

# Handguns and Hotspots:

## Quantitatively Modeling Gun Crime

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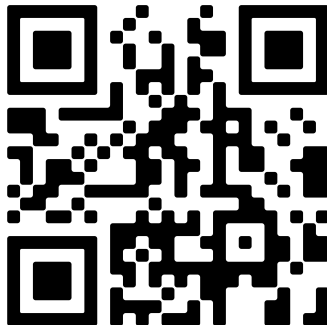
27 March 2021

# Acknowledgements



- Dr. Nathan Pollesch and Café Scientifique
- Dr. Louis J. Gross\*, Dr. Nina Fefferman, Dr. Sergey Gavrilets, Dr. Suzanne Lenhart
- NIMBioS Investigative Workshop: Mathematics of Gun Violence
- UTK Department of Ecology and Evolutionary Biology
- Funding: ASEE NDSEG Fellowship, NIH/NIGMS - IMSD #R25GM086761

shelbymscott.github.io



# Overview

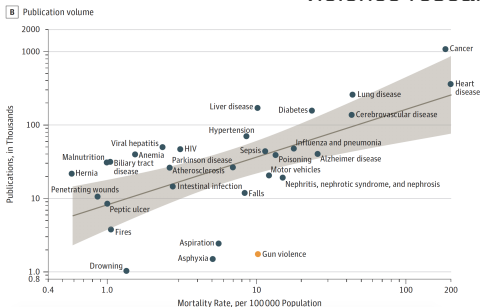
- 1 Introduction and Motivation
- 2 Presentation Outline and Goals
- 3 Question 1: COVID and Crime
- 4 Question 2: Time-based Patterns of Crime
- 5 Question 3: What Are the Underlying Contributors to Crime?
- 6 Conclusions and Future Work

# Introduction (personal)

- B.S. Biomathematics - Rhodes College (2015)
- Undergraduate Research - Agent-Based Modeling of the Santa Cruz Island Fox
- M.S. Statistics - University of Tennessee, Knoxville (2021)
- Masters Project - Bayesian Statistical Analysis of Diabetes Covariates
- Ph.D. Ecology and Evolutionary Biology - University of Tennessee, Knoxville (2021)
- Dissertation Topic - Spatio-temporal Models of Gun Crime in Chicago, Illinois

# The Cost of Gun Violence in the United States

- Gun violence costs the United States \$229 billion annually
- It leads to the death of 36,000 individuals and the non-fatal injury of 85,000 others
- Homicide is the leading cause of death in black males aged 10-24
- 75% of homicides involve the use of a firearm
- (Kellerman 1993) Having a gun in the home increases the risk for homicide occurring in the home
- (1996) Dickey Amendment removes CDC funding for gun violence research



Stark 2017, Joint Economic Committee 2019, APA 2013, CDC 2017, Kellerman 1993

# Missing Quantitative Models in the Literature

Major Question	Mathematical Models						Statistical Models					
	I	II	III	IV	V	VI	I	II	III	IV	V	VI
Analyzing the Spatio-Temporal Distribution	•		•		•		•			•	•	
Impacts of Constraining Gun Availability	•		•	•			•	•				
Effects of Population Characteristics	•		•	•			•	•		•	•	•
Intervention Attempts and their Impacts	•		•				•	•		•	•	•

# Individual Cost of Gun Violence

- Adults reporting exposure to gun violence as children showed an increased likelihood for chronic health conditions and risky behaviors

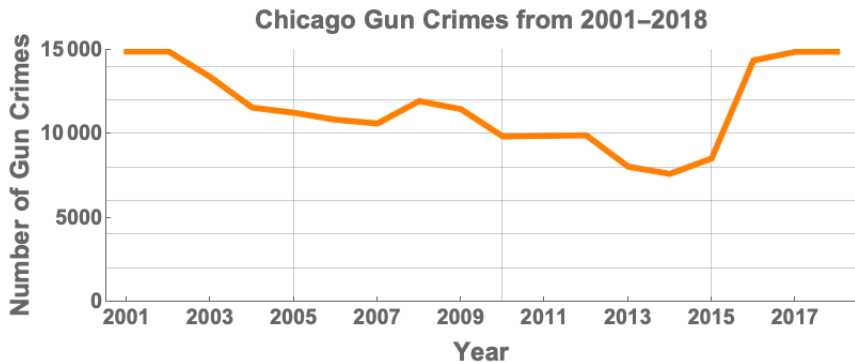
Health Outcome	Risk Increase
Heart Disease	2.2
Stroke	2.4
Chronic obstructive lung disease (COPD)	3.9
Hepatitis	2.4
Ecstasy Use	9.2
Marijuana use	2.9
Poor mental health	2.7
Involvement in juvenile justice system	3.5
Use of substances during sex	6.5
Lack of condom use during sex	2.2

Byrdsong 2016 and Voisin 2016



# The Impact of Gun Crime in Chicago

- Past studies have shown a diffusion of gun crime in both space and time
- Between 2015 and 2016 there was a 68% increase in gun crimes, disproportionately affecting disadvantaged neighborhoods
- Data used for this study:
  - Chicago city crime dataset, 2001 - 2017
  - Selected socio-economic indicators in Chicago, 2008 - 2012



# Project Origin Story

- (2016) Math 582: Mathematical Ecology Class Project
- Create an epidemic model of gun violence in the United States

**Objective (working):** To determine methods to reduce gun violence in a region of the United States while maximizing distribution of guns in that area.

## Methods:

### Use SEIR Model

- Susceptible - Those who own or have access to a gun.
- Exposed - Those who have committed precursor crimes.
- Infectious - Those who have committed acts of violence with a gun.
- Removed - Those who are incarcerated and those who have no access to guns.

### Add Stochasticity

- Attempt to account for lives potentially saved due to gun usage (as in a case where a person uses a gun in order to stop someone from taking a multitude of lives)

### Use OCT

- Discover optimal level of policy to help achieve goal

- Redirection: Use spatio-temporal modeling to observe the epidemic spread of gun crime in Chicago, Illinois.

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# Three Major Questions - The Plan for this Presentation

- Step 1: Introduce the problem
- Step 2: Pose the question
- Step 3: Open the floor for discussion
  - House rule: All discussion must be civil and respectful
  - Based on what you've seen in the news and, more importantly, in your own communities, what do you think the answer to the question will be?
- Step 4: Present my results

## Participation Guidelines

You should keep the following expectations about behavior in mind, which are essential for creating a welcoming and safe environment:

Physical, sexual, and verbal harassment are unacceptable.

Do not discriminate against people because of their identity (e.g. race, gender, sexuality, age, class background, ability, religion, and more).

We expect participants to work together to create a welcoming, inclusive, and safe(r) environment for people from diverse backgrounds.

Ask for consent (i.e. permission) and respect people's boundaries.

Be considerate in your interactions with others and careful about the words you use. Is the language that you're using discriminatory?

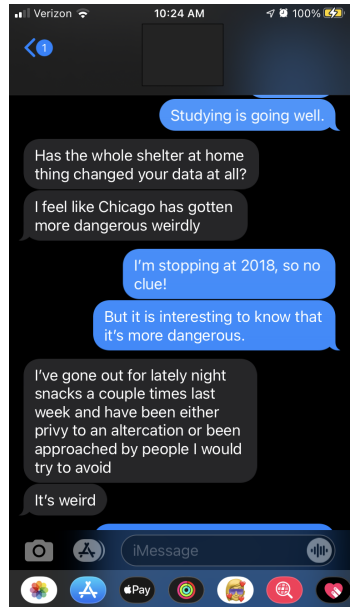
Be mindful of how much time and space you're taking up. Be aware of the dynamics of power and privilege, and whether you're taking advantage of it.

# Q1: Introduction

- March 26, 2020: Text from friend in Chicago
- April 3, 2020: Meeting with advisor, during which this topic was mentioned
- July 31, 2020: First manuscript submitted to Science for publication

## The Takeaways:

- Research ideas can come from anywhere
- “A quick little paper,” is never quick
- In fact, a quick little paper can become a dissertation chapter

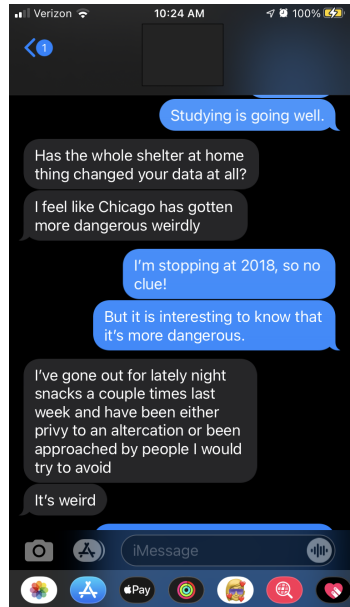


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# Impact of COVID-19 on Crime

- January 24, 2020: First case of COVID-19 in Chicago
- March 9, 2020: State of Emergency declared
- March 21, 2020: Stay at Home order implemented
- **Question 1a:** In the initial time period following implementation of the stay-at-home orders, did crime change?
- **Question 1b:** Were different crime types impacted differently than others?

# Discuss!

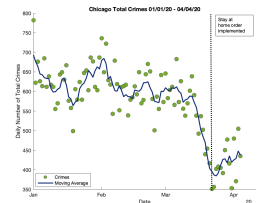
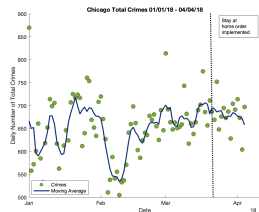
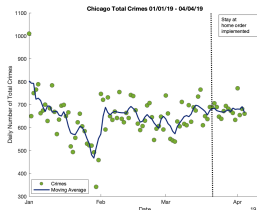
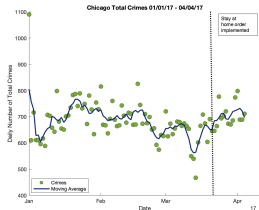


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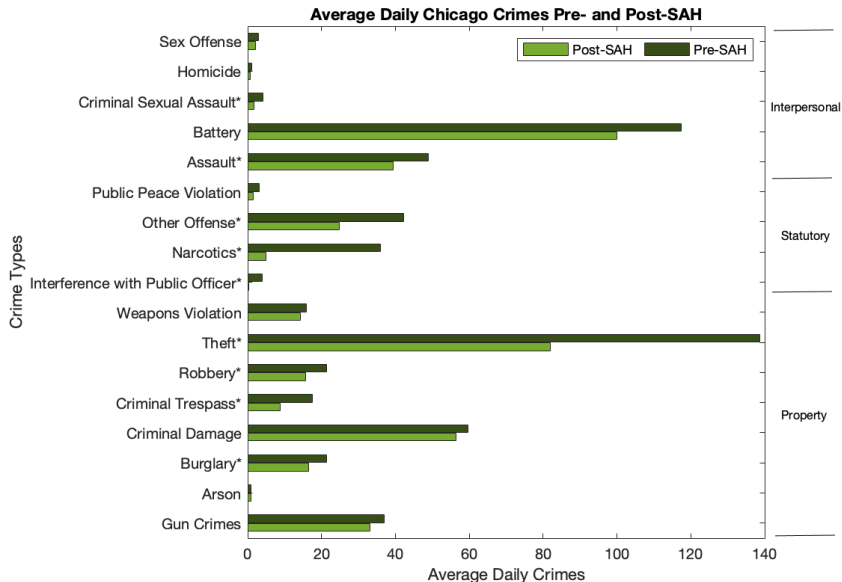


# Impact of COVID-19 on Crime

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# Do the Impacted Crime Types Differ?



# Q2 Introduction

- There are multiple claims about temporal patterns of gun crime in Chicago, IL.
- **Q2a:** Are there variations in crime over years, months, and days?
- **Q2b:** Are there certain holidays that show higher (or lower) numbers of crime than others?

## Experts Discuss Cook County Gun Violence: 744 Deaths In 2017

Leading clinical experts gathered in Cook County this week to discuss gun violence as a public health issue.



Carrie Frillman, Patch Staff

Posted Thu, Feb 1, 2018 at 10:09 am CDT

## Chicago's brutal summer of gun violence

7:30 / By Bridget Brennan

Posted Tue 2 Oct 2018 at 3:03pm, updated Tue 2 Oct 2018 at 5:47pm

## 36 people shot in Chicago over Memorial Day weekend, marking a reduction in gun violence

Aamer Madhani USA TODAY

Published 11:05 a.m. ET May 29, 2018 | Updated 1:59 p.m. ET May 29, 2018

## 43 shot, 5 fatally, in Halloween weekend gun violence

Published October 28, 2018 | Chicago | FOX 32 Chicago

## Chicago shootings leave at least 4 dead, 12 wounded over MLK weekend

## Chicago's deadliest Memorial Day weekend since 2015: 10 shot dead, 39 wounded

The weekend's victims include a 16-year-old boy killed Saturday in Washington Park and a man fatally shot in a Lawndale attack that injured three others.

By Sun-Times Wire | Updated May 26, 2020, 9:22am CDT

# Discuss!

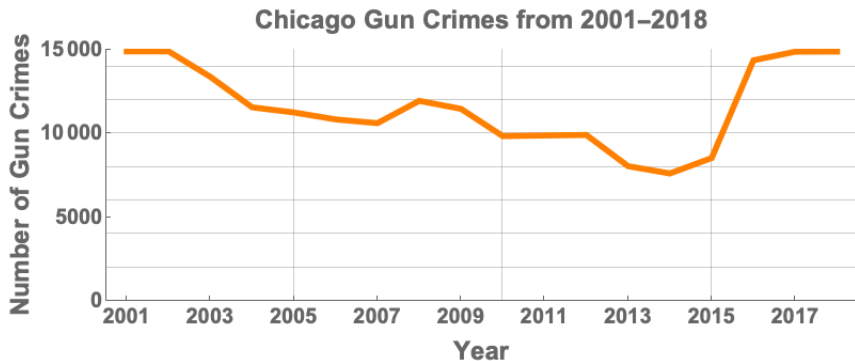


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# Temporal Analysis Results

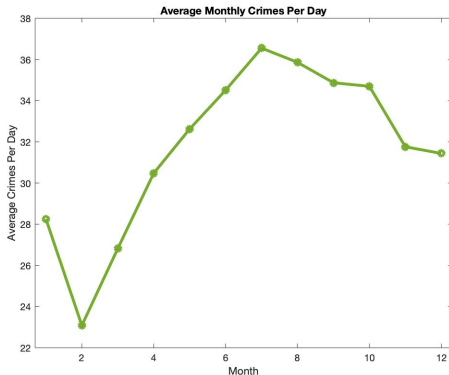
- Are there yearly patterns in gun crime?
- Method:  $t$ -tests



- **Yes**
- Significantly higher years: 2001, 2002, 2016, 2017, 2018
- Significantly lower years: 2013, 2014, 2015

# Temporal Analysis Results

- Are there monthly patterns in gun crime?
- Method:  $t$ -tests



- **Yes**
- February has significantly lower crime than other months

# Temporal Analysis Results

- Are there daily patterns in gun crime? Are there holiday patterns?
- Method: outlier analysis
- and  $t$ -tests

Holiday	Month	$p$ -value	CI	$\sigma$	$t$ -stat	Result
New Year's Eve	December	0.43	$[-3.64, 8.32]$	8.83	0.80	0
<b>New Year's Day</b>	January	$9.8523 \times 10^{-5}$	$[6.39, 17.32]$	8.07	4.41	1
Memorial Day	May	0.33	$[-3.86, 11.27]$	11.17	1.00	0
July 4 <sup>th</sup>	July	0.58	$[-4.95, 8.74]$	10.11	0.56	0
Labor Day	September	0.69	$[-5.04, 7.53]$	9.28	0.40	0
Halloween	October	0.09	$[-1.07, 13.46]$	10.73	1.73	0
<b>Thanksgiving</b>	November	$4.05 \times 10^{-5}$	$[-16.67, -6.62]$	7.41	-4.71	1
<b>Christmas</b>	December	$3.04 \times 10^{-7}$	$[-15.98, -8.23]$	5.72	-6.35	1

- Yes, but not as much as the media reports
- There do not seem to be patterns in which days are outliers between years
- New Year's Day shows significantly higher crime than the rest of January
- Thanksgiving and Christmas show significantly lower crime than the months in which they fall
- When extended to a moving average, many of these patterns dissolve

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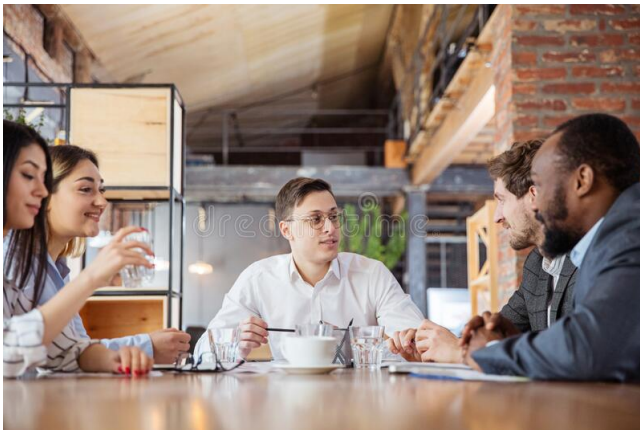
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# Which socio-economic conditions impact the number of gun crime events?

- Method: Negative Binomial Regression with Subset Selection
- Factors tested:
  - Crowding
  - Poverty
  - Unemployment
  - Education level
  - Dependents
  - Per capita income
- **Q3:** Which of these socio-economic factors contribute to gun crime and why?

# Discuss!



# Q3 Results

- Method: Negative Binomial Regression with Subset Selection
- Factors tested:
  - Crowding
  - Poverty
  - Unemployment
  - Education level
  - Dependents
  - Per capita income

Predictor	Coefficient
Poverty	1.0344
Unemployment	1.1123
Dependents	- 0.9477

## Regression Results

$$\log(\# \text{ Gun Crimes}) = 4.1258 + 0.0338 * \text{poverty} + 0.1064 * \text{unemployment} - 0.0537 * \text{dependents}$$

# Model Conclusions

- **Q1:** Did the implementation of stay-at-home orders in response to COVID-19 impact crime dynamics?
- **A1:** Yes. Crime declined in the first two weeks following implementation, but the types of crimes that showed changes were property and statutory over interpersonal.
- **Q2:** Are there temporal patterns of Chicago gun crime?
- **A2:** Yes, sort of. Significant events impact gun crime patterns, but there is some inflation of broader observations.
- **Q3:** Which socio-economic factors contribute to gun crime and why?
- **A3:** Poverty, unemployment, and dependents are all significantly correlated with the number of gun crimes occurring in each community, but the "why" is not as clear.

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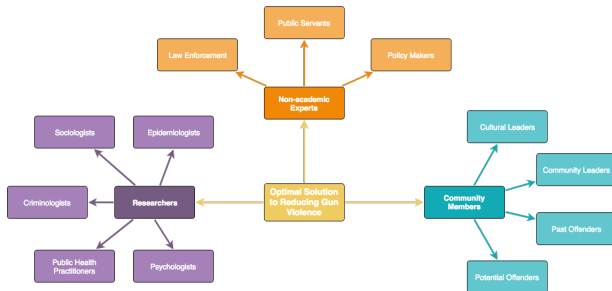
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# Research Conclusions

- Gun crime and gun violence are major public health concerns in the United States
- There is a lack of research on gun crime in the United States
- There are far more factors contributing to gun crime outside the availability of guns
- This is all incredibly complicated. Evidence-based policy is the goal, but it may not be easily accessible.



# Questions?

