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CE Paper
GSW in IL

Trends in Gun Shot Wound Related Emergency Department Visit in Illinois.

Abstract:

Introduction: Gun violence is the lowest it's been in the past 50 years across the US. However, the number of circulating guns is the highest it's been, and gun violence endemics continue to exist in high crime cities like Chicago, with 2016 having one of the highest homicide rates in the city's history. Historically, gun crime was attributed to demographic risk factors, but recent research has suggested that social networks play a significant role in propagating gun violence and may serve as a crucial point of intervention.

Study Aims: The study aims to utilize a novel hospital-based database to track the gun violence-associated burden on the healthcare system.

Methods: The Illinois Hospital Association Health Care and Hospital Data Reporting Services (COMPdata) data for 159 non-federal hospitals was used to analyze trends in ED Gunshot Wound visits over a 27-month period. A Poisson regression was performed to identify Incidence rate ratio (IRR) of mortality and inpatient hospital admission from GSW-related ED visits.

Results: The summer of 2016 recorded the greatest number of GSW-related ED visits, with August of 2016 having 389 visits. Overall, assault GSW accounted for 89.1% of all visits, with Cook County accounting for the greatest number of ED visits. There was no significant difference in mortality by patient groups, however, Hispanics and Medicaid/Medicare patient had significantly higher inpatient admission IRR.

Discussion: Gun violence in Illinois is mostly attributable to spike and drops within the city of Chicago. Hospital data are one approach to track gun violence within the state of IL, and the ED can provide an important venue for addressing social risk factors associated with gun violence.

Introduction:

Public Health Relevance

The United States continues to have one of the highest fire-arm related crime across the world. Gunshot wounds (GSW) account for over 30,000 deaths and 67,000 injuries in the United States annually. (1-3) Recent data showed a total death toll of 313,045 between 2003-2012, with societal costs estimated at \$174.1 billion in 2010. Despite these numbers, the United States is now at the safest point it has been in over the past 50 years. The mortality rate from firearms has been practically unchanged since the

large spike and drop that occurred in the mid 1970s and early 1990s. (4, 5) Compared to the firearm mortality rate of around 14 per 100,000 persons in the 1973-1975 and around 15 per 100,000 persons in 1993, the firearm mortality rate in the United States has declined to about 10 per 100,000 persons. (4) Despite the overall decline in crime, there has been a slight increase in firearm mortality from about 10 per 100,000 persons to about 12.0 deaths per 100,000 persons between 2010 and 2017. In 2017 alone, the total number of deaths in the United States from firearm-related injuries was 39,773, which accounts for about 15.4% of all global firearm deaths (2, 6). Firearm injuries mostly affect men with the age-adjusted mortality rate being 6.0 times that for women.

The two main causes of firearm deaths were suicide and homicide, accounting for 59.3% and 37.3% of firearm deaths respectively.(2) This excessive mortality rate is positively correlated to the number of circulating guns within the United States. Many studies have identified firearm ownership is a major risk factor associated with increased rates of homicide and suicides. (7-10) This poses a major public health concern for a nation that is flooded with circulating guns. The latest data from the 2016 small arms survey shows that the United States led all nations in number of guns circulating with more guns available than there are people at 393,300,000; India was second at 71,100,000. (11) Of these, about 122 million guns were either new or imported acquisitions since 2006. This combination of increasing gun availability and consistent endemic gun violence within the US is a major public health concern. In particular, urban crime places an immense burden on healthcare facilities who serve low income, minority residents.

Gun Violence in Chicago

Within the United States, Chicago is one city that is all too familiar with gun violence. Chicago's long history of gun violence dates back to the early 1900s, but it was part of the national trends in declining homicide that were occurring in almost all American cities since the peak years of the early 1990. (12) However in 2016, Chicago experienced a sudden significant spike in gun violence, raising statewide firearm mortality to 1,490, a rate of 11.7 per 100,000. (13) The homicide rate that year represented a 62% rise in GSW-related homicide from 2015, despite 2013 being Chicago's lowest homicide rate in 4 decades. (14, 15). The Chicago neighborhoods of Austin, Garfield Park, North and South Lawndale, Englewood and West Pullman alone accounted for over 50% of all Illinois shootings in 2016. (16)

Social Causes of Gun Violence and Social Network Analysis

Although historically gun violence has always been attributed to 'long term trend' factors like availability of guns and segregated high poverty areas, the lack of changes in these factors provoked scrutiny about both the specific causes and the underlying epidemiology of the 2016 Chicago spike in shootings. (12) However, it is important to

recognize gun violence as a spatially dependent process that is impacted by positive and negative influences of both neighborhood demographics as well as social networks. Research studies have suggested social networks may play a crucial role in gun violence involvement. One study of arrest records found that 63.1% of 11,000 shootings were due to individuals that were a part of co-offending networks. (17) Each individual was associated with a mean cascade of 2.7 subjects, from which those subjects led to other gun violence cascades, with one cascade involving 469 subjects. Another observational study found that 70 percent all nonfatal gunshot victims were from co-offending networks that comprised less than 6 percent of the city's population. (18) These 'social contagion' findings suggest that public health approaches involving community-based interventions within specific high-risk neighborhoods networks could be much more effective in reducing gun crime.

Study Aims

This study was undertaken in response to the spike in shootings that occurred in 2016. The study aims to utilize a novel database to track the burden of gun violence on the healthcare system by examining ED visits for GSW and hospital deaths and inpatient admissions that are results of these visits. While most studies use police crime statistics to analyze the effects of gun violence on communities, this study uses Illinois Hospital Association data for GSW coded Emergency Department (ED) visits at 159 Illinois hospitals. We analyze data from a 27-month period that includes the 2016 Chicago shooting spike and its aftermath, from January 2016 to March 2018. The data will be used to examine trends in GSW-related ED visits over the study period, display likelihood of inpatient admissions and hospital deaths after GSW ED visits, and map residential zip codes of patients presenting to EDs with GSW.

Methods:

Data Source and Gunshot Wound Codes

The data for this study were derived from the Illinois Hospital Association Health Care and Hospital Data Reporting Services (COMPdata) for all Emergency Department visits at 159 non-federal Illinois hospitals. (19) Identification of GSW was based on International Statistical Classification of Diseases diagnosis E-codes (ICD 10) obtained for ED visits occurring between January, 2016 and March, 2018. The ICD 10 codes for firearm assault, X93-95, suicide, X72-74, unintentional injury, Y22-23, and legal interventions, Y35, were used to determine specific GSW categories. The FY 2019 ICD-10-CM code handbook by the National Center for Health Statistics (NCHS) was used to define each of the firearm categories listed above. Legal interventions were defined as "any injury sustained as a result of an encounter with any law enforcement official,

serving in any capacity at the time of the encounter, whether on-duty or off-duty, including any injury to a law enforcement official, suspect or bystander.”

Patient Characteristics

Categorical age, insurance type, race & ethnicity, and IL region groups were created. Patients’ age was categorized as under 19, 20-34, 34-64, and 65+. Patients’ insurance status included private insurance, Medicare insurance, Medicaid insurance, uninsured status, or other/unknown. Patients’ race and ethnicity were categorized as Non-Hispanic whites, Non-Hispanic Blacks, Hispanic, or Other/Unknown. Illinois regions were categorized as Cook county, the other five Chicago metro area suburban ‘Collar’ counties, and ‘downstate’ as all remaining counties in IL. Other variables from the data set that were utilized included weekend ED visits, discharged dead, and inpatient admissions through the ED. Finally, we categorized low-income based on patients’ zip code-estimated median household income < 35,000 using the 2016 5-year American Community Survey census data.

Data Analysis

Monthly time trends for total, category-based, and region-based GSW related ED visits over the 27-month study period were graphed. Heat maps based on residential zip codes were generated to identify areas with the highest firearm-related injury burden. STATA 14 statistical software (College Station, TX) was used for all analyses. A Poisson regression model was used to estimate incidence rate ratios (IRRs) for the likelihood of deaths and inpatient hospital admissions controlling for patient characteristics and with standard errors adjusted for clustering of observations within hospitals. ([20](#))

Results:

Patient Characteristics

Table 1 highlights the characteristics of patients within each GSW category. There were 7,335 GSW Emergency Department Visits at the 159 IL hospitals recorded between January 2016 and March 2018. These ED visits included 6,533 visits coded as assault GSW (89.1%), 229 coded as attempted suicide GSW (3.1%), 527 coded as unintentional firearm GSW (7.1%), and 46 coded as legal GSW visits (0.6%). A significantly disproportionate number of assault cases occurred in males, individuals between age of 18-45, low income individuals, and non-Hispanic blacks.

Trends in GSW-related ED Visits

Figure 1 highlights trends in GSW-related ED visits by GSW category. Most trend variations in GSW over the 27-month study period occurred among ED visits coded for assault, meanwhile non-assault GSW ED visits remained stable over the study period.

Trends in GSW-related ED visits coded for assault displayed a pattern of escalation in frequency during summer months and de-escalation during winter months. August 2016 recorded the highest number of assault GSW visits (353) and February 2018 recorded the lowest (126) highlighting the downward trend in GSW across the state after the 2016 spike in shootings in Chicago. Figure 2 highlights the trends in GSW-related ED visits by IL hospital region. As expected, a preponderance of ED visits for GSW were in Cook county hospitals, with a similar trend to assault-coded GSW ED visits. Downstate Illinois and Collar County hospitals had stable GSW-related ED visits without much variation. Despite the variation in the number of ED visits by GSW category and region, there was little variation in mortality trends over the 27-month study period for GSW ED patients, with no decline in mortality from 2016. However, there was a significant increase in hospital admission from 107 in January 2016 to 170 in August 2016, followed by a steady decline over the remaining study months down to 75 in March 2018 as depicted in Figure 3.

Hospital Admissions/Deaths

Table 2 highlights the results of the Poisson regressions for hospital mortality and for GSW-related inpatient admissions from the ED. Adults over 65, compared to 20-34-year-old reference group, and uninsured patients, compared to privately insured patients, were the only groups with significantly higher mortality IRR. Assault GSW patients were much more likely to survive compared to non-assault GSW patients, with significantly lower mortality IRR. There were no significant differences in mortality IRR by sex, race/ethnicity, region, income, days of week, or the biannual month period breakdowns between January 2016 and March 2018. However, there was significantly higher IRR for inpatient admission among males, assault GSW patient, adults age 34-65 compared to those aged 20-34, and Medicaid & Medicare patients compared to privately insured patients. Conversely, uninsured patients had significantly lower IRR for inpatient admissions compared to privately insured patients.

Residence Heat Map of ED Visit Patients

Figure 4 displays a heat map of ED visits for GSW by residential zip codes of patients. Most GSW patients were found to be clustered around four neighborhood zip codes with the highest number of GSW ED visits (>250) being in the south and westside neighborhoods of Chicago. Surrounding neighborhoods were found to have an incremental decrease in ED visits with increasing distance from the four neighborhood clusters with the highest number of ED visits. Additionally, data analysis of facilities showed a disproportionate number of GSW-related ED visits, with some hospitals having significantly greater number of GSW ED visits compared to others. Two facilities with disproportionately higher number of GSW-related visits were Mount Sinai Hospital at 1299 visits and Advocate Christ Medical Center at 1606 visits.

Discussion:

Gun violence is quite often researched through the perspective of crime reports and safety. However, it is much less frequently looked at from the perspective of healthcare and Emergency Department visits. This study utilized a novel, hospital-based dataset to track the burden of gun violence on the Illinois hospital system. The use of hospital data, which includes patient address data, can provide a unique approach to public health interventions through targeting ‘social’ risk factors that are often missed through crime reports.

The findings in this study display similar characteristics to those identified in crime statistics data. Summer months tend to have increased ED visits for GSW compared to winter months. This is expected as gun violence is more frequent during warmer weather. Within the 27 months study period, overall trends in ED visits for GSW within the state of Illinois were relatively stable for Collar counties, downstate Illinois, and non-assault related GSW visits as shown in Figure 1. Assault-related GSW ED visits were much more variable but demonstrated an overall declining trend after the 2016 Chicago shooting spike. Figure 4 emphasizes the burden is highest for patients living within specific zip codes in Cook county, with most GSW ED visit patients living in the following zip codes: 60628, 60620, 60644, 60623. Although the data accounts for each ED visit, it does not include a Master Patient Index, or MPI; therefore, we are unable to identify high-risk individuals with multiple visits or enable identification of ‘social contagions.’ These findings do suggest, however, that gun violence in the state of Illinois is mostly driven by assault-related violence in the high-risk neighborhoods of the Chicago metropolitan area. It also highlights the disparities that exist in gun violence among the young adult black male population residing in the south and westside neighborhoods of Chicago. Although demographics and socioeconomic status are often the talking points behind such findings, special considerations should be placed on the influence of gun availability and ‘social ties’ in propagating such crime.

Healthcare Burden

There were significantly increased admissions from the ED during the 2016 shooting spike compared to subsequent months in 2017 and 2018 as shown in Figure 3. Despite the 2016 shooting spike however, there was no significant differences in mortality after admission for sex, race/ethnicity, time of ED visit, month of ED visit. However, there was an increased mortality IRR for adults over 65 years old compared to 20-34-year old patients and uninsured patients compared to privately insured. This higher mortality among the elderly is to be expected, as elderly trauma patients requiring general surgical procedures tend to have worse health outcomes. ([21](#), [22](#)) However, the uninsured population experienced both higher mortality IRR and lower inpatient hospital admission

IRR. This is likely the results of increased inter hospital transfers and longer transfer times to level 1 trauma centers for uninsured patients, both which have been associated with increase mortality. (23-27) Furthermore, the patients from the four zip codes with the highest GSW ED visits alone accounted for 16.7% of all the GSW ED visits by the uninsured population in the dataset. Research studies have demonstrated that nonclinical factors, namely uninsured status among the young adult population and disability in the Medicare population, were associated with lower likelihood of admission among trauma patients (25). This is reflective of a major disparity among these high-risk population, and it underlines an extremely high healthcare burden for trauma centers within these regions. However, this data does not account for the newly opened University of Chicago level 1 trauma center, and its effect in ameliorating these disparities. It would be interesting to follow up this data with trends after the opening of the new trauma center. The results also showed significantly higher inpatient hospital admission IRR from ED visits for males, assault GSW patients compared to non-assault, adults 30-64 years old compared to 20-34-year-old adults, and Medicaid and Medicare patients compared to privately insured patients. These patient populations are likely more reflective of the high-risk neighborhood patient populations that are experiencing more severe gunshot trauma warranting additional inpatient care.

Gun Availability

Despite all the gun violence in Chicago, Illinois remains as one of states with the tightest gun control laws in the nation. Illinois state laws require permits to purchase, permits to carry, and background checks on all individuals interested in purchasing hand guns. (28, 29) Furthermore, there is a 72-hour waiting period for obtaining a gun license permit, and it does not allow for open carry gun permits or out-of-state permits. (28, 29) Despite this, access to guns is permeable to state lines, making state governed gun control laws extremely difficult to police. This is evident in Chicago as the gun trace report from 2017 found that only 2 out every 5 crime-related firearms could be traced back to an Illinois point of sale. This means that about 60% of firearms recovered from crime scenes in Chicago are from out of state, with Indiana accounting for 20% of all firearms recovered. (30) Furthermore, the second and third highest specific gun suppliers for firearms recovered from crime are located in Indiana near some of the south-side neighborhoods with some of the highest gun violence related crime rates. These statistics highlight the complexity of the problem and difficulty in controlling gun violence in Illinois considering a national climate with loosely-regulated gun control laws.

Solutions to Gun Violence

Historically, crime has been resolved by the police forces. However, recent rise in tension between high-risk minority groups and police due to frequent excessive use of force has built a culture of distrust in policing among minorities, which decreases

willingness to cooperate. Recent studies have shown that African-Americans in Chicago are more likely to file complaints of excessive use of force and are less likely to have their complaints sustained. (31) This reflects a racial gap that exist in treatment of high-risk groups that likely makes it both difficult to foster relations between communities and the police department and to find solutions to an active public health concern. However, as suggested by Papachristos, a ‘social contagion’ based approach is a key point of intervention that may play a proactive role in bridging such gaps and reducing the endemic gun violence in such high-risk neighborhoods. (17) One suggested intervention that has been successfully implemented in Washington D.C. is forming a civilian review boards that evaluate police efforts and helps hold police accountable in order to build community efforts.(32) Although this currently exist in Chicago, ineffective oversight board and weak police regulations has limited the effectiveness of such a system. Robert Vargas highlights in his book ‘Wounded City’ that political and gang turf wars play a major role in combating crime as well. The geographical disconnect from nonprofits and political structures intended to combat violence allows for gangs to take control and propagate the violence cycle. Therefore, community blocks that are able to mobilize residents and transform public spaces into nonprofit organization that combat crime have been able to proactively reduce crime rates and increase safety. (33) Cure Violence is an example of an active public health prevention program that utilizes community members to establish relations with high-risk individuals and alter the ‘social contagions’ that may influence their behavior. The program has been effective in reducing crime in 4 of 7 sites where it has been implemented mainly due to its ability to target high-risk adolescents. Survey results from the program found 82% of clients were previously arrested and 45% had five or more prior arrests. (34, 35) This reflects the importance of identifying and tracking high-risk individuals as a point of intervention. Utilizing hospital data may allow for earlier detection of such high-risk individuals and for implementing proactive interventions during the ED visit that are more effective in reducing gun violence.

Study Limitations

First and foremost, our data are only on GSW that reach emergency departments. Therefore, it does not account for direct mortality at scene of crime. Additionally, there is no follow up data for patient visits to identify the long-term effects of GSW on patients. Therefore, one cannot account for delayed mortality outcomes or repeated hospitalizations. As mentioned above, the data does not include a master patient index, and therefore, we are unable to determine return rates or multiple visits of high-risk patients involved in gun violence. There are also no measures of physical and mental outcomes after trauma to assess morbidity. These are important factors to consider as gun violence trauma is associated with significant short-term and long-term physical and psychological distress. (36-38) Also, the data provides the residential zip codes and not direct location of crime. Therefore, it may not directly represent the zip codes where the

crime occurs. However, it does represent the zip codes where most patients live, and therefore, it may serve as a measure of social influences on gun violence and a point of intervention for future prevention of gun violence. Finally, the data is dependent on accurate documentation by healthcare workers on the reason for the ED visit and the type of GSW inflicted. Therefore, the data is likely underestimating the true burden of GSW on healthcare as things are often missed in documentations or recorded differently in different centers.

Conclusion

In conclusion, the United States has experienced a major reduction in crime over the past few decades with many major US cities having much lower homicide rates compared to the past. Chicago continues to experience high levels of assault-related crime, with high burden on Emergency Department by patients from high-risk neighborhoods. The burden is concentrated at a few medical facilities that account for a disproportionate share of total ED visits with most patient residing in 4 high-risk zip codes. Although no significant difference in mortality is found between different patient groups, these data do not account for mortality at the crime scene or long-term morbidity after the initial event. Most effective interventions have been focused on community involvement and targeting high-risk individuals. Therefore, utilizing a universal hospital dataset with MPIs may allow for identification of high-risk individuals and earlier, proactive social interventions to prevent gun violence.

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Table 1. Patients' Characteristics for GSW ED Visits by Category (Percent)

	Assault (n=6,533)	Suicide (n=229)	Unintentional (n=527)	Legal (n=46)	Total (n=7,335)
Sex*					
Male	89.27	83.41	87.67	97.83	89.18%
Age**					
19 & Under	21.78	12.66	16.13	19.57	10.16
20-34	58.38	28.38	40.61	58.70	41.25
35-64	18.77	37.12	33.97	21.74	22.13
65+	1.07	21.83	9.30	0.00	16.44
Race/Ethnicity**					
Non-Hispanic White	5.95	71.18	45.54	19.57	10.92
Non-Hispanic Black	75.92	13.10	31.50	56.52	70.65
Hispanic	8.02	4.80	8.16	15.22	7.98
Other/Unknown	10.10	10.92	14.80	8.70	10.46
Insurance**					
Private	22.03	34.50	41.18	21.74	23.79
Medicaid	51.78	25.76	28.84	45.65	49.28
Medicare	3.06	27.51	10.82	10.87	4.43
Uninsured	21.86	10.04	16.70	21.74	21.12
Unknown	1.27	2.18	2.47	0.00	1.38
Region**					
Cook	76.96	23.14	42.69	63.04	72.73
Collar Counties	5.30	18.34	13.85	8.70	6.34
Downstate IL	17.74	58.52	43.45	28.26	20.93
Admitted**	41.08	53.71	20.11	32.61	39.92
Deceased**	6.72	41.05	2.47	15.22	7.54
Zip Code Median	43.85	6.57	21.77	9.09	40.99
Income <\$35,000**					
Weekend*	37.12	27.51	34.35	30.43	36.58

Data Source: Illinois Hospital Association Health Care and Hospital Data Reporting Services (COMPdata)

* $p < 0.05$ using χ^2 .

** $p < 0.0001$ using χ^2 .

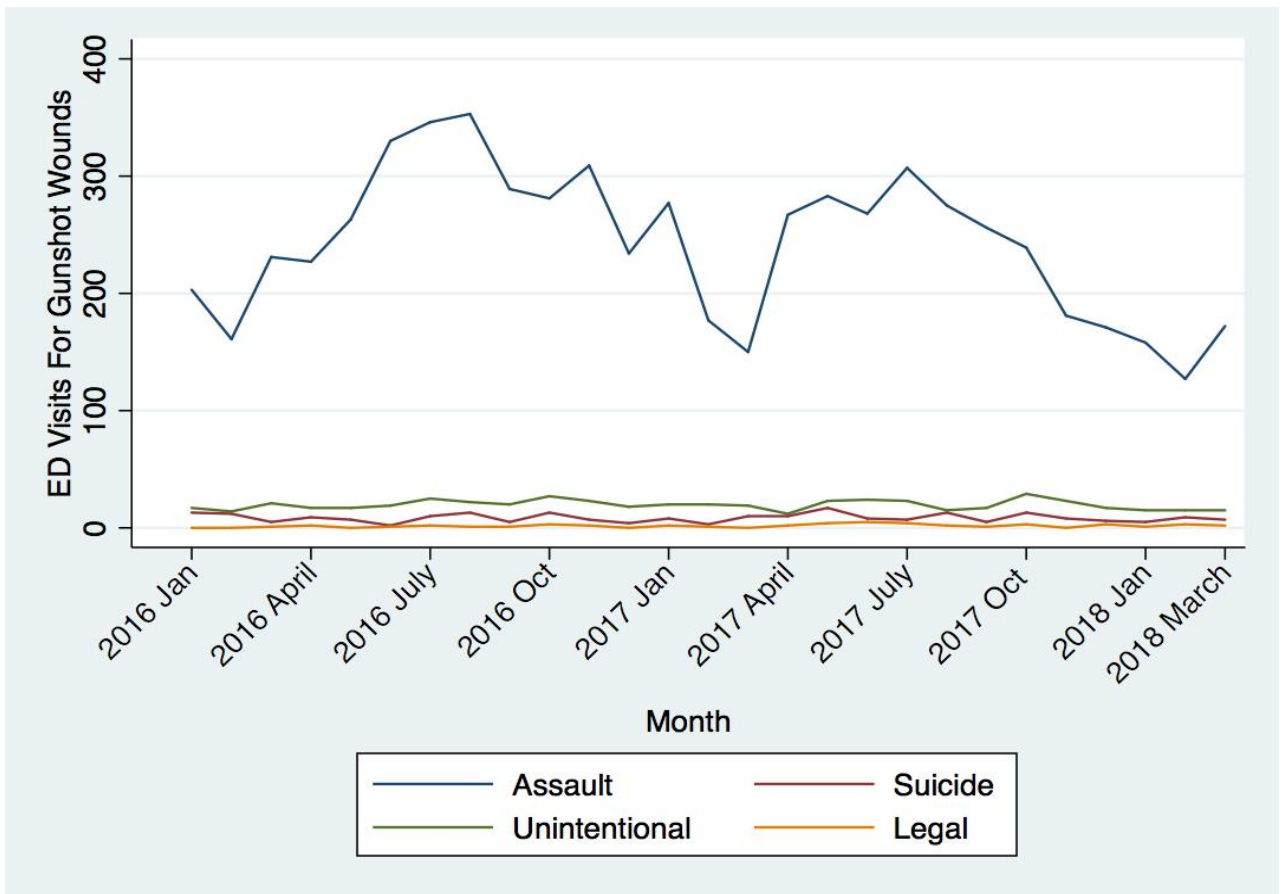


Figure 1. Emergency Department GSW monthly trends by GSW category.

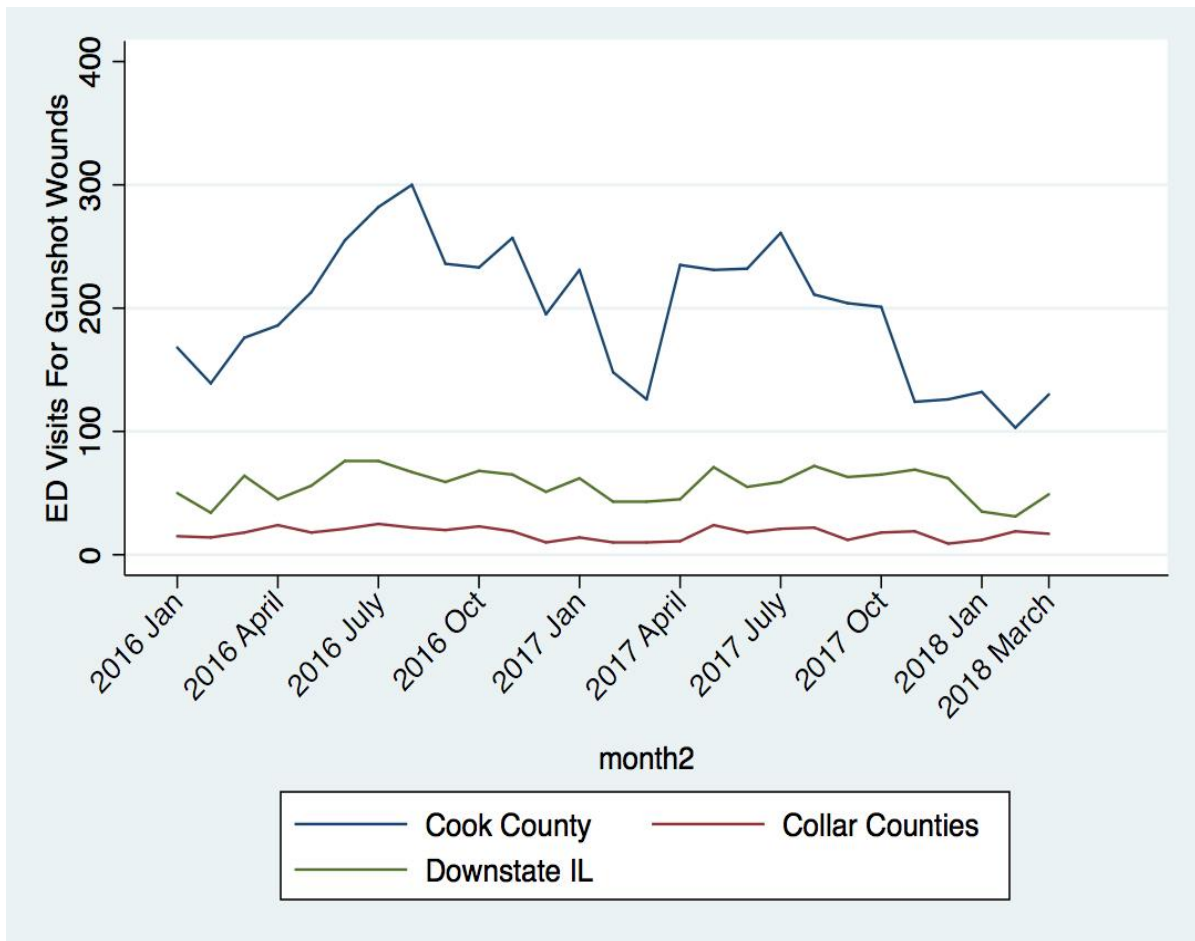


Figure 2. Emergency Department GSW monthly trends by Illinois Region.

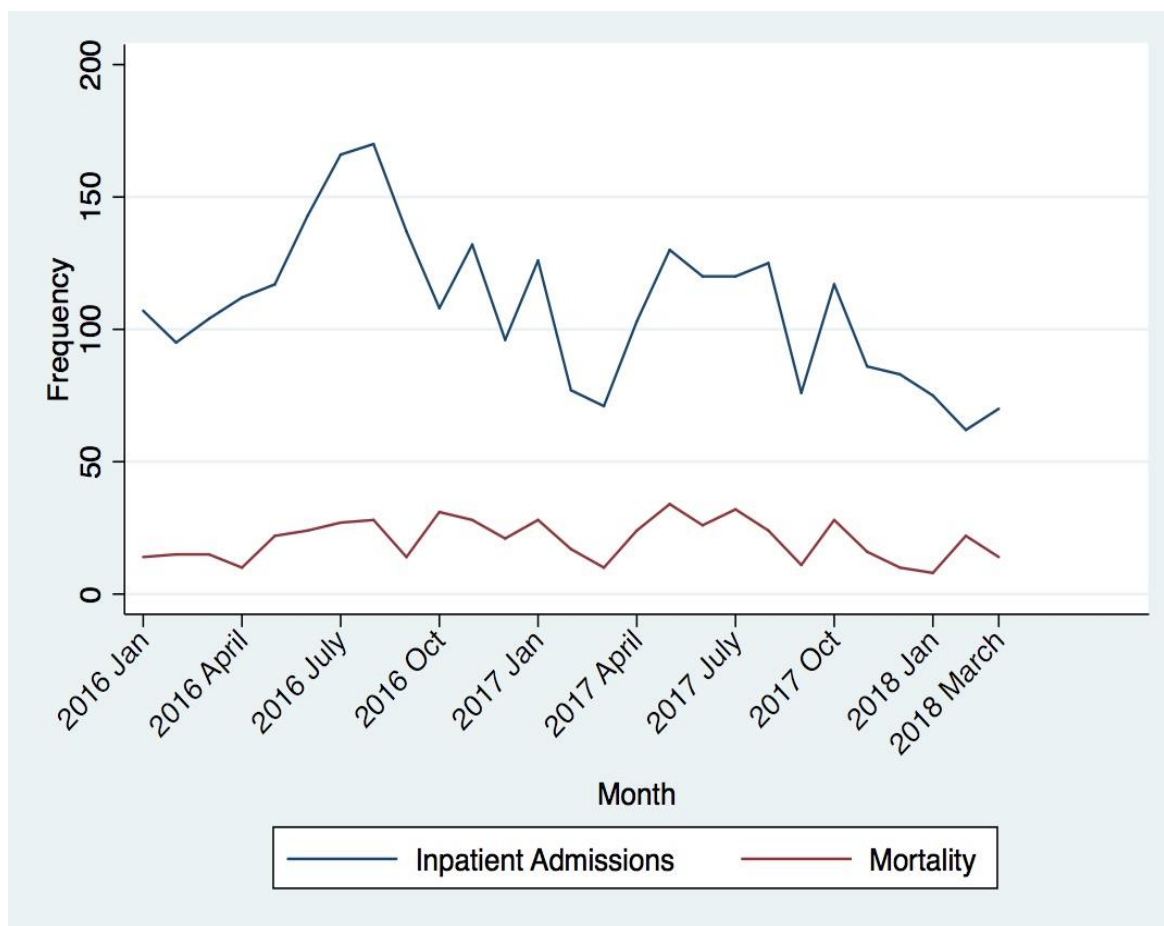


Figure 3. Monthly Trends for Inpatient Admissions and Mortality after GSW ED Visits.

Table 2. Inpatient Admissions and Mortality Incidence Rate Ratios for GSW ED Visits

	Hospital Admission IRR (95% CI)	Deaths IRR (95% CI)
Sex		
Male	*1.19 (1.09-1.31)	1.09 (0.85-1.39)
Female	(Reference)	(Reference)
Type of GSW		
Assault GSW	*1.38 (1.10-1.99)	*0.56 (0.41-0.76)
Non-Assault GSW	(Reference)	(Reference)
Age*		
Under 19	1.02 (0.96-1.08)	1.10 (0.95-1.27)
20-34	(Reference)	(Reference)
35-64	*1.17 (1.05-1.31)	1.04 (0.76-1.42)
65+	1.23 (0.99-1.51)	*2.34 (1.54-3.54)
Race		
Non-Hispanic White	(Reference)	(Reference)
Non-Hispanic Black	0.97 (0.80-1.17)	0.79 (0.53-1.16)
Hispanic	1.18 (0.96-1.45)	0.63 (0.39-1.00)
Other	0.98 (0.80-1.17)	0.86 (0.59-1.33)
Insurance*		
Private	(Reference)	(Reference)
Medicaid	*1.13 (1.02-1.26)	1.10 (0.76-1.59)
Medicare	*1.43 (1.17-1.75)	0.94 (0.61-1.44)
Uninsured	*0.55 (0.45-0.68)	*2.03 (1.57-2.64)
Unknown	0.67 (0.36-1.19)	0.31 (0.09-1.02)
Area*		
Cook	(Reference)	(Reference)
Collar Counties	0.87 (0.69-1.10)	1.10 (0.71-1.70)
Downstate IL	0.91 (0.67-1.24)	0.95 (0.57-1.56)
Zip Code Median Income		
>\$35,000	(Reference)	(Reference)
<\$35,000	*1.01 (1.00-1.01)	1.00 (0.997-1.01)
Day of Week		
Weekday	(Reference)	(Reference)
Weekend	1.05 (0.98-1.14)	0.89 (0.77-1.02)
Months		
1-6	1.04 (0.87-1.25)	0.83 (0.63-1.08)
7-12	1.01 (0.83-1.22)	0.93 (0.70-1.24)
13-18	0.95 (0.78-1.16)	1.09 (0.86-1.40)
19-24	0.91 (0.78-1.07)	0.91 (0.71-1.17)
25-27	(Reference)	(Reference)

*Comparisons with p<0.05 using Poisson regression.

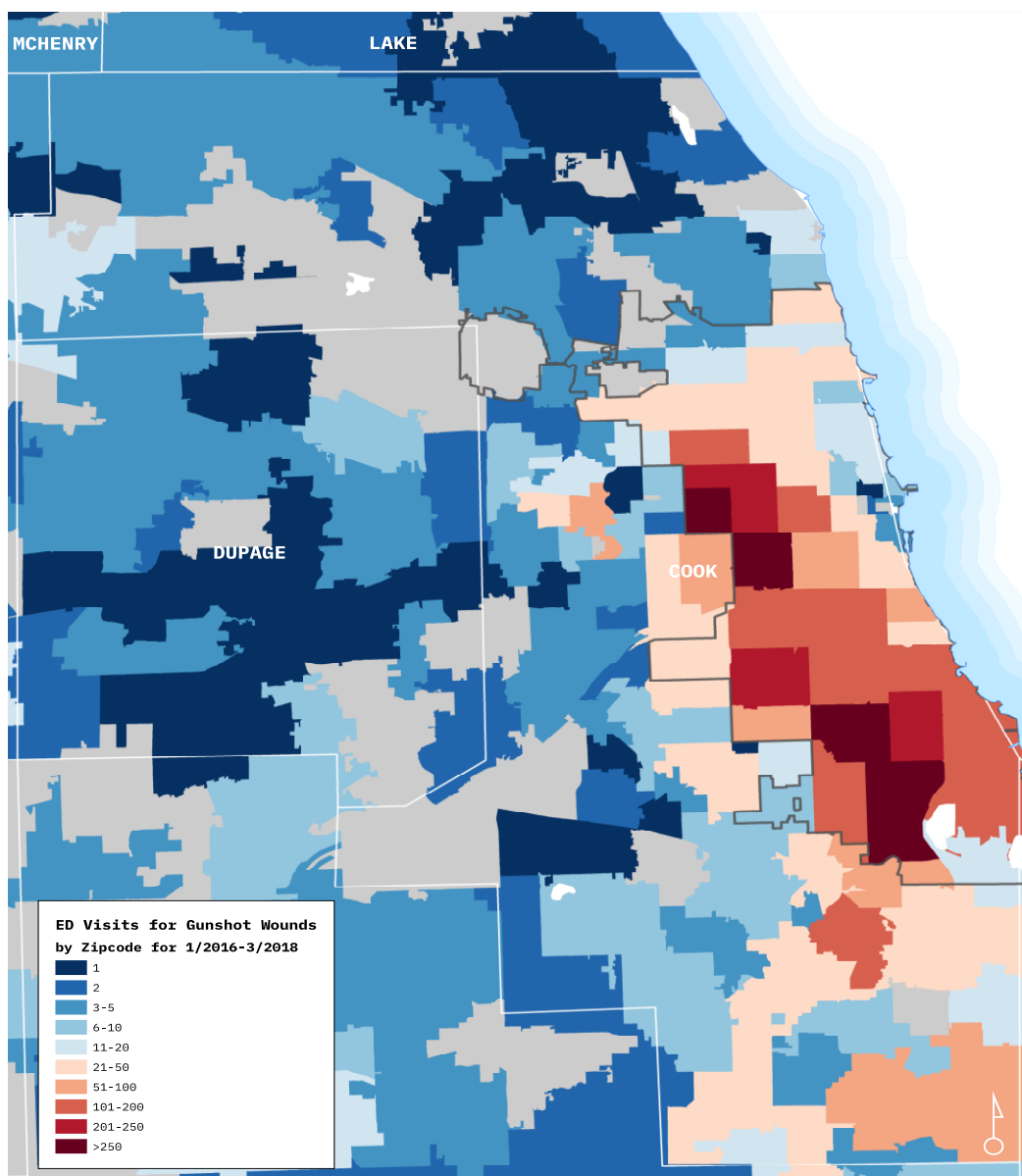


Figure 4. Heat Map for GSW ED visits by Patient's Residential Zip Code.