON-HISPANIC WHITES



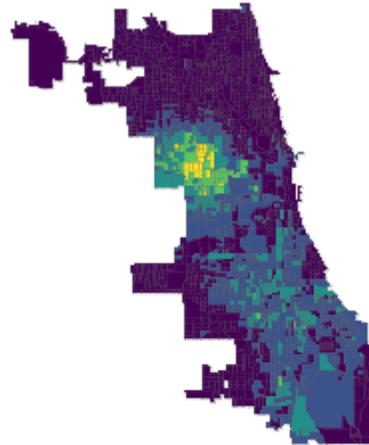
NON-HISPANIC BLACKS



Multivariate Cluster Analysis: Geary's C

Table 1. Area Deprivation Index (ADI) and SMR Quintiles the City of Chicago, Census Block Groups							
		Overall	Q1	Q2	Q3	Q4	Q5
COVID-19 SMR	Mean						
	Std. Dev.						
	Median						
	IQR						
	Minimum						
	Maximum						
Overdose SMR	Mean	0.4228559	0.3029912	0.3612651	0.4048267	0.4587066	0.5862635
	Std. Dev.	0.1120936	0.02936859	0.01166318	0.01385829	0.1218907	0.1218907
	Median	0.4048344	0.3090665	0.361904	0.4046559	0.4572256	0.5539753
	IQR	0.1208925	0.03587949	0.01972479	0.02284863	0.0276682	0.09300106
	Minimum	0.2000000	0.20000000	0.3401264	0.3815395	0.4302713	0.4939976
	Maximum	2.041635	0.3399479	.381361	0.4300928	0.4938191	2.041635
Gun Violence SMR	Mean						
	Std. Dev.						
	Median						
	IQR						
	Minimum						
	Maximum						

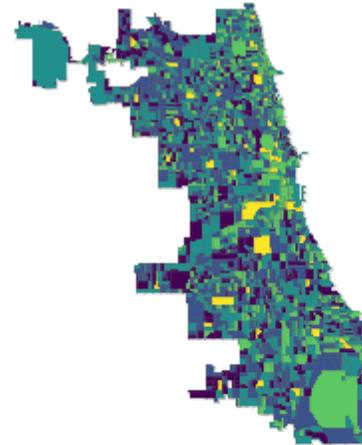
Opioid Overdose (Relative Risk)



Relative Risk

0.038 to 0.384
0.384 to 0.834
0.834 to 1.552
1.552 to 2.833
2.833 to 5.825

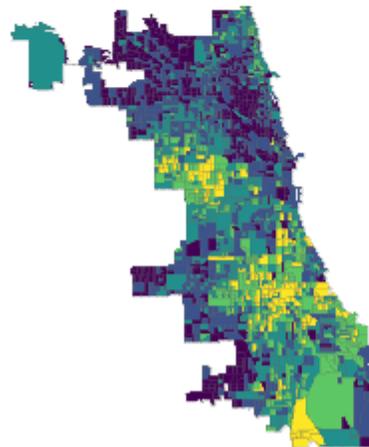
Stay-at-Home (%)



% Staying at Home

0.099 to 0.236
0.236 to 0.298
0.298 to 0.361
0.361 to 0.522
0.522 to 0.813

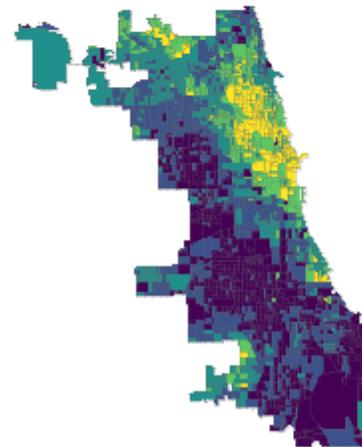
Area Deprivation Index



Economic Hardship

69.8 to 90.3
90.3 to 104.2
104.2 to 120.4
120.4 to 141.5
141.5 to 183.9

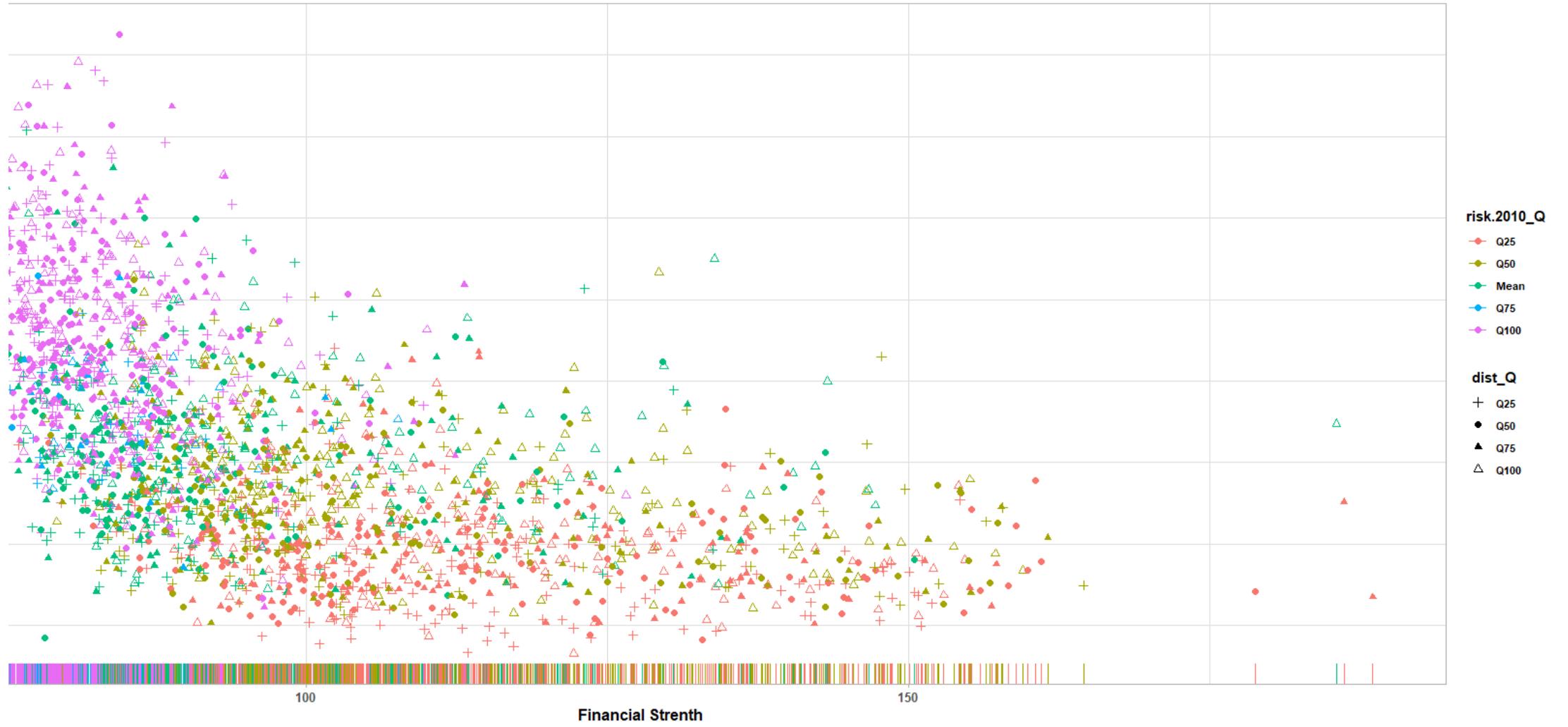
Area Deprivation Index



Financial Strength

67.0 to 84.7
84.7 to 96.7
96.7 to 111.7
111.7 to 132.3
132.3 to 188.5

Relationship Between Economic Inequality and Financial Strength by Stay-at-Home and Posterior Risk of Overdose



First the study regions, \mathcal{S} , is partitioned into $K = 2,324$ non-overlapping areal units

$$\mathcal{S} = \{\mathcal{S}_1, \dots, \mathcal{S}_K\}$$

where each unit contains $J = 3$ response variables and $J = 3$ corresponding offsets

$$Y_k = (Y_{k1}, \dots, Y_{kJ})$$

$$O_k = (O_{k1}, \dots, O_{kJ})$$

The multivariate spatial model is then given by:

$$Y_{kj} | \mu_{kj} \sim f(y_{kj} | \mu_{kj}, v^2), \text{ for } k = 1, \dots, K, j = 1, \dots, J$$

$$g(\mu_{kj}) = \ln(\mu_{kj}) = x_k^T \beta_j + O_{kj} + \psi_{kj}$$

$$\beta_j \sim N(\mu_\beta, \Sigma_\beta)$$

$$v^2 \sim \text{Inverse-Gamma}(a, b)$$

For count variables the link function is the log function $Y_{kj} \sim \text{Poisson}(\mu_{kj})$

Random effects model - Leroux MCAR

Posterior quantities and DIC

Regression equation - $y \sim \text{offset}(\log(\text{E.vec})) + \text{ADI} + \text{SD}$

	OD		GVIO		COVID-19	
	Median	CrI	Median	CrI	Median	CrI
Intercept	-8.434	-9.037 -7.883	-9.140	-9.751 -8.511	-8.508	-9.205 -7.886
ADI	-0.004	-0.008, 0.001	-0.003	-0.010 0.002	-0.004	-0.009 0.002
Stay-at-home	0.019	-1.037,1.018	0.133	-1.175 1.246	-1.821	-3.231 -0.404
σ_{11}	1.020 (0.837, 1.117)					
σ_{22}	7.150 (5.7818, 7.951)					
σ_{33}	6.613 (5.9016, 7.266)					
DIC = 6984.477 p.d = 462.8857 LMPL = -3564.33						

Deprivation and Death

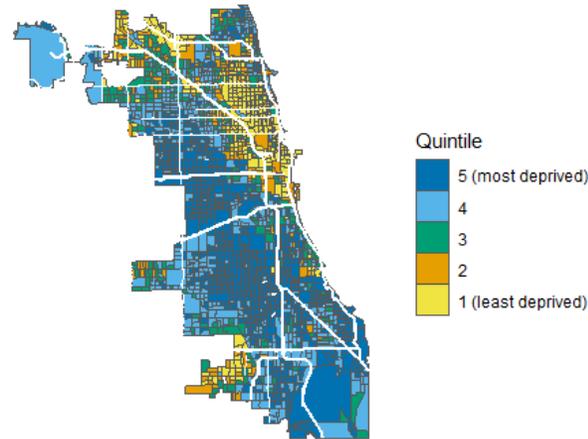
Top Left: Area Deprivation

Top Right: Standardized Mortality Ratios for Opioid-Related Drug Overdose Deaths

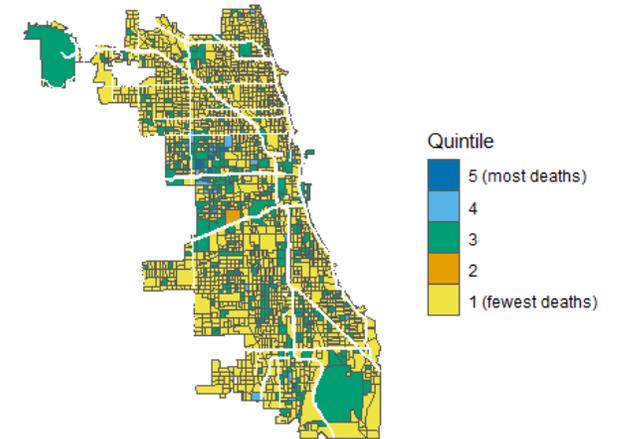
Bottom Left: Standardized Mortality Ratios for Deaths involving gun violence

Bottom Right: Standardized Mortality Ratios for COVID-19 Deaths

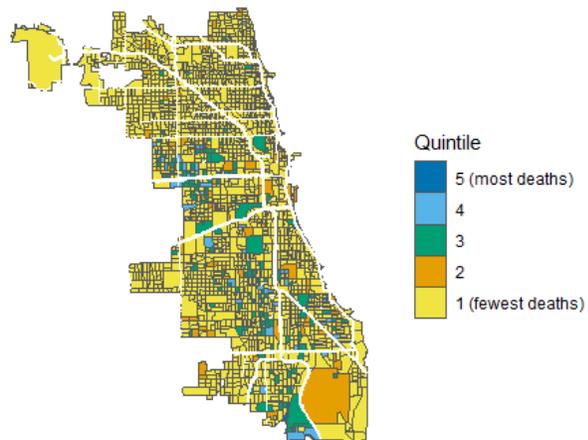
2019 Chicago Area Level Deprivation
ADI Quintiles for Census Block Groups



2020 SMR Overdoses
ADI Quintiles for Census Block Groups



2020 SMR Gun Violence
ADI Quintiles for Census Block Groups



2020 SMR COVID-19
ADI Quintiles for Census Block Groups

