Rural Versus Urban Hospitalizations for Firearm Injuries in Children and Adolescents

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abstract

OBJECTIVES: Firearms are a leading cause of injury and death for children and adolescents in the United States. We examined how hospitalization rates for firearm injuries differ for rural and urban populations.

METHODS: The Kids' Inpatient Database was used to identify hospitalizations for firearm injuries in patients <20 years of age by using *International Classification of Diseases, Ninth Revision* external-cause-of-injury codes. Data from 2006, 2009, and 2012 were analyzed to compare demographics and intent (assault, self-inflicted, unintentional, and undetermined). Urban-rural classification was based on patients' county of residence. Rates were calculated by using weighted cases and US Census data.

RESULTS: There were 21 581 hospitalizations for firearm injuries. The overall hospitalization rate was higher in urban versus rural areas (risk ratio [RR] = 1.95; 95% confidence interval [CI]: 1.81–2.10). Rates were highest for assaults in urban 15- to 19-year-olds (RR = 7.82; 95% CI: 6.48–9.44). Unintentional injuries were the leading cause of hospitalizations in younger age groups in all urban and rural locations. Rates for unintentional injuries were lower among urban versus rural 5- to 9-year-olds (RR = 0.47; 95% CI: 0.36–0.63) and 10- to 14-year-olds (RR = 0.44; 95% CI: 0.37–0.52).

CONCLUSIONS: Hospitalizations for firearm assaults among urban 15- to 19-year-olds represent the highest injury rate. Notably, hospitalizations are lower for urban versus rural 5- to 9-year-olds and 10- to 14-year-olds, and unintentional firearm injuries are most common among these groups. Preventative public health approaches should address these differences in injury epidemiology.

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WHAT'S KNOWN ON THIS SUBJECT: Male sex, nonwhite race, and late adolescent age are risk factors for pediatric and adolescent firearm injuries, but there are no studies in which researchers examine the differences in rates of firearm injury hospitalizations between rural and urban populations.

WHAT THIS STUDY ADDS: Hospitalization rates for firearm injuries are higher in rural areas among 5- to 9-year-olds and 10- to 14-year-olds versus urban populations. Unintentional firearm injuries are the most common cause of firearm injury hospitalizations except among urban 15- to 19-year-olds.

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In 2015, there were 13 723 nonfatal and 2762 fatal firearm injuries in children and adolescents <20 years of age in the United States.[1] Deaths from firearms now rank among the top 3 causes of death in the pediatric population.[1–3] In previous research, it has been identified that male sex, nonwhite race, low median income, and older adolescent age are risk factors for sustaining both fatal and nonfatal firearm injuries[2,4–10]; these data, however, are largely driven by firearm assaults in urban settings. In 2 previous studies, it has been demonstrated that fatality rates due to firearms for urban and rural counties are essentially equivalent both in the overall population and specifically in children and adolescents.[11,12] Rural and urban differences have been noted regarding the cause of injury or death, with suicide and unintentional firearm deaths occurring at a higher rate in rural counties and deaths from firearm homicide occurring at a higher rate in urban counties.[11,12]

Because of limited availability of detailed national statistics on firearm deaths in children and adolescents, data from hospitalizations due to firearm injuries represent an opportunity to examine and better understand the epidemiology and contributing factors that might help explain rural and urban differences and ensure that public health approaches to the prevention of firearm injuries appropriately address variations across different populations. Therefore, our objectives in this study were to determine how hospitalization rates due to firearm injuries differ between rural and urban settings and to compare rates by intent and demographic variables.

METHODS

Study Design and Data Source

We conducted a cross-sectional study of US hospitalizations due to firearm injuries in children and adolescents <20 years of age using the Kids' Inpatient Database (KID), the largest publicly available all-payer pediatric inpatient care database, which was developed for the Healthcare Cost and Utilization Project and created by the Agency for Healthcare Research and Quality.[13] The KID, released every 3 years since 1997, provides a nationally representative sample of hospital discharge data. The most recent data set, released in 2012, includes data on more than 4100 hospitals across 44 states.[13] For our study, we aggregated the data for the years 2006, 2009, and 2012.

The KID includes systematic randomly sampled data from 10% of uncomplicated births and 80% of complicated births and other acute care hospitalizations.[13] Discharge data are weighted to yield national estimates by stratifying hospitals by using the following 6 characteristics: bed size, hospital type, ownership and/or control, rural or urban location, teaching status, and US region. The KID does not include data on cases that do not result in an inpatient hospitalization admission and thus does not include patient deaths that occurred in the emergency department. Unweighted data include over 3 million pediatric discharges for each year of the KID; weighted data are used to provide estimates for over 7 million pediatric discharges each year of the KID.[13]

This study was deemed exempt from approval by the Yale School of Medicine's Institutional Review Board.

Identification of the Sample

We identified eligible hospitalizations as those occurring for fatal and nonfatal injuries due to firearms for children and adolescents <20 years of age at the time of admission. We used external-cause-of-injury codes (E codes) from the *International Classification of Diseases, Ninth Revision, Clinical Modification*[14] to include all hospitalizations due to firearm injuries, specifying the intent of the injury as one of the following: assault (E965.0–E965.4), self-inflicted (E955.0–E955.4, E955.6, E955.9), unintentional (E922.0–E922.4, E922.8–E922.9), and undetermined as to whether the injury was unintentional or purposefully inflicted (E985.0–E985.4, E985.6). We included hospitalizations for firearm injuries due to BB or air guns and excluded those due to paintballs. We also excluded those hospitalizations that were only coded for late effects of injury, removing from the data set those with either a late effects *International Classification of Diseases, Ninth Revision* (ICD-9) or E code (ICD-9: 905–909 and E codes: 929, 959, 969, 989). In addition, we did not include ICD-9 codes or categories that were used to specify legal intervention as a separate category of intent (notably, the 2012 American Academy of Pediatrics policy statement on firearm-related injury states that ~1% of pediatric injuries were classified under this mechanism of intent).[2]

We abstracted the following demographic information: age at the time of hospitalization (0–4, 5–9, 10–14, and 15–19 years of age), sex, race and/or ethnicity (white, African American, Hispanic, or other), type of health insurance (private, Medicaid, self-pay, or other), and the patient's county of residence (including rural or urban classification). The age groupings were chosen to be consistent with the age categories used by the Centers for Disease Control and Prevention Web-based Injury Statistics Query and Reporting System.[1]

Rural and urban classification data in the KID are based on the patient's county of residence[13] and defined by the National Center for Health Statistics.[15] For this study, we matched rural and urban classifications from the KID to

publicly available rural and urban classification data from the US Census Bureau in the following 3 categories: metropolitan counties of >50 000 population (referred to as urban-metropolitan in the KID and defined in this study as urban), micropolitan counties of 10 000 to 49 999 population (defined as micropolitan), and nonmetropolitan nonmicropolitan counties of <10 000 population (defined as rural).[16]

Statistical Analysis

We calculated the weighted estimates of the number of hospitalizations due to firearm injuries during the time period, stratified by intent, age, race, and urban or rural location. Differences in demographic and clinical characteristics were assessed by using χ^2 tests. We calculated the incidence of hospitalizations due to firearm injuries by dividing the aggregated number of weighted hospitalizations by the aggregated number of children and adolescents for each urban and rural location on the basis of 2006, 2009, and 2012 intercensal data.[16] We compared rates of hospitalization for different groups by calculating relative risk ratios (RRs) (using rural counties as the reference group). All analyses were performed by using SAS version 9.4 (SAS Institute, Inc, Cary, NC).

RESULTS

Demographic and Clinical Characteristics

We identified 21 843 hospitalizations due to firearm injuries in children and adolescents <20 years of age during the aggregate study period, including 2006, 2009, and 2012; 262 hospitalizations were excluded because there was no documentation of urban or rural classification per the National Center for Health Statistics categories, resulting in a final sample of 21 581. The demographic characteristics of the hospitalized children and adolescents are shown in Table 1. Most hospitalizations occurred in older adolescents and males, but there were statistically significant differences in the age distribution between urban and rural locations. Across all age groups and urban and rural locations, 15- to 19-year-olds accounted for the majority of the hospitalizations. There were also statistically significant differences across urban and rural categories for racial background and insurance status or payer, as shown in Table 1. Overall, 6% of all children hospitalized died during their hospitalization, and there were no differences between urban and rural location (P = .08).

TABLE 1 Demographic and Clinical Characteristics of Children and Adolescents Hospitalized for Firearm Injuries (Aggregated Data From 2006, 2009, and 2012 KID)

Characteristics	Weighted National Estimates			*P*
	Urban (*n* = 19 819), *n* (%)	Micropolitan (*n* = 1044), *n* (%)	Rural (*n* = 718), *n* (%)	
Age, y				<.001
0–4	414 (2.1)	41 (4.0)	30 (4.3)	
5–9	549 (2.8)	67 (6.5)	57 (8.1)	
10–14	1860 (9.5)	180 (17.5)	172 (24.4)	
15–19	16 686 (85.5)	741 (72.0)	446 (63.3)	
Male sex	17 402 (89.3)	905 (86.9)	635 (88.6)	.05
Race and/or ethnicity				<.001
White	2556 (15.1)	420 (52.8)	400 (71.1)	
African American	9520 (56.2)	206 (25.9)	81 (14.4)	
Hispanic	4004 (26.3)	98 (12.3)	43 (7.6)	
Other	864 (5.1)	71 (9.0)	39 (7.0)	
Insurance				<.001
Private	4866 (24.6)	330 (31.8)	260 (36.3)	
Medicaid	10 043 (50.8)	465 (44.8)	279 (38.9)	
Self-pay	3204 (16.2)	177 (17.1)	118 (16.5)	
Other	1645 (8.3)	66 (6.4)	59 (8.3)	
Died	1198 (6.1)	80 (7.7)	48 (6.7)	.08

Incidence of Hospitalizations for All Types of Firearm Injuries

Rates of hospitalization and RRs for all firearm injuries and for each category of intent and age group are shown in Tables 2 and 3. In Table 2, we show the rates and RRs for urban versus rural areas. In Table 3, we show the rates and RRs for micropolitan versus rural areas. The highest rate of hospitalization due to all categories of intent was 30.68 (95% confidence interval [CI]: 27.63–33.73) per 100 000 persons, occurring in 15- to 19-year-olds in urban areas (Table 2), whereas the lowest rate was 0.71 (95% CI: 0.42–1.00) per 100 000 persons, occurring in 0- to 4-year-olds in micropolitan areas (Table 3).

As shown in Table 2, compared with rural areas, hospitalization rates were higher in urban areas for 15- to 19-year-olds (RR = 2.76; 95% CI: 2.51–3.03) but lower among 5- to 9-year-olds (RR = 0.67, 95% CI: 0.51–0.88) and 10- to 14-year-olds (RR = 0.79; 95% CI: 0.68–0.93). There was no significant difference between 0- and 4-year-olds (RR = 0.91; 95% CI: 0.63–1.32).

As shown in Table 3, micropolitan and rural areas had more similar rates of hospitalization for all categories of intent of firearm injuries, with no statistically significant difference in rates between 0- to 4-year-olds, 5- to 9-year-olds, or 15- to 19-year-olds. Micropolitan 10- to 14-year-olds were less likely to be hospitalized than their rural age counterparts (RR = 0.66; 95% CI: 0.54–0.81).

TABLE 2 Incidence of Hospitalizations for Firearm Injuries by Intent: Urban Versus Rural (Reference Group); Aggregated Data From 2006, 2009, and 2012 KID

	Incidence per 100 000 Persons		RR (95% CI)	*P*
	Urban (95% CI)	Rural (95% CI)		
All intents, y				
0–4	0.80 (0.67–0.92)	0.87 (0.48–1.26)	0.91 (0.63–1.32)	.64
5–9	1.07 (0.92–1.23)	1.61 (1.03–2.19)	0.67 (0.51–0.88)	.004
10–14	3.59 (3.16–4.02)	4.53 (3.51–5.54)	0.79 (0.68–0.93)	.004
15–19	30.68 (27.63–33.73)	11.11 (9.28–12.94)	2.76 (2.51–3.03)	<.001
Assault, y				
0–4	0.18 (0.13–0.24)	—	—	—
5–9	0.31 (0.23–0.38)	—	—	—
10–14	1.50 (1.25–1.76)	—	—	—
15–19	21.44 (19.00–23.87)	2.74 (1.88–3.61)	7.82 (6.48–9.44)	<.001
Unintentional, y				
0–4	0.58 (0.48–0.68)	—	—	—
5–9	0.73 (0.62–0.85)	1.55 (0.98–2.12)	0.47 (0.36–0.63)	<.001
10–14	1.75 (1.52–1.97)	3.97 (3.08–4.87)	0.44 (0.37–0.52)	<.001
15–19	6.54 (5.91–7.18)	5.98 (4.87–7.09)	1.09 (0.96–1.25)	.18
Self-inflicted, y				
10–14	0.12 (0.08–0.16)	—	—	—
15–19	0.90 (0.77–1.02)	1.64 (1.11–2.18)	0.54 (0.42–0.70)	<.001

Estimates that do not meet the criteria for statistical reliability are not shown. —, not applicable.

TABLE 3 Incidence of Hospitalizations for Firearm Injuries by Intent: Micropolitan Versus Rural (Reference Group); Aggregated Data From 2006, 2009, and 2012 KID

	Incidence per 100 000 Persons		RR (95% CI)	*P*
	Micropolitan (95% CI)	Rural (95% CI)		
All intents, y				
0–4	0.71 (0.42–1.00)	0.87 (0.48–1.26)	0.82 (0.51–1.31)	.84
5–9	1.15 (0.78–1.53)	1.61 (1.03–2.19)	0.72 (0.50–1.02)	.07
10–14	2.99 (1.75–4.23)	4.53 (3.51–5.54)	0.66 (0.54–0.81)	<.001
15–19	10.97 (9.29–12.65)	11.11 (9.28–12.94)	0.99 (0.88–1.11)	.83
Assault, y				
15–19	4.32 (3.33–5.31)	2.74 (1.88–3.61)	1.58 (1.27–1.96)	<.001
Unintentional, y				
0–4	0.66 (0.38–0.94)	—	—	—
5–9	1.07 (0.71–1.42)	1.55 (0.98–2.12)	0.69 (0.48–0.99)	.04
10–14	2.61 (2.04–3.18)	3.97 (3.08–4.87)	0.66 (0.52–0.82)	<.001
15–19	4.69 (3.93–5.45)	5.98 (4.87–7.09)	0.78 (0.66–0.93)	.005
Self-inflicted, y				
15–19	1.14 (0.81–1.47)	1.64 (1.11–2.18)	0.69 (0.50–0.96)	.03

Estimates that do not meet the criteria for statistical reliability are not shown. —, not applicable.

Incidence of Hospitalizations for Firearm Injuries by Intent

The leading cause of hospitalization for 15- to 19-year-olds in urban areas was firearm assaults, occurring at a rate of 21.44 (95% CI: 19.00–23.87) per 100 000 persons (Table 2). This rate was 7.8-fold higher (RR = 7.82; 95% CI: 6.48–9.44) than that of 15- to 19-year-olds in rural areas (Table 2). Firearm assaults leading to hospitalization also occurred at a higher rate in micropolitan areas compared with rural areas (RR = 1.58; 95% CI: 1.27–1.96) (Table 3).

Although the majority of firearm injuries occurred among urban 15- to 19-year-olds, unintentional firearm injuries were the leading cause of hospitalizations across all younger age groups in all 3 urban and rural locations. Rates of hospitalization due to unintentional injuries among 5- to 9-year-olds and 10- to 14-year-olds were lower in urban areas when compared with rural areas (RR = 0.47; 95% CI: 0.36–0.63 and RR = 0.44; 95% CI: 0.37–0.52, respectively) (Table 2). Rates of hospitalization due to unintentional injuries were also lower in micropolitan areas compared with rural areas for 5- to 9-year-olds, 10- to 14-year-olds, and 15- to 19-year-olds (Table 3).

Hospitalization rates for self-inflicted injuries were highest in rural areas among 15- to 19-year-olds. Rates of hospitalization for self-inflicted injuries in both urban areas (RR = 0.54; 95% CI: 0.42–0.70) and micropolitan areas (RR = 0.69; 95% CI: 0.50–0.96) were lower in comparison with rural areas.

As shown in Tables 2 and 3, when stratifying by intent, the calculation of hospitalization rates in some of the younger age groups did not meet criteria for statistical reliability and thus were not used for analysis to compare between urban and rural locations.

DISCUSSION

In this study, in which we examined US hospitalizations in children and adolescents due to firearm injuries, there were 3 key findings: (1) the majority of pediatric firearm injuries resulting in hospitalization across all urban and rural locations occurred among 15- to 19-year-olds, and the hospitalization rate in this age group was highest among those living in urban areas; (2) in contrast, hospitalizations due to firearm injuries among 5- to 9-year-olds and 10- to 14-year-olds were lower in urban areas compared with rural areas; and (3) unintentional firearm injuries were the most common cause of hospitalization for the younger age groups (<15 years of age) across all urban and rural areas.

There are limited studies in which researchers compare the rates of firearm injuries between rural and urban settings. Although in pediatric-specific studies researchers

have evaluated firearm deaths and mortality rates between urban and rural locations, they have not examined hospitalization rates nor have they evaluated different pediatric age groups. In 1 study, it was demonstrated that urban and rural counties have overall similar firearm mortality rates but that urban counties have higher firearm homicide rates, whereas rural counties have higher firearm suicide rates.[11] The same group later demonstrated similar findings specifically in children and adolescents (0–19-year-olds), showing that pediatric firearm homicide rates were nearly 3.7 times higher in urban counties but again that overall mortality rates were similar between urban and rural counties.[12]

In our study, we showed that the overall rate of hospitalization due to firearm injuries in children and adolescents is highest among 15- to 19-year-olds living in urban areas, occurring at a rate nearly threefold higher than that of 15- to 19-year-olds living in rural areas. Urban 15- to 19-year-olds account for >75% of all pediatric firearm-related hospitalizations, and they average over 5500 hospitalizations each year or ∼15 hospitalizations per day. Specifically, more than two-thirds of these hospitalizations are related to firearm injuries due to assault, and 15- to 19-year-olds in urban areas are hospitalized for firearm assaults at a rate 8 times higher than 15- to 19-year-olds in rural areas. These findings are consistent with previous studies in which it was demonstrated that older adolescent age in urban locations is a primary risk factor for firearm death and injury.[4,5,8–10] These same studies have also revealed that African American and Hispanic individuals are at an increased risk of sustaining firearm injuries, particularly injuries due to firearm assault. Our study is consistent with these previous findings, revealing that hospitalizations due to firearm injuries occur at a disproportionately elevated rate in both African American and Hispanic youth, especially in urban areas.

Our finding that pediatric hospitalization rates for firearm injuries in 5- to 9-year-olds and 10- to 14-year-olds were lower in urban areas when compared with rural areas has not been reported previously. In previous studies in which researchers compared urban and rural firearm injuries, authors did not distinguish between older adolescents and younger children and adolescents.[11,12] Importantly, the rate of unintentional firearm injuries is higher in rural areas among these younger children compared with urban areas. With these findings, we suggest that approaches to reducing firearm injuries in rural areas should take into account the increased rate of unintentional injuries versus urban areas, and further study is needed to determine the best means of preventing injuries in these different populations. In terms of further possible solutions, the American Academy of Pediatrics has made multiple statements on the need for the promotion of safe firearm storage, and researchers have demonstrated the importance of reducing access to firearms in youth suicide prevention.[2,17] In recent studies, there have also been promising results around community-based interventions to promote safe gun storage practices.[18]

The majority of firearm injury hospitalizations in children <15 years of age were due to unintentional injuries. In these children, unintentional injuries were the leading cause of firearm injury hospitalization in urban and micropolitan areas, and those in rural areas had an even higher rate. In previous studies, it has been documented that unintentional firearm injuries are more common than assault and/or homicide firearm injuries in children and adolescents 0 to 14 years of age.[4,7] However, at least 1 other study in which researchers specifically evaluated both fatal and nonfatal firearm injury rates in this age group revealed that firearm homicide and assault rates were higher than unintentional death and injury rates.[5] Of note, different authors have used different data sources, which may at least partially account for this discrepancy. In our findings, which are based on the largest publicly available all-payer pediatric inpatient database, it is indicated that unintentional firearm injuries are the most common category of intent leading to hospitalization for all age groups except for 15- to 19-year-olds in urban areas (as noted above). Specifically, with regards to rural versus urban settings, studies in which authors evaluate mortality have revealed higher rates of unintentional and suicide firearm deaths in rural areas.[11,12,19,20] In previous studies, researchers have also speculated that this rural-urban disparity with regards to intent and firearm injury may be related to overall gun ownership rates, types of firearms involved, firearm storage practices, or lack of access to trauma care.[19,21–25] Further research is needed to better understand how these geographic differences affect firearm-related injuries.

In addition to higher rates of hospitalization for unintentional firearm injuries in rural areas, our study also showed that rural areas have higher rates of hospitalization for self-inflicted injuries (ie, suicide or suicide attempts) among older adolescents (15–19-year-olds). As noted above, this finding is well supported by previous studies,[11,12,20] and although not a new finding, it is important given the increasing overall rate of suicide in the United States and its disproportionately higher rate of increase among rural communities.[26] The combination of

increased accessibility to firearms and decreased access to appropriate mental health services has been suggested as a partial explanation for this urban-rural discrepancy,[27–30] and higher adolescent suicide rates in rural areas are likely mirroring similar trends for adult suicide rates.[31] Further research in this area is needed to help better design effective suicide prevention efforts.

This study has at least 2 limitations. First, the KID depends on *International Classifications of Disease* coding, which is subject to miscoding and misclassification errors; the ability to discern the mechanism of intent in firearm injury data can be a source of coding error. Likewise, an appropriate law enforcement investigation may not have been fully completed at the time of hospitalization, and determining unintentional versus intentional injuries or assault intent may be unclear.

Second, KID data sets report the number of hospitalizations and not individual children or adolescents. Thus, to calculate population hospitalization rates, we made the assumption that a patient was hospitalized once during the database year and excluded hospitalizations that only listed injury codes for a late effect.

With our study's results, we add further evidence to previous research and demonstrate new findings with regards to rural and urban differences in the rate of hospitalization due to firearm injury among children and adolescents. As with many other public health issues, separating and understanding the different components of this complex problem are essential to designing and monitoring public health efforts to reduce firearm-related injuries. With our findings, we build on previous research and further suggest that the cause and underlying factors leading to firearm injuries in rural communities are likely different from those in urban communities. Thus, to effectively approach these related but different problems, different prevention strategies will likely be required. These might include a combination of individual and community-focused awareness and education campaigns, safety and injury prevention anticipatory guidance and counseling, increased mental health access and screening, and violence prevention programs.

CONCLUSIONS

There are important differences in the rates of hospitalization due to firearm injuries based on intent and age in urban versus rural areas. With these findings, we suggest that a varied public health approach is needed to reduce firearm-related injuries in these different areas of the country.

ABBREVIATIONS

CI: confidence interval
E code: external-cause-of-injury code
ICD-9: *International Classification of Diseases, Ninth Revision*
KID: Kids' Inpatient Database
RR: risk ratio

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