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Commentary: Reducing youth firearm violence and the associated health disparities requires enhanced surveillance and modern behavioral intervention strategies—a commentary on Bottiani et al. (2021)

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Abstract

Youth firearm injury is a worsening public health crisis, and the risks are not distributed evenly. Bottiani et al. skillfully explicated those health disparities, described sociological factors underlying them, and explored avenues for prevention. We supplement their analysis by detailing problems and solutions related to a critical barrier to firearm violence prevention—the nonexistence both of reliable "gold standard" non-fatal firearm injury surveillance data, and systems for near real-time surveillance of firearm injuries at granular spatial scales that would enable to optimization of rapid response protocols and neighborhood-based prevention programs. We conclude with a discussion of modern, scalable, behavioral intervention approaches that could be leveraged to fill the currently absent evidence base resulting from the documented underfunding of youth firearm violence prevention research.

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Introduction

Firearm injuries are an important public health problem, with recent data highlighting continued increases in mortality and morbidity. In particular, epidemiological studies demonstrate that after a period of relative stability from 1999 to 2014, firearm mortality began increasing in 2015, re-setting to a higher endemic level of approximately 12 deaths per 100,000 people thereafter (Goldstick, Carter, & Cunningham, 2020). At the same time, non-fatal firearm injuries which patients survive after receiving hospital care are twice as common as fatal firearm injuries, and have increased to their highest level in the past decade, reaching over 30 injuries per 100,000 people in the most recent data (Kaufman et al., 2021). Not only do the dynamics of fatal and non-fatal injuries differ, but it is easy to see that trends in firearm injury burden vary considerably by region, nature of death (suicide, homicide, unintentional), and demographics (Goldstick et al., 2020; Kaufman et al., 2021), highlighting important health disparities. While epidemiological studies are critical for identifying populations with the greatest need, and providing context for prevention—e.g., many of those with self-directed firearm violence do not reach the hospital (Kaufman et al., 2021), suggesting primary prevention is necessary—leveraging that information requires understanding what drives those disparities.

Bottiani et al. provide a comprehensive overview of the available data on youth firearm injury and, importantly, discuss key sociological factors that may explain existing health disparities. The authors examined several mechanisms by which structural racism has led to disparities in employment availability, school quality, and community blight/disorder that, in turn, contributes to the elevated rates of firearm homicide among Black youth residing in urban settings. Similarly, the authors also examined the role of firearm ownership in increasing mortality rates, particularly for firearm suicides occurring among rural communities. This is especially important, given that firearm suicide comprises the majority of firearm deaths in the US (Goldstick et al., 2020), and firearm use increases lethality of a suicide attempt to nearly 90% (Conner, Azrael, & Miller, 2019). Their analysis also highlights several possible avenues for prevention, which is especially critical given the current dearth evidence-based solutions for firearm violence prevention, due in part to the underfunding of youth firearm violence research relative to other leading causes of death (Cunningham et al., 2019). In this commentary, we supplement their analysis by explicating a critical barrier to intervention development and evaluation—the unavailability of timely and accurate data for both fatal and non-fatal firearm injuries—and discussing other modern intervention strategies that are yet-to-be-leveraged for firearm violence prevention.

Enhanced Surveillance of Firearm Injuries

Bottiani et al. highlighted several settings for youth firearm violence prevention in their analysis, but well-documented shortcomings in both the timeliness and representativeness of existing firearm injury data (particularly non-fatal) prevent fully leveraging these approaches. In this section we distinguish between two related types of surveillance data, each with complementary purposes: a) "gold standard" epidemiological data that produces official estimates of injury burden, which is well-developed for fatal firearm injury (e.g.,

wonder.cdc.gov) but is largely underdeveloped for non-fatal firearm injury, and b) near real-time surveillance data that can inform rapid-response and other short-term resource allocation.

Representativeness of non-fatal firearm injury data

 Determining reliable sources for non-fatal firearm injury data in the U.S. remains a critical issue within the field, impeding a complete understanding of the magnitude of the problem, as well as the development of evidence-based solutions. The CDC has also long provided estimates of non-fatal firearm injuries from the National Electronic Injury Surveillance System (NEISS), a probability sample that uses medical charts abstracted from approximately 100 hospitals. This dataset has contributed to the understanding of the total rates of nonfatal injuries, but there are concerns about representativeness and estimation stability based both on the relatively small fraction of hospitals sampled and the changing sample composition (Cook, Rivera-Aguirre, Cerdá, & Wintemute, 2017). Specifically, details are limited on the characteristics of sampled hospitals including state, urban-rural location, and trauma center status, making it uncertain whether the hospitals sampled are representative of the universe of approximately 5,000 U.S. emergency departments. In addition, limited data elements preclude analysis by geographic location and race necessary for targeting state and local interventions and understanding racial disparities in non-fatal injuries.

 Nonfatal firearm injury data can also be collected from medical billing data which is available in state administrative discharge data sets and is aggregated by the Agency for Healthcare Research and Quality (AHRQ) Healthcare Cost and Utilization Project. The Nationwide Emergency Department Sample (NEDS) has been available since 2009, with hospital level variables on trauma center status and patient level variables on injury severity. The data are sampled from over 900 hospitals providing the most reliable national estimates available of overall non-fatal firearm injury rates. Unfortunately, the NEDS is limited by not providing data by state or by race. A broader limitation is that current case definitions rely on hospital billing codes to delineate a hospital visit for firearm injury treatment, raising concern that not all non-fatal firearm injuries are being captured accurately, especially when separating out interpersonal, self-directed, and unintentional injuries. Taken together, this raises concerns that data sources like NEDS may produce biased estimates for non-fatal firearm injuries despite their comparatively broad coverage.

 Expanding the NEISS database to include a larger and more nationally representative sample of hospitals as well as key hospital characteristics is critical to addressing limitations raised above. Such an effort would generate more stable national estimates of non-fatal firearm injuries, facilitate evaluation of the generalizability of NEISS findings, and could be used to both inform and evaluate prevention efforts. Modifying guidelines for selecting hospital billing codes could improve the reliability of hospital billing data as a basis for surveillance, particularly if hospitals and their coders were supported and incentivized for accurate coding of injury intent. Further, much of the needed data may already live within what is collected by hospitals, law enforcement, first responders, media, and service agencies. This volume of data calls for novel data capture

approaches that synergize multiple sources of information to produce *timely* estimates of injury burden, at any geography, to augment the "gold standard" systems that are required for fatal and non-fatal injury surveillance.

Mechanisms for Real-time Surveillance Data to Inform Prevention Efforts

While the authors discuss important possibilities for community-based interventions, these programs are inherently restrained by available data when deciding where, when, and how to focus limited public health resources. Currently, data available to researchers and public health workers who work in violence prevention often comes from year-end reports, and is often not spatially granular enough to use for identifying microareas most in need of resources. Nearer to real-time data would, for example, allow adaptive focusing of efforts like the Ceasefire violence interruption intervention mentioned by Bottiani et al., based on spatio-temporally proximate hot spots. Similarly, spatio-temporal spikes in firearm suicides could dictate foci for efforts like mobile mental health units and firearm safety PSAs. Thus, enhanced timely surveillance of firearm injuries is a critical to augment to "gold standard" epidemiological data sources present in the year end reports.

Local police agencies routinely collect data on fatal and non-fatal shootings, including time and location, along with victim and shooter demographics, injuries, and relationships. While police agencies can, and sometimes do, share these data in a timely fashion, this process is not standardized. Broadly sharing these data could enable community organizations to respond to changes in violence in real-time. Currently, law enforcement holds these data, making policing the only basis for the rapid response strategies in most jurisdictions. A handful of police agencies share data (e.g., https://www.policedatainitiative.org/), with some making fatal and non-fatal shootings data openly available, with a few days' time lag and location abstracted to the nearest city block, demonstrating the feasibility of this approach. Emergency medical services (EMS) data could also supplement these data and potentially address reporting gaps in communities where community/police relations are poor.

Enhanced surveillance systems for firearm injuries could also be constructed in analogous fashion to those developed for opioid overdose surveillance in the wake of the opioid epidemic. States such as Michigan have leveraged data systems such as the Emergency Medical Services Information System (EMSIS), and data from autopsies (Goldstick et al., 2021), and other bespoke systems such as the Overdose Detection and Mapping Application Program (http://www.odmap.org/), where responders can enter data at the scene, have been mobilized to generate near real-time overdose surveillance systems. Parallel logic could be used to enhance firearm injury surveillance, which would open new avenues for prevention initiatives, since the most efficient allocation of resources must be based on the most spatio-temporally proximate data.

In the absence of comprehensive, official data sources, crowdsourced solutions also have potential to provide a timely basis for firearm injury surveillance. Most prominently, the Gun Violence Archive (https://www.gunviolencearchive.org/) collates reports of shootings from media, social media, and police sources to provide detailed reports that are updated daily. Several data sources focused specifically on police-

involved shootings have emerged given the critical societal importance of this relatively rare cause of death. These real-time data sources can inform rapid response, research, and advocacy, but the methods of data collection are not always transparent, and the quality is not always assured (Kaufman et al., 2020). Unifying multiple sources of data could cross-verify each source, providing the robust information we need to inform timely intervention.

Modern Strategies for Behavioral Interventions

We now supplement the discussion of Bottiani et al by considering novel individual-level behavioral intervention approaches that are currently undergoing efficacy testing. These approaches integrate novel technologies to enhance salience for the population of interest, as well as gain efficiencies that will enable economies of scale if found to be efficacious in large scale studies.

Telehealth and remote treatment

A key limitation within the field of violence prevention has been low youth engagement in programs. Attaining modest engagement has traditionally required intensive in-person contact that limits scalability and sustainability of programs if they are found to be effective. Given recent shifts in the availability and use of telehealth due to the COVID-19 pandemic, there exists an opportunity to capitalize on this technology to centralize violence prevention services within behavioral hubs. Such an approach would preserve the future translation and dissemination potential of effective programs, while also addressing common barriers identified in prior research, including the need for increased availability of counselors and adolescent transportation issues. In addition, given the absence of mental health services in many rural communities, which likely also contribute to the disparities in firearm suicide rates discussed by Bottiani et al., increasing the use of behavioral hubs may be an effective strategy to increase access to treatment, especially in areas with lower population density, and addressing elevated rates of firearm suicide.

Automated electronic interventions

Behavioral interventions are also increasingly incorporating emergency mobile health (m-health) technologies such as two-way text-messaging, smartphone apps, and highly conversational chat-bots to augment traditional behavioral therapy intervention approaches. Combining behavioral therapy approaches with m-health technology may be more effective than either alone, but this advantage has not yet been leveraged for firearm violence prevention. In addition, m-health technologies offer a platform that is engaging, especially among adolescents, and is able to deliver content with high fidelity and tailored to the individual's needs in real-time (i.e., just-in-time interventions). More recently, m-health technology has also been integrated into adaptive intervention designs, allowing for variability in the dose and modality of intervention content to address issues of low engagement and non-response. While the efficacy of such approaches has not yet been demonstrated, several studies applying this approach are currently being tested and this novel direction remains a promising area of research within the field of violence prevention.

Social media and social network based interventions

Social norms and influences are critical components of youth behaviors, and violence behaviors are no exception. There is empirical evidence that firearm violence, specifically, propagates through social networks (Green, Horel, & Papachristos, 2017), which raises the possibility that intervention effects could also diffuse through such networks. This logic has been successfully applied to optimize a school bullying intervention by selecting the central elements of the school's social network for individual intervention, in an attempt to maximize diffusion (Paluck, Shepherd, & Aronow, 2016), but this remains an untapped resource for other outcomes, such as firearm violence. Similarly, given that youth of all races and socioeconomic positions are heavily involved in social media such as Facebook, Instagram, TikTok, and SnapChat, embedding intervention strategies into social media platforms may not only enhance youth engagement, but also produce beneficial diffusion across a much broader social network than those existing within a school.

Conclusion

While the enhanced focus on firearm violence in recent years has grown the field, particularly with over a dozen projects funded under the first firearm-specific RFA from the federal government in decades (https://www.cdc.gov/violenceprevention/firearms/funded-research.html), the reality is there are very few tested interventions for youth firearm violence. Improving our firearm injury surveillance infrastructure is a critical prerequisite to leveraging this new opportunity because it would both improve foci and evaluation of interventions, and would open new responsive intervention strategies that rely on spatio-temporally proximate conditions. Another next step involves identifying effective interventions and coupling them with smart screening for future firearm violence risk (Goldstick et al., 2017) to get resources to those who need them most. Scalable solutions, such as app-based therapy, social media interventions, and dynamically gauging response based on ambulatory assessments, have shown promise for behavior change in other domains and that promise must now be leveraged for reducing firearm injuries and the associated health disparities.

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