Positioning public health surveillance for observational studies and clinical trials: The St. Louis region-wide hospital-based violence intervention program data repository

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ABSTRACT

Introduction: Firearm injuries are a public health epidemic in the United States, yet a comprehensive national database for patients with firearm injuries does not exist. Here we describe the methods for a study to develop and query a new regional database of all patients who present to a St. Louis level I trauma hospital with a violent injury, the St. Louis Hospital-Based Violence Intervention Program Data Repository (STL-HVIP-DR). We hypothesize that the STL-HVIP-DR will facilitate identification of patients at risk for violent injury and serve as a comparison population for participants enrolled in clinical trials.

Methods: The STL-HVIP-DR includes all visits made for violent injury to four level I trauma hospitals in St. Louis, Missouri between January 1, 2010 and December 31, 2019. Two health systems representing the four participating hospitals executed a data sharing agreement to aggregate clinical data on firearm injuries, stabbings, and blunt assaults. Dataset variables include demographic hospital and timestamp, medical, and insurance information.

Results: A preliminary cross-sectional query of the STL-HVIP-DR reveals 121,955 patient visits among the four partner level I trauma hospitals for a violent injury between 2010 and 2019. This includes over 18,000 patient visits for firearm injury.

Discussion: The STL-HVIP-DR repository fills a critical gap regarding identification and outcomes among individuals who are violently injured, especially those with non-lethal firearm injuries. It is our hope that the methods presented in this paper will serve as a primer to develop repositories to help target violence prevention services in other regions.

1. Introduction

Firearm injuries are a public health epidemic in the United States (US); each year more than 39,000 people die from firearm injuries, and an estimated 133,000 people are injured with firearms [1]. St. Louis, Missouri is at the epicenter of this epidemic [2,3]. Victims of violence often find themselves trapped in a cycle of violence and sustain repeated injuries. Often this violence escalates, beginning with blunt force but progressing to firearm injury and in some cases death [4–7]. Understanding the nature and cycle of violence is key to designing effective interventions.

Despite high morbidity and mortality from firearm injuries, national data are limited by the lack of accurate counts of firearm injuries [8–10]. Existing national databases focus on mortality; a national database for patients with repeat firearm injuries who survive transport to the hospital does not exist, and state-wide trauma registries do not reliably capture patients who are discharged directly from the emergency department (ED) without a trauma service evaluation.

Individual hospitals and health systems can easily assess the volume and nature of visits made for violent injury at their own facilities but are not able to see if patients have sought care for similar injuries at other hospitals. Gaining access to this trajectory in the data is critical in light of the cycle of violence, and characterizing these repeat patients and their injuries is needed to design effective interventions.

Here we describe the methods we used to develop a regional repository, the St. Louis Hospital-Based Violence Intervention Program...
Data Repository (STL-HVIP-DR). This repository was planned in tandem with the regional hospital-based violence intervention program, also known as Life Outside Violence (LOV). The repository was designed to support the evaluation of the LOV program, as well as other local research projects that would help to fill the local epidemiological and research gap related to violence and violence prevention.

The central motivation for the STL-HVIP-DR is that rigorous cross-sectional and retrospective observational cohort studies will facilitate and enhance understanding about the trajectory of violence and identification of patients at risk for violent injury; this knowledge will be available to inform development and implementation of targeted violence intervention services to patients in need of such care; and these services then have the potential to decrease the high burden of morbidity and mortality from violent injuries—especially firearm injuries—in our region.

2. Materials and methods

2.1. Data sharing agreement

The planning for the repository took place over four years between 2015 and 2018, and culminated in a data sharing agreement (DSA) between two health systems of St. Louis University and Washington University in St. Louis, which represent the four partner hospitals: Barnes Jewish Hospital, Cardinal Glennon Children’s Hospital, St. Louis Children’s Hospital and St. Louis University Hospital. These four facilities are the only level 1 trauma centers in St. Louis City, and presumably see the majority of these injuries. The participating hospitals included two adult and two pediatric—one adult and one pediatric from each system. The DSA allows each hospital to contribute clinical data on visits made for violent injury for aggregation in the repository. The study period was January 1, 2010 through August 2021, which is the end of the first phase of the LOV program. The DSA (Appendix A) lays out the data elements to be included in the queries; stipulates a data approval and review committee (DRAC) to oversee the repository’s use for research and evaluation, and identifies the Institute for Public Health (IPH) at Washington University in St. Louis as the honest broker. This project has been approved by the Washington University in St. Louis’ Institutional Review Board. Building a repository is governed by a particular type of IRB specific to the activities required to build and maintain a repository. A manual of procedures was developed to outline the duties of the IPH staff for creating, documenting, validating, and distributing the data as outlined in the DSA.

2.2. Target population

Inclusion criteria included encounters for injuries resulting from a firearm or a blunt or penetrating trauma. These injuries were operationalized by external cause of injury diagnosis codes or e-codes (International Classification of Diseases 9 and 10: ICD-9 and ICD-10). The full list of codes can be found in Table 1. The first installment of the repository includes visits made between January 1, 2010 and December 31, 2019. This database will continue to update quarterly in 2020.

2.3. Data collection methods

IPH staff initially attempted to collect encounter data directly from the participating hospitals, each of whom had a different process for handling internal data requests. Electronic health record (EHR) and trauma registry data—which included additional data elements that are entered in a separate database for more severe trauma cases—were requested. Changes in EHR platforms over the study period, however, complicated efforts for some hospitals to access all their data. Identification of unique patients across health systems was also a challenge. There was not a unique patient identifier across health systems, and the DSA did not include social security numbers which is needed for accurately linking records. The team tested several ways to identify unique patients using fuzzy matching approaches, including creating a hash code using the name, date of birth, and visit date, and using the Soundex algorithm which creates an identifier based on the phonetics of names [11–13]. Ultimately the initial attempt to create the repository yielded an incomplete dataset without a sufficiently reliable way to identify unique patients across systems.

In search of a more complete data set, the IPH connected with the Missouri Hospital Association (MHA), a nonprofit member organization that represents every acute care hospital in the state. All four participating hospitals share their discharge data with MHA, so they were able to provide the full dataset outlined in the DSA. MHA exists to advocate for policies to improve health and healthcare for the state, as well as provide reporting responsibilities. MHA agreed to provide it, and an agreement between MHA and WUSTL was executed that fulfilled the goals of the DSA. (Appendix B). MHA also computes a longitudinal patient identifier that is stable across institutions and over time.

2.4. Data elements

Data elements outlined in the DSA included demographic information (name, race, gender, date of birth, and zip code of residence), hospital information and timestamps (medical record number, ED arrival and discharge timestamps, hospital arrival and discharge time-stamps, time of death, and whether a patient had died on arrival), medical information (ICD codes), and insurance information (payer/carrier). A full list of variables included in the STL-HVIP-DR is listed in Appendix C.

| Table 1
| STL-HVIP-DR injury E-codes |
|-----------------------------|
| E917 Striking against or struck accidentally by objects or persons |
| E922 Accident caused by firearm and air gun missile |
| E963 Assault by hanging and strangulation |
| E965 Assault by firearms and explosives |
| E966 Assault by cutting and piercing instrument |
| E968 Assault by other and unspecified means |
| E969 Late effects of injury purposely inflicted by other person |
| E983 Hanging strangulation or suffocation undetermined whether accidentally or purposely inflicted |
| E985 Injury by firearms air guns and explosives undetermined whether accidentally or purposely inflicted |
| E986 Injury by cutting and piercing instruments undetermined whether accidentally or purposely inflicted |
| E987 Falling from high place undetermined whether accidentally or purposely inflicted |
| E988 Injury by other and unspecified means undetermined whether accidentally or purposely inflicted |
| E989 Late effects of injury undetermined whether accidentally or purposely inflicted |
| W32 Accidental handgun discharge and malfunction |
| W33 Accidental rifle, shotgun, and larger firearm discharge |
| W34 Accidental discharge & malfunction other and unspecified firearm and guns |
| X93 Assault with a handgun |
| X94 Assault by rifle, shotgun, larger firearm discharge |
| X95 Assault by other unspecified firearm and gun discharge |
| X99 Assault by sharp object |
| Y00 Assault by blunt object |
| Y01 Assault by pushing from a high place |
| Y04 Assault by bodily force |
| Y08 Assault by other specified means, initial encounter |
| Y09 Assault by unspecified means |
| Y22 Handgun discharge undetermined event |
| Y23 Rifle, shotgun, larger firearm discharge, undetermined event |
| Y24 Firearm discharge undetermined intent |
| Y28 Contact with sharp object undetermined event |
| Y30 Falling, jumping, pushed from high place undetermined event |
| Y33 Other specific events, undetermined event |
2.5. STL-HVIP-DR external data sharing plan

The STL-HVIP-DR was designed to facilitate local investigation of the nature of violence by way of clinical data through rigorous cross-sectional and retrospective observational cohort study designs. It can also facilitate quasi-experimental designs in which participants enrolled in prospective violence prevention programs are matched with those not enrolled in order to assess the potential impact of such programs. Data sharing allows scientists to expedite the translation of research results into knowledge, products, and procedures to improve human health. Sharing data reinforces open scientific inquiry, encourages diversity of analysis and opinion, promotes new research, makes possible the testing of new or alternative hypotheses and methods of analysis, supports studies on data collection methods and measurement, facilitates the education of new researchers, enables the exploration of topics not envisioned by the initial investigators, and permits the creation of new datasets when data from multiple sources are combined.

Due to the sensitive nature of protected health information, full datasets will not be available to the public. However, investigators may request data sets through an application process established by the data approval and review committee (Appendix A). Any request will outline which data variables are being requested, how they will be analyzed, who will have access to the data, and how the data will be destroyed once the intent of the request has been fulfilled. To protect the integrity of the data, the requester must submit proof of IRB approval or exemption from their institution prior to the release of the data. Aggregate or limited datasets are permitted to be released. The requesting researchers will be notified that they may only use the data for the purposes for which it was requested and only by the individuals listed in the request. The requesting researcher(s) will be responsible for notifying the project PIs upon completion of analysis and indicate the manner in which the data were destroyed. Any presentations, abstracts, or publications done must include an acknowledgement/reference of the study funding source.

2.6. Anticipated results

Given the high rates of violence in our region, we anticipate that the query of the STL-HVIP-DR will reveal a high burden of injury as a result of interpersonal violence (blunt assault, stabbings, gun shot wounds) among patients included in this data repository. Following preliminary study, we anticipate that a significant proportion of patients will present with firearm injuries, and that this cohort will be largely young, African American males [14].

2.7. Preliminary data

A total of 121,955 visits were included in the first installment of the repository, and represent injuries from assaults, accidents, or intents unknown which presented to one of the four partner level I trauma hospitals in St. Louis, MO between 2010 and 2019. Of those total visits, 18,336 visits were made for firearm injury, and include assaults, accidents, or unknown intent but do not include suicide attempts. There were 11,389 unique patients who made those 18,336 visits for firearm injury. From the total visit sample, there were also 39,378 visits that were coded as an assault, and those visits were made by 30,922 unique patients. Visit demographics for both the firearm and the assault subsamples are in Table 2.

3. Discussion

This repository will help fill a critical gap regarding the identification and trajectory of violence among individuals who present to the hospital with a violent injury. Given the dearth of available data and research on gun violence, this will be especially important regarding non-lethal firearm injuries. To our knowledge, The STL-HVIP-DR is the first repository of its kind to link comprehensive emergency department and hospitalized inpatient injury data from multiple university systems and level I trauma hospital systems at the regional level to better delineate the regional burden of disease. The methods presented in this paper could serve as a blueprint for developing similar repositories.

Currently, there are no extant nation-wide or Missouri state-wide databases that track non-lethal firearm injuries in a way that would allow for recurrent firearm injury calculation. However, the robust nature of longitudinal patient information within this data repository will allow for the calculation of more accurate recidivism rates than individual institutions can achieve on their own. Additionally, we anticipate that it will be possible to leverage this repository to generate predictive risk models of firearm injury recidivism, including quantification of whether prior trauma injury increases the likelihood of subsequent firearm injury or other traumatic injuries. Such a tool could confer tremendous benefit in early identification of patients at risk for violent injury at the bedside in emergency departments and hospital inpatient wards, allowing for subsequent early engagement with violence intervention programs and protective services to mitigate the risk of injury.

This repository also contains sufficient identifiers to link with other datasets, including trauma registry data obtained from each participating hospital, the National Death Index, and social determinants of health data. Trauma registry data contains more information about the injury location and severity that will be important in understanding the nature of violence. Patients who die outside of the hospital will not have their death information captured in EMR data, so it will be necessary for accurate recidivism rates to identify all deaths. Given the lack of individual level risk factors available through EMR data pulled in this way, we will have to use local census, index, and environmental data linked by patient identifiers as proxies to measuring that risk.

### Table 2

| Demographic | All Assaults (n = 30,922) | Firearm Injuries (n = 11,389) |
|-------------|--------------------------|-----------------------------|
| Age         |                          |                             |
| Mean (SD)   | 29.7 (15)                | 28.7 (13)                   |
| IQR         | 20–39                    | 20–35                       |
| Sex, n (%)  |                          |                             |
| Male        | 20,669 (67)              | 9822 (86)                   |
| Female      | 10,249 (33)              | 1559 (14)                   |
| Unknown     | 4 (<1)                   | 8 (<1)                      |
| Race, n (%) |                          |                             |
| Caucasian   | 7553 (24)                | 1543 (14)                   |
| African-American | 22,156 (72) | 9467 (83)                   |
| Other       | 689 (3)                  | 148 (1)                     |
| Unknown/refused | 524 (1)     | 231 (2)                     |
| Ethnicity, n (%) |              |                             |
| Hispanic/Latino | 448 (1)       | 121 (1)                     |
| Other       | 30,350 (98)             | 11,218 (98)                 |
| Unknown     | 124 (<1)                | 50 (<1)                     |
4. Conclusions

4.1. Innovation

The STL-HVIP-DR is among the first registry of its type in the US to allow for data sharing in pursuit of linking ED and hospital trauma data among multiple hospital and health systems at the regional level.

4.2. Clinical and public health significance

Given the immense burden of violent injuries on victims, families, and hospital systems, analysis of the STL-HVIP-DR has the potential facilitate and enhance identification of patients at risk for violent injury, prompting provision of violence intervention services to patients in need of such care. Additionally, these data can be applied for capacity planning and resource allocation regarding HVIP staffing and core services regionally through the STL-HVIP, and in the larger population at other centers utilizing a HVIP model.

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Appendix A. Supplementary data

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.conctc.2020.100683.

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