RESEARCH BRIEF

Data Necessary to Develop a Sentinel Surveillance System for Drug Use by Drivers in Crashes: A Review of the Existing Landscape

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Impaired driving continues to be a significant source of injury, death and financial burden on society. Alcohol-impaired driving alone accounted for nearly 11,000 traffic deaths in 2017 (NCSA, 2018). Drugs other than alcohol are also believed to play a substantial role in crashes, injuries and deaths. However, the magnitude of their role is less well understood due to data limitations stemming from a number of barriers to the collection and analysis of this information. Drug testing requires complex, expensive equipment, which is not as readily available as breathalyzer equipment used for alcohol impairment testing. Furthermore, even when drivers are tested for drugs, the quality of the information about the kinds of tests performed and the results of those tests is often inadequate for meaningful analysis. But gathering data on impairment from substances besides alcohol is critical to understanding their role in motor vehicle crashes and developing effect countermeasures to prevent injuries and deaths.

One possible solution is to develop a sentinel surveillance system. The objectives of the project reported here were to: (1) identify existing sources of data that can be used to monitor and identify trends in drugs used by drivers involved in crashes on an ongoing basis; (2) establish mechanisms to access and use those data for research purposes; and, (3) to assess the feasibility of developing a sentinel surveillance system to monitor the involvement of non-alcohol drugs in motor vehicle crashes.

What is a sentinel surveillance system?

Sentinel surveillance systems facilitate our understanding of potential public health concerns by monitoring threats through the compilation and processing of high quality data from a network of prearranged reporting sites (Nsubuga, et al., 2006). An ideal system is able to signal trends, identify outbreaks, and monitor reduction efforts in the community through simple protocol and frequent communication. It is also ideal for this system to leverage existing data systems to provide prompt reporting with limited resources (Nsubuga, et al., 2006). At the heart of a sentinel surveillance system are partnerships with community members and facilities that grapple with the public safety concerns at hand.

An example of sentinel surveillance includes the ongoing efforts of the World Health Organization (WHO) and the Joint United Nations Programme on HIV/AIDS (UNAIDS). This collaboration was formally established in 1996 as the "UNAIDS/WHO working group on global HIV/AIDS and STI surveillance" (UNAIDS/WHO, 2000). One effort of this group has been establishing sentinel surveillance sites to track trends and presence of HIV infection levels. Monitoring HIV infection levels in a population helps to better target prevention efforts and identify trends in the disease (UNAIDS/WHO, 2000).

METHODS

This project took a systematic three-stage approach. The first stage included subject matter expert interviews and a literature review to develop background on potential data sources for a sentinel surveillance system. This involved meetings with state officials and database administrators to get a broad overview of the availability and accessibility of data relevant to the project goals. It also incorporated a thorough review of the literature associated with the use of these databases and a look at previous efforts to link data to create similar public health surveillance systems.

Next, researchers narrowed the evaluation to specific surveillance system approaches. This involved more in-depth discussions with state officials and database administrators to add to what was learned in stage one by

focusing on the pros and cons associated with each data source. Thus, while the first stage focused on what data was available, the second stage focused on the best data to include in the sentinel surveillance system. Finally, the information obtained in stage one and two led to stage three, a discussion of how the system would be created based on feasible approaches.

Stage 1: What data are available?

Scan of the landscape

Awareness of the available resources for states was critical in determining which data sources were feasible and appropriate for inclusion in a sentinel surveillance system. Literature was reviewed to establish an in-depth understanding of database development, impaired driving data linkage and data integration challenges. In addition to the literature review, meetings were held with a dozen state officials and database administrators to investigate several approaches in creating a sentinel surveillance system for drugged driving.

An essential piece of this project required coordinating directly with database managers from both state and national officials. Discussions with state officials revealed that data entry protocols vary not only from state to state, but across jurisdictions and agencies within the same state. These data sources must be interpreted within each state's environment which includes various policies, standard procedures, police training and resources.

Notable data sources

Several notable data sources reviewed for inclusion in the sentinel surveillance system are widely used and well-known, despite the potential issues associated with the data sources — particularly the toxicology data. These data sources provide lessons through their successes and challenges and are essential to consider when attempting to develop an enhanced data linkage system for toxicology and traffic data.

For instance, the Fatality Analysis Reporting System (FARS) is a prominent database that is often cited as one of the best traffic-safety-data resources. Maintained by the National Highway Traffic Safety Administration (NHTSA), FARS is a national census of all fatal crashes in the United States that occurred on public roads and involved at least one person who died within 30 days as a result of the collision. It provides an accurate and comprehensive national record of lives lost on the roads in the U.S. However, toxicology data found in FARS has severe limitations, which led NHTSA to issue a research note cautioning the usage of FARS for drugged-driving research (Berning & Smither, 2014).

Another notable widely use database for road safety research is the Crash Outcome Data Evaluation System (CODES). This is a motor vehicle data linking platform that was created to link data from various state databases to inform health outcomes and related policy and legislation (Kindelberger & Milani, 2015). Commonly linked databases include police crash reports, EMS records and hospital treatment records. Some states may have toxicology data embedded in their hospital records, records provided by emergency medical services or trauma registry data (Milani, et al, 2015). CODES uses a specific software that links data using probabilistic linkage methodology that takes into account possible variation between identifiers in multiple datasets (Cook, et. al, 2015). One challenge noted with this linkage system was the inconsistent definitions and variables used by the various state agencies (Cook, et. al, 2015). From 1992 to 2013, NHTSA worked with states to develop data linkage programs under the CODES effort. State CODES programs became fully autonomous in 2013. At the time of the review fifteen states were still using the CODES system that had been established in their state.

Stage 2: What data are best to use?

Assessing the feasibility of data sources

Throughout the first stage of the study, optimal standards emerged for a database that could form a sentinel surveillance system. Underlying themes were identified in the literature review, web searches and meetings with state officials and database administrators to develop a foundation for the next phase of the study. The second stage included evaluating potential data sources based on optimal standards.

At a minimum, a sentinel surveillance system for monitoring trends in drug involvement among people involved in motor vehicle crashes requires the ability to link data on drivers involved in crashes with data on the drugs used by these drivers. Eleven optimal standards were identified to assess the potential of the data sources. Although generally equally weighted, having objective drug test results was considered one of the most significant offerings.

Optimal standards include:

- Drug test results included
- Consistent drug-testing protocol
- Linkable data
- Brief hiatus between driving event and test
- Minimal missing data
- Representative data
- Recent data
- Continually collected and updated data
- Cost effective
- Driving data included
- Accessibility

RESULTS

Potential approaches

Two potential database approaches were identified for the development of a sentinel surveillance system. These included transportation-related databases and trauma-related data sources. Transportation-related databases included those that are federally, state or privately managed. Trauma-related data sources included general medical level databases, as well as existing surveillance systems (drug-use related, but not specific to traffic safety). No single approach was fully able to meet all sentinel surveillance system data availability and quality criteria. Instead, each approach had strengths and weaknesses that may provide some, but not complete insight into drug prevalence in motor vehicle events. Nevertheless, it was important to define these optimal standards and evaluate each data source accordingly. The "optimal standards" for databases were used to rate the databases in each of these approach areas. Tables 1 and 2 detail whether or not the data sources met these standards.

Approach 1: Transportation-related databases

Ten transportation-related data sources were identified (see appendix A for full list with description). As can be seen in Table 1 (below), a number of data sources met a sufficient number of criteria to be considered an optimal data source for inclusion in a sentinel surveillance system. However, the lack of consistent drug testing protocols, which is one of the most important elements of drug testing, limited the potential of most sources. Consistent protocols to ensure the results are valid and meaningful, particularly when reporting on the prevalence of drug use across multiple locations or nationwide, were not met by any source.

A number of additional limitations were later identified regarding this approach. A common feature in successful states with drug data was having a single centralized toxicology laboratory. Unfortunately, few states showed promising practices of toxicological data collection and linking for a sentinel surveillance system. Further, and of particular significance, using state and local data involves linking traffic and toxicology records to include crash data, police accident reports (PARs), toxicology reports and fatality reports. In particular, some traffic outcome data would need to be linked or linkable to reliable toxicology data. This type of system would require responsibility of prompt data entry across multiple groups (traffic, police, toxicologists and coroners) in order to be effective. Oversight and meticulous organization would be necessary to ensure all of this information was properly collected, as this linkage process and reporting is not usually occurring in states. Relying on numerous people to collect complete and accurate data along with entering this information in a timely fashion is likely challenging.

Approach 2: Trauma-related data sources

Ten trauma-related data sources were assessed (see Appendix A for full list with descriptions). This includes both existing databases (e.g., NTDB), as well as general data collection sites (e.g., trauma centers). This assessment revealed that trauma centers are one of the most viable options for data monitoring using a sentinel surveillance system. In fact, among the ten sources identified, four were existing sentinel surveillance systems. The type of data collected varies by state and by facility, but can include a combination of the following: drug tests; drugs administered; time of drug administration (i.e., crash site, in the ambulance and upon admission); and hospital admission and discharge information.

A number of characteristics of trauma centers make them strong candidates for inclusion in a sentinel surveillance system. Specifically, this designation of trauma center is capable of providing care to patients regardless of injury severity. This reduces the potential bias of excluding certain types of harm (e.g., more severe injury). Further, often trauma centers have an inherent research mission that provides an incentive for these trauma centers to

Table 1: Transportation-related Data Sources Reviewed Using Standards Developed for a Sentinel Surveillance System

	Federal			State				Other		
	FARS	CRSS	CODES	S-DWI	CRASH	EARS	MIDAS	Corners	DRE	ITSMR
Drug test results included	X			X	X	X	X	X	X	
Consistent drug-testing protocol										
Linkable data			X		X	X		X	X	X
Brief hiatus between driving event and test			X		X	X	X			X
Minimal missing data		X				X		X	X	X
Representative data	X	X			X	X	X	X		X
Recent data	X	X	X		X	X	X	X	X	X
Continually collected and updated data	X	X			X	X	X		X	X
Cost effective	X	X	X		X	X	X	X		X
Driving data included	X	X	X		X	X	X	X	X	X
Accessibility	X	X	X	X	X	X	X			
Total	**7**	**7**	**6**	**2**	**9**	**10**	**8**	**7**	**6**	**8**

Table 2: Trauma-Related Data Sources Reviewed Using Standards Developed for a Sentinel Surveillance System

	General Trauma Data						Existing Sentinel Surveillance			
	NTDB	NEMISIS	ADD	NHCS	HL7	Trauma	NDEWS	DAWN	MNDOSA	DOFSS
Drug test results included	X		X	X	N/A	X	N/A	X	X	X
Consistent drug-testing protocol									X	
Linkable data	X	X	X	X	N/A	X	X	X	X	X
Brief hiatus between driving event and test	X	X	X	X	N/A	X	N/A	N/A	X	X
Minimal missing data	X	X	X	X	X	X	X	X	X	X
Representative Data				X				X		
Recent data	X	X	X		N/A	X	X		X	X
Continually collected and updated data	X	X	X	X	N/A	X	X		X	X
Cost effective	X	X				X	X	X	X	X
Driving data included	X	X	X	X		X			X	
Accessibility	X	X	X	X	X	X	X	X	X	X
Total	**9**	**8**	**8**	**8**	**7**	**9**	**8**	**7**	**10**	**8**

*N/A = not applicable

partner with researchers and drives the mission to collect high-quality data.

There are some limitations to consider with trauma center data. For example, drugs inevitably metabolize during the lapse of time between traveling from the crash site to the trauma center; thus, if the patient is transported to the trauma center from a remote location, the quantity of drugs in his or her system will change during that time. Ideally, samples for testing (either blood or urine) should be taken from the patient as soon as possible following the traffic event to achieve the most accurate, reliable and timely toxicology outcome. In addition, emergency medical service data needs to be linked to hospital data to accurately reflect the drugs and dosage given to the patient by paramedics as part of the patient's care plan.

Stage 3: What is the most accessible approach?

Ultimately, it was determined that very few requests for procedural alterations would need to be completed in order to access trauma center data. This is because most of the data of interest are already being collected by trauma centers. Furthermore, patient records and associated medical reports would be more comprehensive from hospitals and trauma centers than from many, if not all, other proposed data sources. The main issue with accessibility is that medical records and patient information are protected by the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule. Waivers for the HIPAA Privacy Rule may be granted under specific circumstances, including for health information to be used for research or public health purposes. Surveillance programs, such as MNDOSA (Minnesota Drug Overdose and Substance Abuse Pilot Surveillance), have effectively addressed this barrier; however, it remains to be seen if this could be done in every state. Ultimately, it would be feasible to link data from trauma centers with admissions data and hospital data.

Individual trauma centers will undoubtedly vary on the level of detail of the records that are kept, as well as the matrices used for toxicology testing, the drug panel that is used and drug testing protocols (e.g., drug testing all trauma patients). There is no set standard for any of these elements.

Thus, it assumed the best way forward would be to reach an agreement with a number of trauma centers nationally that would form the foundation of a pilot program to collect the surveillance data from multiple hospitals, using the same variables, testing procedures and matrices.

DISCUSSION

Several emerging issues accentuate the need for improved data on the prevalence of drugs in drivers. These issues include the opioid epidemic, rapidly shifting cannabis-legalization climate and the large number of individuals using prescription and over-the-counter drugs. This type of public health information would not only provide invaluable insight into the increasing impact of various drugs and drug combinations, but would also facilitate the monitoring of changing drug trends in drivers. In addition, these data are critical for developing effective drugged driving countermeasures and deploying limited resources to address impaired driving.

Accurate and representative data related to drugged driving simply do not exist. This lack of reliable data is mostly driven by the cost and complexity of conducting non-alcohol drug testing. There is no "breathalyzer" for drugs other than alcohol. Non-alcohol drug testing most often involves the collection of blood, urine or oral fluid. These techniques can be invasive and require collection from a trained individual. Furthermore, the testing of non-alcohol drugs requires relatively expensive equipment and trained professionals to run these tests. The result of these challenges is that drug testing is rarely performed and, when it is performed, there is tremendous variance in testing procedures and capabilities. Specifically, there are large inconsistencies in drug testing in and procedures across the numerous facilities that perform toxicological testing on drivers.

Given the great importance of drugged driving information to public safety and the inability of existing data to provide this information, the creation of a new sentinel surveillance system is needed to fill this critical public safety gap. At a minimum, an effective sentinel surveillance system of drugged driving needs to contain a(n):

- Representative sample of drivers
- Comprehensive drug panel (i.e., results on a substantial number of drugs)
- Confirmation testing to indicate the quantity of drugs in the body (i.e., not just presence)
- Near real-time estimate of prevalence

- Method for continuous data collection for future monitoring
- Consistent toxicology protocol (e.g., drug panel, drug matrix, cutoff levels)

This initial project developed a potential method for creating a sentinel surveillance system of drug-involved driving. After consulting existing literature, research resources and experts including trauma center personnel, the team believes the proposed approach is feasible, sustainable and cost effective. An ideal next stage of work would demonstrate the efficacy of this approach through a pilot study of one or more trauma centers.

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APPENDIX A: DATA SOURCES AND SENTINEL FEASIBILITY

Transportation-Related Data Sources

#	Name	Type	Usefulness of system	Description
1	**Fatality Accident Reporting System (FARS)**	Database	Established method of combining existing documents and databases into central system.	Nationwide data on fatal motor vehicle traffic crashes. Data are maintained by a state agency and entered into system by trained FARS Analyst. These data are collected solely from existing documents and databases.
2	**Crash Report Sampling System (CRSS)**	Data system	Contains aggregate police crash report data.	Replaces NHTSA's National Automotive Sampling System (NASS) - General Estimates System (GES) Data System in 2016. Includes all police-reported motor vehicle crashes that occur on a traffic way. Data is obtained from police accident reports (PAR).
3	**Crash Outcome Data Evaluation Systems (CODES)**	Database/Data Linking Platform	Established data linkage system that links crash, vehicle, and behavioral characteristics	Data that link crash, vehicle and behavior characteristics to medical and financial outcomes. CODES was phased out in 2013, although some states still maintain their existing systems.
4	**State DWI Tracking (S-DWI)**	Database	A system to track DWI-related offenses.	The system provides a means to track driving while intoxicated offenses from arrest to the final disposition. Some systems have a search function to identify prior DWI and traffic offenses.
5	**Collision Report Analysis for Safety Highways (CRASH)**	Database	Contains aggregate police crash report data.	The central repository for law enforcement crash reports, used by all law enforcement agencies across the state of Kentucky. Includes tests prompted by suspicion as defined by the impression of investigating officer. This system is maintained by the Kentucky state police.
6	**Colorado Electronic Accident Reporting System (EARS)**	Database	System that contains statewide crash reports.	Colorado's motor vehicle crash reporting system that houses statewide law enforcement crash reports.
7	**Model Impaired Driving Access System (MIDAS)**	Database	Statewide database that linked driver history records, arrest records, and criminal records. A function provided monitoring of drug and alcohol treatment along with drug test results.	NHTSA project in collaboration with the state of Alabama to develop statewide DWI tracking built upon the existing system, Law Enforcement Tactical System (LETS). MIDAS was designed to combine all jurisdictions' driver history records, arrest records and criminal records. An alcohol and drug assessment tool was added to the MIDAS system, which tracked treatment progress along with drug test results.
8	**State Medical Examiners and Coroners Organizations**	Database	A database that may include advanced forensic testing on death investigations to possibly identify motor vehicle crash fatalities.	Death investigation systems typically include either a coroner system, medical examiner system or both. These investigation systems and laws can vary by state, region and county.
9	**Drug Recognition Expert (DRE) Evaluation Database**	Database	A streamlined DRE Evaluation Database captures data from the traditional DRE Form into an electronic database.	A drug recognition expert is a police officer trained in identifying drivers under the influence of drugs. The most useful DRE Evaluation Database was created by The Institute for Traffic Safety Management and Research (ITSMR).
10	**The Institute for Traffic Safety Management and Research (ITSMR)**	Database	System allows for data entry directly into a database via tablet and web application, which provide real-time data entry and more timeliness reporting. The data are transferred directly to a central database.	ITSMR developed an electronic data entry, reporting and management system. Data collected mirrors the standardized DEC printed form. DREs utilizing this system do not have to duplicate data entry; the data are automatically entered into the National DRE database once completed by DRE. Two components, a web-based application and a tablet application, allow DREs to complete evaluations in the field. The tablet application streamlines the process and allows for real-time data entry, and has all capabilities of the traditional paper form.

Trauma-Related Data Sources

#	Name	Type	Usefulness of system	Description
1	**National Trauma Data Bank (NTDB)**	Database	Aggregate traumatic injury and death data throughout the U.S.	Traumatic injury and death data from throughout the U.S. Collected at hospital level, then aggregated into state and national datasets.
2	**National EMS Information Systems (NEMSIS)**	Database	State data submitted quarterly to the National EMS registry.	National database used to store EMS data from the local, state and national levels of the US and Territories. NEMSIS is a universal standard for how patient care info is collected from a 911 call. In 2014, a revision allowed sharing data in near real-time. Supported by NHTSA's Office of EMS.
3	**Administrative Discharge Data (ADD)**	Database	Hospital data records that could include inpatient admissions, ED visits, ambulatory surgery, etc.	Hospital data records – varies by state. Can include information on inpatient stays, emergency room visits, ambulatory surgery, hospital services (in and outpatient). Minnesota has a centralized system that offers specialized reports to the public or agencies for a fee.
4	**National Hospital Care Survey (NHCS)**	Database	Example of data integration from a variety of sources.	Integrates inpatient data formerly collected by the National Hospital Discharge Survey (NHDS), emergency department and outpatient data collected by the National Hospital Ambulatory Medical Care Survey (NHAMCS) and substance-involved visit data previously collected by the Drug-Abuse Warning Network (DAWN). Data collected from only a sample of hospitals.
5	**Health Level Seven International (HL7)**	Database	Established standards and framework to facilitate data exchange.	Non-profit standards developing organization, providing framework and standards for the exchange, integration, sharing and retrieval of electronic health information. Provides training opportunities and support.
6	**Trauma Center**	Database	Collects data in real time, to include a combination hospital admission, discharge data, and possibly crash data.	A facility, often within a hospital's emergency room that treats patients who suffer from serious injuries, including those related to crashes. The type of data collected varies by state and by facility, but can include a combination drug tests, drugs administered, time of drug administration (at the crash site, in the ambulance and upon admission) and hospital admission and discharge information.
7	**National Drug Early Warning System (NDEWS)**	Resource/ Surveillance System	Central hub for information exchange on emerging drug trends.	Virtual network of community of researchers, practitioners and citizens to monitor emerging drug use trends.
8	**Drug Abuse Warning Network (DAWN)**	Surveillance system	Surveillance system monitoring drug-related visits in hospitals.	Nationally represented public health surveillance system that continuously monitors drug-related visits to hospital emergency departments. Program ended in 2011.
9	**Minnesota Drug Overdose and Substance Abuse Pilot Surveillance (MNDOSA)**	Surveillance System	Current sentinel surveillance system established in collaboration with hospitals with a focus on recreational drug use.	Current sentinel surveillance system established in collaboration with hospitals to combine data related to fatal and nonfatal cases of drug overdoses. This system has enhanced toxicology testing to include a comprehensive list of drugs, including synthetics.
10	**Kentucky's Drug Overdose Fatality Surveillance System (DOFSS)**	Database/ Surveillance system	Comprehensive data linkage system, specific to drug overdose fatalities.	Comprehensive database that links data to better understand drug overdose fatalities. This includes death certificates, medical examiner autopsy reports, coroner investigation reports, post-mortem toxicology reports and Kentucky All Schedule Prescription Electronic Reporting (KASPER) records.