Comprehensive Local Injury Surveillance for Pediatric Fatal and Nonfatal Firearm Injury Prevention Planning

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Since 2019, injuries from firearms have surpassed motor vehicle crashes as the *leading* cause of death among children and youth (0-19 years) in the United States.[1] Furthermore, the US has a nearly 25 times higher firearm homicide rate compared to other developed countries.[2] Therefore, firearm injury prevention, particularly for children and youth, is a significant public health priority.

In the Centers for Disease Control and Prevention's (CDC's) public health approach to injury prevention, *defining the problem* based on evaluation of injury data is the first step that should be undertaken before prevention strategies are implemented for maximum effectiveness.[3] It is important to realize that fatalities due to firearm injuries are only part of the problem as nonfatal firearm injuries are 2 to 3 times more common than fatal injuries in children and youth.[4,5] Among children who survive firearm injuries, a third have a physical disability and 60% experience psychological sequelae.[6,7] Therefore, the national discussion around consequences of firearm violence *must* include nonfatal injuries, especially in the pediatric population.

To fully define the problem of firearm injury, information from multiple sources needs to be gathered through ongoing surveillance efforts.[8] Currently, no single national, regional, or local surveillance system captures fatal and nonfatal firearm injury events in a comprehensive fashion. The CDC has numerous publicly available surveillance systems that include national firearm-related injury data and estimates, but these focus solely on firearm fatalities. One of these is the National Violent Death Reporting System (NVDRS)[9], a state-based surveillance system that pools violent death data for homicides, suicides, and unintentional firearm-related deaths from law enforcement, medical examiners, toxicology reports, and death certificates. This database also captures contextual details surrounding the deaths such as alcohol abuse, job problems, or mental health stressors. The Web-Based Injury Statistics Query and Reporting System (WISQARS) is populated by the National Vital Statistics System (NVSS).[10] This online fatal injury system allows for querying national-level firearm mortality estimates and is stratified by various demographic characteristics such as age, race, and gender as well as some contextual details such as intent. Since 2019, however, the nonfatal firearm data for children has been deemed not reliable due, in part, to changes in hospital participation resulting from hospital closures or mergers.[11] The Wide-ranging ONline Data for Epidemiologic Research (WONDER) database, populated by NVDRS, provides slightly more contextual detail for firearm deaths than WISQARS but also does not include nonfatal firearm injury data.[12]

The Federal Bureau of Investigation's (FBI's) Uniform Crime Report documents homicides occurring in the US for children and adults but does not capture suicides or nonfatal firearm-related injuries.[13] Additionally, the Bureau of Justice Statistics (BJS) conducts the National Crime Victimization Survey annually among a representative sample of US residents who are interviewed about the frequency, characteristics, and consequences of nonfatal crimes.[14] However, it does not include data regarding violent events among children younger than 12 years.

Hospital-level data on patients presenting with firearm-related injuries can be obtained from the National Trauma Data Bank (NTDB),[15] which includes injury data from over 900 trauma centers; databases managed by the Agency for Healthcare Research and Quality Healthcare Cost and Utilization Project (H-CUP), which include the Kids Inpatient Database, National Inpatient Sample, and the Nationwide Emergency Department Sample)[16]; and the National Electronic Injury Surveillance, which reports emergency visits for injuries.[17]

The advantage of the national surveillance systems is that they are broad in scope and designed to provide national or broad regional estimates. However, they are limited in that they do not provide data on nonfatal firearm injury in children; they offer little information about the social factors, context, or shooting types; and local data cannot be determined. The hospital-level databases do include nonfatal firearm injury data and may offer data on shooting types and social factors related to either the victim or the shooting event, but they miss many fatal injuries at the scene (particularly suicides). An additional issue is that some national databases are based on weighted estimates and thus may not accurately reflect local conditions; it is not possible to determine city-, county- or region-specific data from these databases (Table 1). In order to plan local prevention efforts, an accurate local injury estimate of firearm injury ("defining the problem") is essential.

Table 1: Comparisons of Existing Publicly Available Surveillance Systems for Fatal and Nonfatal Firearm Injuries in the US

	NVDRS[a]	NVSS[b]	UCR[c]	NCVS[d]	NTDB[e]	NEISS[f]	H-CUP[g]
Data type	Individual data from all 50 states	Individual data from all 50 states	Individual data from participating law enforcement agencies (over 18,000 agencies)	National representative sample from 150,000 households	Individual data from participating trauma centers (over 900 centers)	Nationally representative probability sample of hospitals	Weighted estimates from 7 million pediatric hospitalizations per year (KID and NIS); 145 million emergency department visits (NEDS)
Firearm injuries							
A Outcome							
Fatal	✓	✓	✓		✓	✓	✓
Nonfatal				✓	✓	✓	✓
B Types							
Homicides/interpersonal	✓	✓	✓	✓	✓	✓	✓
Suicide/self-inflicted intentional	✓	✓			✓	✓	✓
Unintentional	✓	✓			✓	✓	✓
C Data sources							
Law enforcement	✓		✓				
Hospital/healthcare setting					✓	✓	✓
Medical examiners reports	✓	✓					
Survey				✓			
D Contextual details							
Surrounding the injury	✓	✓		✓	✓	✓	✓
About the affected persons	✓	✓	✓	✓	✓	✓	✓

a. National Violent Death Reporting System (NVDRS) – contributes national data for CDC's Web-Based Injury Statistics Query and Reporting System (WISQARS)
b. National Vital Statistics System (NVSS) – contributes national data for CDC's Wide-ranging ONline Data for Epidemiologic Research (WONDER)
c. Unified Crime Reporting Program (UCR)
d. National Crime Victimization Survey (NCVS)
e. National Trauma Data Bank (NTDB)
f. National Electronic Injury Surveillance System (NEISS)
g. Healthcare Cost and Utilization Project (H-CUP) maintains several databases: Kid's Inpatient Database (KID), Nationwide Emergency Department Sample (NEDS), National Inpatient Sample (NIS)

A great example of local surveillance is that for motor vehicle crashes (MVCs). Information on fatal and serious nonfatal MVCs is available at the local level and is mandated by law. While local police compile vehicle crash data for their jurisdictions, the Highway Safety Act of 1973 (23 U.S.C. 152) requires that each state conduct and systematically maintain a survey of all highways to identify hazardous locations that may constitute a danger to vehicles and to pedestrians.[18] These data are typically compiled at the state level, either by the state police or the state department of transportation, but they allow for local analysis to be conducted. The law establishes a benefit-cost methodology for identifying safety project locations and for assigning priorities. The act provides mandates for states and an earmarked funding source for safety improvements. States cannot use the excuse of lack of funding to avoid having to improve the safety of the highways. Unfortunately, such legislation and funding does not yet exist for firearm events.

Given the limited state and national surveillance data for firearm injury, defining the problem to create targeted and tailored interventions to decrease firearm injury in children requires establishment of local firearm injury surveillance systems. A comprehensive database is needed that links firearm injury data from diverse sources such as healthcare providers, emergency services, law enforcement, forensic services, and planning agencies. In addition, collaboration between agencies that collect these data is essential for purposes of data sharing and joint development and implementation of injury prevention efforts.

Our recommendation for building a comprehensive surveillance system of local firearm injury in children is guided by the CDC's Socio-Ecological Model framework for prevention, which considers the interplay between individuals (relationships), community, and societal levels that put children and youth at risk for firearm injury (Figure 1).[3,19] More specifically, this framework searches for relevant and modifiable risk factors for injury prevention.[19] It is important to realize that risk factors, especially in pediatric firearm injury, often vary based on firearm injury types (interpersonal violence, unintentional, intentionally self-inflicted).[20] Thus, unique socio-ecological models are likely required to evaluate prevention of each of the pediatric firearm injury types.

Individual risk factors for unintentional shootings include young age and homes with unsecured weapons.[21,22] For suicide, the presence of a gun in the home and a history self-harm are strong determinants.[23,24] Substance and alcohol misuse are positively associated with both interpersonal violence shootings[25-27] and firearm suicide among adolescents.[28,29] Prior violence exposure is also an individual factor associated with firearm violence.[30-32] Relationship factors such as participation in gangs or gang-related violence are associated with an elevated risk of firearm injury.[33,34] Failure to secure weapons has been estimated to increase unintentional shootings and suicides by up to a third.[35] Policies, such as child access protection (CAP) state laws requiring secure household firearm storage, have been associated with decreased pediatric firearm injuries.[36]

There are definite community correlates of firearm fatalities and injuries. Concentrated disadvantage (poverty, lack of jobs, and broken families) and predominantly minority communities have long been correlated with homicide rates.[37-42] While neighborhood, community, and environmental factors are often a backdrop of firearm violence, they are not an

explanation for childhood violence, given that the vast majority of people do not commit crimes, even in the poorest neighborhoods.[43-45]

Figure 1: Socio-ecological model for injury prevention adapted for firearm injury prevention.
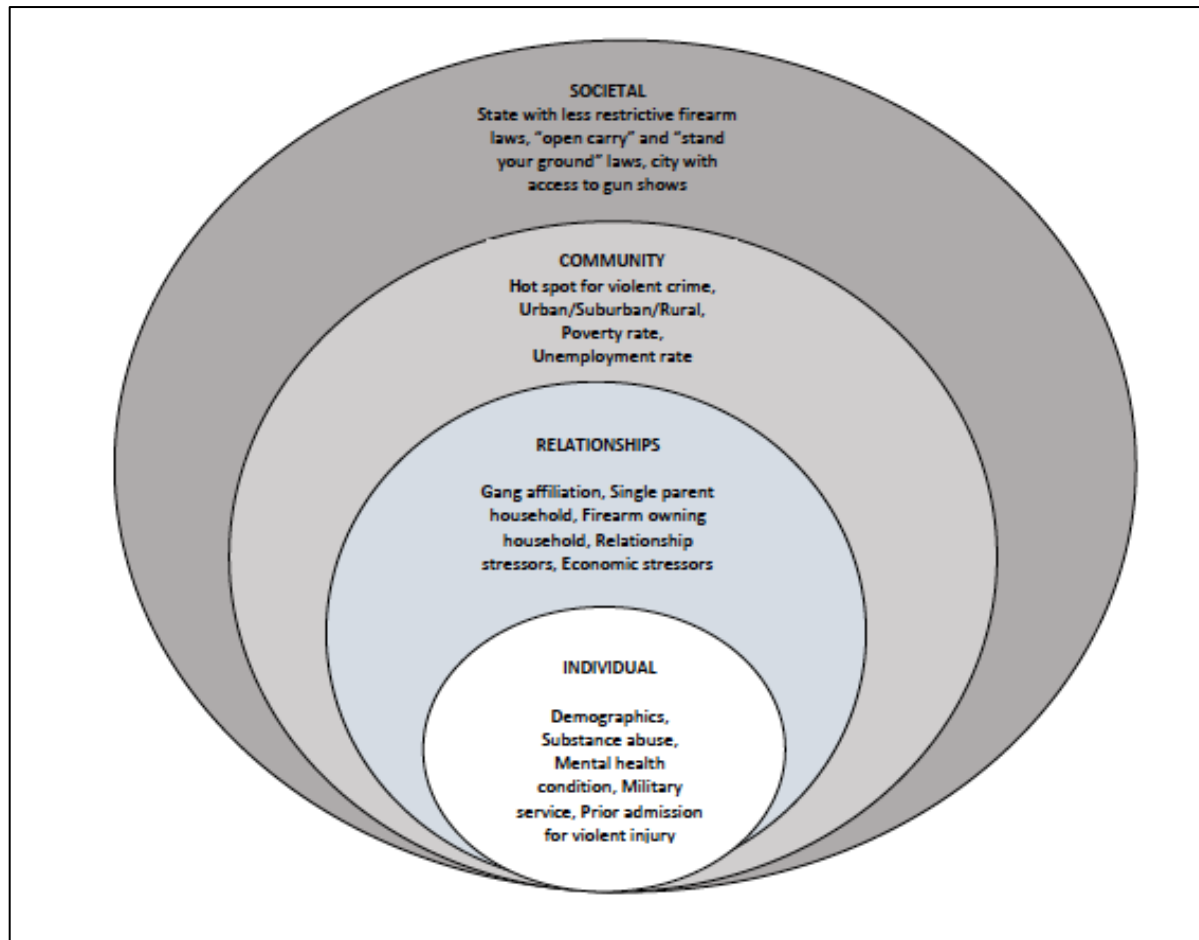
The following is a description of possible data sources that should be considered when developing a surveillance system for firearm injury at the local level:

Hospital-level data: Data on patient demographics, injury date and time, shooting intent, injury types and severity, insurance status, and residence locations can be obtained from emergency center data or billing records. Additionally, detailed chart review of electronic health records as well as clinician and social worker notes may provide information on social risk factors such as gang involvement, drug or alcohol use, household characteristics, and prior admissions for violent injury. Hospitals designated as trauma centers often have institutional trauma registries that are searchable for firearm injury data.

County medical examiner's (ME's) office data: Victims with firearm injuries that are fatal at the scene are usually not transported to hospitals. Thus, collaboration with the ME office is critical for obtaining forensic records that contain detailed data on demographics and circumstances including shooting intent and social risk factors such as household characteristics and drug or alcohol use.

Police incident records: Records on crimes committed with a firearm can provide useful information regarding shooting location, date, and time. However, this data can be limited regarding individual characteristics as personal information on both victims and assailants is usually legally protected.

Emergency medical services (EMS) records: Prehospital data can provide important information on shooting locations and patient demographics. While this documentation is sometimes included in hospital records, directly accessing the database of large EMS agencies in the region may provide valuable information.

Census Bureau: The Census Bureau is a great source of community and neighborhood-level data. Information can be obtained on the residential population and is broken down by a wide variety of factors such as age, ethnicity, household characteristics, income, and poverty levels.

Planning agencies. Other sources of neighborhood-level data are from the various city and regional planning agencies. Land-use information on general land-use categories of parcels (residential, commercial, industrial) as well as the type of residential use (eg, single-family, multifamily) indicates the types of environments where shootings occur. Data on roadways can provide information about the volume of traffic on particular roads. Data on neighborhood amenities, such as parks, churches, community centers, and recreational centers that might mediate firearm violence, can be obtained

from the regional planning agency. Data on alcohol-serving businesses, a land use that has been associated with firearm violence, can be obtained from the state alcohol board that usually documents alcohol licenses

Data obtained from these sources has definite limitations, particularly regarding individual risk factors. We do not generally know how individuals obtained their firearms or how long they have been exposed to them. We do not know what level of firearm training these individuals have experienced (if any). Also, we do not know whether their involvement in a shooting incident (either as a victim or a perpetrator) included other persons. This type of data must be obtained indirectly, either from the police who sometimes document this or from surveys of victims and families, which could potentially be collected during hospital evaluations. A new concept called "trauma-informed care," which includes individual violence-exposure screening during hospital admissions, is gaining popularity and is likely to gain widespread adoption going forth, which will be a potential additional source of this data.[46]

In summary, firearm injury prevention for children and youth should be a top public health priority. National data provides only a partial depiction of the significance of the problem through fatal data reports. Until there are mandated national or regional surveillance systems such as those for MVCs, local firearm injury surveillance will be necessary to plan informed injury prevention efforts.

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