Annual Incidence of Hospitalization for Nonfatal Firearm-Related Injuries in New York From 2005 to 2016

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Abstract

IMPORTANCE In the US, approximately 40,000 people die due to firearm-related injuries annually. However, nonfatal firearm-related injuries are less precisely tracked.

OBJECTIVES To assess the annual incidence of hospitalization for nonfatal firearm-related injuries in New York and to compare the annual incidence by sex, race/ethnicity, county of residence, and calendar years.

DESIGN, SETTING, AND PARTICIPANTS This retrospective cross-sectional study used data from the New York Statewide Planning and Research Cooperative System for patients aged 15 years or older who presented to an emergency department in New York with nonfatal firearm-related injuries from January 1, 2005, to December 31, 2016. Data were analyzed from January 15, 2019, to April 21, 2021.

EXPOSURE A nonfatal firearm-related injury, defined by International Classification of Diseases, Ninth Revision, Clinical Modification and International Statistical Classification of Diseases, Tenth Revision, Clinical Modification codes.

MAIN OUTCOMES AND MEASURES The annual incidence of nonfatal firearm-related injuries was calculated by determining the number of patients with a nonfatal firearm-related injury each year divided by the total population of New York.

RESULTS The study included 31,060 unique patients with 35,059 hospital encounters for nonfatal firearm-related injuries. The mean (SD) age at admission was 28.5 (11.9) years; most patients were male (90.6%) and non-Hispanic Black individuals (62.0%). The overall annual incidence was 18.4 per 100,000 population. Although decreasing trends of annual incidence were observed across the state during the study period, this trend was not present in all 62 counties, with 32 counties (51.6%) having an increase in the incidence of injuries between 2005 and 2010 and 29 (46.8%) having an increase in the incidence of injuries between 2010 and 2015. In 19 of the 30 counties (63.3%) that had a decrease in incidence in earlier years, the incidence increased in later years.

CONCLUSIONS AND RELEVANCE The annual incidence of hospitalization for nonfatal firearm-related injuries in New York during the study period was 18.4 per 100,000 population. Reliable tracking of nonfatal firearm-related injury data may be useful for policy makers, hospital systems, community organizers, and public health officials as they consider resource allocation for trauma systems and injury prevention programs.


Key Points

Question What was the annual incidence of hospitalization for nonfatal firearm-related injuries in New York from 2005 to 2016?

Findings In this cross-sectional study of 31,060 patients with 35,059 hospital encounters for nonfatal firearm-related injuries in New York from 2005 to 2016, the overall annual incidence of hospitalization for nonfatal firearm-related injuries was 18.4 per 100,000 population. The annual incidence of these injuries in the state decreased during the study period, but this trend was not observed in all counties.

Meaning These findings may be useful for policy makers and public health officials as they consider resource allocation for trauma systems and injury prevention programs.

+ Invited Commentary
+ Supplemental content

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Introduction

In the US, approximately 40,000 people die due to firearm-related injuries each year. This is similar to the number of deaths that occur each year from motor vehicle crashes or liver disease. However, compared with other leading causes of death, firearm-related violence remains underrepresented in the scientific literature in part owing to the paucity of extramural funding. One study suggested that this area of investigation receives 1.6% of expected research funding compared with other leading causes of death.

This lack of investment is apparent in the absence of infrastructure to reliably track nonfatal firearm-related injuries. Although deaths are publicly reported and reliably described, national data on nonfatal firearm-related injuries are limited. For example, the US Centers for Disease Control and Prevention (CDC) reported that 133,895 (95% CI, 31,329-236,461) nonfatal firearm-related injuries occurred in 2017—an estimate so imprecise as to render it unhelpful in understanding the scope of this problem. This lack of precision was the result of using a small number of hospitals to derive the estimates, which have been increasingly imprecise over time. More recently, the CDC deemed the nonfatal firearm-related injury data so unreliable that the estimates are no longer publicly available. Without reliable data, it is challenging to understand the scope of the problem, to develop prevention strategies, and to track their effectiveness.

Although federal data on nonfatal firearm-related injuries are unavailable or insufficient, data from state or regional health care systems can provide opportunities to better measure and track these injuries. For example, the New York Statewide Planning and Research Cooperative System (SPARCS) is an all-payer, state-level database that captures 100% of inpatient hospitalizations and emergency department visits within the state. Such a comprehensive data system offers the ability to examine the county-level incidence of nonfatal firearm-related injuries over time and to explore meaningful covariates associated with geographic differences and other disparities.

This study used New York SPARCS to assess the feasibility of using such a state-level database to evaluate the annual incidence of nonfatal firearm-related injuries in New York. We also compared the annual incidence of nonfatal firearm-related injuries by sex, race/ethnicity, county of residence, and calendar years to examine whether disparities existed in nonfatal firearm-related injuries and their temporal changes. We explored whether differences occurred by geographic location and assessed the association of socioeconomic status with county-level disparities in nonfatal firearm-related injuries.

Methods

Database and Cohort Creation

We performed a cross-sectional study using retrospective data obtained from the New York SPARCS database from January 1, 2005, to December 31, 2016, to develop a comprehensive statewide cohort of individuals aged 15 years or older who visited the emergency department for nonfatal firearm-related injuries. The SPARCS database captures 100% of inpatient hospitalizations and emergency department visits throughout the state. We chose the age cutoff of 15 years because youths aged 15 to 18 years have been shown to have patterns of firearm-related injuries similar to those of the adult population. This study was in compliance with ethical standards and was approved by the institutional review board committee of the New York State Department of Health. Because all data obtained from SPARCS were deidentified, informed consent was not required. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cross-sectional studies.

Firearm-related injuries were identified using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) external cause of injury codes for patients with a discharge date between January 1, 2005, and September 30, 2015. International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes were used for those who were discharged...
between October 1, 2015, and December 31, 2016. The list of ICD-9-CM and ICD-10-CM codes used in this study followed those indicated in reports published by the CDC [9,10] (eTable in the Supplement). Patients who visited an emergency department for firearm-related injuries and survived to hospital discharge were included. Patients who died in the emergency department or during the index hospitalization were excluded.

Outcomes and Study Variables
The primary outcome was the annual incidence of nonfatal firearm-related injuries, calculated as the number of patients with a nonfatal firearm-related injury each year divided by the total population of New York obtained from the US Census Bureau. [11-13] We compared the annual incidence by age, sex, and race/ethnicity. Race/ethnicity was self-reported and was categorized as non-Hispanic White, non-Hispanic Black, Hispanic, Asian, or other. "Other" included American Indian and Alaska Native, Native Hawaiian and Other Pacific Islander, and 2 or more races.

Statistical Analysis
Data were analyzed from January 15, 2019, to April 21, 2021. For the descriptive analysis of the demographic and clinical characteristics, we calculated medians (with interquartile ranges) for continuous variables and counts (with percentages) for categorical variables. We calculated the annual incidence of nonfatal firearm-related injuries for each calendar year from 2005 to 2016 and further stratified by sex, race/ethnicity, and county of residence.

We explored the correlation between the county-level annual incidence of nonfatal firearm-related injuries and the county-level median household income from 2010 to 2016 by plotting the incidence of nonfatal firearm-related injuries in a given county and that county’s median income each year and calculating the regression coefficient with 95% CI and P value. All dollars were inflation adjusted to 2016 dollars. [14] The median household income analysis included 39 counties (62.9% of all New York counties) because the US Census Bureau only reported annual estimates of median household income for counties with populations of more than 65 000. We also performed a linear regression to examine whether median household income in 2010 could estimate the change in annual incidence between 2010 and 2015. Temporal changes in annual incidence of nonfatal firearm-related injuries between 2 years were evaluated using 2-proportion Z tests.

The threshold of statistical significance was set at α = .05 using 2-sided testing for all analyses. Analyses were performed using Stata, version 15.0 (StataCorp LLC). Heatmaps of the annual incidence and the changes in numbers of nonfatal firearm-related injuries by New York county in specific years were created using Tableau Desktop, version 2020.2 (Tableau Software Inc).

Results
A total of 35 059 encounters for nonfatal firearm-related injuries sustained by 31 060 unique individuals were assessed (Table). The mean annual number of encounters was 2922 (129.2). Most patients were male (90.6%) and non-Hispanic Black individuals (62.0%). The mean (SD) age at admission was 28.5 (11.9) years. Overall, the median length of stay was 1 day (interquartile range, 0-4.0 days) (with those who were discharged from the emergency department assigned a length of stay of 0 days). Among those admitted to the hospital, the median length of stay was 4.0 days (interquartile range, 2.0-8.0 days). Most encounters (85.0%) were for patients from large metropolitan areas, and 10.7% of patients sustained nonfatal firearm-related injuries more than once during the study period.

The overall annual incidence of nonfatal firearm-related injuries in New York over the study period was 18.4 per 100 000 population. The annual incidence of nonfatal firearm-related injuries was 9 times higher among male individuals than among female individuals (34.9 vs 3.8 per 100 000 population). Non-Hispanic Black individuals had the highest incidence of nonfatal firearm-related injuries (75.5 per 100 000 population); this incidence was 40 times higher than that among Asian
individuals (1.9 per 100,000 population), 21 times higher than that among White individuals (3.6 per 100,000 population), and 6 times higher than that among Hispanic individuals (13.6 per 100,000 population) (Figure 1).

Geographic disparities were observed among counties (Figure 2), with interquartile ranges of 4.1 to 11.8 per 100,000 population in 2005, 3.9 to 14.1 per 100,000 population in 2010, and 3.4 to

### Table. Baseline Characteristics of Patients With Nonfatal Firearm-Related Injuries in New York From 2005 to 2016

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient-level characteristics (n = 31,060)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sex, No. (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>28,152 (90.6)</td>
</tr>
<tr>
<td>Female</td>
<td>2,904 (9.3)</td>
</tr>
<tr>
<td>Missing</td>
<td>4 (0.01)</td>
</tr>
<tr>
<td><strong>Race/ethnicity, No. (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>19,264 (62.0)</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>4,169 (13.4)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>3,944 (12.7)</td>
</tr>
<tr>
<td>Asian</td>
<td>271 (0.9)</td>
</tr>
<tr>
<td>Other*</td>
<td>1,732 (5.6)</td>
</tr>
<tr>
<td>Missing</td>
<td>1,680 (5.4)</td>
</tr>
<tr>
<td><strong>Hospital encounters per patient, No. (%)</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>27,723 (89.3)</td>
</tr>
<tr>
<td>&gt;1</td>
<td>3,337 (10.7)</td>
</tr>
<tr>
<td><strong>Encounter-level characteristics (n = 35,059)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Age, mean (SD), y</strong></td>
<td>28.5 (11.9)</td>
</tr>
<tr>
<td><strong>Length of stay, median (IQR), d</strong></td>
<td>1 (0–4)</td>
</tr>
<tr>
<td><strong>Urbanicity of the county of residence, No. (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Large metropolitan</td>
<td>29,807 (85.0)</td>
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<tr>
<td>Medium metropolitan</td>
<td>2,760 (7.9)</td>
</tr>
<tr>
<td>Small metropolitan</td>
<td>639 (1.8)</td>
</tr>
<tr>
<td>Micropolitan</td>
<td>634 (1.8)</td>
</tr>
<tr>
<td>Noncore</td>
<td>318 (0.9)</td>
</tr>
<tr>
<td>Missing</td>
<td>901 (2.6)</td>
</tr>
</tbody>
</table>

Abbreviation: IQR, interquartile range.

* Other includes American Indian and Alaska Native, Native Hawaiian and other Pacific Islander, and 2 or more races.
15.2 per 100,000 population in 2015. The annual incidence in the state decreased from 20.5 per 100,000 population in 2005 to 18.8 per 100,000 population in 2010 (P < .001) and then to 16.8 per 100,000 population in 2015 (P < .001). However, the annual incidence increased to 18.8 per 100,000 population in 2016 (P < .001).

Despite the decreasing overall annual incidence during the study period, the decrease was not consistent among all counties. Between 2005 and 2010 (Figure 3A), 32 (51.6%) counties had increasing annual incidence; between 2010 and 2015 (Figure 3B), 29 counties (46.8%) had increasing incidence. Among the 30 counties with decreases in firearm-related injuries between 2005 and 2010, 19 (63.3%) had an increase in incidence in the later period.

The correlation between the annual incidence of nonfatal firearm-related injuries and median household income at the county level from 2010 to 2016 is presented in Figure 4. Counties with lower median household income had a greater annual incidence of nonfatal firearm-related injuries, but the result was only statistically significant before accounting for county-level clustering (unclustered analysis: regression coefficient, −1.520 per $10,000 [95% CI, −2.269 to −0.772]; P < .001; after accounting for county-level clustering: regression coefficient, −1.520 per $10,000.

Figure 2. Annual Incidence of Nonfatal Firearm-Related Injuries in New York Counties in 2005, 2010, and 2015

A) Incidence in 2005
B) Incidence in 2010
C) Incidence in 2015

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[95% CI, −3.149 to 0.108], \( P = .07 \). Median household income was not correlated with the change in annual incidence of nonfatal firearm-related injuries between 2010 and 2015 (regression coefficient, 0.034 per $10,000; 95% CI, −1.120 to 1.188; \( P = .95 \)).

**Discussion**

This cross-sectional analysis demonstrated the feasibility of using a comprehensive state-level database to assess the annual incidence of nonfatal firearm-related injuries. The annual incidence of nonfatal firearm-related injuries in New York between 2005 and 2016 was 18.4 per 100,000 population, which was approximately 3 times the incidence (5.9 per 100,000 population) of fatal firearm-related injuries during the same period.\(^\text{15}\) Racial/ethnic disparities were substantial, with
non-Hispanic Black individuals sustaining the highest incidence of nonfatal injuries. Furthermore, even though the overall incidence of firearm-related injuries in New York decreased significantly during the study period, important geographic disparities were observed.

Nonfatal firearm-related injuries are incompletely recorded at the federal level.4,6 The lack of systematic collection and reporting of data on nonfatal firearm-related injuries limits the ability to examine survivors’ long-term health and the full impact of firearm-related injuries, including direct and indirect health care costs and other sequelae associated with these injuries.6 Surviving firearm-related injuries has been associated with increased risk for chronic pain and other chronic medical conditions, including substance use and mental health disorders, underscoring the need to systematically improve care for this patient population.16,17

The use of a comprehensive, statewide database adds to the literature attempting to quantify the scope of nonfatal firearm-related injuries. A previous study18 in which nonfatal firearm-related injury rates were reported relied mainly on data sampled from a proportion of emergency department visits that were weighted to estimate national rates. With use of the New York SPARCS, the present study could assess a comprehensive count of injuries for an entire state rather than sampled data, more granular data at the county level, and variation across counties within the same state. Our study showed that existing health care system clinical data can be used to provide more comprehensive information regarding these injuries and suggests that improvement in the infrastructure to facilitate this strategy nationally is needed.

Although the overall state-level incidence of firearm-related injuries decreased over time, this overall decrease was not distributed uniformly across counties. This variation likely reflects the complex ways that socioeconomic and other factors at the neighborhood level may be associated with nonfatal firearm-related injuries. The literature on the geographic disparities in the incidence of firearm-related injuries over time is limited.19 More research is needed to evaluate the association between temporospatial changes in sociodemographic factors and the incidence of firearm-related violence.

Our analysis also suggests that the racial disparities in the incidence of firearm homicides20,21 may be similar to those in the incidence of nonfatal firearm-related injuries. In the present study, non-Hispanic Black individuals had the highest incidence of nonfatal firearm-related injuries, sustaining nonfatal firearm-related injuries at a rate 40 times higher than that among Asian individuals, 21 times higher than that among White individuals, and 6 times higher than that among Hispanic individuals. Previous literature has demonstrated factors associated with firearm-related injuries, including income inequality,22,23 lack of trust in institutions,24 lack of government spending on education and social and public services,25 barriers to social mobility,26 and racial segregation.27,28 Racial segregation and lack of government spending on social safety nets and education systems can affect upward social mobility and is associated with interpersonal violence.26 We found that men had a 9 times higher annual incidence of nonfatal firearm-related injuries than women. The finding is consistent with the results reported by Gani et al.,29 who used the Nationwide Emergency Department Sample data in the US from 2006 to 2014.

Better understanding of the mechanisms underlying the decreasing incidence of nonfatal firearm-related injuries in New York, which decreased from 20.5 per 100 000 population in 2005 to 16.8 per 100 000 population in 2015 (before increasing again in 2016), is an important area for continued study. The regulatory approach to firearms in New York may be 1 factor. Several studies have described an association between strict gun laws and a lower incidence of firearm-related fatalities.30-31 The overall decrease in nonfatal firearm-related injuries in New York coincided with the enactment of strict laws in New York regulating the purchase and possession of certain firearms during this same time frame. For example, between 1992 and 2016, the New York state legislature enacted 40 new firearm provisions, including the Secure Ammunition and Firearms Enforcement Act of 2013, New York’s omnibus gun control law33; the same number of firearm injury prevention laws passed in Hawaii and was only surpassed by Massachusetts (45), California (46), Maryland (47), and Connecticut (62).35 Given challenges with confounding owing to states with fewer firearms often
being those that pass the most restrictive gun laws, the causal relationship between specific laws and fatal and nonfatal firearm-related injuries is an important area for future study.

**Limitations**
This study has limitations. First, the calculations of nonfatal firearm-related injuries presented in this study contained uncertainty because some individuals who sustained a nonfatal firearm-related injury may not have sought medical care. Although prior analyses suggest that this number is less than 10%, it is difficult to quantify precisely. Second, the data were limited to New York and did not capture people from New York who were hospitalized in another state. It is unknown whether the trends found in New York are generalizable across other states and regions, again suggesting the importance of having a national data infrastructure to better evaluate nonfatal firearm-related injuries. Third, owing to SPARCS data availability, only data through 2016 were available for this analysis. The absence of real-time reporting of these data, which would be most useful for directing interventions, suggests the need to increase investment in data reporting systems substantially. Fourth, the SPARCS diagnosis codes transitioned from ICD-9-CM to ICD-10-CM in October 2015. The transition may have led to inconsistencies in the eligibility and identification of those included in this study.

**Conclusions**
In this cross-sectional study, the overall annual incidence of nonfatal firearm-related injuries in New York over the study period was 18.4 per 100,000 population. For each person who died of a firearm-related injury, 3 individuals survived. Complete nonfatal injury data may be useful for policy makers, hospital systems, community organizers, and public health officials when they consider resource allocation for trauma systems and injury prevention programs. Investment in improved reporting of nonfatal injuries appears to be needed to inform a national effort to improve care for survivors of these injuries and to gain a better understanding of the totality of firearm-related violence in the US.
Administrative, technical, or material support: Chen, Chang, Westfal, Hung.

Supervision: Chang, Kelleher, Masiakos, Sacks.

Conflict of Interest Disclosures: None reported.

Meeting Presentation: This paper was presented in part at the 2019 Society of General Internal Medicine Annual Meeting; May 9, 2019; Washington, DC.

REFERENCES


**SUPPLEMENT.**

eTable. International Classification of Diseases (ICD), 9th and 10th edition, clinical modification (CM) code used to define firearm-related injuries