Pediatric firearm injury related emergency department visits and hospitalizations: a population-based study in the United States

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Summary

Background Firearm injury (FI) is the leading cause of death in children and adolescents in the United States (US). We describe the epidemiology of pediatric FI-associated emergency department (ED) visits and hospitalizations in the US stratified by race and ethnicity.

Methods Data on pediatric (0–17-year-olds) FI were analyzed using the 2019 Nationwide Emergency Department Sample (NEDS) and Kids' Inpatient Database (KID), the largest all-payer databases in the US for ED visits and pediatric hospitalizations, respectively. FI encounters were stratified by race and ethnicity. Poisson regression was used to identify factors associated with in-hospital mortality. Sampling weights were applied to generate nationally representative estimates.

Findings There were 7017 pediatric ED visits with FI (NEDS); 85.0% (5961/7017) were male and 73.0% (5125/7017) were adolescents (15–17 years). Overall, 5.5% (384/7017) died in the ED; 53.1% (3727/7017) of ED encounters did not result in hospitalization. There were 2817 pediatric FI hospitalizations (KID); 84.1% (2369/2817) were male and 71.6% (2018/2817) were adolescents; 51.4% (1447/2817) of FI were unintentional, 42.8% (1207/2817) were assault-related, and 5.8% (163/2817) were self-inflicted. Black children had the highest proportion (52.6%; 1481/2817) of hospitalizations among all race and ethnicities ($p < 0.0001$ vs. White). White children had the highest proportion of hospitalizations for self-inflicted injuries (16.6% [91/551] vs. 4.9% [25/504; $p < 0.0001$] in Hispanics and 1.7% [24/1481] in Blacks; $p < 0.0001$). The majority (56.5%; 1591/2817) of hospitalizations were patients from low-income zip codes (median annual-household-income <$44,000); 70% (1971/2817) had Medicaid as the primary insurance payer. Overall, 8.0% (225/2817) died during FI-associated hospitalizations. Self-inflicted injuries had the highest in-hospital mortality (prevalence ratio = 8.20, 95% CI = 6.06–11.10 vs. unintentional).

Interpretation Black children and children with lower household incomes were disproportionately impacted by FI resulting from assaults and accidents, while White children had the highest proportion of self-inflicted FI injuries. Public health and legal policy interventions are needed to prevent pediatric FI.

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Research in context

Evidence before this study

Firearm injury (FI) is a major public health challenge in the United States (U.S.). In 2016, FI was second only to motor vehicular crashes (MVC) as a leading cause of death in children and adolescents. An updated analysis in 2020 showed FI as the leading cause of pediatric death in the U.S. Compared to peer countries (based on economic indices of development), the U.S. is the only country in which FI is the leading cause of death among children and teens.

We searched the PubMed database for published studies pertaining to the epidemiology and national burden of childhood FI in the U.S. at the emergency department and hospitalization level. The search terms used were: "Firearm Injury" (MeSH), "Gunshot Wound Injury" (MeSH), "United States of America" (MeSH) AND ("Children" OR "Adolescents"). The overall burden of FI on hospital admissions, emergency department (ED) visits in the US has been reported previously for adults. However, contemporary demographics of ED visits and hospitalizations in children with FI stratified by race and ethnicity in the US are not available.

Added value of this study

This nationally representative study describes the burden of FI-associated ED visits and hospitalizations in children and adolescents in the US, stratified by race and ethnicity. The study provides evidence that Black children and children with lower household incomes are disproportionately impacted by FI resulting from assaults and accidents, while White children had the highest proportion of self-inflicted FI. Self-inflicted FI was associated with a higher mortality among ED visits as well as hospitalized patients as compared to other FI injury types.

Implications of all the available evidence

This study highlights racial disparities in FI and FI related deaths among US youth. Public health and legal policy interventions are needed to prevent pediatric firearm injuries in the US.

Introduction

Firearm injury (FI) is a major public health challenge in the United States (US).[1,2] The US leads all high-income countries in FI related deaths.[3,4] While the US population constitutes less than 5% of the global population, nearly half of all civilian firearms are owned by those living in the US.[5] The global Small Arms Survey, which draws on survey data from >200 countries, reported that the number of civilian-owned firearms in the US (~390 million guns) exceeds the US population (~330 million).[6]

In a 2016 analysis of the Wide-ranging Online Data for Epidemiologic Research (WONDER) system of the Centers for Disease Control and Prevention (CDC), FI was second only to motor vehicular crashes (MVC) as a leading causes of death in children and adolescents in the US.[7] A 2020 update to this analysis showed that FI had overtaken MVC as the leading cause death among children and adolescents in the US.[8–10] To place in context, a 2022 report compared FI deaths among children and teens in the US with peer countries (based on economic indices of development); the US was the only country among its peers in which FI was the leading cause of death among children and teens.[11]

Among US children under 12 years, firearms are implicated in almost a quarter of all unintentional injuries.[12] The high level of firearm ownership in the US, coupled with a rise in firearm acquisition, pose risk to younger children who are particularly vulnerable to unintentional injury and homicide.[13,14]

The medical and social impact of FI on children and adolescents is profound, conferring long-lasting physical and mental disabilities that require intense medical interventions.[15] The burden of FI on healthcare costs, hospital admissions, and emergency department (ED) visits in the US has been reported.[12,14–17] While nationally representative data in the US pertaining to FI- related ED visits are available through 2016,[14,18,19] contemporary data for ED presentations or hospitalizations that are specific to children and adolescents are lacking. Recent reports pertaining to FI in adults suggest that there are marked disparities by gender, race and ethnicity, which have increased in recent years.[20] Analysis of FI by race and ethnicity has not been reported for children. This study describes the burden of FI-associated ED visits and hospitalizations in children and adolescents in the US, stratified by race and ethnicity.

Methods

Data source

ED visits and hospitalizations in which only the 'initial' encounter of FI was listed as a diagnosis, were analyzed using the 2019 Nationwide Emergency Department Sample (NEDS) and 2019 Kids' Inpatient Database (KID) databases, respectively. Those FI-related encounters other than the initial visit (i.e.,

which are categorized as 'subsequent' visit and/or 'sequela' in the respective databases) were not included in this analysis.

NEDS and KID were developed as part of the Healthcare Cost and Utilization Project (HCUP), which includes national encounter-level healthcare data and is sponsored by the Agency for Healthcare Research and Quality (AHRQ). NEDS is the largest publicly-available ED database in the US. In 2019, NEDS included more than 30 million ED discharges from 989 participating hospitals in 41 states and District of Columbia. NEDS is a 20% stratified single-stage cluster sample of the US hospital-owned EDs, representing approximately 84% of all US ED visits. Hospitals are randomly sampled and stratified by geographic region, urban-rural location, teaching status, ownership, and trauma-level designation. All ED discharges in each selected cluster were included in this analysis.

KID is the largest all-payer inpatient database for pediatric hospitalizations, representing approximately 98% of all pediatric hospitalizations in the US. The 2019 KID employs a two-stage stratified random sample of 10% of normal neonate discharges and 80% of other pediatric discharges from 4000 hospitals in 49 participating states and District of Columbia. Hospitals were stratified based on geographic region, hospital control, urban or rural location, teaching status, bed size, and freestanding vs. non-freestanding hospital type. Discharges were randomly sampled from participating hospitals, stratified according to the type of discharge (i.e., newborn or non-newborn discharge of a pediatric patient) and then sorted by state, hospital, diagnosis-related group (DRG) and a random number within each DRG. Weights for each stratum were calculated using the number of American Hospital Association universe of discharges that each sampled discharge represents in the stratum.

Since NEDS and KID are de-identified public databases, the study was deemed exempt from review by the Johns Hopkins Medical Institutions Institutional Review Board. All HCUP guidelines, as described in the data use agreement, were followed.[21]

Study population

The unit of analysis was an initial pediatric (age <18 years) ED encounter or hospitalization discharge related to FI. FI were classified as "accident", "assault", or "intentional self-harm" (self-inflicted) per the International Classification of Diseases, Tenth Revisions, Clinical Modification (ICD-10-CM) diagnostic codes. The ICD-10 code range for external causes of morbidity V00-Y99 is a medical classification list provided by the World Health Organization (WHO).[22] The ICD-10-CM code of FI has 'initial', 'subsequent', and 'sequela' related encounters for the injury; based on ICD-10-CM coding, only the 'initial' encounters from FI were included for these analyses. In both NEDS and KID, discharges are not tracked for repeat visits or readmissions and the two databases are not linked; while it is possible for an individual patient to be included more than once in the study, this would only occur in the event of more than one (i.e., two independent) 'initial' ED visit/hospitalization, reflecting another FI or if the patient is transferred between hospitals. Visits that were coded as follow-up were not included in the analysis. Detailed ICD-10-CM codes for each type of FI are listed in Supplemental Table S1.

FI related to a legal intervention were excluded from the final analysis due to the limited sample size (weighted n = 53 in NEDS and n = 18 in KID). Up to 40 ICD-10-CM diagnosis codes in KID and up to 35 ICD-10-CM diagnosis codes in NEDS were used to identify FI. Each observation in NEDS and KID contains information on demographics, hospital characteristics, discharge information and patient outcomes.

Statistical analysis

The primary goal of this descriptive analysis was to examine the demographic factors associated with ED visits or hospitalizations related to FI in children in the US stratified by race and ethnicity. Analyses of the NEDS and KID databases were conducted separately. The analysis was restricted to patients aged <18 years at admission. Sampling weights provided by HCUP for KID and NEDS were incorporated to account for the complex survey designs and generate national-representative estimates of FI associated ED visits and hospitalizations.[23] Taylor series linearization was used to estimate variance.

Variables of interest included demographics (age, sex, race, urban-rural designation, ZIP code household income, and Census region), clinical information (mortality and severity of illness), primary insurance payer, and hospital characteristics (hospital control, bed size, teaching status, and freestanding). The all patients refined diagnostic related groups (APRDRG) severity index was used to categorize clinical severity as defined by HCUP. The APDRG severity index, which is available for all cases, is a validated inpatient classification system; it is widely accepted in the US as a case-mix measure and accounts for the overall severity of illness, the risk of mortality during the visit, the overall prognosis and treatment difficulty as defined by the need for interventions and resource intensity.

Descriptive analyses of NEDS and KID were stratified by race and ethnicity, and the weighted number and percentage of FI hospitalization in each subgroup was calculated. P-values were estimated using χ^2 tests for categorical variables, and one-way ANOVA was used for continuous variables. Additional χ^2 tests were conducted for group-wise comparisons. The geographic distribution of pediatric FI-associated ED

visits and hospitalizations per 100,000 pediatric population across four different US regions (Northeast, South, Midwest and West) was also plotted; data were not available at the state level. Estimates of the total resident population were taken from the US Census bureau.[24] The population of children was calculated by subtracting those ≥18 years from the total population. Poisson regression was used to estimate prevalence ratios and identify factors associated with in-hospital mortality among FI-associated ED visits and hospitalizations in the NEDS and in the KID, respectively. Missing values were excluded using available case method when performing statistical tests. All the above analyses were replicated using raw unweighted data (Supplemental Tables S2–S5).

All analyses were conducted using svy commands in Stata/MP version 15.1 (Statacorp, College Station, TX) and R version 4.2.0 (R-Core Team, Vienna, Austria).

Role of the funding source

The funders/sponsors had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Results

There were 7017 pediatric FI-associated ED visits derived from NEDS 2019 (Fig. 1). Of these visits, 57.8% (4053/7017) were from unintentional causes, 39.2% (2750/7017) due to assault, and 3.0% (214/7017) were from self-inflicted injury (Table 1). The majority (53.1% [3727/7017]) were treated and discharged home, 41.4% (2907/7017) were admitted or transferred to a hospital facility and 5.5% (384/7017) resulted in death in the ED. Of all FI-associated ED visits, 61.8% (4336/7017) were treated in a Level I or II trauma hospital. Overall, 85.0% (5961/7017) of ED visits were male. Black children accounted for 50.2% (3525/7017) of FI-associated ED visits. While the majority (73.0% [5125/7017]) were young adolescents (ages 15–17 years), 9.0% (634/7017) of children who presented to an ED with FI were <10 years-old. Those living in ZIP codes with the median annual household incomes <$44,000 comprised 52.2% (3660/7017) of the ED FI visits. Among Black children 47.7% (1680/3525) of ED visits for FI were assault-related, while 19.2% (311/1624) of White children and 41.1% (462/1124) of Hispanic children were admitted to ED due to assault-related FI. In contrast, White children had the highest overall proportion of intentional self-inflicted ED visits due to FI (8.4% [136/1624]), compared to Black (0.6% [20/3525], $p < 0.0001$) and Hispanic (1.9% [22/1124], $p < 0.0001$) children (Table 1).

The overall incidence of pediatric ED visits was 9.61 per 100,000 pediatric population in the US in 2019. The South had the highest incidence of FI-associated ED visits (13.95 per 100,000 pediatric population) and the Northeast had the lowest incidence (4.03 per 100,000 pediatric population) among children in 2019 (Fig. 2).

In 2019, there were 2817 weighted pediatric hospitalizations associated with FI in KID (Fig. 1). Of these, 51.4% (1447/2817) were due to unintentional causes, 42.8% (1207/2817) due to assault, and 5.8% (163/2817) due to self-inflicted injury. The majority of hospitalizations were among males (84.1% [2369/2817]) and children aged 15–17 years (71.6% [2018/2817]). More than half (52.6% [1481/2817]) of pediatric FI-associated hospitalizations were among Black children. Only 1.7% (24/1481) of Black children were injured due to intentional self-inflicted FI. In contrast, Whites had the highest proportion of intentional self-inflicted injuries (16.6%

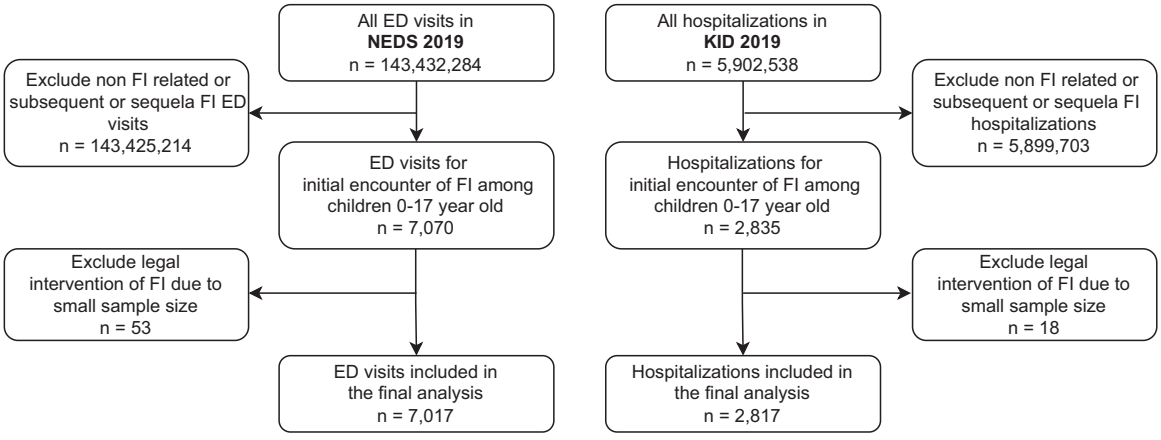

Fig. 1: Flow diagram of the inclusion and exclusion criteria of the weighted study populations.

	Overall n = 7017	White n = 1624 (23.1)	Black n = 3525 (50.2)	Hispanic n = 1124 (16.0)	Other n = 475 (6.8)	Missing n = 270 (3.8)	p value
Firearm injury type							<0.0001
Unintentional	4053 (57.8)	1177 (72.5)	1825 (51.8)	640 (56.9)	254 (53.5)	158 (58.4)	
Assault	2750 (39.2)	311 (19.2)	1680 (47.7)	462 (41.1)	198 (41.7)	99 (36.6)	
Intentional self-inflicted	214 (3.0)	136 (8.4)	20 (0.6)	22 (1.9)	23 (4.9)	13 (4.9)	
Sex							0.47
Female	1056 (15.0)	276 (17.0)	537 (15.2)	140 (12.4)	65 (13.7)	39 (14.3)	
Male	5961 (85.0)	1348 (83.0)	2988 (84.8)	984 (87.6)	409 (86.3)	232 (85.7)	
Age (years)							<0.0001
0–9	634 (9.0)	219 (13.5)	269 (7.6)	47 (4.2)	55 (11.6)	44 (16.1)	
10–14	1258 (17.9)	484 (29.8)	519 (14.7)	160 (14.2)	49 (10.2)	47 (17.3)	
15–17	5125 (73.0)	921 (56.7)	2736 (77.6)	916 (81.6)	371 (78.1)	180 (66.6)	
Primary payer							<0.0001
Medicaid	4533 (64.6)	761 (46.9)	2606 (73.9)	736 (65.5)	276 (58.1)	154 (57.0)	
Private insurance	1334 (19.0)	612 (37.7)	409 (11.6)	159 (14.1)	95 (20.1)	59 (21.9)	
Self-pay	904 (12.9)	169 (10.4)	418 (11.9)	174 (15.5)	95 (20.1)	48 (17.6)	
No charge/other	182 (2.6)	60 (3.7)	57 (1.6)	48 (4.2)	[a]	[a]	
ED event							0.25
Alive and released	3727 (53.1)	896 (55.2)	1899 (53.9)	576 (51.2)	231 (48.7)	125 (46.2)	
Admitted or transferred	2907 (41.4)	642 (39.5)	1453 (41.2)	510 (45.4)	194 (40.9)	107 (39.5)	
Died in ED	384 (5.5)	85 (5.3)	173 (4.9)	38 (3.4)	49 (10.4)	39 (14.3)	
Mortality							0.039
Did not die in the hospital	6479 (92.3)	1497 (92.2)	3287 (93.2)	1066 (94.9)	401 (84.5)	228 (84.4)	
Died in the ED	384 (5.5)	85 (5.3)	173 (4.9)	38 (3.4)	49 (10.4)	39 (14.3)	
Died in the hospital	139 (2.0)	42 (2.6)	59 (1.7)	11 (1.0)	24 (5.1)	[a]	
Teaching status of hospital							<0.0001
Non-teaching	1438 (20.5)	643 (39.6)	501 (14.2)	175 (15.6)	57 (12.1)	61 (22.5)	
Teaching	5579 (79.5)	981 (60.4)	3024 (85.8)	948 (84.4)	417 (87.9)	210 (77.5)	
Hospital trauma level designation							0.0011
Level I or II	4336 (61.8)	787 (48.5)	2452 (69.6)	617 (55.0)	292 (61.6)	188 (69.4)	
Level III or non-trauma center	2681 (38.2)	837 (51.5)	1073 (30.4)	506 (45.0)	182 (38.4)	83 (30.6)	
Patient location							<0.0001
Central counties of metro areas	2426 (34.6)	251 (15.5)	1399 (39.7)	517 (46.0)	195 (41.1)	65 (24.0)	
Fringe counties of metro areas	1147 (16.4)	266 (16.4)	622 (17.6)	175 (15.6)	56 (11.7)	29 (10.8)	
Counties in metro areas of 50,000–999,999 population	2354 (33.6)	524 (32.3)	1158 (32.9)	370 (33.0)	188 (39.6)	113 (42.0)	
Micropolitan or not metropolitan counties	1071 (15.3)	573 (35.3)	343 (9.7)	56 (5.0)	36 (7.5)	63 (23.2)	
Median ZIP code household income							<0.0001
$1–$43,999	3660 (52.2)	662 (40.8)	2148 (60.9)	471 (42.0)	225 (47.4)	153 (56.7)	
$44,000–$73,999	2670 (38.1)	721 (44.4)	1164 (33.0)	527 (46.9)	162 (34.2)	95 (35.3)	
$74,000+	576 (8.2)	199 (12.3)	176 (5.0)	113 (10.0)	67 (14.1)	22 (8.0)	
Census region of hospital							<0.0001
Northeast	464 (6.6)	103 (6.4)	209 (5.9)	99 (8.8)	53 (11.2)	0	
Midwest	1529 (21.8)	349 (21.5)	802 (22.8)	147 (13.1)	66 (13.8)	165 (61.0)	
South	3972 (56.6)	917 (56.5)	2312 (65.6)	425 (37.8)	243 (51.1)	75 (27.8)	
West	1052 (15.0)	254 (15.7)	202 (5.7)	452 (40.3)	113 (23.8)	30 (11.1)	

Race were presented in n (row %), and categorical variables were presented in n (column %). Column percentages may not sum to 100% due to missingness. Primary payer had 64 (0.9%) missing values, mortality had 15 (0.2%) missing values, patient location had 19 (0.3%) missing values and median ZIP code household income had 111 (1.6%) missing values. Mortality and patient location had weighted number of missing values < 10 and other variables had no missing values. p values were computed using Scott-Rao design-adjusted χ^2tests for categorical variables. Missing values were excluded using available case method when calculating p values. [a]Weighted number <10 were suppressed per HCUP guidelines.

Table 1: **Nationally representative estimates of characteristics of children with firearm injury presenting to emergency departments in 2019 (data derived from NEDS).**

[91/551]) compared to Black (p < 0.0001) and Hispanic (p < 0.0001). Of all FI-associated hospitalizations in KID, 8.0% (225/2817) died at the hospital. The majority of all pediatric FI-associated hospitalizations were in private non-profit (69.7% [1964/2817]) and teaching (95.8% [2700/2817]) hospitals. While the most common

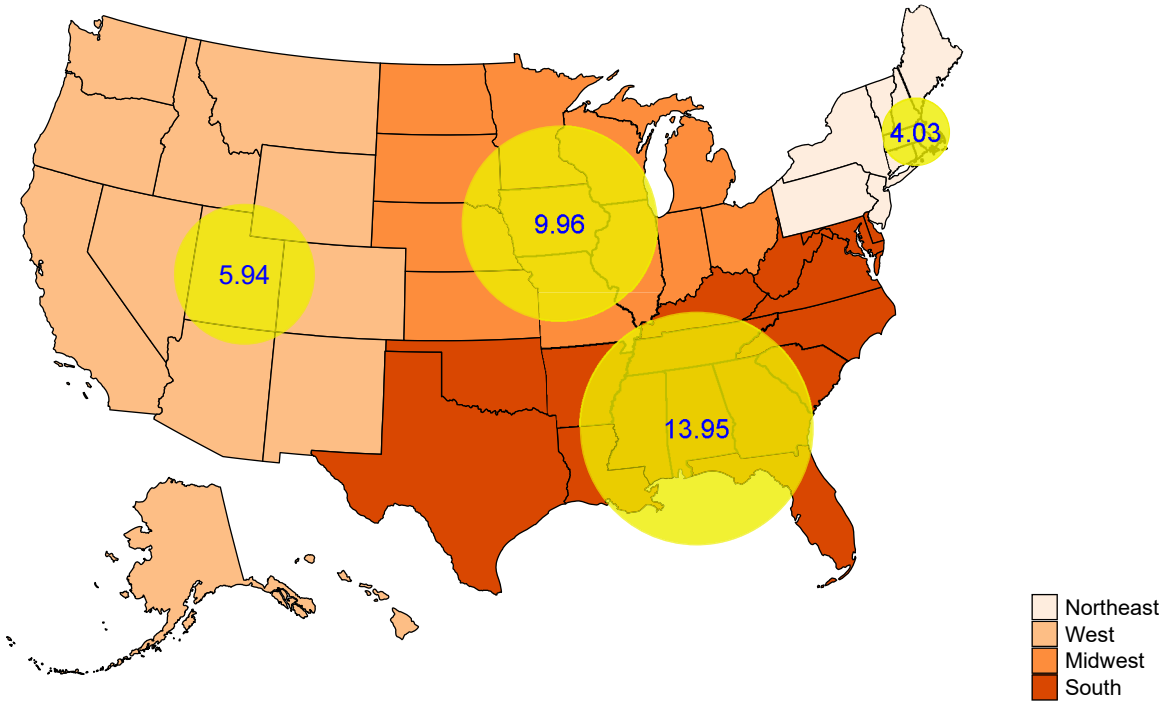

Fig. 2: **Geographic distribution of pediatric FI-associated ED visits per 100,000 population in the US (data derived from NEDS 2019).** Note: Numbers in the circle represent the number of children FI ED visits or hospitalization per 100,000 population in the US. A darker red color and a larger circle represent a higher number of FIs per 100,000 population. The overall incidence of FI ED visits was 9.61 per 100,000 populations among US children in 2019. The population of children was calculated using total population minus population ≥18 years. Source of regional children population: Estimates of the Total Resident Population and Resident Population Age 18 Years and Older for the United States, States, and Puerto Rico: July 1, 2019 (SCPRC-EST2019-18+POP-RES) Population Division, U.S. Census Bureau, https://www.census.gov/data/tables/time-series/demo/popest/2010s-state-detail.html. Release Date: December 2019. Accessed 06/28/2022.

insurance payer in FI victims was Medicaid (70.0% [1971/2817]), Black children had a higher proportion of Medicaid coverage (77.0% [1140/1481]) than other groups ($p < 0.0001$ vs. White). The highest proportion of cases (42.3% [1193/2817]) was from the central counties of metro areas (Table 2).

The overall incidence of pediatric FI-associated hospitalizations in the US was 3.86 per 100,000 population. The South had the highest incidence of FI-associated hospitalizations (5.11 per 100,000 population) and the Northeast had the lowest incidence (2.38 per 100,000 population) among children in 2019 (Fig. 3).

In univariable analysis, self-inflicted FI was associated with a seven-fold higher in-hospital mortality among ED visits (prevalence ratio (PR) = 7.11 [95% CI = 4.31–11.73]) and an eight-fold higher morality compared to accidental FI among hospitalized patients (PR = 8.20 [95% CI = 6.06–11.10]) (Tables 3 and 4). Hospitalized patients who were self-pay (i.e., those who had no insurance, were ineligible for governmental assistance, and were not designated as a "no charge" patient) trended to have higher in-hospital mortality as compared to patients who were insured by Medicaid (PR = 1.62 [95% CI = 0.96–2.75]).

Discussion

In this study, data from two nationally representative databases provide insight into the burden of FI in the US pediatric population. This study shows that Black children and children from zip codes with lower household income were disproportionately impacted by FI, especially those resulting from unintentional injuries and assaults. The majority of ED FI visits were related to unintentional causes and assaults and only a small proportion were due to self-inflicted injuries. The relatively small proportions of children with ED visits or hospitalizations attributed to self-harm is likely due to the high lethality of suicide attempt by FI (i.e., these events are possibly not being captured as deaths in the ED/hospital). Unlike intentional self-inflicted FI, the majority of the ED FI presentations were treated and discharged home, approximately 40% were admitted to hospital and about 5% resulted in deaths in the ED. Similar to other reports,[15] our study found that males comprised the majority of pediatric ED visits and hospitalizations for FI. Per the U.S. Centers for Disease Control and Prevention, overall FI-related deaths in the U.S. reached their highest level in nearly 40 years in 2019,[25] whereby FI surpassed motor vehicular crashes as

	Overall n = 2817	White n = 551 (19.6)	Black n = 1481 (52.6)	Hispanic n = 504 (17.9)	Other n = 176 (6.2)	Missing n = 106 (3.8)	p value
Firearm injury type							<0.0001
Unintentional	1447 (51.4)	331 (60.1)	760 (51.4)	224 (44.5)	73 (41.4)	59 (56.0)	
Assault	1207 (42.8)	129 (23.4)	696 (47.0)	255 (50.6)	87 (49.5)	40 (37.7)	
Intentional self-inflicted	163 (5.8)	91 (16.6)	24 (1.7)	25 (4.9)	16 (9.1)	[a]	
Sex							0.027
Female	449 (15.9)	110 (19.9)	222 (15.0)	81 (16.1)	17 (9.9)	19 (17.6)	
Male	2369 (84.1)	441 (80.1)	1259 (85.0)	423 (83.9)	159 (90.1)	87 (82.4)	
Age (years)							<0.0001
0–9	299 (10.6)	79 (14.4)	160 (10.8)	28 (5.6)	15 (8.5)	16 (15.0)	
10–14	502 (17.8)	133 (24.1)	240 (16.2)	87 (17.2)	23 (13.2)	19 (17.5)	
15–17	2018 (71.6)	338 (61.5)	1080 (72.9)	390 (77.3)	138 (78.3)	71 (67.5)	
APR-DRG severity							0.24
Minor or moderate loss of function	1420 (50.4)	261 (47.4)	743 (50.1)	275 (54.6)	93 (52.6)	49 (45.9)	
Major or extreme loss of function	1396 (49.5)	290 (52.6)	737 (49.8)	229 (45.4)	84 (47.4)	57 (54.1)	
Outcome during hospitalization							<0.0001
Alive	2590 (91.9)	476 (86.5)	1403 (94.7)	476 (94.4)	151 (85.4)	84 (79.7)	
Died	225 (8.0)	74 (13.5)	76 (5.2)	27 (5.3)	26 (14.6)	21 (20.3)	
Length of stay (days)	7.4 (0.3)	7.3 (0.7)	7.4 (0.3)	7.9 (0.7)	6.2 (0.7)	6.5 (1.1)	<0.0001
Primary payer							<0.0001
Medicaid	1971 (70.0)	297 (53.9)	1140 (77.0)	344 (68.3)	117 (66.3)	73 (69.0)	
Private insurance	538 (19.1)	198 (36.0)	195 (13.2)	89 (17.6)	36 (20.4)	20 (18.6)	
Self-pay	183 (6.5)	33 (6.0)	100 (6.8)	32 (6.4)	11 (6.3)	[a]	
No charge/other	116 (4.1)	20 (3.6)	40 (2.7)	39 (7.7)	12 (7.0)	[a]	
Hospital control							0.040
Government, nonfederal	625 (22.2)	117 (21.3)	283 (19.1)	157 (31.1)	51 (28.9)	17 (16.3)	
Private, nonprofit	1964 (69.7)	388 (70.5)	1091 (73.7)	296 (58.8)	108 (61.1)	81 (76.2)	
Private, investor-owned	229 (8.1)	45 (8.2)	107 (7.2)	51 (10.2)	18 (10.0)	[a]	
Bed size of hospital							0.19
Small or medium	892 (31.7)	149 (27.0)	517 (34.9)	140 (27.7)	61 (34.5)	26 (24.7)	
Large	1926 (68.3)	402 (73.0)	964 (65.1)	364 (72.3)	115 (65.5)	80 (75.3)	
Teaching status of hospital							0.0011
Nonteaching	118 (4.2)	45 (8.2)	39 (2.6)	22 (4.3)	[a]	[a]	
Teaching	2700 (95.8)	506 (91.8)	1442 (97.4)	482 (95.7)	168 (95.2)	101 (95.7)	
Freestanding children hospital							0.97
No	2419 (85.8)	469 (85.3)	1267 (85.6)	436 (86.6)	151 (85.4)	95 (89.8)	
Yes	399 (14.2)	81 (14.7)	214 (14.4)	68 (13.4)	26 (14.6)	11 (10.2)	
Patient location							<0.0001
Central counties of metro areas	1193 (42.3)	99 (17.9)	692 (46.7)	275 (54.6)	92 (52.4)	35 (33.3)	
Fringe counties of metro areas	460 (16.3)	107 (19.4)	258 (17.4)	56 (11.1)	26 (14.7)	13 (12.7)	
Counties in metro areas of 50,000–999,999 population	846 (30.0)	183 (33.2)	427 (28.9)	154 (30.6)	42 (23.6)	40 (37.6)	
Micropolitan or not metropolitan counties	307 (10.9)	161 (29.2)	100 (6.8)	15 (2.9)	16 (9.3)	15 (13.9)	
Median ZIP code household income							<0.0001
$1–$43,999	1591 (56.5)	232 (42.2)	991 (66.9)	226 (44.8)	84 (47.8)	58 (54.9)	
$44,000–$73,999	986 (35.0)	243 (44.1)	411 (27.8)	227 (45.0)	65 (36.8)	40 (37.6)	
$74,000+	201 (7.1)	66 (12.0)	65 (4.4)	42 (8.3)	26 (14.6)	[a]	
Census region of hospital							<0.0001
Northeast	274 (9.7)	38 (6.9)	160 (10.8)	35 (7.0)	31 (17.4)	11 (10.1)	
Midwest	592 (21.0)	112 (20.4)	368 (24.8)	43 (8.5)	31 (17.8)	38 (35.8)	
South	1456 (51.7)	318 (57.7)	848 (57.2)	183 (36.3)	66 (37.6)	41 (39.0)	
West	496 (17.6)	83 (15.0)	106 (7.2)	243 (48.2)	48 (27.2)	16 (15.1)	

The severity of an illness is divided into four subclasses according to the All Patients Refined Diagnosis Related Groups (APR-DRG), which was developed by 3 M Health Information Systems: (1) minor loss of function (includes cases with no comorbidity or complications), (2) moderate loss of function, (3) major loss of function, (4) extreme loss of function. APRDRG severity classifications 1 and 2 are deemed low-risk, whereas classes 3 and 4 are deemed high-risk. Race were presented in n (row %) and categorical variables were presented in n (column %), and continuous variables were presented in mean (SD). Column percentages may not sum to 100% due to missingness. Median ZIP code household income had 39 (1.4%) missing values. APR-DRG severity, outcome during hospitalization, primary payer, and patient location had weighted number of missing values <10 and other variables had no missing values. p values were computed using Scott-Rao design-adjusted χ^2tests for categorical variables and one-way ANOVA for continuous variable. Missing values were excluded using available case method when calculating p values. [a]Weighted number < 10 were suppressed per HCUP guidelines.

Table 2: **Nationally representative estimates of characteristics of children with firearm injuly hospitalized in 2019 (data derived from KID).**

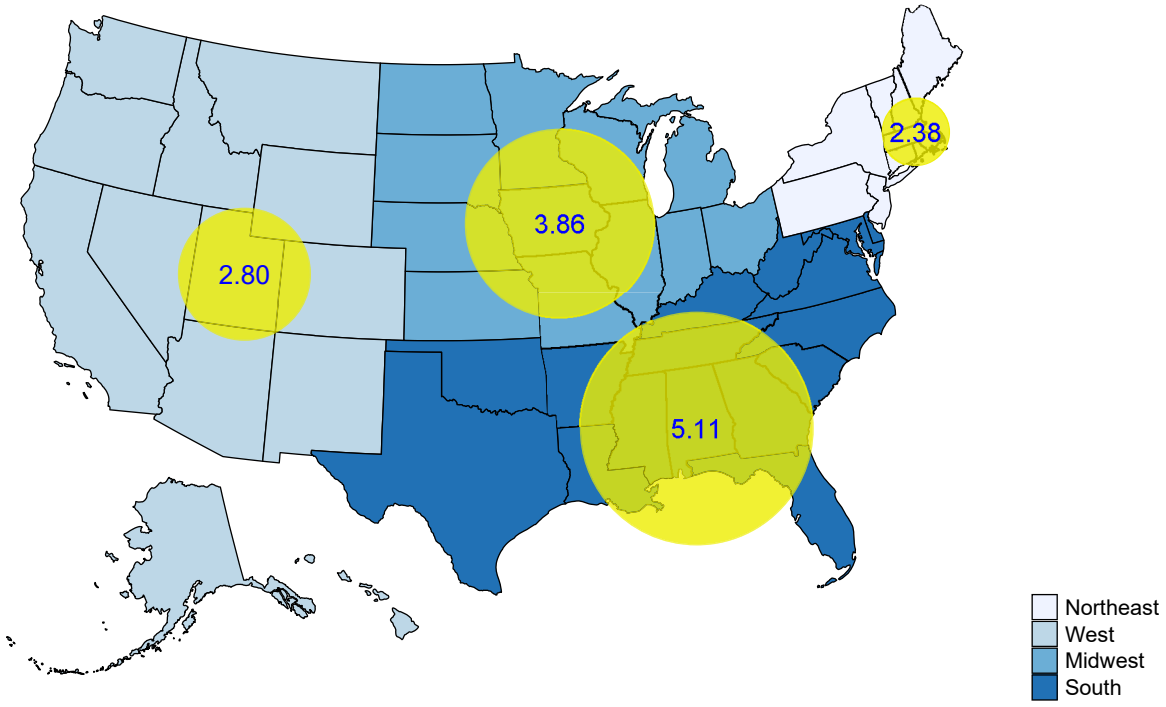

***Fig.* 3: Geographic distribution of pediatric FI-associated hospitalizations per 100,000 population in the US (data derived from KID 2019).** Note: Numbers in the circle represents the number of children FI related hospitalization per 100,000 population in the US. A darker blue color and a larger circle represent a higher number of FIs per 100,000 population. The overall incidence of hospitalizations was 3.86 per 100,000 population among US children in 2019. The population of children was calculated using total population minus population ≥18 years. Source of regional children population: Estimates of the Total Resident Population and Resident Population Age 18 Years and Older for the United States, States, and Puerto Rico: July 1, 2019 (SCPRC-EST2019-18+POP-RES) Population Division, U.S. Census Bureau, https://www.census.gov/data/tables/time-series/demo/popest/2010s-state-detail.html. Release Date: December 2019. Accessed 06/28/2022.

the leading cause of death in children in the US.[26] While adolescents between the ages 15 and 17 years are at the highest risk of FI, we report that children younger than 10 years of age, including infants, are also affected. Our findings corroborate other reports that younger children, especially those less than 10 years, are increasingly being involved in FI.

Racial disparity pertaining to gun violence is well established.[15,16] Black and Hispanic students are disproportionately impacted by gun violence and associated trauma.[16,27] In our study, Black children had both the highest overall prevalence of FI-associated admissions as well as the majority of unintentional and assault related admissions. Per the 2020 US census, 14% of the US population were Black,[24] yet Black children accounted for 50.2% of ED visits and 52.6% of hospitalizations for FI in our study,[28] thus offering another example of racial and socio-economic disparities in the US extending to the pediatric age group. By contrast, White children had the highest number of intentional FI, which is consistent with previous reports,[29] and likely reflects suicide attempts.

FI is linked to socioeconomic class.[19] Over half of the FI-associated ED visits were for children living in ZIP codes with the lowest median annual household incomes (<$44,000). In addition, children who were self-pay (i.e., those who had no insurance and were ineligible for governmental assistance) had the highest in-hospital mortality compared to those with some form of medical insurance. Across different settings, Black youth have been shown to be disproportionately affected by FI and associated deaths. There are several systemic factors driving these disparities, including underlying racial segregation; disparities and inequities in health likely deepen the racial disparities in FI violence.[30]

There is geographical variability in FI in the US. For example, the southern census region had the highest incidence both for FI-associated ED visits and FI-related hospitalizations, while the northeast had the lowest incidence. The reasons for these geographical variabilities need further study and assessment of long-term implications.

While this study reports on FI related encounters drawing from the two largest ED and hospital databases in the US, there are several limitations. First, the study captures only FI related cases who arrived in the ED alive. Any deaths that occurred before arrival to the ED would not have been captured in either the NEDS or

	NEDS			
	Deceased n = 384	% (95% CI)	PR (95% CI)	p value
Sex				
Female	38	3.6 (1.9–6.7)	Ref.	
Male	346	5.8 (4.6–7.4)	1.62 (0.81–3.25)	0.18
Age group				
0–9	57	8.9 (5.1–15.1)	Ref.	
10–14	74	5.9 (3.4–10.1)	0.66 (0.31–1.40)	0.28
15–17	253	4.9 (3.8–6.4)	0.55 (0.30–1.01)	0.053
Race/Ethnicity				
White	85	5.3 (3.4–8.1)	Ref.	
Black	173	4.9 (3.5–6.8)	0.93 (0.54–1.61)	0.80
Hispanic	38	3.4 (1.8–6.2)	0.64 (0.30–1.37)	0.25
Other	49	10.4 (4.9–20.7)	1.98 (0.86–4.57)	0.11
Firearm injury type				
Unintentional	202	5.0 (3.8–6.5)	Ref.	
Assault	106	3.9 (2.3–6.3)	0.77 (0.45–1.33)	0.35
Intentional self-inflicted	76	35.5 (22.3–51.3)	7.11 (4.31–11.73)	<0.0001
Primary payer				
Medicaid	193	4.2 (3.1–5.7)	Ref.	
Private	66	4.9 (2.9–8.3)	1.16 (0.63–2.14)	0.63
Self	116	12.8 (8.5–18.9)	3.01 (1.77–5.10)	<0.0001
No charge/other	10	5.5 (1.6–17.2)	1.30 (0.38–4.46)	0.67
Teaching status of hospital				
Nonteaching	105	7.3 (5.0–10.5)	Ref.	
Teaching	279	5.0 (3.8–6.6)	0.68 (0.43–1.09)	0.11
Hospital trauma level designation				
Level I or II	208	4.8 (3.5–6.5)	Ref.	
Level III or non-trauma center	176	6.5 (4.7–9.1)	1.36 (0.87–2.13)	0.17
Patient location				
Central counties of metro areas	183	7.5 (5.5–10.2)	Ref.	
Fringe counties of metro areas	68	5.9 (3.3–10.4)	0.78 (0.40–1.52)	0.47
Counties in metro areas of 50,000–999,999 population	76	3.2 (2.0–5.2)	0.43 (0.25–0.76)	0.0034
Micropolitan or not metropolitan counties	57	5.3 (3.1–8.9)	0.71 (0.38–1.30)	0.26
Median ZIP code household income				
$1–$43,999	164	4.5 (3.2–6.2)	Ref.	
$44,000–$73,999	144	5.4 (3.8–7.6)	1.20 (0.76–1.90)	0.44
$74,000+	52	8.9 (5.2–15.0)	2.00 (1.05–3.80)	0.036
Census region of hospital				
West	53	5.0 (2.7–9.0)	Ref.	
Midwest	89	5.8 (3.7–9.0)	1.16 (0.55–2.46)	0.13
South	237	6.0 (4.5–7.9)	1.19 (0.61–2.32)	0.12
Northeast	[a]	[a]	[a]	[a]

Deceased columns were presented in n (% deceased). Prevalence ratios were estimated using univariable Poisson regressions. Overall N for each subgroup was presented in Table 1. Abbreviation: PR: Prevalence ratio. CI: Confidence interval. [a]Weighted number <10 were suppressed per HCUP guidelines.

Table 3: **Weighted in-hospital mortality among children with firearm injury presenting to emergency departments in 2019 (data derived from NEDS).**

KID databases. Second, this study focuses on the first FI-associated visit/admission. This study was not designed to capture the long-term impact of gun violence on survivors. Third, while both NEDS and KID databases have rigorous quality control measures, misclassification of ICD-10 coded hospital data can occur and is especially problematic for characterizing the type of FI (e.g., intentional self-harm, accidental, etc.).[31–33] Reassuringly, similar HCUP databases like the National Inpatient Sample, have been validated extensively against the National Hospital Discharge Survey and Medicare Provider Analysis and Review Files.[34] Fourth, race and ethnicity are complex variables and associations need to be assessed carefully.[35] Not all

	KID			
	Deceased n = 225	% (95% CI)	PR (95% CI)	p value
Sex				
Female	38	8.4 (5.9–11.6)	Ref.	
Male	187	7.9 (6.7–9.3)	0.95 (0.65–1.38)	0.78
Age group				
0–9	22	7.3 (4.5–11.4)	Ref.	
10–14	53	10.6 (7.9–14.2)	1.46 (0.87–2.46)	0.15
15–17	150	7.4 (6.2–8.9)	1.02 (0.61–1.71)	0.93
Race/Ethnicity				
White	74	13.5 (10.6–17.1)	Ref.	
Black	76	5.2 (4.0–6.7)	0.38 (0.27–0.55)	<0.0001
Hispanic	27	5.3 (3.3–8.4)	0.39 (0.23–0.66)	0.00048
Other	26	14.6 (9.3–22.3)	1.08 (0.66–1.78)	0.76
Firearm injury type				
Unintentional	81	5.6 (4.5–7.0)	Ref.	
Assault	68	5.7 (4.3–7.4)	1.01 (0.71–1.44)	0.96
Intentional self-inflicted	75	46.1 (37.5–54.9)	8.20 (6.06–11.10)	<0.0001
Any transfusion				
No	155	6.2 (5.3–7.4)	Ref.	
Yes	71	20.4 (16.0–25.7)	3.27 (2.50–4.29)	<0.0001
Primary payer				
Medicaid	126	6.4 (5.2–7.8)	Ref.	
Private	63	11.8 (9.0–15.4)	1.84 (1.30–2.62)	0.00063
Self	19	10.4 (6.2–16.8)	1.62 (0.96–2.75)	0.072
No charge/other	15	12.8 (7.3–21.4)	2.00 (1.13–3.54)	0.017
Hospital control				
Government, nonfederal	47	7.5 (5.3–10.6)	Ref.	
Private, nonprofit	159	8.1 (6.8–9.6)	1.08 (0.73–1.58)	0.70
Private, investor-owned	19	8.2 (5.4–12.4)	1.09 (0.63–1.88)	0.75
Bed size of hospital				
Small or medium	54	6.0 (4.5–8.1)	Ref.	
Large	171	8.9 (7.5–10.5)	1.47 (1.05–2.07)	0.026
Teaching status of hospital				
Nonteaching	[a]	4.6 (1.7–11.8)	Ref.	
Teaching	219	8.1 (7.0–9.4)	1.77 (0.66–4.73)	0.26
Freestanding children hospital				
No	200	8.3 (7.1–9.7)	Ref.	
Yes	24	6.1 (3.9–9.3)	0.74 (0.46–1.16)	0.19
Patient location				
Central counties of metro areas	75	6.3 (4.8–8.3)	Ref.	
Fringe counties of metro areas	40	8.8 (6.2–12.4)	1.39 (0.89–2.19)	0.15
Counties in metro areas of 50,000–999,999 population	74	8.7 (6.8–11.1)	1.39 (0.95–2.02)	0.092
Micropolitan or not metropolitan counties	34	11.2 (7.4–16.6)	1.78 (1.09–2.91)	0.022
Median ZIP code household income				
$1–$43,999	105	6.6 (5.4–8.2)	Ref.	
$44,000–$73,999	84	8.6 (6.8–10.8)	1.29 (0.94–1.78)	0.12
$74,000+	32	16.0 (11.0–22.7)	2.41 (1.60–3.63)	<0.0001
Census region of hospital				
West	40	8.1 (5.6–11.5)	Ref.	
Midwest	47	7.9 (5.9–10.5)	0.98 (0.62–1.55)	0.38
South	111	7.6 (6.2–9.3)	0.94 (0.62–1.43)	0.27
Northeast	27	10.0 (6.4–15.5)	1.24 (0.70–2.21)	0.45

Deceased columns were presented in n (% deceased). Prevalence ratios were estimated using univariable Poisson regressions. Overall N for each subgroup was presented in Table 2. Abbreviation: PR: Prevalence ratio. CI: Confidence interval. [a]Weighted number <10 were suppressed per HCUP guidelines.

Table 4: **Weighted in-hospital mortality among children with firearm injury hospitalized in 2019 (data derived from KID).**

HCUP Partner organizations provide information on race and ethnicity. The availability of this information may differ by year. Additionally, the reporting of information on race and ethnicity can vary by hospital. Fifth, the findings indicate significant geographical variability in the incidence both of FI-related ED visits as well as hospitalizations based on census regions. However, the analysis precludes state level reporting as only census region data are available in the databases. This may limit the epidemiological implications as the census regions encompass multiple states, with possibly varied social and firearm policies and state-level firearm legislation. Finally, other sociologic variables, such as household educational level, English proficiency, household employment and/or food insecurity, pertain to health care disparities and could also be associated with FI; however, these were not available in the databases.

FI remains a major public health challenge in the US,[1,2] contributing substantially to short- and long-term disability and mortality.[36–38] In addition to the direct effect on patients, FI places an immense burden on the healthcare system.[17,39] A rise in gun violence and the associated increase in ED visits and hospital admissions has put further pressure on the healthcare system, risking a decline in the overall quality of patient care.[40] Several studies have reported on the short-term and long-term health effects, financial ramifications and developmental burden of FI in adults; our study described the impact on children.[2,41] The American Academy of Pediatrics (AAP) advocates for stronger gun laws, and recommends steps to mitigate the adverse effects on children, adolescents, and their families.[42,43] The AAP endorses a number of specific measures, that include revised legislative and regulatory approaches spanning the manufacture, sale, purchase, ownership, and use of firearms, including a ban on semiautomatic assault weapons, along with funding research efforts and educational initiatives that pertain to the prevention of FI.[42] Our study highlights the extent of FI and associated deaths in children in the US, along with the racial and socioeconomic disparities that continue to contribute to this public health crisis. The findings can help to guide interventions aimed at reducing the burden of FI in children.

Contributors

Drs. Goel and Tobian and Mr. Zhu had full access to all the data in the study and take responsibility for the integrity of the data and accuracy of the data analysis. Concept and design: Goel, Zhu, Bloch, Tobian. Acquisition, analysis or interpretation of data: All authors. Drafting of the manuscript: Goel, Zhu, Bloch, Tobian. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: Goel, Zhu, White. Administrative, technical, or material support: Goel, Bloch, Tobian. Supervision: Goel, Bloch, Tobian.

Data sharing statement

Raw data from NEDS and KID is publicly available for access after signing the *HCUP* Data Use Agreement. Programming codes in Stata/MP and R can be provided by the corresponding author upon request.

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Declaration of interests

All authors signed an Author Statement Form, and completed an individual ICMJE COI Form. Dr. Gehrie received payments or honoraria from Grifols Diagnostics, Cerus Corporation, Instrumentation Laboratories, and Wiley. No other authors have declared any relevant conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2023.100503.

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