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A new pandemic and an old epidemic: The impact of COVID-19 and gun violence as measured by years of potential life lost in a US city

William B. Risinger, MD\textsuperscript{a}, Samuel J. Pera, MD\textsuperscript{a}, Neal Bhutiani, MD, PhD\textsuperscript{a}, Matthew Ruther, PhD\textsuperscript{b}, Brian G. Harbrecht, MD\textsuperscript{b}, Jason W. Smith, MD, PhD\textsuperscript{a}, Matthew V. Benns, MD\textsuperscript{a}, Keith R. Miller, MD\textsuperscript{a,\textsuperscript{b}}

\textsuperscript{a} Department of Surgery, University of Louisville School of Medicine, KY
\textsuperscript{b} Department of Urban and Public Affairs, University of Louisville, KY

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\section*{A B S T R A C T}
\textbf{Background:} The COVID-19 pandemic has altered daily life on a global scale and has resulted in significant mortality with \textgreater 985,000 lives lost in the United States alone. Superimposed on the COVID-19 pandemic has been a concurrent worsening of longstanding urban gun violence. We sought to evaluate the impact attributable to these 2 major public health issues on the greater Louisville region as determined by years of potential life lost.

\textbf{Methods:} Using the Collaborative Jefferson County Firearm Injury Database, all firearm injuries from January 1, 2011 to December 31, 2021 were examined. The COVID-19 data was compiled from the Louisville Metro Department of Public Health and Wellness. Pre-COVID (March 1, 2019–February 29, 2020) and COVID (March 1, 2020–February 28, 2021) time intervals were examined. The demographics, outcomes data, and years of potential life lost were determined for the groups, and injury locations were geocoded.

\textbf{Results:} From 2011 to 2021, there were 6,043 firearm injuries in Jefferson County, Kentucky. During the COVID time interval, there were 4,574 years of potential life lost due to the SARS-CoV-2 virus and 9,722 years of potential life lost due to all-cause gun violence. In the pre-COVID time interval, there were 5,723 years of potential life lost due to all-cause gun violence.

\textbf{Conclusion:} In Louisville, greater years of potential life lost were attributable to firearm fatalities than the SARS-CoV-2 virus. Given the impact of COVID-19, the robust response has been proportionate and appropriate. The lack of response to firearm injury and fatality is striking in comparison. Additional resources to combat the sequelae of gun violence are needed.

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\section*{Introduction}

COVID-19 was deemed a pandemic by the World Health Organization on March 11, 2020.\textsuperscript{1} Since the start of the pandemic, there have been around 80 million infections and 985,000 deaths occurring in the United States alone.\textsuperscript{2} Jefferson County, which includes the city of Louisville, KY, experienced a significant burden of disease. Daily new cases in Jefferson County peaked at 79.0 per 100,000 people in the winter of 2020.\textsuperscript{3} By comparison, St. Louis County, Missouri (includes city of St. Louis), Cook County, Illinois (includes city of Chicago), and Hamilton County, Ohio (includes city of Cincinnati) each had their highest daily case rates in the winter of 2020, peaking at 85.1, 90.0, and 90.4 per 100,000 people, respectively.\textsuperscript{4}

As the United States began to grapple with the COVID-19 pandemic, endemic gun violence in many urban regions concurrently experienced significant increases. Studies from across the United States have examined this increase, with certain regions experiencing disproportionately higher amounts of intentional self-inflicted and unintentional gunshot injuries.\textsuperscript{4,5} Like many communities, Louisville, KY has seen an ongoing increase in gun violence over the past decade. In line with this trend, during the
coinciding COVID-19 pandemic in 2020 there were substantial increases in the incidence of gun violence in Louisville. It has been suggested that the rise in gun violence experienced around the country during the COVID-19 pandemic may be related to factors such as stay-at-home orders and decreased access to mental health care.6,7 However, causal relationships remain unproven.

The impact of COVID-19 on our region and the world has been substantial. The national and locoregional response to the SARS-CoV-2 virus has been widespread and decisive, involving all levels of government with substantial resources allocated to addressing the pandemic. Firearm injury and fatality, although recently acknowledged as a public health issue, has not received a similar level of resource distribution or attention despite years of impact on communities throughout the United States.

From a morbidity and mortality standpoint, COVID-19 predominantly impacts older individuals, whereas the burden of firearm injury is borne by younger individuals. Traumatic injury of any etiology has long been a significant contributor to years of potential life lost (YPLL) as unintentional injury, homicide, and suicide together remain in the top causes of death from the first to fifth decades of life.8 Gun violence (including unintentional, suicide, and homicide) has recently overtaken motor vehicle accidents as the leading cause of trauma-related YPLL in the United States.9

In the context of the different governmental responses and demographics impacted by these 2 public health issues (1 pandemic and 1 epidemic), we sought to compare the mortality attributable to the COVID-19 pandemic and firearm injury, respectively, by using available databases to account for YPLL in Jefferson County, Kentucky. Specifically, we sought to examine the YPLL from both all-cause gun violence (including fatalities from intentional self-inflicted, unintentional, and interpersonal incidents) and interpersonal gun violence alone. We hypothesized that in our community, YPLL from gun violence would outpace YPLL due to the COVID-19 pandemic.

Methods

Jefferson County Collaborative Firearm Injury Database

After institutional review board approval from the University of Louisville (including approval to conduct the research without obtaining the patient’s written HIPAA authorization), data from the Jefferson County Collaborative Firearm Injury Database (designed and maintained by the University of Louisville Department of Surgery and Trauma Institute) were reviewed, including all firearm injuries between January 2011 and December 2021. This database captures all gun violence incidents in Louisville, KY and includes patients seen at the regions only American College of Surgeons verified adult level 1 trauma center (including both patients admitted to the hospital and those evaluated and released from the emergency department) and victims of firearm injury encountered by the Louisville Metropolitan Police Department.10 Demographic information for the database was obtained via patient self-reporting and electronic health records. To establish the decade long trends in all-cause, interpersonal, unintentional, and intentional self-inflicted gun violence in our region, data from January 2011 to December 2021 were examined. For direct comparison between COVID-attributable and gunshot-attributable mortality, specific 12-month time intervals were examined. The pre-COVID time interval was defined as the 12 months before the onset of the pandemic (Mar 1, 2019–Feb 29, 2020). Alternatively, the COVID time interval was defined as the first 12 months of the pandemic (Mar 1, 2020–Feb 28, 2021).

COVID database

COVID-19 data for Louisville, KY were obtained from the Jefferson County Public Health Department website.11 The data obtained included cumulative incidence (per 100,000 people) and death rates (per 100,000 people) sorted by ZIP codes in Jefferson County.

Geocoding and mortality gradient map creation

Injury addresses for all firearm injury incidents from 2011 to 2021 and incidents resulting in fatality for the previously defined COVID time interval (Mar 1, 2020–Feb 28, 2021) were geocoded using GIS software (ArcGIS 7.1.4) with a 70% and 92% match rate, respectively. Geocoded gun violence and COVID-19 data were then used to create mortality gradient maps of Jefferson County detailing ZIP-code level mortality rates from the SARS-CoV-2 virus and gun violence corrected for population during the first 12 months of the pandemic. Of note, this map underestimates the true burden of gun violence mortality since approximately 8% of deaths could not be matched to a specific ZIP code within the county. However, given that these deaths were known to have occurred in Jefferson County, Kentucky, they were included in the total YPLL calculations.

Calculation of YPLL

The YPLL were calculated by taking the total number of deaths occurring in each age bracket (consisting of 5-year increments) and multiplying by the difference between the median age in each bracket and the end age for average life expectancy, selected in this case to be 75 years of age.12,13 The YPLL calculations were carried out for all-cause gun violence (intentional self-inflicted, unintentional, and interpersonal) and interpersonal firearm injury alone for the previously defined pre-COVID and COIVD time periods. In addition, a yearly average YPLL was calculated for all-cause and interpersonal gun violence by analyzing gun violence mortality from 2011 to 2021 in Louisville, KY. These were then compared to the YPLL from COVID-19 during the first 12 months of the pandemic.

Statistical analysis

Standard 2-tailed t tests were used to compare continuous data, whereas Fisher exact tests were used to compare categorical data. Statistical analyses were performed using Microsoft Excel (Redmond, WA), MedCalc (Ostend, Belgium), and Stata (College Station, TX).

Results

A total of 6,043 gun violence incidents in Jefferson County were identified between January 2011 and December 2021 (Table I). Injuries from firearms were classified as either unintentional (n = 516), intentional self-inflicted (n = 444), interpersonal (n = 4,970), or unknown (n = 113). Firearm injuries in Jefferson County have increased over the last decade (Figure 1). The incidence of all-cause gun violence (per 100,000 people) has increased from 37.51 in 2011 to 131.51 in 2021. Although unintentional and intentional self-inflicted injuries have increased over time, interpersonal assault injuries remain the predominant contributor to gun violence in Louisville, KY, comprising 82.24% of injuries in this database. Along with the increase in the incidence of gun violence has been an associated increase in firearm injury mortality (Table I). The incidence of interpersonal firearm fatality has increased from 5 to >20 per 100,000 individuals over the study interval (2011–2021).
When the previously defined pre-COVID and COVID time periods were compared, a 99.6% increase in interpersonal gun violence was seen (475 vs 948). In contrast, intentional self-inflicted gun violence showed no change (47 vs 46), and unintentional gunshot incidents demonstrated an increase of 37% (65 vs 89) over the same time interval. The mortality from firearm injury also increased with 149 deaths in the pre-COVID time period compared to 242 deaths in the COVID time interval.

Basic demographic and outcomes data comparing interpersonal injuries during the pre-COVID and COVID time periods are demonstrated in Table II. There were no significant differences between the COVID and pre-COVID time periods with respect to basic demographics, injury severity, hospitalization, hospital length of stay, ICU length of stay, and ventilator days. Gun violence in our cohort tended to involve young, African American men with average injury severity scores between 7 and 8 during both time periods.

When patients presenting to the University of Louisville Hospital level I trauma center, emergency operative intervention, defined as those moving directly to the operating room upon arrival to the hospital, was required less frequently in the COVID time period (23.56 vs 20.34%, \( P = .02 \)).

Table 1

| Year | Population | All cause | Interpersonal | Intentional self-inflicted | Unintentional |
|------|------------|-----------|---------------|---------------------------|--------------|
| 2011 | 746,458    | 37.51 (280) | 30.14 (225)  | 3.48 (26)                | 2.68 (20)    |
| 2012 | 751,802    | 41.63 (313) | 32.59 (245)  | 4.12 (31)                | 2.92 (22)    |
| 2013 | 759,427    | 43.72 (332) | 35.55 (270)  | 3.16 (24)                | 4.35 (33)    |
| 2014 | 762,038    | 44.75 (341) | 36.21 (276)  | 3.41 (26)                | 4.07 (31)    |
| 2015 | 765,322    | 48.87 (374) | 5.23 (40)    | 4.13 (34)                | 5.23 (40)    |
| 2016 | 767,770    | 51.65 (397) | 4.44 (34)    | 4.44 (34)                | 4.35 (33)    |

Incidence and mortality per 100,000 people (corrected for population) in Jefferson County, KY from 2011 to 2021. Variables presented as rate per 100,000 people (n). For all-cause, interpersonal, intentional self-inflicted, and unintentional gun violence, incidence is listed above mortality.

Figure 1. Incidence of gun violence in Jefferson County, KY from 2011 to 2021, divided by mechanism into interpersonal, unintentional, and intentional self-inflicted gun violence.
The injury locations for all-cause firearm mortality and COVID-19 mortality were geocoded and used to create ZIP code–level mortality maps demonstrating death rates (per 100,000 people) from gun violence and COVID-19 in Jefferson County during the previously defined COVID time intervals. Continuous variables presented as mean (standard deviation). Categorical variables presented as n (percentage). ER, emergency room; ICU, intensive care unit; YPLL, years of potential life lost.

Demographic and hospital outcomes for interpersonal gun violence in the previously defined pre-COVID and COVID time intervals. Continuous variables presented as mean (standard deviation). Categorical variables presented as n (percentage). ER, emergency room; ICU, intensive care unit; YPLL, years of potential life lost.

Demographic and hospital outcomes for interpersonal gun violence in the previously defined pre-COVID and COVID time intervals.

Table II
Demographics and hospital outcomes of interpersonal gun violence

|                        | Pre-COVID1 (n = 475) | COVID1 (n = 948) | P value |
|------------------------|----------------------|------------------|---------|
| Average age (y)        | 28.99 (12.11)        | 29.54 (12.55)    | .44     |
| Ethnicity:             |                      |                  | .65     |
| African American       | 361 (76%)            | 714 (75.32%)     |         |
| Caucasian              | 93 (19.58%)          | 205 (21.41%)     |         |
| Hispanic               | 6 (1.26%)            | 9 (0.95%)        |         |
| Asian                  | 2 (0.42%)            | 1 (0.11%)        |         |
| Male                   | 396 (83.37%)         | 763 (80.49%)     | .22     |
| Female                 | 79 (16.36%)          | 185 (19.51%)     |         |
| Hospital disposition*  |                      |                  | .65     |
| Admission              | 187 (46.87%)         | 307 (41.98%)     |         |
| Death in ER            | 30 (7.52%)           | 55 (7.88%)       |         |
| Discharge from ER      | 182 (45.61%)         | 336 (48.14%)     |         |
| Operative percentage   | 94 (23.56%)          | 142 (20.34%)     | .02     |
| Average length of stay (d) | 6.50 (7.65) | 6.71 (8.57) | .77 |
| Average ICU length of stay (d) | 4.97 (7.82) | 3.99 (4.81) | .34 |
| Average ventilator days | 621 (8.94)          | 4.23 (4.03)      | .22     |
| Average injury severity score | 7.11 (10.75) | 7.86 (9.52) | .26 |

Discussion

This study evaluated the impact of COVID-19 and firearm injury as determined by YPLL in Louisville, KY. During the designated COVID time interval, more YPLL were attributable to firearm fatalities of any type and from interpersonal gun violence alone than were attributable to the SARS-CoV-2 virus.

Firearm violence in Jefferson County is an endemic issue. All-cause gun violence and subgroupings by mechanism (interpersonal, unintentional, and intentional self-inflicted) have all increased substantially over the past decade and exponentially in recent years. Superimposed on this decades-long rise in gun violence, Louisville, in line with many other US cities, has experienced an associated increase in gun violence since the start of the COVID pandemic in March 2020.24 However, in contrast to other studies, the epidemic in our region consisted predominantly of interpersonal injuries, a pattern consistent with that noted before the pandemic. Moreover, from a demographic and outcomes perspective, gun violence in the pre-COVID and COVID time intervals remained quite similar. Although the association between the COVID-19 pandemic and increased firearm injury and fatality remains notable, and one could speculate as to the relative contribution of heightened economic stressors and civil unrest, given the decades-long increases experienced by our region, this association may also be coincidental.

Firearm fatality in our region, regardless of the nature of the injury disproportionately impacts younger individuals. COVID-19, meanwhile, predominantly impacts older individuals from a mortality standpoint.15 This difference is graphically represented in Figures 3 and 4. Through the lens of YPLL, the findings in our region are particularly worrisome. In Jefferson County, the YPLL attributable to gun violence during the COVID-19 pandemic outnumbered the YPLL attributable to the SARS-CoV-2 virus itself. More importantly, in the 12 months preceding the onset of the COVID-19 pandemic (defined in our study as the pre-COVID time period), the number of YPLL due to firearm injury was comparable to the YPLL attributable to the SARS-CoV-2 virus during the first 12 months of the pandemic. Likewise, over the past decade, the average yearly loss of potential life years in Louisville, KY to gun violence is similar to the YPLL due to the COVID-19 pandemic. These findings did not minimize the significant human impact of the SARS-CoV-2 virus, but rather reinforced the fact that mortality from firearm injury possesses a magnitude comparable in our city to one of the deadliest pandemics the United States has experienced.

Although COVID-19 and gun violence impact different demographics for different reasons, the mortality attributable to both issues substantially impacts the Louisville Metro area. Previous research has demonstrated that the SARS-CoV-2 virus has impacted vulnerable communities to a greater extent than affluent communities from a morbidity and mortality standpoint.16,17 As previously reported by our group, gun violence in Louisville, KY also disproportionately impacts vulnerable communities.18 These disparities are evident in the higher mortality from both COVID-19 and gun violence in city’s west end, which historically is home to a large proportion of Louisville’s vulnerable communities (Figure 2).

From a policy standpoint, these 2 public health issues have generated markedly different responses. The COVID-19 pandemic spurred passage of the Coronavirus Aid, Relief, and Economic Security Act on March 27, 2020 and the American Rescue Plan Act of 2021, which provided $2.2 trillion and $1.9 trillion, respectively, to address pandemic-related issues.8,20 The Coronavirus Aid, Relief, and Economic Security Act appropriated $27 billion to the Department of Health and Human Services, 4.3 billion dollars to the Center for Disease Control (CDC), and 950 million dollars to the National Institute of Health. The National Institute of Health–led Accelerating COVID-19 Therapeutic Interventions and Vaccines saw a partnership between the public and private sectors to address the pandemic.11 In addition, the federal government provided substantial subsidies for vaccine candidates, for example, providing $955 million for research on the Moderna vaccine alone.9

Gun violence, meanwhile, has received a comparatively smaller investment on a federal level. The National Center for Injury Prevention and Control’s Division for Violence Prevention is currently funding 16 projects with a fiscal allotment of approximately $8 million per year.21 This funding represents a change from previous federal policy, as before 2018 the federal government did not fund firearm injury prevention research under the auspices of the CDC due to the Dickey Amendment (1996). This amendment, although
only prohibiting funding from being used for gun control advocacy, stifled research at the CDC.\textsuperscript{24} This halting, incremental response to firearm injury in the United States stands in stark contrast to the rapid, expansive, and collaborative efforts undertaken in response to the COVID-19 pandemic.

One possible explanation for the difference in resource allocation between the COVID-19 pandemic and endemic gun violence is the perceived risk to the general population. At the outset of the pandemic, everyone was at risk of contracting the SARS-CoV-2 virus. Although certain characteristics such as age and pre-existing conditions elevate the risk of a severe infection, importantly these characteristics exist across all geographic and socioeconomic boundaries. In contrast, Figure 2 demonstrates that gun violence in Louisville, KY is much more likely to occur within areas of concentrated disadvantage.

Previously, we have demonstrated that a variety of socioeconomic parameters are associated with regions of high incidence of firearm injury in Jefferson County. Structural racism in Louisville has been examined, and it has been observed that redlined neighborhoods (those receiving the lowest grade on the Home Owner’s Loan Corporation maps from the 1930s) are the same areas that see the highest incidence of firearm injury in our city today.\textsuperscript{18} In addition, we have shown that neighborhoods with more severe food insecurity have increased levels of intentional firearm injury in Jefferson County.\textsuperscript{25} This situation is not unique to Louisville and has been demonstrated in urban areas throughout the United States.\textsuperscript{26–28} Simply stated, the community at large does not live with an equal threat of gun violence.

Another obvious consideration for resource allocation was the early and tangible goal of COVID-19 eradication through widespread vaccination. Although there is no vaccine for gun violence, targeted interventions such as the Cure Violence program have demonstrated promising results.\textsuperscript{29–31} Within the city of Louisville, local government and grassroot entities such as the Louisville Metro Office for Safe and Healthy Neighborhoods and Christopher 2X Game Changers organization have partnered with our

Figure 2. Mortality gradient maps of Jefferson County comparing all-cause gun violence and COVID-19 mortality (per 100,000 people) during the first 12 months of the pandemic. Higher death rates for both COVID-19 and gun violence occur in the city’s west side, with a more pronounced east-to-west discrepancy noted for gun violence based on map gradients.
institution to provide support, education, and advocacy. Without adequate resources allocated for education, prevention, and community engagement, it is highly unlikely that the gun violence epidemic will recede.

The present study should be interpreted considering several limitations. First, the study was retrospective in nature with inherent limitations. Second, we examined a single urban region with an ongoing gun violence epidemic. The generalizability to other urban and rural communities is unclear. However, if the average age of death from firearm injury is taken to be 30 years of age and that from COVID-19 estimated to be 70 years of age, then the YPLL for each death (assuming an end age of 75 years) will be 45 and 5 years, respectively. Given this 9:1 ratio, the YPLL from gun violence in any given community will exceed that from COVID-19 unless the total number of deaths from the SARS-CoV-2 virus is 9 times greater than the total number of deaths from firearm injury. Other regions and cities can apply the 9:1 ratio to quickly compare the attributable mortality of COVID-19 to gun violence.

In conclusion, the COVID-19 pandemic has resulted in significant morbidity and mortality both in Louisville, KY and throughout the country. Although the COVID-19 pandemic is not over,
significant progress has been made because of an aggressive and resource-intensive response. In contrast, gun violence has been a public health issue in the city of Louisville, KY and across the United States for well over a decade and has trended upward over time. Though the number of deaths from gun violence are significantly less than those attributed to COVID-19, the demographics of firearm injury are such that it has resulted in a greater number of years of potential life lost for victims in Louisville. Despite its long tenure and severity, the resource allocation and response to gun violence has been comparatively restrained. Given the persistence and prevalence of gun violence, policymakers and communities must cooperate on the local, state, and federal level to both identify and address underlying issues underpinning this public health issue.

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**Conflict of interest/Disclosure**

The authors have no conflicts of interests or disclosures to report.

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