NC-FASTER SYNDROME VALIDATION REPORT

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The Carolina Center for Health Informatics (CCHI) in the Department of Emergency Medicine at the University of North Carolina at Chapel Hill prepared the *NC-FASTER Syndrome Validation Report*, 2021. Lead authors are listed below. For more information about CCHI, please visit our website (https://cchi.web.unc.edu/). For more information about NC DETECT, please visit our website (http://ncdetect.org/) or email us at ncdetect@listserv.med.unc.edu.

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Introduction

The North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT) is a grant-funded, population-based surveillance system that collects data for public health surveillance and early event detection. NC DETECT receives emergency department (ED) visit data, North Carolina Poison Control (NCPC) data, emergency medical services (EMS) data, data from select urgent care centers, and data from inpatient and outpatient encounters in the NC HealthConnex, North Carolina's statewide health information exchange (HIE). NC DETECT is managed by the Carolina Center for Health Informatics (CCHI) at the University of North Carolina at Chapel Hill under a contract with the North Carolina Division of Public Health (NC DPH) Communicable Disease Branch.[1] NC DETECT collects ED visit data from all 24/7, acute-care, civilian, hospital-affiliated EDs as mandated by NC General Statute § 130A-480.[2] As of July 28, 2021 there were 126 facilities sending ED visit data to NC DETECT (a full list of participating EDs is available at http://ncdetect.org/participating-hospitals).[1] Since NC DETECT is primarily designed for acute event detection (e.g., infectious disease outbreaks, bioterrorism, etc.) and situational awareness, facilities are required to submit ED visit data to NC DETECT at least once daily; most submit three times a day. While many data elements are available in near real-time, data elements tied to hospital billing (such as diagnosis codes) may take up to a few weeks to enter the system. The near real-time data are available to authorized users through a secure Web application, and annual static data sets are made available to researchers approximately six months after the close of the calendar year through a Data Use Agreement.[3] NC DETECT receives a variety of ED visit data elements for research and surveillance purposes, including patient sex, patient age, patient county of residence, visit date and time, chief complaint, mode of transport, expected source of payment, ED discharge disposition, and diagnosis codes. Please visit https://ncdetect.org/data-elements/ for a full list of data elements.[1]

In 2020, North Carolina (NC) received funding for the Firearm Injury Surveillance Through Emergency Rooms (FASTER) surveillance program. To achieve the proposed program objectives, the NC Injury and Violence Prevention Branch (IVPB) partnered with NC Division of Public Health's Epidemiology Section's Surveillance Systems Unit (SSU), the University of North Carolina (UNC) Injury Prevention Research Center (IPRC), and the CCHI. This partnership leverages the existing Syndromic Surveillance (SyS) work with ED visit data in NC to work towards the FASTER goals of increased timeliness of firearm injury reporting and dissemination of findings and insights derived from these data to key firearm injury prevention stakeholders.

The utility of data produced by NC-FASTER is dependent on the syndrome definition(s) used to identify firearm-related injuries, as well as the underlying data quality. NC has over 18 years of experience developing and evaluating syndrome definitions for use with SyS ED visit data. Syndrome definitions based on keywords from chief complaints (and triage notes, when available) and ICD-10-CM final diagnosis codes are routinely added to NC's in-house SyS system, NC DETECT, and shared publicly. NC DETECT currently provides access to over 240 active case definitions for ED visit data, including CDC case definitions for firearm-related injury.

We are currently assessing data quality with regards to quality of injury mechanism coding in NC DETECT ED visit data, focusing especially on facility trends related to firearm-related injury mechanism discharge diagnosis codes, while simultaneously evaluating the CDC all-intents firearm-related injury case definition in our data. The objective of this report is to describe the latter effort and our preliminary syndrome validation findings based on comparing information contained in free text fields with ICD-10-CM diagnosis codes provided for each visit.

Findings detailed in this report will be used to make recommendations for ongoing improvement in FASTER syndrome definitions, for the benefit of NC-FASTER and all other endeavors using NC DETECT ED visit data for injury work.

High Level Findings

False Positive Determination

In our sample of 1475 firearm-related ED visits identified using the CDC V.2 SyS definition, we conservatively identified 84 false positive visits (5.7%) through independent record review. Based on these findings, the CDC V.2 SyS definition correctly identified non-fatal firearm-related ED visits in our NC DETECT data roughly 94% of the time. The majority of false positive ED visits were identified by evidence of a subsequent encounter or a CDC V.2 exclusion term in the chief complaint field. About 20% of false positives offered an alternative medical explanation for the ED visit other than a firearm-related injury. Almost half of the false positive visits identified had an "initial visit" ICD-10-CM firearm code despite clear evidence of it being a subsequent encounter. In addition to providing recommendations on how to improve upon the existing CDC V.2 SyS definition, this investigation also identified the importance of the additional context information provided in the triage note field.

Shooter Category Determination

In our sample of 1391 true positive firearm-related ED visits, we identified 90 (6.5%) self-inflicted injuries,125 (9.0%) other-inflicted injuries, and 1176 (84.5%) injuries where the category of the shooter was not specified. The shooter for each record was manually coded by two independent reviewers using our novel shooter and intent scheme and a conservative approach which necessitated strong evidence in the record. The shooter could only be categorized if explicitly stated in one of the three text fields: chief complaint, triage note or disposition diagnosis description. . Of the 215 injuries where a shooter type was identified, 92.6% of identifications were based on the information provided in the triage note. Although the triage notes were the most commonly used "text field" to identify the shooter, there were still many records where the triage note was missing or did not provide adequate information to determine the shooter type. A handful of records used the chief complaint and disposition diagnosis description to identify the shooter. These results highlight the importance of detailed triage notes as they commonly provide crucial information for shooter determination.

Intent Category Determination

In addition to shooter type identification, the 1391 true positive firearm-related ED visits were also analyzed for intent based on text fields. In this sample of firearm-related injuries, 122 (8.8%) were intentional, 280 (20.1%) were unintentional, 998 (71.7%) were undetermined and 2 (0.14%) had law enforcement involvement. These results are not mutually exclusive and several were double coded to account for conflicting information in the text fields and involvement of law enforcement. Most visits grouped into undetermined intent had inadequate information provided about the incident. Furthermore, 686 (68.7%) and 19 (1.9%) of the records coded as undetermined did not have a triage note or chief complaint, respectively. The unintentional category was also heavily influenced by the chief complaint as many had the ICD-10-CM W.34: "accidental discharge from unspecified firearm" copied and pasted into the text field. Every time the word "accidental" was used in the chief complaint the injury was coded as unintentional (this occurred 177 times). If records with the W.34 ICD-10-CM code copied into the chief complaint were excluded, there would only be 103 (7.4%) injuries classified as unintentional. These results confirm the importance of the free text fields as they allow for more specific coding of firearm-related injuries.

Trend and Cluster Analysis

NC DETECT uses three different cumulative sum (CUSUM) algorithms developed by the CDC EARS tool for cluster detection.[4] These CUSUM algorithms use a 28-day baseline to identify clusters (counts that are higher than expected); each algorithm has slight variations with the intention of detecting different types of cluster presentations. Given that several NC counties are rural with relatively low populations and commensurately low daily ED visits, we also require a minimum ED visit count of 3 for a cluster to be designated, even if the EARS process identifies a count higher than expected The NC DETECT cluster detection process is run daily for all four firearm definitions by facility and patient county of residence.

General Methods

To evaluate the intent classification of CDC SyS firearm injury definitions, we used data from a sample of 1,475 firearm injury-related ED visits in NC DETECT identified by the CDC firearm injury SyS definitions. The sample was created by randomly selecting 2 weeks from each quarter of 2019-2020, for a total of 16 weeks. A week was defined as extending from Friday to the following Thursday to ensure contiguous weekend days were included in the sample. This design ensured different seasons and full weekends were included, in light of temporal and seasonal patterns in firearm injuries described in the literature. CDC firearm injury SyS definitions, comprised of ICD-10-CM discharge diagnosis codes and chief complaint keywords and exclusion terms, were used to categorize these firearm injury visits, resulting in five groups: all-intents, assault, intentional self-directed, unintentional, and undetermined intent.

To assess the accuracy of the CDC SyS firearm injury classifications, two medically-trained independent reviewers conducted hand reviews of the full sample to identify false positives and evaluate intent using record-level information, including the chief complaint (CC) and triage notes (TN) text fields, to compare to the intent(s) assigned by the ICD-10-CM discharge diagnosis codes.

False Positive Determination

False positives were defined conservatively as visits for which there was *clear evidence* in the data record that the visit was either 1) not associated with a firearm-related injury, 2) a subsequent encounter for treatment of a firearm-related injury, and/or 3) met exclusion criteria under the CDC V.2 SyS all-intents definition. Once individual review was complete, the two research assistants met to reconcile disagreements until a consensus was reached on all observations.

The purpose of this report is to provide a foundation for further improvement of the existing syndrome definitions. The table below provides a summary of reviewer guidance for whether a visit was coded as a true or false positive, for reference in these ongoing syndromic definition improvement efforts.

Table 1. False Positive Identification Schema

True Positives	False Positives
Firearm-related chief complaint + firearm-related ICD-10-CM code(s), **initial encounter**	Firearm-related chief complaint + firearm-related ICD-10-CM code, **subsequent encounter**
Firearm-related chief complaint, **initial encounter** w/o firearm-related ICD-10-CM code(s)	Non-firearm-related chief complaint + firearm-related ICD-10-CM code, **subsequent encounter**
Missing or non-firearm-related chief complaint + firearm-related ICD-10-CM code(s), **initial encounter**	Presence of CDC V.2 exclusion term in chief complaint field (see **Table 3**)
No evidence supporting a subsequent encounter. Assumed it was an initial encounter even if injury was days/weeks old.	Any evidence of a **subsequent encounter** even when a firearm-related ICD-10-CM initial encounter code was present.
Initial encounters regardless of acuity (For both active bleeds and retained objects if evidence supported an initial encounter).	Any evidence of a **subsequent encounter** when a firearm-related ICD-10-CM code was absent.
All initial visits included **unless CDC V.2 exclusion term(s) present** in chief complaint.	Evidence present for an **alternative medical explanation** even when a firearm-related ICD-10-CM code was present

Note: Some observations lacked a chief complaint, but the triage note often provided additional information.

RESULTS

Using the above criteria, **84 ED visits were identified as false positives (5.7%).** The majority of these false positives were identified as subsequent encounters for old gunshot wounds. A more detailed breakdown is presented in **Table 2.**

Table 2. False Positives by Rationale

False Positive Rationale	Count (%)
Firearm-related chief complaint + firearm-related ICD-10-CM code, **subsequent encounter** (ex. "GSW" + X95.9XXD – Assault by unspecified firearm discharge, subsequent encounter)	15 (17.9%)
Non-firearm-related chief complaint + firearm-related ICD-10-CM code, **subsequent encounter** (ex. "Stomach Pain" + X95.9XXD – Assault by unspecified firearm discharge, subsequent encounter)	1 (1.2%)
Presence of CDC V.2 exclusion term in chief complaint field (see **Table 3**) (ex. "BB gun" OR "pellet gun" OR "Wound recheck")	18 (21.4%)
Evidence of a **subsequent encounter** + firearm-related ICD-10-CM code, **initial encounter** (ex. "Re-evaluation" + W34.00XA - Accidental discharge from unspecified firearms or gun, initial encounter)	39 (46.4%)
Evidence of a **subsequent encounter** w/o any firearm-related ICD-10-CM code (ex. "Paraplegic from GSW" w/o relevant firearm code)	9 (10.7%)

Alternative medical explanation +/- any firearm-related ICD-10-CM code (ex. "catheter causing pain" OR "back pain" OR "UTI")	17 (20.2%)
Total:	**99 (117.9%)**

Note: **These categories are not mutually exclusive.** There were 84 false positives identified, and some were counted more than once in this table because they met more than one rationale for being false positive.

ANALYTIC CONSIDERATIONS

Initial Encounter vs. Acuity Level

There exists a need to further clarify whether it is of interest to identify only acute firearm injury-related ED visits, or only initial firearm injury-related ED visits. For example, a patient who is shot and immediately presents to the ED with an actively bleeding gunshot wound is both initial and acute. It is their first visit to an ED for this injury and the injury itself is acute relative to when the patient was shot. Occasionally, however, the injury is not acute or the visit is not initial. For example, a patient with a less severe injury, such as an unintentional wound to their finger, may opt to not seek emergency care immediately. Instead, when their finger becomes infected days later, they present to the ED for the first time since acquiring the gunshot wound. This would be considered an initial visit, but the injury relative to the time of the firearm discharge would not be considered acute. Another example is a patient who was shot on vacation and visited an ED in another state, but then immediately presented to an ED in NC once they returned home. Their visit is initial relative to the NC ED visit data but not relative to their injury – they already visited an ED for this injury. For this investigation, we prioritized initial encounters over acute encounters, which seems to align with the CDC's intention given the exclusion terms included in the V.2 definition. Thus, even if an injury was not acute, if the visit was an initial visit (barring exclusion on other grounds, for instance reference to a BB gun or a pistol whip) the visit was included as a true positive. Initial encounters were determined relative to any ED, not just NC EDs. Therefore, the patient who visited an ED while on vacation would be considered a subsequent encounter and coded as a false positive.

Subsequent Encounters

As stated previously, we conservatively included all initial ED visits for a firearm related-injury as true positives, regardless of the acuity of the injury itself. Evidence of a subsequent encounter largely dictated the visits we identified as false positives. We considered a visit a subsequent encounter if *any* evidence in the record suggested that the patient had been seen previously in an ED or a hospital for the relevant gunshot injury. Within our NC DETECT data, we are unable to identify transfer ED admissions or track patients across different hospitals, so we were unable to systematically rule out ED to ED transfers.

CDC V.2 Chief Complaint Exclusion Criteria

According to the CDC Firearm Injury V.2 definition, "the exclusions are only applied to the chief complaint text when a discharge diagnosis code is not present."[4] In other words, when our analytic sample was pulled from NC DETECT, exclusion terms were only applied to visits that lacked a relevant ICD-10-CM code in order to remove them from the sample. Thus, of the 18 false positives identified by manual review using the chief complaint exclusion terms, all 18 visits had a recorded firearm-related ICD-10-CM code present, which correctly identified them as a firearm-related injury under the CDC V.2 definition. That being said, the reviewers chose to still identify these visits as false positives (1) due to potential discrepancies when comparing ICD-10-CM final diagnosis codes based on physician diagnoses to chief complaint notes written

by nursing staff, and (2) because, of the 18 visits identified, 7 of those visits provided evidence of a subsequent encounter, and 11 false positive visits were uniquely identified by the exclusion terms alone (13.1% of false positives). While this was a small percentage of the identified false positives, it is important to note these additional visits, which were identified for exclusion when exclusion terms were applied independent of discharge diagnosis codes. For this false positive determination, we applied these exclusion terms solely to the chief complaint field.

Additional Exclusion Criteria
Our impression is that the CDC V.2 SyS definition aims to exclude visits for firearm-related injuries that involve non-bullet projectiles (pellets, BBs, water, Nerf) or do not involve bullets at all (kickbacks, pistol whips). While the CDC V.2 SyS definition is clear in defining the *firearms* of interest, it is less clear in defining the *injuries* of interest. More information is needed to determine whether the definition is intended to be limited to penetrating bullet injuries, or also include lacerations or bullet grazes. It seems to require bullet involvement (excluding blunt force trauma – e.g., pistol whips), but whether that bullet must penetrate the victim remains unclear. With this in mind, we did come across a few additional terms that were not included in the list of exclusion terms that may be of interest to the CDC to add to their definition.

- "**Laceration**" – occurred 5x in the chief complaint field and 12x in the triage note field. It was sometimes, but not always, exclusive from a true gunshot puncture wound. This is important given that it may not be a suitable exclusion term should the CDC be interested in both penetrating and non-penetrating bullet-related injuries. For this investigation, all of these occurrences were coded as true positives since "laceration" was not on the exclusion term list nor did it imply a subsequent encounter.
- "**Kicked**" in addition to "kickback" – occurred 2x in the triage note field in relation to a shotgun. These were coded as true positives since "kicked" was not on the exclusion term list, nor did it imply a subsequent encounter.
- "**Reevaluation**" or "**reval**" – occurred 3x in the chief complaint and 2x in the triage note fields. These were all coded as false positives due to evidence of subsequent encounters.
- We would also recommend separating "wound" from terms such as "recheck" and "infection", as they do not always present together.

Table 3. Visits Identified by CDC V.2 SyS Definition Chief Complaint Exclusion Terms

Exclusion Term	Found in Chief Complaint	Found in Triage Note
No gun	0	0
Remove gun	0	0
Heard or hearing gun	0	0 of 7 considered false positives
Hit head	0	0
Kickback	0	0
Water gun	0	0
Pellet	**4 false positives**	2 of 10 considered false positives
BB gun	**5 false positives**	2 of 7 considered false positives
Rubber bullet	0	0
Paint ball gun	0	0
Nerf gun	0	0
Air gun	0	0 of 1 considered false positives
Spring gun	0	0
Pistol whip	**1 false positive**	0
Nail gun	0	0

Staple gun	0	0
Stun, laser, or Taser gun	0	0
Struck or hit with gun/pistol	0	0
Bloodshot	0	0
Fake	0	0
Allergy shot	0	0
Injection	0	0
Follow up	0	5 of 5 considered false positives
Chronic	0	1 of 1 considered a false positive
Wound check, care, recheck	**5 false positives**	2 of 7 considered false positives
Infection	**3 false positives**	1 of 4 considered a false positive

"Infection" is listed under wound infection in the formal CDC V.2 SyS definition, but we identified any mention of "infection" in the chief complaint field, even without being preceded by the word "wound." We chose to do this retrospectively after assessing the chief complaint fields of identified subsequent false positive visits. It is also important to note here that a number of the CDC V.2 SyS definition exclusion terms did not appear in our sample at all.

Triage Notes

Triage notes were included in approximately 600 of the ED visits in the sample (40.7%). Among *true positive* visits with a triage note (550 of the 1391 true positive visits – 39.5%), 118 visits lacked reference to a gunshot wound in the chief complaint field (21.5%). In fact, 18 of those visits had a blank chief complaint field, and 99 of those visits provided information on the mechanism of the patient's injury in the triage note field instead. As shown in **Table 3**, triage notes also present another opportunity to identify *false positives*. Among the 84 false positives identified, 50 included information in the triage note field. And of those 50, 20 visits lacked any indication of a firearm injury or a CDC exclusion term in the chief complaint field. Rather, information with regards to the potential injury was found only in the triage note, with 16 of the visits specifically referencing a gunshot wound in the triage note but not in the chief complaint field. Thus, further inclusion of triage note information from all reporting facilities may serve to improve the identification of firearm-related injuries.

It is also important to note here that while the triage note often provides more information than the chief complaint, when present, the two text fields cannot be used interchangeably. It is difficult to search for exclusion terms in the triage note field (1) because of the increased diversity in text language available given the length allowed for the triage note, and (2) because of the difficulty in searching for multi-word phrases. For example, if we wished to exclude "shotgun kickback," searching the triage note for this phrase may prove difficult since the words may not appear in proximity. Thus, someone with a note stating "was shooting a SHOTGUN and was hurt by KICKBACK" would not be properly excluded. This would increase the number of false positives. On the other hand, if we tried to exclude "air gun," we might accidentally exclude a triage note that stated: "patient here for GUN shot wound. Resting comfortably on room AIR." Thus, we would end up underestimating true positives. So, while the triage note is valuable for the reasons described above, the list of inclusion/exclusion terms (or at the very least how they are operationalized) will need to be adjusted to reflect the different conditions of the triage note (more words = easier for exclusion phrases to get a hit even on a true positive visit). But some terms seem to do quite well (see "follow up" in Table 3), so additional validation studies may prove helpful in developing triage note-based definitional criteria.

Issue of Conflicting Information

Throughout this process, there were a number of instances where there was conflicting information between the chief complaint, the triage note, and the included ICD-10-CM codes. For instance, the chief complaint may have said "GSW," the triage note may have said "patient presents with c/o productive cough, hemoptysis, and chest pain x3 weeks," and the record included a number of injury-related codes including those indicating a motor vehicle collision, but no firearm-related injury codes. In these cases , the coders were instructed to rely conservatively on the chief complaint. Thus, even if an alternative explanation, such as pneumonia secondary to an old motor vehicle injury, could explain why the patient presented, if the chief complaint indicated a "GSW" (or any variation thereof, including slight typos such as "GSE") the visit was coded as a true positive.

There were also a few times when the chief complaint and the triage note presented conflicting information. In one such instance, the chief complaint indicated "GSW" while the triage note indicated "multiple stab wounds to neck, chest, abdomen, and left arm" and no firearm-related ICD-10-CM codes were included in the record. In these instances, the chief complaint was again relied upon and this was coded as a true positive. For our investigation, we decided that the chief complaint would trump all other text fields, since the foundational CDC V.2 SyS definition only included exclusion terms for the chief complaint. However, it is important to note that if exclusion terms for the triage note had been identified, this example may have been coded as a false positive, given the evidence that this may have been a stabbing rather than a firearm injury.

Alternative Medical Explanations

Visits coded as false positives due to an alternative medical explanation deemed more likely than a firearm-related injury represented a variety of medical conditions, including abdominal pain, cough, headache, foot pain, back pain, urinary pain or infection, and psychiatric evaluations. These were often linked to injury sequelae and coded as both a subsequent encounter and an alternative medical encounter, although most provided no indication of a firearm-related injury in the chief complaint.

Injury Intent Determination

Prior to independent record review, the CDC V.2 firearm injury SyS definitions were applied to the complete sample of 1475 visits, resulting in five intent categories: all-intents, assault, intentional self-directed, unintentional, and undetermined. Of the 1,475 firearm injury ED visits sampled, 214 visits (14.5%) were classified as assault, 20 (1.4%) intentional self-harm, 1,019 (69.1%) unintentional, and 263 (17.8%) undetermined (no intent available). Multiple intents were listed for 41 visits (2.8%); 38 (92.7%) were classified as both assault and unintentional and 3 (7.3%) were classified as both intentional self-harm and unintentional.

To assess the accuracy of the existing CDC SyS intent classification (above) which uses the ICD-10-CM codes, two independent reviewers evaluated each visit and determined the intent using only the information provided in the text fields: chief complaint (CC), triage note (TN), and disposition diagnosis description. Before reviewing the entire sample, investigators created intent subcategories in a pilot study using a 10% sub-sample (n=151 ED visits). Initial results from this pilot study helped to develop a novel coding scheme for shooter and intent determination, which was applied instead of the CDC SyS definition for the purposes of this investigation.

Pilot Study Findings and Creation of Novel Shooter and Intent Scheme

From the pilot study, there were four key themes identified, which served as the framework for a novel shooter and intent scheme. First, there was a large portion of the sample where the intent was determined by the ICD-10-CM diagnosis codes listed on the record. However, there was no way to corroborate these findings because the "text fields" provided no additional information. Additionally, unintentional firearm-related injuries were difficult to confirm when the ICD-10-CM W34.00XA was copied into the chief complaint field and the additional text fields were empty. Third, the chief complaint and triage notes occasionally contained conflicting information, which lead to double coding (identification and attribution of multiple intent or shooter categories to a single observation). Finally, separating the shooter from the intention was challenging. This lead to the creation of a novel shooter and intent coding scheme that separates the identification of shooter and the intention, shown below in **Figure 1.**

Figure 1. Applied Shooter and Intent Scheme
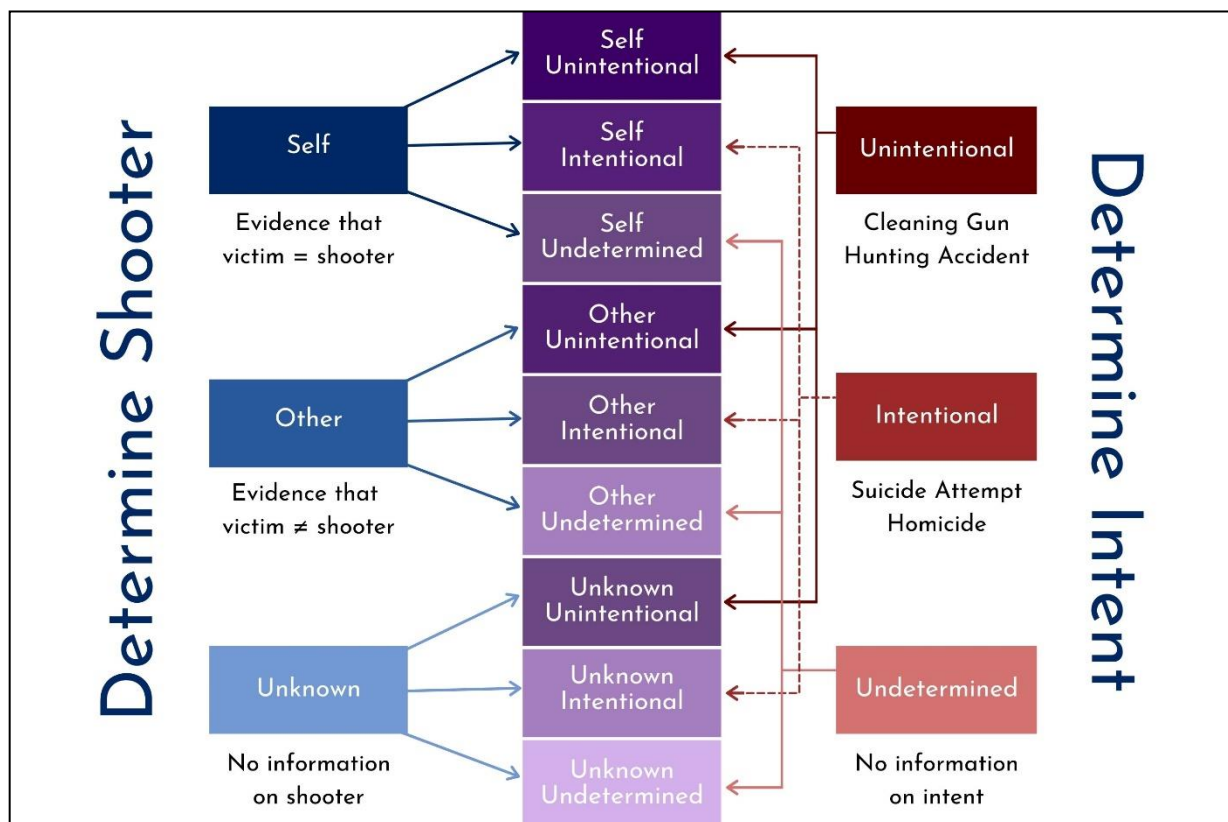
Full Sample Review

Of the 1475 ED visits in the sample, 1391 visits were identified as true positives, or true firearm-related injuries based on the above definition criteria. Two clinically trained research assistants reviewed each of the 1391 GSW ED visits and identified the shooter and the shooter's intention for each visit using the scheme shown in **Figure 1.** Only the true positives were used for this investigation.

The novel shooter and intent scheme was applied to the entire 1391 sample during manual review by each reviewer independently. Each category was defined conservatively; if the exact shooter or intent was unable to be identified from the text fields (chief complaint, triage notes, and disposition diagnosis description) the visit was categorized as shooter "not otherwise

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specified" and intention "undetermined". Once individual review was completed using the guidelines outlined above, the two research assistants met to reconcile disagreements until a consensus was reached on all observations.

RESULTS

Shooter Determination Results

The novel shooter and intent scheme was used to determine the shooter in each of the 1391 true positive firearm-related ED visits. After consensus was reached, reviewers identified 90 (6.5%) self-inflicted injuries, 125 (9.0%) other-inflicted injuries and 1176 (84.5%) injuries where the shooter type was not specified. **Table 4** lists the scenarios used to assign each shooter category, while **Tables 5-6** provide incidence totals of each scenario by shooter type.

We did not include a separate table for the "not specified" category. The "not specified" category had the greatest number of ED visits for shooter determination and the information provided in the text fields varied and often provided no additional information. Of the 1176 shooter "not specified" ED visits, 827 had no triage note. Only 17 records without a triage note were coded as either self-inflicted or other-inflicted. In those 17 visits, the chief complaint provided enough information to make a determination. However, unlike those 17 records, many other encounters had only "GSW" in the chief complaint or different relatives of "GSW", such as "GSW-leg," "gunshot wound," or "EMS-GSW" which did not provide enough information to determine the shooter. Of the 1176 visits, 348 visits had a chief complaint that said only "GSW" with no additional information. This is an underestimate of the number of uninformative chief complaint fields, because many records had variations on "GSW" (as specified above).

Table 4. Shooter Identification Schema

Self-Inflicted	Other-Inflicted	NOS
Cleaning weapon and injured self Dropping weapon and injured self Playing with weapon and injured self Evidence of a suicide attempt Self-inflicted GSW stated in text Shotgun "kicked" or ricochet injury	GSW to the back (anatomy-based) Shot while in bed or sleeping Evidence of a fight or argument Accidental/Unintentional discharge that injured another individual Assault or evidence of other criminal activity (held at gun point, drive by) Multiple shots heard in public Law enforcement shooting	No specific information provided about the shooter

Note: Above listed scenarios were ascertained from the Chief Complaint, Triage Note, and Disposition Diagnosis Description text fields.

Table 5. Self-Inflicted GSW Visits by Scenario

Self-Inflicted Gunshot Wound Scenario*	Count (%)
Self-inflicted GSW occurred while cleaning weapon	22 (24.4)
Self-inflicted GSW occurred after dropping weapon	6 (6.7)
Self-inflicted GSW occurred while playing with weapon	5 (5.6)
Indication of suicide attempt	6 (6.7)
Self- inflicted GSW stated to be accidental but no further information	27 (30.0)
Self-inflicted GSW occurred due to a weapon malfunction	15 (16.7)
Self-inflicted GSW injury occurred due to bullet ricochet or weapon kickback	6 (6.7)
Clear information that GSW was self-inflicted but miscellaneous	3 (3.3)
Total	**90**

*These categories are mutually exclusive.

Table 6. Other-Inflicted GSW Visits by Scenario

Other-Inflicted Gunshot Wound Scenario*	Count (%)
GSW occurred to the back	16 (12.8)
GSW occurred while victim was asleep	6 (4.8)
GSW occurred during an argument	8 (6.4)
GSW states victim was shot accidentally by other individual (e.g. friend)	8 (6.4)
GSW occurred during an assault or suspected criminal activity	17 (13.6)
GSW was the result of a drive by shooting	20 (16)
GSW victim was seemingly targeted (held at gun point/undercover detective)	3 (2.4)
GSW occurred during a crossfire	1 (0.8)
GSW victim heard multiple shots	25 (20)
GSW was the result of law enforcement shooting	2 (1.6)
GSW occurred while victim was out and had no weapon on their person (e.g. walking, mall, etc.)	22 (17.6)
Total	**128**

*These categories are not mutually exclusive.

Table 7 shows where we found the information used to identify the shooter for each observation where a shooter could be identified. For example, a chief complaint was present in 208 of the 215 visits where the shooter was determined, however, only in 10 visits was the chief complaint the sole determinant of shooter identification. The triage note and disposition diagnosis description were counted as a combination category for four of the visits because the information provided in both the triage notes and disposition diagnosis description were similar and led to the same shooter determination.

Table 7. Location of Shooter's Identification Information

Text Field in Record	Count (%)
Chief Complaint Only	10 (4.7)
Triage Note Only	195 (90.7)
Disposition Diagnosis Only	6 (2.8)
Triage Notes & Disposition Diagnosis Description	4 (1.9)
Total	**215**

*Most significant categories, not exhaustive list

Intent Determination Results

The novel shooter and intent scheme was used to determine the intention of the shooter for each firearm injury. There were 122 (8.8%) intentional injuries, 280 (20.1%) unintentional injuries, 998 (71.7%) undetermined intent, and 2 (0.14%) law enforcement-involved shootings. **Table 8** lists the scenarios used to assign each intent category, while **Tables 9-10** provide incidence totals of each scenario by shooter type.

The undetermined intent category does not have its own table because of the magnitude of scenarios, all of which vary slightly in their rationale for why an intention could not be assigned. Of the 998 visits coded as undetermined, there were 686 (68.7%) ED visits that both lacked a triage note and the chief complaint field did not contain information available to determine intent.

Table 8. Intent Identification Scenarios

Intentional	Unintentional	Undetermined
Evidence of an argument or fight Indication that the patient was targeted Evidence of an assault Evidence of multiple GSWs Indication that patient was asleep Indication of criminal activity Drive-by shootings Self-inflicted gunshot or suicide attempt	Any evidence of accidental/unintentional discharge	No specific intent information provided

Note: Above listed scenarios were ascertained from the Chief Complaint, Triage Note, and Disposition Diagnosis Description text fields.

Table 9. Visits by Intent Type Scenario

Intent	Scenario Category*	Count (%)
Intentional	GSW occurred during an argument	9 (0.7)
	GSW was seemingly targeted (e.g. gunpoint/undercover detective)	11 (0.8)
	GSW was stated to be an assault	11 (0.8)
	GSW was sustained to the back, could have been the result of multiple GSWs	3 (0.2)
	GSW occurred while victim was in bed or sleeping	4 (0.3)
	GSW occurred during suspected criminal activity	6 (0.4)
	GSW was the result of law enforcement involvement	2 (0.1)
	GSW was sustained during a drive by shooting	16 (1.2)
	GSW was the result of multiple weapon firings	61 (4.4)
	GSW was the result of suspected attempted suicide	7 (0.5)
Unintentional	GSW was the result of an accidental/unintentional injury explained in the triage note or disposition diagnosis description (e.g. cleaning or playing with weapon)	102 (7.3)
	GSW was categorized as unintentional because ICD-10-CM code was pasted into chief complaint	177 (12.7)
Undetermined	GSW listed in CC, no additional information provided	360 (25.9)
	All other encounters where intent could not be determined	638 (45.9)

*These categories are not mutually exclusive.

Final Intent Results

Of all 1391 ED visits reviewed, the majority were unspecified shooters with undetermined intent (955 visits, 68.7%). The next largest category was unintentional self-inflicted (79 visits, 5.7%). The third largest category were intentional shootings committed by others (74, 5.3%). **Table 10** provides an incidence of each shooter and intent scenario.

Table 10. Final Shooter and Intent Determination Results

Shooter	Intent	Count
Self	Intentional	7 (0.5%)
	Unintentional	79 (5.7%)
	Undetermined	5 (0.4%)
Other	Intentional	74 (5.3%)
	Unintentional	18 (1.3%)
	Undetermined	38 (2.7%)
	Law Enforcement	2 (0.1%)
Not Specified	Intentional	41 (4.0%)
	Unintentional	183 (13.2%)
	Undetermined	955 (68.7%)

Note: The total visit count in this table is 1402 as 11 visits were double-coded (see below).

ANALYTIC CONSIDERATIONS

Role of the Chief Complaint

When determining the shooter involved, the chief complaint typically offered little information. The chief complaint often would say "GSW", "Assault", the anatomical location of injury, or the diagnosis code: "accidental discharge from unspecified firearm". Other than "assault", none of these entries provides any indication of who the shooter was. However, the chief complaint was used extensively to determine intent. Since the shooter and intent were determined from the text fields (chief complaint, triage notes, and disposition diagnosis description), the stated chief complaint was used to determine intent regardless of whether the verbiage matched a diagnosis code. "Accidental discharge from unspecified firearm" occurred in 177 ED visit chief complaints and these were coded as unintentional. However, several of these encounters also included contradictory information in the triage note which provides a more detailed explanation of the mechanism of injury.

Double-Coding Results with Conflicting Information

The purpose of separating the shooter from the intent was to identify what we could about events even when we lacked full information. By separating the two, we could identify partial event information, such as who was the shooter, even if we did not know the intent - or vice versa. The CDC combined categories result in less detailed information; unintentional injuries include both self and other unintentional injuries. The CDC also groups injuries with an undetermined ICD-10-CM code with unintentional. By separating the shooter from intent our results are more detailed and provide more information.

This categorization process also allowed for the double-coding of intent. In other words, intent categories were not mutually exclusive. For example, a given observation may state "Accidental discharge from unspecified firearms or gun, initial encounter" in the chief complaint field, and "possible suicide attempt. Bystander took gun out of hand" in the triage note. The chief complaint would elicit an "unintentional" code, while the triage note would elicit an "intentional" code, especially with added evidence of a bystander. This visit would thus be double-coded. While some double-codes may have been helpful, such as coding for both "intentional" and "law enforcement involvement," often the double-coding was conflicting, such as in the previous example. This issue needs to be further investigated. It would be a waste of valuable information to simply code conflicting visits as "undetermined" when the record does provide evidence to the true intent, but guidance is needed on what to prioritize if different parts of the record conflict. This guidance is also needed to address the use of ICD-10-CM code W34.00XA in the chief complaint field when it conflicts with information provided by the patient.

Anatomic Considerations

As mentioned in the intent determination results, anatomic location of the GSW was considered during this investigation in a limited way. It was assumed that anyone shot in the back was shot by someone else, given the difficulty in shooting oneself in the back, regardless of intentionality. Two other anatomic locations also appeared frequently: GSWs to the hand and buttocks. GSWs to the hand were often unintentional, due to weapon cleaning incidents,but GSWs to the hand could also result from placing one's hand in front of themselves in self-defense when shot intentionally by someone else. Thus, unlike GSWs to the back, GSWs to the hand were not assumed to be caused by oneself or someone else based on anatomy alone; there needed to be additional information in the record to determine shooter and intent. Similarly, a GSW to the buttocks may have resulted from an assault, or having unintentionally fired a weapon in its holster; thus supporting information was needed to definitively determine the intent and the shooter.

Determining the Shooter and Intent from Multiple GSW

After discussion with our project team, it was decided that a "multiple wound" description in the ED visit record did not automatically mean that the shooter was someone else (categorized as "other"). One gunshot could result in multiple wounds due to both entry and exit wounds, as well as wounds from a bullet passing through an extremity to a different part of the body. Because of this, reviewers were careful to distinguish between multiple wounds and multiple gunshots. Also, depending on the anatomical region of the first gunshot, an individual could theoretically shoot themselves more than once. Thus, rarely was the shooter identified by the number of gunshots alone. However, although multiple gunshots could not be used to determine the shooter, they were coded as intentional. Automatic weapons are tightly restricted to the public, and the vast majority of weapons in use require an individual to have to fire the weapon one time for each bullet. Repeatedly firing a weapon was deemed intentional in a single injury incident.

Role of the Triage Notes

When determining the shooter and intent, triage notes were consistently the most informative item in the record. For example, when determining the shooter, 195 of the 216 ED visits where the shooter could be distinguished were determined solely based on information in the triage notes. When triage notes were not available, there were a few instances where the chief complaint or the disposition diagnosis description could be used. Typically, when the disposition diagnosis description was used to determine the shooter, the text field read like the triage note, instead of a typical listing of ICD-10-CM codes.

Trends and Cluster Analysis

Figure 2 compares recent rates and counts of firearm-related injury by year and intent across three data sources: death certificate data, ED data from NC DETECT, and death data from NC-VDRS. Compared to death data, ED visits see very high, and increasing, numbers of firearm injuries categorized as unintentional. This trend is similar to that noted in the scientific literature and other FASTER states, likely reflecting the increased lethality of firearms when used with intent to injure. Future validation work should continue to assess what proportion, if any, of these unintentional injuries may be miscoded self-harm or assault injuries. Figure 2 also shows that NC-VDRS and death certificates have very similar rates, counts, and trends, suggesting NC-VDRS is likely best used for more detailed questions, while death certificate data are best used when more timely fatality data are needed. Lastly, as noted in the figure, NC-FASTER and NC DETECT do not yet have a syndrome definition for firearm injuries from legal

intervention (broadly defined, injuries caused by police or other law enforcement agents while on duty; this classification does not speak to the legality surrounding the event).

Figure 2. NC Firearm-Related Injury Trends by Intent and Data Source, 2016-2020
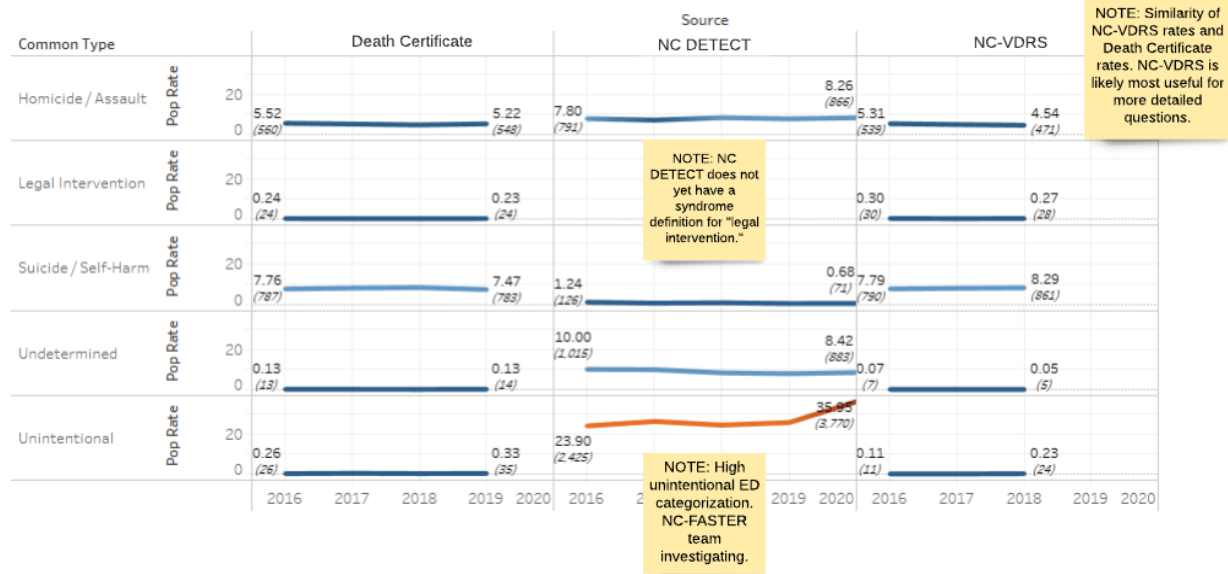
NC DETECT uses three different cumulative sum (CUSUM) algorithms developed by the CDC EARS tool for cluster detection.[5] These CUSUM algorithms use a 28-day baseline to identify clusters (counts that are higher than expected); each algorithm has slight variations with the intention of detecting different types of cluster presentations. Given that several NC counties are rural with relatively low populations and commensurately low daily ED visits, we also require a minimum ED visit count of 3 for a cluster to be designated, even if the EARS process identifies a count higher than expected.

While these algorithms were implemented for the purposes of detecting infectious disease outbreaks, they are also used in NC for detection of overdose clusters. In January 2021, the four CDC firearm injury syndromes developed as part of FASTER were incorporated into NC DETECT and included in the daily CUSUM processing. From January 1, 2021 through July 13, 2021, 137 county-level firearm clusters have been identified. Only one cluster was identified for firearm-related assault, while 51 clusters were identified for unintentional firearm injury and 85 clusters were identified for the all-intents definition.

Conclusions

False Positive Determination
In our sample of 1475 firearm-related ED visits identified using the CDC V.2 SyS definition, we conservatively identified 84 false positive visits (5.7%) through independent record review. Based on these findings, the CDC V.2 SyS definition correctly identified non-fatal firearm-related ED visits in our NC DETECT data roughly 94% of the time. In the process of identifying these false positives, we came across two distinct obstacles: (1) defining the injury of interest and (2) utilizing information in the triage note field. When creating a SyS definition, the type of firearm-related injury intended to be identified needs to be clearly defined. This "injury of interest" definition statement needs to include information on both the acuity of the injury (time since being shot, level of medical need – active bleed, infection, etc.) and the type of wound

(penetrating or non-penetrating, bullet-related or not, etc.). In addition to defining the inclusion criteria, a better understanding of the rationale for listed exclusion terms could aid in understanding of the types of encounters meant to be excluded by these terms. For example, the term "removing gun" could potentially exclude true positives, especially unintentional injuries, even though the rationale may be to exclude non-penetrating injuries. Additionally, considering that information from the chief complaint and ICD-10-CM diagnosis codes come from different stages of the medical evaluation process, it may be detrimental to limit evaluation of exclusion criteria in the chief complaint field based on information in the diagnosis codes when applying the CDC V.2 definition. As for triage notes, our investigation supported the informative role of having complete triage note fields available for record review. As stated previously, the triage note field cannot be treated in the same way as the chief complaint, so efforts to increase facility reporting of triage notes needs to be coupled with additional validation efforts to improve the accuracy of triage note inclusion and exclusion criteria, if triage notes are included in syndrome definitions.

Intent Category Determination

In our sample of 1391 true positive firearm-related ED visits initially identified using the CDC V.2 SyS definitions and verified by two independent reviewers, we worked to identify the specific shooter and specific intent for each encounter. Unlike the CDC V.2 definition, our novel shooter and intent scheme separated the shooter from the intention. We found that 79 (5.68%) of the ED visits were caused by an unintentional self-inflicted gunshot wound, and 74 (5.32%) of ED visits were other-inflicted intentional shootings. However, the largest category was unspecified shooters with undetermined intent, which accounted for 955 visits (68.7%).

Although the novel shooter and intent scheme allows for a more detailed determination of each ED visit, the majority of encounters still could not be classified into specific groups. Many times, this was the result of limited or no information provided in the chief complaint and/or the triage note. Information in the triage note field, when present, often included information about how the injury occurred (e.g. while cleaning a gun or in a drive by shooting). For the majority of the records we were able to classify, determinations were based upon the information provided in the triage note. However, there were 682 triage notes missing entirely. For the encounters where triage notes were missing, the chief complaint and sometimes the disposition diagnosis description contained information that allowed for shooter and/or intent determination. Since a large portion of the triage notes were missing, it would have been helpful if the other text fields could have provided more information.

Recommendations and Next Steps

Based on our findings, we recommend the following considerations as new SyS definitions for nonfatal firearm-related injuries are developed and validated:
- Clearly define the injury of interest for a given definition.
- Clearly define the acuity of interest for a given definition.
- Consider developing separate coding schemes for the shooter of the gun and the intention behind the shooting.
- Clearly define intention based on either the intention to pull the trigger or the intention to harm the specific target.
- Provide example scenarios for each shooter and/or intent category to help coders.
- Encourage greater reporting of triage note information from NC EDs.
- Consider developing and testing exclusions terms for the triage note field.
- Consider expanding upon existing exclusion terms for the chief complaint field.

These findings were presented to our community partners at our NC-FASTER partners meeting on 8/4/2021 from 10AM-12PM virtually on Zoom.

Potential next steps include:
- Evaluating these results by individual hospital to provide targeted feedback on data documentation to individual facilities within North Carolina.
- Consider use of machine-based text analysis to improve accuracy of intent designation and identification of false positives in larger data samples.
- Evaluate the costs associated with staffing needed to review and respond to firearm clusters. In order for this work to move forward, additional resources will be needed to utilize this data.

References

1. Carolina Center for Health Informatics. NC DETECT website. Carolina Center for Health Informatics, Department of Emergency Medicine University of North Carolina at Chapel Hill. Available at: http://ncdetect.org/. Last updated July 28, 2020. Accessed July 2, 2021.
2. North Carolina General Statutes. Section 10.34 (b), Article 22 of Chapter 130A-480 of the North Carolina General Statutes (H1414 SL 2004-124). 2004.
3. Harmon KJ, Waller AE, Barnett C, Proescholdbell SK, Marshall S, Dellapenna AJ. The UNC Department of Emergency Medicine Carolina Center for Health Informatics Report, Overview and Analysis of NC DETECT Emergency Department Data for Injuries: 2010. Chapel Hill: NC. Carolina Center for Health Informatics, Department of Emergency Medicine, University of North Carolina at Chapel Hill, 2012. Available at: http://ncdetect.org/reports/.
4. Centers for Disease Control and Prevention. Firearm-Related Injury Syndromic Surveillance Definitions. Atlanta, GA: 2020.
5. Hutwagner L, Thompson W, Seeman GM, Treadwell T. The bioterrorism preparedness and response Early Aberration Reporting System (EARS). J Urban Health. 2003 Jun;80(2 Suppl 1):i89-96. doi: 10.1007/pl00022319. PMID: 12791783; PMCID: PMC3456557.