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Exploratory Analysis of 2012 National Emergency Medical Services Information Systems (NEMSIS) Data to Derive a Drug/Alcohol Overdose Scoring Index (DOSI) to Predict Prehospital Survival

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ABSTRACT

Emergency Medical Services (EMS) are a vital and necessary resource for communities and are relied upon for a multitude of services. As drug overdoses and poisonings continue to trend upward, the impact on EMS agencies increases. There are a limited number of data repositories dedicated to aggregate surveillance EMS data at local, state, and national levels.

2012 NEMSIS data was used to create a screening tool to predict the survivability of a drug/alcohol poisoning or overdose (DAPO) event when EMS services are requested. The screening tool, Drug Overdose Scoring Index (DOSI) was derived from candidate variables. The DOSI screening tool was tested and validated with a randomly selected set of cases from the 2012 NEMSIS case records.

DOSI variables were selected if *P*<0.05 in final regression model; 911 call, EMS level, gender, and EMS Time@scene. AUC's of 0.794 (*P*<0.001, 95% CI: 0.773, 0.816) and 0.802 (*P*<0.001, 95% CI: 0.773, 0.816) were reported, with good discriminative ability by ROC analysis. The DOSI threshold score = 157 with showed 82% sensitivity 68% specificity.

General dataset characteristics indicated: overall mortality was < 1% for all EMS responses; mortality from drug/alcohol related events was 3.25% (N=1,092,509). Whites were less likely to survive. 20-29 year olds (N=222,490) had highest number of DPI(+) cases. Only 21.8% of 911 calls reported drug/alcohol use. Residence was the most common incident location at 53% of EMS response calls. Nearly 81% of DPI(+) patients were treated and transported.

NEMSIS reporting is voluntary; generalizations beyond the dataset population cannot be made, limiting utility. 911 calls were underreported since patient health status may be unknown or withheld; specific drugs and amounts taken were not available, so associations or influences could not be assessed. At local, regional, or state levels, DAPO data may be useful in matching EMS resources to community needs. As one of the largest surveillance repositories for pre-hospital events, many other areas of public health in addition to the overdose epidemic can be explored.

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TO DERIVE A DRUG/ALCOHOL SCORING INDEX (DOSI)

TO PREDICT PREHOSPITAL SURVIVAL

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INTRODUCTION

Overview of Emergency Medical Services

Emergency Medical Service (EMS) systems have been in place since the Napoleonic wars. Dominique Jean Larrey, Napoleon's chief surgeon, was heralded as the creator of the "flying ambulance," a horse-drawn carriage that transported carry injured soldiers to a nearby hospital for treatment. Larrey was also responsible for the triage concept of treating the seriously injured on site in the field. During the Civil War, similar practices were used to evacuate soldiers from the battlefield.[1] By the late 1800s, civilian medical service systems were in place, involving physicians, undertakers, fire departments, and volunteer personnel.[1] From 1966 until 1973, EMS regulated by the Department of Transportation (under the Highway Transportation Act, which mandated federal oversight in states' EMS programs).[1] Performance standards were used as incentives for matching grants and demonstration projects. States could then develop Regional Medical Programs (RMPs) based on local area needs, and they could employ experimental and groundbreaking technologies.[1]

Mouth-to-mouth resuscitation and cardiopulmonary resuscitation (CPR) were developed as life-saving measures between 1958-1960.[1] However, while emphasis was placed on cardiovascular events, stroke, and trauma (motor vehicle crashes), the field of EMS was still perceived more as a transport service rather than a provider of medical care.[1] In 1976, authority was transferred from the Department of Transportation to the cabinet of Health and Human Services; emphasis began to shift to pre-hospital treatment services, as EMS providers took advantage of matching grants and innovative technologies.[1] During this time, there was little standardization among regional medical programs, resulting in a broad range of ability and quality of care.[1] Core educational requirements and multi-level certification programs were implemented to generate well-trained and experienced emergency services personnel in the pre-hospital environment.[1,2] Today, states and locales may vary in treatment protocols based on factors such as multiple regulatory and administrative bodies responsible for regulating different sectors of emergency medical care, proximity to emergency department, qualifications of EMS personnel on-board ambulance (Basic level EMT vs. paramedic), medicines carried on board, or patient's decision to accept treatment.[1,2]

According to the Federal EMS Act of 1973 (P.L. 93-154), an EMS system is "an entity that provides for the arrangement of personnel, facilities and equipment for the effective and coordinated delivery of health care services under emergency conditions in an appropriate geographic area."[2] The Institute of Medicine (IOM) defines emergency medical services (EMS) as pre-hospital and out-of-hospital medical activities including 911 and dispatch, emergency medical response, field triage and stabilization, and transport by ambulance or helicopter to a hospital or other facilities.[2] The IOM identifies emergency medical services as an essential part of the healthcare safety net because EMS respond to a dispatched event regardless of ability to pay.[2] EMS response is available around the clock, and responders are trained and certified to provide appropriate intervention under a myriad of circumstances.[2] A variety of organizations can provide ambulance transport and/or EMS services.[2] These providers may be for-profit entities, non-profit organizations or government based operations.[2] In addition, EMS may be affiliated with an institution or an independent entity; staffing may be volunteer or paid.[2] Many communities have combined EMS with Fire Departments.[3] The National Highway Transportation Safety Administration (NHTSA) in its *EMS Agenda for the Future*, envisions EMS integrated with public health and public safety agencies for acute care management.[4]

There are many federal agencies overseeing EMS operations, including the Department of Health and Human Services (DHHS), Department of Justice (DOJ), Department of Homeland

Security (DHS) and the Department of Transportation (DOT). The National Highway Transportation Security Administration (NHTSA) oversees guidelines for EMS educational standards and core competencies, state licensure, and professional certification.[2,4-6] Each state and U.S territory, however, determines how these standards are applied, leaving variation within the EMS structure. Each of the EMS levels have specific performance responsibilities.[2,4-6] EMS, mandatory, pre-hospital training prepares response personnel to rapidly evaluate health status and treat the patient using standardized protocols.[5,6] A diverse skill set is also necessary in order to address the wide variety of acute injuries or trauma encountered in the pre-hospital setting.

EMS providers are challenged to arrive at the incident location as quickly as possible. This is based on the "gold standard" of arriving on scene within eight minutes of being dispatched.[7] This standard is based on a single study that determined "non-traumatic victims of cardiac arrest have a better outcome if basic life support (BLS) CPR is started within four minutes of cardiac arrest, and advanced life support (ALS) is started within eight minutes or less in at least 90% of EMS responses".[7]

EMS Response and Drug Overdose

On scene response by emergency medical service personnel is most commonly initiated through a call placed to 911 or a community's primary service answering point (PSAP). This call may or may not correctly identify the source of injury to the patient(s), so EMS must be adequately prepared to respond to nearly any health crisis. Once EMS responders arrive at the incident location, they observe the patient *in situ* to identify sources compromising the patient's health status.[8,9] These professionals are trained to establish and/or maintain, for each patient, three system functions: an open and clear airway; respiratory breathing; and blood circulation throughout the body.[8,9] These interventions are essential in keeping the patient alive and are commonly referred to as the ABCs (i.e., airway, breathing, and circulation).[8,9] All certified EMS responders are able to perform these tasks.[8,9]

Common medications carried on an EMS unit or ambulance include oxygen, oral glucose, activated charcoal, aspirin, and epinephrine.[10,11] Oxygen is used for the treatment of hypoxemia and shock, oral glucose for hypoglycemia, activated charcoal for certain poisoning events, aspirin for acute coronary syndromes (chest pain), and epinephrine for cardiac stimulation, asthma, and anaphylaxis.[7,8,9,10,12,13] Medications may vary somewhat depending on state regulations.[11] These would include naloxone (Narcan), Nalmefen, and Methadone to treat narcotic overdoses.[13]

EMS outcome events involve patient treatment and transport to a facility (medical or non-medical), patient refused treatment, patient treated and released, no treatment required or patient dead at the scene.

Overdose Events

The Centers for Disease Control and Prevention (CDC) estimated that in 2014, there were 47,055 drug overdose deaths in the United States, of which 28,647 (61%) were opioid related.[14] Since 2000, deaths involving opioids have tripled.[14] Drug overdose deaths were 1.5 times more frequent than motor vehicle deaths in 2014.[14] Estimates from the Drug Abuse Warning Network (DAWN) for 2011 indicate that there were nearly 5.1 million drug related visits to U.S. Emergency Departments.[15,16] Of these, 2,462,948 ED visits involved drug misuse or abuse in 2011;[15,16] 606,583 (24.6%) drug related ED visits also included alcohol use.[16-18]

Acute pre-hospital injury and trauma EMS personnel commonly encounter are drug and/or alcohol poisoning or overdoses (DAPO). EMS response calls to treat these occurrences have become much more frequent.[19] Pre-hospital overdose events are often based on opioid-containing substances. Naloxone (Narcan), an opioid antagonist, is an effective antidote for opioid containing substances (agonists) and can provide an estimate of opioid related overdoses using the frequency of naloxone administration by EMS.[19] For example, between August 8, 2010 and May 19, 2015, in Allegheny County, PA, there were 10,044 overdose related calls. From

January 1, 2014 - September 30, 2015, naloxone was administered to counteract probable opioid overdoses 1,466 times compared to 636 naloxone doses given in that period 2014.[20] This is an underestimate of total opioid overdoses because naloxone is not administered for all overdose events.[20]

In 2013, Indianapolis EMS reported naloxone use 629 times; in 2014 naloxone was administered 1,061 times (69% increase) and 1,225 times in 2015, (15% increase).[21] Similarly, New York State has seen substantial increases in naloxone use as well, with 7,649 EMS distributions in 2013 and 11,992 instances in 2014 (57% increase).[22] In these instances, it is not known if the annual upward trend of naloxone use by EMS arose from increased availability and access to naloxone supplies annually or if the number of opioid related overdoses increased that were able to be treated with naloxone as naloxone supply levels were held relatively constant.

Overdose and poisoning events typically impair the respiratory, cardiovascular and/or nervous systems. In determining whether a patient has overdosed, *in situ* assessment protocols are performed by licensed emergency medical services providers.[9,13,23,24]

Signs of inadequate breathing include: pale skin color, cyanosis, increased pulse rate, increased respiratory rate, coughing, or shallow breaths.[8,11] If a DAPO patient cannot breathe on their own, a bagged valve mask or other breathing support device may be required. Use of breathing support devices may be limited, based on availability of certified EMS personnel.[8,9,12]

Electrolyte solutions (bicarbonate, potassium, sodium) and intravenous (IV) fluids (Ringer's and dextrose) are used when a DAPO patient's pH chemistry has been altered. Glucose testing to monitor blood sugar levels is common practice.[8,9,12] Instances of traumatic injury coincident with a drug/alcohol overdose event such as a vehicular accident, bullet wound, stabbing, assault, or drowning would further compromise an individual, necessitating more invasive measures, so rapid transport to an emergency center would be the appropriate course of action.[8,9,12]

Table 1. lists commonly abused drugs, general symptoms, and routine treatment interventions after sustaining the patient's "ABC's".

Alcohol Poisoning

Alcohol poisoning is often caused by binge drinking, where excessive quantities of alcohol are consumed in a given interval.[23] The CDC characterizes binge drinking as at least 5 alcoholic beverages for men and at least 4 alcoholic beverages for women over a short time period; on average binge drinkers consume 8 drinks per binging event.[25] Binge drinking by adults is reported to occur an average of 4 times a month by nearly 38 million adults.[25] The 2014 National Survey on Drug Use and Health (NSDUH) reported that 139.7 million Americans at least 12 years of age are current alcohol consumers and 43.6% of those are binge drinkers. Current alcohol use is defined as any alcohol consumed within the past 30 days.[24]

The Substance Abuse and Mental Health Services Administration's (SAMHSA) Drug Abuse Warning Network tracks the impact of drug use in the United States through Emergency Department (ED) visits at selected EDs across the country. 2010 public use data revealed 438,718 ED visits related to opioid misuse and 408,021 related to benzodiazepine misuse. It was estimated that 81,365 (18%) involved alcohol with opioid use. Benzodiazepines in combination with alcohol use was seen in 27.2% of the cases.[14]

Death by alcohol poisoning was estimated at an annual average of 2,221 deaths per 1 million persons aged 15 years and older in the United States between 2010-2012 (approximately 6 deaths/day) according to mortality data from the CDC.[25] These instances listed alcohol as the principal cause of death on death certificates.[25]

However, many alcohol related deaths occur from combined drug use, traffic accidents, unintentional injuries, homicide, and suicide rather than single substance fatality from alcohol poisoning.[25] 16.2% of 2014 deaths involving opioids also involved alcohol and 24.6% of benzodiazepine fatalities also involved alcohol.[17,26] There were 9,976 motor vehicle deaths which involved alcohol in 2014.[17,26]

EMS providers monitor vital signs, and breathing since alcohol causes respiratory depression.[23-27] Glucose may be administered for sugar imbalances in alcohol poisoned patients. [23-27] A blood alcohol concentration (BAC) of 300-400 mg/dL is sufficient to cause unconsciousness in most cases, although 400 mg/dL may be fatal in those who have not built up a tolerance to alcohol.[23-27]

Polypharmacy

Alcohol is frequently found in connection with polypharmacy (multiple substances taken concurrently) or combined drug use (CDU) instances.[27,28] Visits to the emergency department (ED) where alcohol is involved occurred 9.33% of the time across all age groups in the 2010 Nationwide Emergency Department Sample (NEDS), a stratified sample of all non-federal civilian hospitals providing ED services. [17]

Polypharmacy is also a common occurrence in the elderly; older adults frequently experience multimorbidity (multiple health impediments) and have multiple medical specialists and physicians.[29] A lack of communication between interventionists can put the aged at risk due to prescription errors, adverse reactions, or overdoses from improper prescribing. Pharmacokinetics (drug absorption and metabolism, etc.) and pharmacodynamics (effects of drug on body) may predispose older people to adverse outcomes.[29]

By 2030, the population of those over 65 years of age is projected to be 71 million (compared to 35 million in 2000).[29]

Medical Amnesty and Good Samaritan Laws

A large number of drug overdose fatalities occur because of the fear of criminal charges and/or arrest by bystanders. [30,31] As of 2015, thirty seven states had passed "Good Samaritan Laws" that provide medical amnesty to bystanders and friends who call 911 (or PSAP) to aid a drug/alcohol overdose event.[32,33] Medical amnesty, shields bystanders from criminal charges for possession of an illicit substance, and focuses on saving lives in the pre-hospital environment.[32,33] Several states provide training programs on administration of naloxone by non-medical personnel and laypersons (co-drug users, family, friends, and law enforcement) as a means to prevent opioid fatalities.[31-33] Rates of alcohol use, in 18-25 year olds is disproportionate between college students and non-college students.[34] While there are no specific estimates, the CDC reports increases in alcohol related deaths among college students, which may also be associated with the number of drug overdose fatalities.[34] As a result, many colleges are deciding whether to put medical amnesty laws in place for heavy alcohol drinking as well. [34] Medical Amnesty and Good Samaritan Laws are intended to support rather than supplant EMS activities, since patient stabilization, monitoring, and follow up care in the pre-hospital environment may be required.

National Emergency Medical Information Systems (NEMSIS) Data

In 2001, the National Association of State EMS Directors and National Highway Safety Transportation Administration (NHSTA) jointly developed an emergency medical services database, the National EMS Information Systems (NEMSIS), to collect critical data elements outlined in the 1998 NHSTA document *EMS Agenda for the Future* (www.nemsis.org).[4] The NEMSIS pilot project to collect standardized data from multiple states started in 2003 and contained data from 3 of 4 states (Delaware, Minnesota, Mississippi, North Carolina-no information which state did not submit data) participating in a pilot study. This pilot study served as a template for the national EMS data repository.[35] The NEMSIS Technical Assistance Center

(TAC) was developed at the University of Utah in 2005 with financial support from the CDC.[35] NEMSIS is a voluntary program in which participating states collect EMS event data.[36] The NEMSIS database collects actual EMS events from the time an EMS unit is requested until the patient is no longer in the services of the EMS. This surveillance database is not based on patient self-report, although some information may be relayed by the patient or responsible party; most information is provided by EMS and other affiliated pre-hospital personnel.[36] NEMSIS participants use a standardized format to report and submit data to state agencies and the NEMSIS TAC.[36]

There are 83 required elements called “National Elements” that each participating state/territory reports to NEMSIS Technical Assistance Center (TAC) for aggregation. The NEMSIS v.2.21 variable elements list can be downloaded from the NEMSIS TAC website (www.nemsis.org).[36] Patient characteristics such as gender, age, race, ethnicity, and region type are part of the national dataset; specific personal and health information (vital signs) pertaining to the response effort are restricted from public use. EMS services such as length of time to arrive at scene, highest EMS rank on scene, medications given, procedures used, and payment type are included as NEMSIS National Elements.[36]

Between 2009 - 2012, the number of states reporting to NEMSIS increased from 26 to 42, a 6l% increase in states reporting. State confidentiality mandates prohibit a state-by-state breakdown of reporting agency numbers, but the total number of reporting agencies also increased from 2,112 in 2009 to 8,439 in 2012, representing a 300% increase in reporting agencies.[37] Similarly, a 243% increase in the number of event records occurred between 2009-2012 from 5,767,090 to 19,831,189 records.[37] Increased participation by states and agencies likely influenced the significant increase in event records, which could not be determined in the publically available dataset. The number of 911 responses involving treat and transport of patients by EMS went from 3,367,668 patients to 10,733,925, in this time frame, representing a

219% increase from participating states and agencies.[37] As of 2015, all states are working with NEMSIS to provide data from select EMS agencies to the NEMSIS TAC.

Other publically available datasets containing information on drug overdoses are available, such as the Drug Abuse Warning Network (DAWN), the Medical Expenditure Panel Survey (MEPS), National Emergency Department Sample (NEDS), or the Healthcare Utilization Panel Survey (HCUP).

These databases are largely based on self-report, thus, they may not contain specific EMS related interventions nor capture pre-hospital occurrences.

In 2009, NEMSIS began adapting its database to become Health Level 7 (HL7) compliant, a standardized format that will allow for sharing information across different sectors in the healthcare field.[38] NEMSIS data collected prior to 2015 are not HL7 compliant and cannot be easily compared across different healthcare sectors.[38]

PROBLEM STATEMENT

Drug overdoses have steadily risen since 2000.[14] The Centers for Disease Control (CDC) and Prevention estimated that over 500,000 fatal drug overdoses occurred from 2000 - 2015. Opioid overdoses, in particular, are at epidemic crisis levels. A myriad of factors ranging from increased drug trafficking, involving more potent and lethal doses, to widespread use across socioeconomic, age, gender, and race. There is no simple solution or magic bullet. A variety of approaches and strategies need to be considered

In 2014, the CDC estimated the number of drug overdose deaths of 47,055, of which 28,647 (60.8%) were attributed to opioid containing substances.[14] Drug overdose deaths in 2015 were estimated at 52,404, an increase of 11.4% from 2014.[14] There were 33,091 opioid related deaths, 63.1% of drug overdose deaths in 2015.[14] Increases in the number of overdoses and overdose-related fatalities from the misuse of prescription medications and opioid containing substances remains the largest class of abused substances. These drugs are often also used in conjunction with alcohol, creating a toxic, lethal cocktail.[14]

In recent years, heroin has become more prominent due to low cost, widespread availability, easy access, and highly addictive properties.[39] Heroin can be made even more lethal by "cutting" or mixing it with other substances, such as fentanyl, and its derivatives, without the user's knowledge.[39] Because heroin is a cheaply and easily obtained street drug, drug dealers are target suburban communities and younger populations.[39] The National Drug Intelligence Center reports that the production of heroin increased 668% from 2002 to 2011.[39] In those nine years, Mexican production of heroin went from 6.8 metric tons per year to 50 metric tons per year.[39] Drug trafficking from South America and Mexico has provided even more widespread availability across the United States. Communities across the United States report accounts of local heroin epidemics and drug overdoses yielding anecdotal evidence through news and media outlets.[39] The Robert Crown Center for Health Education indicates in its report, *Understanding*

Suburban Heroin Use, that first time heroin users between the ages of 12-17 reach nearly 34,000 in a given year and 3,753 daily users in the 12-17 year old age range.[40]

Statistics on drug overdose and poisonings are generally reported as a function of Emergency Department (ED) visits. EMS patients treated in the pre-hospital setting and transported to the ED are captured in their data, but those treated and released, DOA, or who have refused treatment are not counted, so actual overdoses are underreported. A State's Vital Statistics Department contains all mortality records, which includes the primary and underlying cause(s) of death, but does not include those who survive a poisoning or overdose episode. Data on poisoning and overdose occurrences in the pre-hospital setting is limited, and the impact of pre-hospital treatment by EMS services as an outcome measure is not commonly reported. Few studies include Faul et al, Garza et al, and Kinsman et al; each have done recent work with EMS data and drug overdoses in efforts to address the opioid crisis.[41-44]

PURPOSE STATEMENT

Further assessments of overdose related EMS services could provide a framework for prioritization of resources and further development of alcohol poisoning and drug overdose prevention and treatment strategies, capturing populations undetected in other datasets.

Adding to studies on EMS data recently done by Faul et al, Garza et al, and Kinsman et al, this paper will focus on deriving a screening tool to predict risk of not surviving a drug/alcohol poisoning or overdose event in the prehospital setting. Scoring indices have been used in public health to compare diagnostic tests, medicines, and risk of disease.[45,46] Applying this metric to address overdose events requesting EMS response would be a low cost, easily used tool to assess patient risk from overdose. Based on the number of parameters, calculating a risk score, could be completed with a calculator, automated in a spreadsheet, or by using a "mobile app."

A brief overview of the DOSI development process follows. Personal characteristics, situational parameters, and EMS interventions will be examined to predict the risk of death from a drug/alcohol poisoning and overdose (DAPO) event in the pre-hospital setting. Case records from the 2012 National Emergency Medical Services Information Systems (NEMSIS) database will be randomly selected and tested to find the optimal risk predictors to derive a drug/alcohol overdose scoring index (DOSI) through logistical regression. This screening tool will be tested and validated with another set of DPI(+) case data to establish how well the DOSI performs in discriminating between cases that survive and cases that do not survive using receiver operating characteristic (ROC) curve analysis. Because no comparable dataset is available, validation testing of the DOSI metric will use a subset of random cases from the 2012 NEMSIS dataset. DOSI scores will be a composite value based on the predictors; scores at or above the threshold cut point would have a given risk associated with surviving a DAPO event.

METHOD

NEMSIS Dataset and Population Characteristics

The 2012 National Emergency Medical Services Information Systems (NEMSIS) EVENTS dataset contained event records from 42 participating states and select EMS agencies within those states and territories. From January 1, 2012 through December 31, 2012, 19,831,189 patient needs were responded to by emergency medical services (EMS) in a pre-hospital environment. In 2012, 1,385,385 EMS events were related to drug and/or alcohol poisoning or overdoses (DAPO) for 1,092,509 cases. Suspected or probable drug/alcohol overdose was based on patient and/or bystander information or EMS assessment at the incident location. These events were recorded as drug poisoning indicator positive (DPI(+)). Cases included DPI(+) persons older than 9 years of age. DAPO cases were identified through other variables in the dataset indicating poisoning or overdose from drugs and/or alcohol, such as Provider Primary impression, Provider Secondary Impression, Cause of Injury, Complaint reported by Dispatch, and/or Condition. An outcome variable, Mortality Indicators was created to differentiate between DPI(+) cases surviving and not surviving. A dataset dictionary explaining key variables used in analyses was created and found in the appendix (listed as document 1.).

The dataset containing DPI(+) event records was randomly split into two datasets; one of which was used to create the Drug Overdose Scoring Index (DOSI) screening composite and the other to use as a validation dataset to test the DOSI. The developmental prediction dataset contained 545,605 DPI(+) case records and the validation dataset contained 546,904 DPI(+) case records.

Drug overdose scoring Index (DOSI)

Development of DOSI was based on cross-tabulation and logistic regression to assist in identifying DPI(+) persons at risk for not surviving an overdose event outside of hospital and medical facilities. Situational and demographic variables included in the logistic regression model were: 911 call complaint, incident location, geographic area type, EMS service level, EMS time to scene, EMS time at scene, procedures used, number of procedures used, medications given, number of medications given, age, race, and gender.

Backward stepwise logistic regression by with likelihood ratio tests was used to determine statistically significant variables (at $P<0.05$) for the DOSI. Cases with missing values for any candidate variables were excluded from analyses. The DOSI was created as a composite score based on the sum of the selected predictor variables. Individual variable indices were derived from the β coefficients in the final logistic regression model. β coefficients were multiplied by 10 and rounded to the nearest whole integer. Since some of the β coefficients were negative and resulted in negative index scores, each raw score was adjusted such that the most negative score was re-scaled to 0. The most negative individual score was (-29). Thus, all individual raw scores had (+29) added to them so the lowest individual score could be 0 for that predictor variable.

Receiver Operating Characteristic Curve (ROC)

Receiver operating characteristic (ROC) analysis, a graphical representation of the false positive rate (sensitivity) and the false negative rate (1-specificity), was used to predict the chance of surviving a DAPO event when EMS services were requested based on DOSI scores for DPI(+) cases in the 2012 NEMSIS dataset. The ROC curve captured how well the DOSI score performed in correctly discriminating between cases who survived and cases who don’t survive the DAPO event. The area under the ROC curve (AUC) is used to assess the discriminative ability of the model. Higher AUC values indicate better discrimination; an AUC of 0.5 indicates no discrimination. A threshold cutoff was determined by finding the DOSI value had maximum sensitivity and maximum sensitivity. DOSI scores were assessed with the validation dataset.

The validation dataset, consisting of randomly selected cases from the 2012 NEMSIS dataset, was used to test and evaluate the performance of the drug overdose scoring index (DOSI) by applying the DOSI to a ROC analysis to assess the sensitivity, specificity, and positive and negative predictive values.

RESULTS

DPI(+) Demographic Dataset Characteristics

In 2012, EMS personnel provided assistance or care to 19,831,189 individuals, of which 5.5% (N=1,092,509) were suspected of drug(s) and/or alcohol involvement. Of these cases, nearly 1% (N=197,591) did not survive the EMS response event. Incident mortality for a suspected DAPO episode was 3.25%. There were 6,440 deaths among DPI(+) cases. Mortality in the DPI(+) population occurred 0.6% of the time. There were 1,385,385 DPI(+) related events in the NEMSIS 2012 dataset. Neither specific drugs or alcohol (or drug/alcohol classes) nor suspected amounts used were available.

Overall the developmental and validation datasets had similar characteristics) based on logistic regression models and Chi-square analysis (Table 2. and Table 3.); there were no marked differences between them. Due to missing data, only 34,914 valid cases were analyzed in the developmental dataset and 34,829 cases were analyzed from the validation dataset; this was 6.4% of all possible cases in each dataset.

74% of the DPI(+) cases were identified as white in each dataset. More males were randomly selected for the validation dataset (6l.1%) than in the developmental data set (60.4%) at $P<0.001$. 21.3% of the cases were between 40-59 years of age in both datasets ($P<0.001$). 911 call complaints reported ingested poison as the most frequent report for DPI(+) (23%) ($P<0.001$) in both data sets.

Urban areas were the predominant geographical area type (> 75%) EMS service was requested for suspected overdose. Most often, responding EMS spent less than 15 minutes at scene (56% of visits). 64% of the time EMS reported arriving at the incident location within 8 minutes (the “gold standard”).[7,47] Nearly 48% of the time an ambulance squad’s highest certified rank on board was an ALS, Level 1 and less than 1% of the time paramedics were listed as the highest level of service for a DAPO event. Regarding procedures and medicines used in EMS response, venous access was needed 17% of the time and oxygen was administered 18% of the time. Naloxone was used nearly 8% of the time in DPI(+) treatment and intervention.

19% of the time, Street and Roadways were the second frequent incident location for DPI(+) intervention by EMS. Analyzing incident locations may show patterns and trends within a community.

Nearly 18% of DPI(+) required Oxygen and nearly 8% were given naloxone or activated charcoal as treatment interventions by EMS. More than one medicine was used in 21.5% of cases. Naloxone was used more than once for 21.5% of DPI(+) cases needing more than one treatment intervention. Oxygen was used more than once in 19.8% of DPI(+) cases needing more than one treatment intervention. Data from 2015 NEMSIS analysis Faul et al, showed 141,462 single naloxone administrations were given.[43,44] Multiple doses of naloxone was given 18.24% of the time naloxone was used.[43,44] 173,016 people were given 214,611 doses of naloxone in 2015 (1.24 doses/person).[44,43]

Pearson's Chi-Square Test of Association

Thirteen variables selected as candidates for the DOSI were: 911 complaint, incident location, geographic area type, EMS level, EMS time to scene, EMS time spent on scene, procedures used, total number of procedures, medicines given, total number of medicines given, age, race, and gender. Each of these variables was assessed in bivariate analyses with mortality. Pearson's chi-square was calculated to observe whether the candidate variable was associated with DAPO survival.

Table 3. shows results of Pearson's Chi-square analysis for both datasets. In the DOSI Developmental dataset, variables that were statistically significant at $P<0.05$ were 911 reported complaint, incident location, EMS service level, geographical region type, age, race, gender, EMS time to scene and EMS time spent at scene.

Logistic Regression

Logistic regression was used to select candidate variables for the DOSI. All candidate variables were entered into the model. Backward stepwise logistic regression was used to evaluate which variables would be appropriate to include in the DOSI. Four out of thirteen predictor variables remained in the final logistic regression model ($P < 0.05$) and were used to compute the DOSI: 911 call complaint, responding EMS level, EMS time spent at scene, and gender.

Adjusted individual variable scores were used to compute DOSI scores for each DPI(+) case in the prediction model (values were adjusted by adding 29, the largest negative value in the variable set, to each raw score so that the lowest score was set to 0 and negative values were eliminated). A DOSI score was calculated only if all four individual variables contained a non-negative value. Table 4. lists variables included in the DOSI with raw and adjusted scores (scaled to 0 as baseline). In the DOSI developmental model, 196,015 out of 545,605 DPI(+) cases (35.9%) received a DOSI. The Validation model similarly had 197,207 valid DPI(+) cases out of 546,904 (36.0%) that received a DOSI. The average and median index scores were 167 and 169 in both datasets; in 3.6% of the DPI(+) valid cases 177 was the most commonly occurring score (19,437 cases). This score was slightly higher than in the validation model which showed 169 (19,059 cases) as the most common score. The range of reported adjusted DOSI scores for both datasets fell between 96 – 192. Figures 1a. and 1b. depict the frequency distribution of DOSI results among DPI(+).

ROC Curve Derivation and Validation

DOSI computations derived from the developmental dataset were used to predict the outcome (surviving or not surviving) connected with drug overdose cases when EMS services have been enlisted based on the true positive rate (sensitivity) and false positive rate (1-specificity). Larger DOSI scores represent surviving a drug/alcohol poisoning or overdose episode. The ability of the ROC curve to discriminate and correctly predict survival or death of DPI(+) cases from DOSI values was well above 0.50, with the area under the curve at 0.794 (*P* <0.001, 95% CI 0.773, 0.816) showing that the scoring index is a reliable indicator at predicting survival. ROC curves for the development and validation data are illustrated in Figures 2a. & 2b. 195,326 DPI(+) cases were identified as alive (99.6%) and 689 (0.4%) of (DPI+) cases were identified as not surviving. The outpoint score of 156.5 yielded sensitivity of 81% and specificity of 67%, and was *P*<0.001. The threshold where both sensitivity and specificity were maximized. 79.6% of all DPI(+) cases had scores of 156.5 or higher in the developmental dataset. Sensitivity and 1-specificity values are listed in Table 6.When the DOSI was applied to the validation model, results were comparable. The AUC value for the validation model was 0.802 (*P* <0.001, 95% CI: 0.780, 0.825). 196,595 cases were identified as surviving (99.7%), while 612 DPI(+) cases were identified as not surviving. The cutpoint score of 156.5 (the threshold of maximum sensitivity and specificity in the development dataset) measured sensitivity at 82% and specificity at 67.5%. At this point, 79.8% of the DPI(+) cases had a score of at least 156.5. The positive predictive value for DPI (+) cases at this level was 99.8%. This showed that the number of people who had a score at the cutpoint threshold of 156.5, the probability of surviving a drug overdose when EMS respond would be 99.8%. The negative predictive value was 0.3%; meaning that for the number of people who do not have the threshold score off 156.5, the probability of not surviving was 0.3%.

DISCUSSION

Introduction

The DOSI screening tool to determine the predictive ability of surviving a pre-hospital drug overdose event using EMS providers was developed and validated using 2012 National Emergency Medical Services Information Systems (NEMSIS) data. A logistic regression model was used to determine which variables were used as predictors, significant at (P <0.05). The final model contained 911 call complaint, EMS level, EMS time spent on scene, and gender. The DOSI was applied to the validation model, yielding 0.814 AUC (P <0.001, 95% CI: 0.780, 0.825) indicating good discrimination. The cutpoint threshold DOSI score was 156.5.

The goal of this analysis was to develop and validate a screening tool using 2012 NEMSIS data to predict the risk associated with a drug and/or alcohol poisoning (DAPO) event where EMS services were requested for treatment in a pre-hospital setting was the goal of this analysis. Since this was an exploratory analysis, DOSI was created using logistic regression to select for those variables which were significant. Regression coefficients in the final model were multiplied by ten to generate components of the DOSI score, which were added together to produce a composite score. False positive and false negative rates were plotted to determine how well the DOSI predicted a margin of safety for surviving a DAPO event or conversely, the risk of dying from the overdose. DOSI was evaluated with the validation dataset to authenticate its use as a screening tool.

Previous studies used similar methods to derive risk scores for other health outcomes. Developing a clinical scoring index e to predict risks of contracting disease or measuring test performance between diagnostic tools, treatment interventions, medical procedures or medicines is quick and efficient way to assess reliability and performance. Smith et al,[46] and Nigrovic et al,[45] devised indices to predict risk of a disease state and applied their indices to formulate questionnaires for clinicians to use to aid in deciding appropriate intervention strategies. Smith et al, developed a screening tool (HIRI-MSM) in 2012 to predict risk of incident HIV infection among men engaging in sex with other men.[46] The HIRI-MSM index included criteria on drug use and social/behavioral risk factors. Nigrovic et al, developed a tool for clinicians to detect and differentiate between bacterial meningitis and aseptic meningitis based on a compilation of diagnostic test results.[45] These tools can helped standardize clinical practices and provide decision rules to clinicians.

DOSI development and performance testing was patterned after these indices. This DOSI screening tool could be used as a mechanism to assist in strategies and allocation of EMS resources in responding to drug/alcohol overdose events based on the frequency of scores. In this instance, a higher DOSI score translates to a lower risk of overdose fatality and a lower DOSI score predicts a higher risk for not surviving the overdose (based on the criteria in the scoring index). The threshold criteria was determined to be $\geq$156.5 (maximum sensitivity and specificity). For example, if increasing numbers of opiate overdoses were occurring in an area (low DOSI scores) the number of naloxone kits, higher ranked EMS personnel may be fewer, or distance traveled for follow up care may be longer than in an area which had an abundance DPI(+) cases with lower DOSI scores, where resources could be staged nearby for easier access and response.

DOSI scores, linked to probable illegal activity, could be added/uploaded to a grid or mapping application in near-real time, to pinpoint hotspots that could be relayed to law enforcement for near-real time follow up. Jeremy Campbell of 11Alive, WXIA news used this strategy to identify heroin death incidents. .[48] Campbell and his team of investigative reporters found “The Triangle”, by mapping heroin overdose deaths, and noticed a large cluster in the greater Atlanta Metro area and determined that heroin overdoses escalated over 4100% (as of March 2016), from young people aged from 17-30.[51] Bobbi Christina, Whitney Houston’s daughter, was among those who died from a heroin-related overdose.[48] (This rash of heroin overdose deaths was featured in a five episode web video series.)[48] Data driven surveillance tools such as FirstWatch based in Encinitas, Ca, use inputs such as DOSI to derive algorithms to pinpoint hot spot locations and detect patterns at the local community level.[42,49]

Overview of DPI(+) Characteristics

In developing the DOSI criteria, a review of the dataset was necessary to understand what the dataset was comprised of and to understand how the variables could be used. The public dataset contained categorical variables which were used to determine likelihood of surviving a DAPO event and create the DOSI screening tool. A general overview of the dataset for DPI(+) individuals and DAPO events follows:

In 2012, EMS response to drug/alcohol events accounted for 5.5% of treatment interventions. Death related to suspected overdose occurred in less than 1% of all pre-hospital mortalities recorded in NEMSIS and 0.6% of all suspected DPI(+) mortalities. The low prevalence of mortality for DPI(+) cases in this study may indicate that (1) EMS personnel are a valuable resource in stabilizing the suspected DPI(+) patient; and/or (2) the health status of a DPI(+) patient, when EMS were on the scene, did not rise to the level in which a patient was severely compromised. This could be influenced by widespread patient/caller awareness to alert 911 when it is recognized that patient health has been compromised.

DPI(+) 911 call complaints play an important and integral role in EMS patient care. Accurately describing patient condition (including any medications or drugs used) and incident location, so EMS can arrive as quickly as possible, are key factors that can indirectly influence the health status of the patient. NEMSIS data for DPI(+) cases showed that the most commonly reported complaint was ingested poisonings (21.5%); however, as overdose poison symptoms can vary, or other, more obvious traumas might exist, and a DAPO event might include a myriad of complaints recorded in lieu of an overdose or poisoning event. In this analysis, 17.6% of 911 call reports were excluded as missing data. Because agreement between what was called into dispatch and the actual patient condition (based on EMS assessment) is not always the same which could be an impediment to proper care. Factors such as social stigma and fear of legal ramifications may dissuade a caller from revealing true health conditions leading to underreporting of overdose events by misclassification.[50]

Moreover, a review of drug/alcohol characteristics was limited since the dataset did not provide the specific types of drugs or alcohol used nor relative amounts. Only broad and general categories were used to describe drug/alcohol related incidents.

The most common location where EMS arrived to treat a DPI(+) patient was at a residence (58%). Analysis of incident locations may show patterns and trends within a community and allow for proper staging of resources, or in the case of illicit drug use or distribution, provide other agencies, with information that may be pertinent in curbing activity.[41,42,44]

Frequent EMS response to street and roadways was the second most frequent response location (18%); DPI(+) could be coincident with traffic and vehicular accidents, resulting from an impaired driver under the influence of drugs and/or alcohol. 2009 National Highway Transportation Safety Association (NHTSA) data showed that 18% of drivers tested positive for at least one drug in vehicular fatalities.[51]

Multnomah County, Washington also used incident locations as an estimate of opioid overdoses. Between 2013 – 2014, this county saw a 16.7% increase (to 632 overdoses) based on EMS response to incident locations. This, however, was an underestimate of 911 overdose responses for the county since law enforcement or fire department responses were not captured but played an active role in response efforts.[52]

EMS Outcome Measures

For EMS based outcomes, NEMSIS data surveillance captured probable instances of overdose where DPI(+) were released by EMS, refused treatment, or were transported to a facility other than hospital. These events were likely not recorded in other datasets, so underreporting of drug overdose morbidity likely happened and could be substantial in densely populated areas where EMS runs are frequent. Overdose events that are "minor" and where follow up care is not needed (or refused) at time of service or in instances where patients refuse to be treated may also include a subset of people who are "repeat offenders" and are a high risk for an overdose fatality. In instances of opioid overdose, naloxone serves as the preferred treatment for revival since it can quickly reverse overdoses with minimal side effects. Currently, there is a paucity of data relating pre-hospital, EMS response, and drug/alcohol overdose events, amidst a widespread public health crisis in the United States.

However, as opioids become much more potent and lethal at smaller doses, multiple naloxone kits may be required to stabilize the patient, draining supplies and increasing costs to maintain appropriate levels for communities. Between 1996 - 2006, Narcan (naloxone) reversed over 10,000 overdose cases (based on CDC estimates).

NEMSIS cases in 2012 (N=1,092,509) revealed that treat and transport was, by far, the most common occurrence in 81% (n=882,615) of DAPO events. Transport away from the incident location could be to a hospital, emergency department, trauma center, other medical facility, treatment center, institution, or jail. DPI(+) patients refused treatment 7.3% (n=79,300) of the time.2.5% (n=27,851) of the time, EMS treated and released DPI(+) patients. In 2012, 0.4% (n=4,274) DPI(+) individuals were found dead at the scene when EMS arrived. (This predictor variable should have been included as part of the DOSI analysis, but the overlap in one of the category levels "dead at scene" was used to derive the Mortality variable and caused analytical processing issues in logistic regression, when tested). This variable, however, is a better quality indicator of patient status than "alive" or "did not survive" because there is measure of degree or quality of health that was not otherwise found in predictor variables.

DOSI Screening Tool

The DOSI screening tool served as a mechanism to look at personal, situational, or EMS intervention characteristics to find optimal predictors for surviving an overdose event among suspected drug/alcohol overdose cases. DPI(+) selection of variable predictors for the DOSI composite was based on the statistical significance at $P<0.05$. Thirteen candidate variables (911 complaint, incident location, geographical area type EMS service level, EMS time to scene, EMS time at scene, Procedures used, # of procedures, medicines given, # medicines given, age, race, gender) were entered into the model simultaneously and removed one at a time if the p-value for the likelihood ratio was greater than $P > 0.05$ (starting with the largest P value). In the final model, the four variables remaining were gender, EMS level, 911 call complaint, and EMS time spent at scene. Their regression coefficients were used to set the scale for the individual components of the composite scores. Only 6.4% (34,914) of the cases were used to produce DOSI (N=545,605 DPI(+) cases.) Listwise deletion eliminated eligible DPI(+) cases if any of the four selected variables were missing from that case (each case had to have valid data for each of those 4 variables). Multiplying the β coefficient of those regressors by 10 and rounding produced whole number scores. It was possible for an individual variable to have a negative score (based on a negative β coefficient, indicating a less likely outcome than the reference variable in logistic regression) which subsequently, increased the risk of not surviving the event. The β coefficient of 45+ minutes for the variable EMS time spent at the scene, had the most DOSI value of -29. To keep the weighting of the variables established by the β coefficients consistent, all scores were increased by (+29) so that the minimum score for any given individual DOSI would be ≥ 0.

ROC Curve

The ROC curve plotted the false positive rate with the false negative rate of the DOSI scores to determine if the predictive ability of DOSI was effective in discriminating between

(DPI)+ cases that survive and those who do not. This based on the area under the plotted curve (AUC). AUC comparator ratings considered 0.9 - 1.0 = "Excellent"; 0.80 - 0.90 = "Good"; 0.70 – 0.80 = "Fair"; and 0.60 – 0.70 = "Poor" in discriminating ability. <0.50 failed discrimination.[53,54] When AUC is at 0.5, the discriminative ability of the model is no better than chance.[54] The developmental model was considered "Fair" with 0.794 AUC; when the DOSI was tested on the validation model, the AUC was 0.802, performing slightly better with a rating considered "Good" for the DOSI screening tool's discriminating ability. Both models were statistically significant at $P < 0.001$. (Figures 2a. and 2b.). Using the score of 156.5, the positive predictive value (PPV) in the validation dataset was 99.7%. Meaning that among DPI(+) cases whose score was at least 156.5, the probability of surviving the DAPO incident was 99.7%. The negative predictive value (NPV) at this DOSI score was 0.3%. In broad terms, among those who did not have a DOSI of >156.5, the probability of not surviving a DAPO event was 0.3%.[53,54] For this analysis, a low NPV indicates the chances of survival were favored the DPI(+) with a score of 156.5 or greater. A DOSI score of 125 had a false positive rate of 99.9% but a false negative rate of 15%; a DOSI score of 175 a false positive rate of 27.1% and a false negative rate of 91.7%. Table 6. lists select DOSI scores, sensitivity, and 1-specificity values. 156.5 was the threshold cut off score, the value where the false positive rate and the false negative rate were each maximized (relative to each other).

Study Design Limitations

The 2012 NEMSIS dataset contained over 34 million event records for 19,831,189 patients seen by EMS providers between January 1, 2012 and December 31, 2012. Forty two states provided records from participating Emergency Medical service providers (voluntary submission) and identity of reporting EMS and states was not part of the publically available dataset; data was aggregated by the NEMSIS Technical Assistance Center (TAC) in Utah.[36,38] Compiled data may not be representative of the population in local communities, regional areas, or the state or territory represented because of voluntary participation, so results are not likely representative beyond the population contained herein.

Given HIPAA and state or local ordinances or regulations, complete event records were not publically available. Many responses were coded as “not recorded, not available, not applicable, or unknown” depending on how the EMS provider, state, or NEMSIS TAC (upon cleaning the data) coded the event record. These were recoded as “system missing” data for SPSS analyses. All usable non-missing data was categorical. Misclassification bias and under-representation of drug/alcohol overdose events may have resulted from the way data were classified or from being coded as missing data.

A review of drug/alcohol characteristics was limited since publically available NEMSIS data did not provide specific types of drugs or alcohol used nor their relative amounts, which contributed to misclassification and information biases. The proportion of drug only, alcohol only, and combined drug and alcohol use determinations could not be made; those characteristics would be an integral asset to the DOSI to aid in identifying risks associated with a DAPO event and may have changed not only the overall composite scores, but could have changed the individual parameters that comprised the DOSI score (in this analysis was based on the statistical significance of the logistic regression model). There were a number of instances where misclassification or identification bias occurred and are described below.

The limited focus of generally referencing drugs and alcohol (as drug or alcohol poisoning precluded the ability to distinguish medications prescribed to patients in overdose instances or provide associations to any underlying health issues. As an example, calcium channel blockers such as Norvasc or Procardia are commonly prescribed to treat high blood pressure. Overdose symptoms from calcium channel blockers include: low heart rate, confusion, difficulty breathing, nausea, coma, or seizure;[8,9] symptoms common to many overdoses as well as other diseases, but could result in misclassification.

Similarly, in elderly populations or in multimorbid situations, polypharmacy is common and can lead to drug interactions, accumulation of toxins (from slowed/altered metabolic processes); overdoses could be inadvertently misclassified as a cardiac, renal, or pulmonary events. [29]

Another instance in misclassification could occur during self-report or bystander call-in with cases involving illicit overdoses. Fear of recrimination from law enforcement may preclude one from revealing true or accurate descriptions, or delay in calling EMS, further endangering the DPI(+) patient's life.[51]

Use of an independent dataset to validate the DOSI other than the one used to develop the screening index would be ideal as a quality assurance protocol; in this instance, however, the large number of DPI(+) event records in the 2012 NEMSIS dataset allowed for random splitting into two separate dataset to test and validate the screening scores. Each dataset had population pools greater than 545,000 and very similar characteristics (Table 2).

Listwise deletion removed cases from the analysis if any variable in the design matrix contained missing information might result in selection bias. One option would have been to not include variables that were missing for any observation in the dataset, (after setting a threshold criteria) but that would likely increase unaccounted variability in regression models and/or exclude meaningful variables in the analysis. Candidate variables were kept in the model since this dataset contained over 1,092,509 case records (prior to random splitting of dataset into the developmental model and the validation model), and there were still enough valid cases remaining such that the integrity of the analytical process remained with respect to statistical power.

The "true" health status or condition of the patient was not corroborated with any measurement data since baseline, routine measures are not available (heart rate, blood pressure, pulse rate, oxygen levels, temperature) and only general, broad symptom category descriptions were listed based on self-report, bystander report, or EMS assessment. Using measurement data to derive a scoring index would be apropos in the clinical setting and allow for decision making based on evidence based measurements for heart rate, blood pressure, materials ingested, or breathing rate. This would allow for a more patient centric DOSI score, likely more relatable and robust with respect to appropriate treatment options.

This analysis looked at drug/alcohol overdose events and EMS response in a pre-hospital environment. Since this dataset did not provide specifics on substance, route of exposure, or suspected amount taken, the level of detail and the strength of the DOSI for practical applicability is considerably less as a screening tool than if these parameters were available, limiting its use as a true diagnostic tool, since the composite DOSI criteria was based on statistical significance.

Notably, one of the statistically significant variables, EMS time spent at scene, is determined after EMS intervention; as such, the health status of the patient is generally known as would be whether the overdose was a fatality, so deriving a score to predict the risk of not surviving with that particular predictor is not practical for DOSI.

However, in retrospect, a better selection for a candidate variable in the DOSI model would have been to use the EMS outcome variable which used the category levels, treated and released, treated and transported, treatment refused, and dead at scene. And although more complicated, this variable as the dependent variable in a multinomial logistic regression model to determine DOSI may have given very different statistically significant predictors.

NEMSIS Data Collection Revision

NEMSIS data collection efforts are undergoing revisions to become Health Level 7 Compliant (HL7) which would allow for sharing of data across different sectors of public health and medical fields since data inputs and coding would be uniform with respect to definitions and identification of symptoms, conditions, and other classifications used between pre-hospital and other health sectors.[38] With increased participation (all 50 states are contributing some data as of 2015), expanded variable fields and uniformity across different medical and health sectors, NEMSIS has the potential to become a more valuable resource in identifying needs within communities, regions, and states to enhance public health services through EMS provide[38]

Overdose Surveillance through NEMSIS

Providing surveillance data to medical facilities, health departments, law enforcement, DEA, or other agencies in a quick and efficient manner is a daunting task, but a necessity in order to combat this horrific epidemic of substance abuse, addiction, and overdose fatalities. Another challenge is the ability to communicate not only inter-agency, but intra-agency, across local and state boundaries, or between different entities altogether.

Using key elements from NEMSIS, an early warning alert network could be developed, from information (collected in real and near real time) and disseminated by (by dispatch or other similar entity) taking advantage of current technologies using rapid transmission rates (via email, text messaging, alert notification calls, or website uploading and posting) could be used to provide notification of overdose events across a wide area. Standardized key information (tiered or level access) could get out to a variety of authorized sources in a matter of seconds. This would allow for current, relevant and standardized uniform information (reducing chance of misinformation) to focus on effective resource allocation strategies within medical facilities (trauma centers, emergency departments, treatment centers, etc.), public health and public safety, and law enforcement. This would be especially effective in instances of multiple overdoses occurring over short period of time. Creation of an overdose early warning network with elements from NEMSIS data would provide an alert to events, summarize and identify hotspots and perhaps provide information on substances used. In cases where substance is more lethal (for example, mixed with fentanyl derivatives) early warning alerts could also allow for extra cautionary measures for personal protection. An early warning notification system exists for drinking water utilities on the Ohio River (created in the 50's due to phenolic releases and unabated raw sewage discharges into the river) to convey discharge and spill information from reports generated (sources come from industry, environmental agencies, public health officials, and citizens) received by an entity who would, in turn, transmit it to stakeholders (in this case, drinking water utilities), who could take action to protect their consumers.[56] Because the Ohio River is bordered by six states, pollution issues can be complex and state and local agencies may not share information.[56] Using a facilitator to disseminate and maintain open lines of communication through a network, allows issues, such as those, to be addressed and resolved. A network relay of information, similar to the United States Coast Guard's (USCG) National Response Center (NRC) where all spills/discharges to U.S. waterways must be reported could serve as a template for an overdose alert network. Dispatchers or primary service answering points (PSAP) could forward essential overdose elements to a facilitator who manages the data and disseminates to appropriate agencies. Creating a network that relays select NEMSIS items, similar to the USCG's NRC reporting system, electronically usually shortly after an event occurs, near real time, (possibly through dispatch), would transmit information, at low cost, rapidly so decisions could be made related to follow up patient care, local, state, or federal law enforcement, community assets and allocation of EMS resources, or public health intervention.

Within the concept of alert notification, DOSI (or a version of DOSI) could serve as a status indicator (traffic light concept: Red = "danger", action needed, Yellow = "warning", prepare for action; Green = “status OK”) by mapping incident locations as a visual representation of what is happening.

CDC's *Guidelines for Field Triage of Injured Patients (2011)*, could be expanded to include a section dedicated to overdoses.[57]

While the concept of a drug overdose scoring index (DOSI) was an easily derived and validated, as a practical, functional tool, the application was lacking based on the selection criteria of variables (β coefficient, statistical significance) with primary focus on patient outcome. Repositioning the DOSI to focus on EMS based outcomes may yield a more meaningful screening index, translatable into actionable items to address overdose poisonings within the public health community.

CONCLUSION

EMS are responsible for responding to a myriad of patient conditions; as such, there was a broad spectrum of subject areas available for research. At epidemic and crisis levels is the issue of drug and alcohol related poisoning and overdose (DAPO) events; the focal point of this paper. While poisoning and overdoses can result from a variety of exposures, including prescription medicines, over-the-counter medications, vitamins and nutritional supplements, this paper centered on opioid containing substances and EMS response.

The 2012 National Emergency Medical Services Information Systems (NEMSIS) publically available dataset contained information collected by EMS personnel either by self-report or EMS assessment using a standardized format required for submission to the NEMSIS technical assistance center (TAC). Information is aggregated by the TAC throughout the calendar year and becomes available for analysis within a few months (compared with other datasets); [38] this is a valuable asset- a short lag time between collection and analysis expedites findings to public health, scientific, and general population communities, paving the way for improved outcome measures for morbidity and mortality. Primary caregivers are Emergency Medical Services personnel (EMS), who are trained and licensed to provide immediate care to any individual, in a wide variety of places and circumstances. Calls into 911 or a primary service answering point (PSAP) are self-reported or from a bystander and as soon as key information such as patient health status and incident location are ascertained, EMS are dispatched to the scene and, upon arrival, assess the situation and take measures to improve the patient's health status.

Studies involving pre-hospital EMS events are not as prevalent as findings based on clinic, treatment center, hospital, or emergency department data (based on literature review searches). Using NEMSIS data provided an opportunity to focus on a vital and necessary community resource and integral sector of public health – the emergency medical service responder. EMS are often first to provide medical assistance in the pre-hospital environment and are commonly called upon to stabilize and treat patients involved in a drug or alcohol related poisoning or overdose (DAPO). According to Kinsman, et al, 2014 estimates of EMS encounters involving suspected drug overdoses exceeded 430,000 and naloxone was used more than 150,000 times.[41] For example, incident response location mapping may lead to finding "off-the-grid" overdose clusters (patients treated and released on scene or where treatment was refused) that may not be otherwise captured.

This paper focused on drug and/or alcohol related poisonings or overdoses in a pre-hospital setting. A screening tool based on composite scores from select variables from suspected drug and/or alcohol cases in the pre-hospital setting was created to rate DPI(+) cases and predict their risk of an overdose fatality. A drug overdose scoring Index (DOSI) was developed as a screening tool to assess the risk of fatality for an individual suspected of a drug or alcohol overdose.

There was close agreement in development of DOSI and validation of the screening tool. AUC reported values were 0.794 (P <0.001, 95%CI: 0.773, 0.896) and 0.802 (P <0.001, 95%CI: 0.780, 0.825) respectively. Scoring range of values, based on case indices, ranged from 97-192. The threshold cutpoint, the point where the false positive rate and the false negative rate were both maximized and relating to the predictive ability of the DOSI, was maximized at a DOSI score of 156.5. (79.8% of cases in validation model had a score of at least 156.5). Scores lower than 156.5 had higher false positive rates and lower false negative rates; scores higher than 156.5 had lower false positive rates and higher false negative rates.

Results may not be generalizable beyond this dataset since only 42 U.S. states and territories participated, and only select agencies within those areas submitted data to NEMSIS Technical Assistance Center (TAC). Participation by EMS agencies was voluntary and identification of agencies and reporting states was not part of the publically available dataset.

However, for those agencies that did participate, uniform data entry fields and codes were required so there is standardization among reporting agencies allowing for direct comparisons.

While the publically available dataset had limitations with respect to misclassification and information biases, these surveillance records contain metrics which can contribute greatly to public health at the pre-hospital and first responder level as it captures populations that may not be accounted for in other data repositories and in morbidity data. Near real time surveillance information could be quickly communicated. For research and analyses, data is uploaded to the NEMSIS TAC quarterly, cleaned, and made publically available within months; in turn, findings and trends can be put forth in a timelier manner, relevant to issues at hand.

Using this surveillance data in near-real time (locally) through an early warning alert network or on a grid mapping system to visually show trends and hotspots is useful since knowledge transfer would occur quickly.

Migration to Health Level 7 (HL7) would likely strengthen the usefulness of NEMSIS, with standardization across other public health and medical datasets.

The NEMSIS dataset is a valuable research tool because it details events occurring outside of the hospital or emergency department. Currently there is a paucity of data relating pre-hospital data, EMS response and drug/alcohol overdose events, amidst a widespread public health crisis in the United States. Changes to medical coverage and health care plans have likely had an impact on EMS providers in both frequency of EMS response runs and the type of acute care they are required to provide. EMS personnel being called upon to respond to drug overdoses has become an all too common occurrence, but these response records, which are standardized, have provided a large repository of data, collected in near, real-time that could be a valuable tool in developing strategies to further harm reduction efforts for substance abuse overdoses and deaths resulting from overdoses and to help support and justify needs for expanded services or pooling/sharing resources between communities and regions.

Although development of a DOSI screening tool to evaluate cases for determining the risk of not surviving was successful, the variables that contribute to the score (911 call complaint, EMS level, gender, and EMS time on scene) might have limited practical applicability, since one of the variable inputs was determined only after the EMS event occurred (time spent on scene). This scoring system, however, indicates potential areas for future research and could serve as a prototype for a more practical screening tool created by using different variable inputs. Next steps would be to further analyze candidate variables to produce a better designed scoring matrix.

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APPENDIX

NEMSIS KEY VARIABLES DICTIONARY

These data dictionary definitions are based on the National Emergency Medical Services Information System (NEMSIS) Data dictionary V 2.2.1 (2006), which is available online at WWW.NEMSIS.ORG. The complete NEMSIS dictionary segregates variables in three categories: Demographic information, which describes EMS system information; EMS event information which describes the EMS response and measures; and XML formatting which describes elements used to migrate version 2.2.1 data elements between data systems (NHTSA, 2006). The NHTSA compilation describes main variables available in the publically available dataset (National Elements). Variables computed and/or recoded by the researcher were done to combine groups within variables, to convert to numeric values, and/or facilitate analytical model processing. This dataset contains 72 publically accessible NEMSIS variables and recoded/computed variables. Variables were categorical, nominal values. The 2012 dataset created by merging NEMSIS files contains 35,476,795 records.

EventID: This a unique ID number that registers each 911 PSAP call as a single event. EventID's assigned for this dataset start January 1, at 00:00:00 through December 31, at 12:59:59. EventID is the linking variable used to merge different dataset files together.

Common Null Values: These descriptors are embedded in data set elements to describe the "not" situation. Not available, not known, not reporting, not recorded or not applicable. Some reporting agencies (based on local/state policies or regulations) could not provide information to NEMSIS, so coded under Null value. In variables that have been recoded, these values were combined. *These were coded as "system missing" during analysis.*

Complaint Reported by Dispatch (E03_01): Call information given to the responding unit vehicle by dispatch. NHTSA EMD Chief Complaint Types are used to describe complaint; common null values apply. PSAP was data collector. This variable was recoded to consolidate complaint groups and to isolate drug/poisoning symptoms (COMPL03_01) to facilitate dataset analysis. Null values were combined and coded as "system missing. **Cardiac Arrest** was used as the reference category.

Gender (E06_11): The patient's gender. Common null values apply. Data collector is EMS personnel or information electronically linked through a pre-existing report such as hospital record or patient care report. Gender was recoded (GEND06_11); Null values were combined and coded as "system missing". **Male** was used as the reference category.

Race (E06_12): Race of patient using US Office of Management and Budget (OMB) classifications. Common null values were used. Race was recoded (RACE06_12X) to combine categories. Null values combined and coded as "system missing. **White** was used as the reference category.

EMS Service Level (E07_34): This is the EMS service level defined according to the Center for Medicare and Medicaid Services (CMS). Common null values apply. Data collector is EMS personnel, possibly professional billing service. EMS Service Level was recoded to (EMS07_34X). Null values were combined and coded as "system missing. The reference category was **BLS.**

Incident Location (E08_07): Place where EMS locate patient may coincide where incident occurred. Common null values apply. String values are recoded into numeric values to facilitate analysis (LOCA08_07X). The data collector is EMS personnel. Null values were treated as "system missing". **Residence** was used as the reference location.

Medication Given (E18_03recoded): Any medication administered by EMS personnel. Recoded (consolidated) description provided by NEMSIS because inputs could be based on common, generic, trade names and abbreviations. No standardized drug index or coding scheme exists during time of data collection. Common null values apply. Data collector is EMS personnel/EMS Agency. String value categories were recoded into numeric values and medications were combined (MEDS18_03). Null values were treated as "system missing". **Oxygen** was used as the reference category.

 # Meds Given (TMEDSUM2): This variable was created to count how many medicines were administered. This could be multiple doses of the same medicine or different medicines. Null values were combined and coded as "system missing". **1 Med given** was the reference category.

Procedure Description (E19_03): Name of the procedure(s) performed on patient by EMS personnel. Common null values apply. Data collector is EMS personnel. String value categories were recoded to combine categories; Null values were combined and coded as "system missing". Variable was recoded into (PROCS19_03). **Cardiac Monitoring** was the reference category.

 # Procedures Used (SUMPROCS): This variable was created to count the number of procedures used. This could be either the same procedure multiple times or different procedures. Null values were combined and coded as "system missing". **1 PROC used** was the reference category.

EMS incident outcome (E20_10): Variable characterizes what, if any, post EMS intervention, took place. Data collector is EMS personnel. Variable groups were recoded (EMSOUT20_10X) to combine groups and convert string variables to numeric values. Null values were combined and coded as "system missing". **Treat & Transport** was the reference category.

Geographical area type: Describes region by area type EMS event took place in. This is the highest level descriptor available in the public use dataset to protect patient identification. Data collector is EMS personnel or pre-existing hospital database records. String value categories were recoded into numeric values. Null values were combined and coded as "system missing". Recoded as (REURB_01). **Suburban** was the reference category.

EmsSceneTime: Arrival time of EMS unit to patient including treatment measures. NEMSIS computed variable; elapsed time from time unit arrived on scene to through patient treatment. Time recorded ranges from 0-1498 minutes, rounding to whole minute. Variable was recoded into time ranges in 15 minute intervals (ONSCEN_01X). Null values were combined and coded as "system missing". **0-15 Min** was the reference category.

EmsSystemResponseTime: NEMSIS computed variable; average time from time dispatch notified unit to Unit arrives on scene. Variable was recoded group system response times into category ranges. Variable was recoded into time groups (EMS2SCEN_01X) in 15 minute intervals after the first <8 minute interval (gold standard time). Null values were combined and coded as "system missing". **<8 MIN** was the reference category.

AgeGroup: NEMSIS grouped variable in increments of 10 years from starting at 1 year of age-99 years of age; Age also grouped by <1 year of age and >=100 years of age. For this analysis, 0-9 years was treated as "missing" for DPI(+) since count levels were low in analyses. String variable groups recoded into numeric groups (AGE06_14X). Null values were combined and coded as "system missing". **30-39 YRS** was used as the reference category.

Computed Drug/Poison indicators (DPI_01X): This variable combined instances of drug overdose and poisoning designations in the merged dataset. Alcohol intoxication instances and chemical poisoning instances were included because within some categories these were combined with drug overdose or poisoning events and other times they were not. Drug poisoning indicators were derived from recoded variables for Condition code, EMS Primary Assessment, EMS Secondary Assessment, Complaint recorded by dispatch (911 call complaint), Alcohol/Drug indicator, and Cause of Injury. These are probable/suspected cases. This was coded as a binary variable. **DPI not PRES** was the reference category.

Computed Mortality Indicator (MI_01X): This variable was computed to capture instances where the patient did not survive. The Mortality indicator variable was derived from recoded variables for Condition code, EMS Primary Assessment, EMS Secondary Assessment, Complaint recorded by dispatch (911 call complaint), Cause of Injury and EMS Outcome. A binary outcome variable for mortality was created. **DID NOT SURVIVE (DNS)** was the reference category.

These variables were created to screen individual cases in the dataset to predict whether a case would survive a DAPO event based on a value from the scoring index DOSI. DOSI was created from 4 variables. 911 call complaint, EMS service level, Gender, and EMS time spent on scene. These variables were computed based on the β coefficient from a backward logistic regression analysis and were statistically significant at $P < 0.05$.

DOSIGEN1: This variable calculates a base score for a DPI(+) case based on gender.

DOSITME1: This variable calculates a base score for a DPI(+) case based on the amount of time EMS spent on scene.

DOSIEMS1: This variable calculates a base score for a DPI(+) case based on the highest EMS provider on scene.

DOSI911A: This variable calculates a base score for a DPI(+) case based on the 911 complaint called into dispatch.

DOSISUMX1: This is a summation variable of DOSIGEN1, DOSIEMS1, DOSITME1, and DOSI911A. Cases were excluded from if there was a missing value for any of the 4 component DOSI. This was used in ROC analysis.

Table 1. **Common Substances of Abuse, General Symptoms, and EMS Treatment**

Substance Class	Commonly Overdosed Substance	General Symptoms	EMS Intervention
Alcohol	Ethanol, methanol, isopropyl alcohol	nausea, vomiting, impaired thinking, slow reaction times, slurred speech, shallow breathing	IV glucose & fluids, diazepam
Narcotics, opioid	OxyContin, Percocet, Heroin	pinpoint pupils, slurred speech, slow heart rate, shallow breathing, confusion, blue nails and lips, constipation	Naloxone
CNS Stimulants/amphetamines	Cocaine,"uppers", crack, Ritalin, Ecstasy	aggressive, hallucinations, hyperthermia, tremors, anxiety, mood swings. chest pain, elevated pulse & heart rate, seizures, breathing difficulty, hyperactive	Midazolam, Lorazepam
Hallucinogens	LSD, Ketamine, PCP, psilocybin mushrooms, bath salts	paranoia, fear, euphoria, hallucinations, elevated heart rate, blood pressure, tremors, dilated pupils, dizziness, numbness, appetite loss, dry mouth	keep patient calm, benzodiazepines
TCA/Antidepressants	Lexapro, Prozac, Elavil	disorientation, increased serotonin levels (anxiety, restlessness, irregular heart rate), elevated temp, seizure	Sodium Bicarbonate, Benzodiazepines
Organophosphate poisoning	malathion, parathion, nerve gas(VX, sarin), chlorpyrifos	salivation, bronchorrhea, sweating, abdominal pain, diarrhea, muscle paralysis, brachicardia	Atropine
Acetaminophen	Tylenol, paracetamol, mapap	abdominal pain, nausea, sweating, jaundice, vomiting, convulsions, coma*	Activated charcoal
Benzodiazepines	Xanax, Ativan, valium, Ambien, Klonopin	slurred speech, blurred vision, drowsiness, sedation, breathing difficulty, loss of coordination, loss of inhibition	
Aerosolized solvents	canned whipped, cream, hairspray, paint, air	varied, may include, hypoxia, slurred speech, euphoria, drowsiness, delusions, headache, confusion	
over-the-counter products	pain relievers, sleep aids, diet pills, allergy relief	varied, may include allergic reaction, drowsiness, difficulty breathing, seizures, arrhythmias	
Beta blockers (epinephrine)	Toprol, Sectral	tachycardia, arrhythmia, hypoglycemia, hypothermia, blurred vision, confusion, convulsions	glucagon, IV fluids
calcium Channel blockers	Amlodipine (Norvasc), Cardizem	syncope, chest pain, weakness, confusion, peripheral edema, headache, nausea, slowed heart rate, hypotension	Calcium Chloride

Ensure ABC function to stabilize patient in overdose/poisoning events**

*may be delayed onset of symptoms up to 12 hrs after ingestion
**ABC's= airway, breathing and circulation. EMS Personnel treat to clear airway of obstruction, maintain proper oxygen levels and respiration, and maintain and monitor blood pressure and heart rate.

Source: http://www.emergencymedicalparamedic.com/organophosphate-poisoning/

Source: https://louisvilleky.gov/sites/default/files/ems/pdf_files/lmems_protocols_-_final_version_2.01_0.pdf

Table 2. Characteristics of DAPO (+)* Cases in Developmental Dataset and Validation Dataset from 2012 NEMSIS Case Records

		DOSI Developmental Dataset		Validation Dataset	
		(n = 34,914)		(n= 34,829)	
911 COMPLAINT	Ingested Poison	7907	22.65%	7943	22.75%
	Traumatic Injury	3189	9.13%	3184	9.12%
	Breathing Problem	1680	4.81%	1696	4.86%
	Chest Pain	2274	6.51%	2282	6.54%
	Heart (non cardiac arrest)	270	0.77%	268	0.77%
	Unconscious/fainting	3344	9.58%	3465	9.92%
	Seizure/convuls/stroke/CVA	1625	4.65%	1615	4.63%
	Stabbing/GSW	294	0.84%	284	0.81%
	Traffic accident	1878	5.38%	1805	5.17%
	Man down (unk reason)	1927	5.52%	2006	5.75%
	Other complaints	10159	29.10%	9861	28.24%
	Cardiac Arrest (REF)	367	1.05%	420	1.20%
LOCATION	Hospital/Med Facility	1572	4.50%	1567	4.49%
	Rehab/Instit/Jail	440	1.26%	434	1.24%
	Industrial/business setting	2832	8.11%	2854	8.17%
	Sport/leisure/rec venue	333	0.95%	342	0.98%
	Nat. Waterbody	71	0.20%	65	0.19%
	Public bldg.	1416	4.06%	1454	4.16%
	Street/roadway	6744	19.32%	6631	18.99%
	Other Location	1354	3.88%	1366	3.91%
	Residence (REF)	20152	57.72%	20116	57.62%
PROCEDURE	Airway procedures	700	2.00%	710	2.03%
	P-OX/BP/CAPN/CO2	1070	3.06%	1073	3.07%
	Patient Assessment	1713	4.91%	1681	4.81%
	BGA	1416	4.06%	1422	4.07%
	Venous Access	5926	16.97%	5835	16.71%
	EKG/CPR/Defib	824	2.36%	816	2.34%
	Other procedures	21247	60.86%	21289	60.98%
	Cardiac Monitoring (REF)	2018	5.78%	2003	5.74%
AGE RECODE	10-19 YRS	2407	6.89%	2302	6.59%
	20-29 YRS	6840	19.59%	6939	19.87%
	40-49 YRS	7442	21.32%	7435	21.30%
	50-59 YRS	7434	21.29%	7456	21.36%
	60-69 YRS	3113	8.92%	3083	8.83%
	70+ YRS	1783	5.11%	1778	5.09%
	30-39 YRS (REF)	5895	16.88%	5836	16.72%
MEDS GIVEN	Naloxone/Act. Charcoal	2773	7.94%	2722	7.82%
	Salines	3455	9.90%	3440	9.85%
	Dex/Lact/Ringer's Soln's	454	1.30%	449	1.29%
	Other Meds	21930	62.81%	21952	62.87%
	Oxygen (REF)	6302	18.05%	6266	17.95%
REGION TYPE	Urban	26471	75.82%	26322	75.39%
	Rural	3876	11.10%	3908	11.19%
	Wilderness	900	2.58%	940	2.69%
	Other	355	1.02%	399	1.14%
	Suburb (REF)	3312	9.49%	3260	9.34%
EMS LVL	BLS, Emerg	6502	18.62%	6591	18.88%

	ALS, LV1	16616	47.59%	16488	47.22%
	ALS, LV2	9311	26.67%	9175	26.28%
	Paramedic	60	0.17%	72	0.21%
	BLS (REF)	2425	6.95%	2503	7.17%
EMS 2 SCENE	9-15 MIN	9272	26.56%	9133	26.16%
	16-30 MIN	2833	8.11%	2903	8.31%
	31+ MIN	459	1.31%	512	1.47%
	<=8 MIN (REF)	22350	64.01%	22281	63.82%
RACE	Black	5951	17.04%	5936	17.00%
	Native Am/Alsk	602	1.72%	639	1.83%
	Other Race	2487	7.12%	2406	6.89%
	White (REF)	25874	74.11%	25848	74.03%
EMS TIME AT SCENE	16-30 MIN	13502	38.67%	13547	38.80%
	30-45 MIN	1536	4.40%	1556	4.46%
	45+ MIN	400	1.15%	402	1.15%
	0-15 MIN (REF)	19476	55.78%	19324	55.35%
TOTAL # of MEDS GIVEN**	2 Meds given	6693	19.17%	6512	18.65%
	3 Meds given	1143	3.27%	1207	3.46%
	1 Med Given (REF)	27078	77.56%	27110	77.65%
TOT # PROCS USED**	2 PROCS USED	1203	3.45%	1239	3.55%
	3+ PROCS USED	131	0.38%	123	0.35%
	1 PROC (REF)	33580	96.18%	33467	95.86%
GENDER	FEMALE	13796	39.51%	13492	38.64%
	MALE (REF)	21118	60.49%	21337	61.11%

*DAPO(+) = Cases considered positive for drug and/or alcohol poisoning or overdose based on 911 call description and/or EMS assessment

Table 3. Bivariate Analysis of Risk factors and Mortality for Drug/Alcohol Poisoning and Overdoses-Developmental Dataset

		Did not Survive	Alive	Totals	Pearson's Chi-Square	*P* value
911 COMPLAINT		2681	446504	449185	46556.34	<0.001
	Ingested Poison	345	116937	117282		
	Traumatic Injury	112	44651	44763		
	Breathing Problem	53	15757	15810		
	Chest Pain	31	18092	18123		
	Heart (non cardiac arrest)	7	2371	2378		
	Unconscious/fainting	256	32217	32473		
	Seizure/convuls/stroke/CVA	24	16642	16666		
	Stabbing/GSW	68	2727	2795		
	Traffic accident	214	24158	24372		
	Man down (unk reason)	350	35389	35739		
	Other complaints	211	134947	135158		
	Cardiac Arrest (REF)	1010	2616	3626		
LOCATION		3093	490933	494026	674.82	<0.001
	Hospital/Med Facility	50	27816	27866		
	Rehab/Instit/Jail	18	7695	7713		
	Industrial/business setting	155	42984	43139		
	Sport/leisure/rec venue	26	5329	5355		
	Nat. Waterbody	18	834	852		
	Public bldg.	49	26984	27033		
	Street/roadway	353	95872	96225		
	Other Location	114	25011	25125		
	Residence (REF)	2310	258408	260718		
PROCEDURES		3296	542309	545605	11.23	0.129
	Airway procedures	58	9179	9237		
	P-OX/BP/CAPN/CO2	115	20602	20717		
	Patient Assessment	264	44406	44670		
	BGA	119	23634	23753		
	Venous Access	445	70811	71256		
	EKG/CPR/Defib	66	9821	9887		
	Other procedures	2083	335561	337644		
	Cardiac Monitoring (REF)	146	28295	28441		
AGE RANGE		3196	514700	517896	177.36	<0.001
	10-19 YRS	71	38340	38411		
	20-29 YRS	610	110756	111366		
	40-49 YRS	682	108744	109426		
	50-59 YRS	747	105105	105852		
	60-69 YRS	355	41847	42202		
	70+ YRS	145	21945	22090		
	30-39 YRS (REF)	586	87963	88549		
MEDS GIVEN		1390	232515	233905	2.71	0.608
	Naloxone/Act. Charcoal	103	17752	17855		
	Salines	139	25503	25642		
	Dex/Lact/Ringer's Soln's	23	3372	3395		
	Other Meds	849	142460	143309		
	Oxygen (REF)	276	43428	43704		

REGION TYPE		3296	542309	545605	113.59	<0.001
	Urban	2358	426121	428479		
	Rural	426	53990	54416		
	Wilderness	139	13783	13922		
	Other	51	8918	8969		
	Suburb (REF)	322	39497	39819		
EMS LVL		1260	274985	276245	111.24	<0.001
	BLS, Emerg	298	83599	83897		
	ALS, LV1	561	118926	119487		
	ALS, LV2	323	44667	44990		
	Paramedic	4	381	385		
	BLS (REF)	74	27412	27486		
EMS 2 SCENE		3284	53500	536784	14.33	<0.001
	9-15 Min	733	126258	126991		
	16-30 Min	290	40616	40906		
	31+ Min	36	8566	8602		
	<=8 Min (REF)	2225	358060	360285		
RACE		2612	402923	405535	138.35	<0.001
	Black	274	70815	70889		
	Native Am/Alsk	54	10967	11021		
	Other Race	123	29242	29365		
	White (REF)	2161	292099	294260		
EMS TIME AT SCENE		1824	462366	464190	6067.44	<0.001
	16-30 Min	649	157347	157996		
	30-45 Min	211	20619	20830		
	45+ Min	416	6497	6913		
	0-15 Min (REF)	548	277903	278451		
TOTAL # of MEDS GIVEN**		1533	236407	237940	3.07	0.216
	2 Meds given	258	41209	41467		
	3+ Meds given	36	7198	7234		
	1 Med Given (REF)	1239	188000	189239		
TOT # PROCS USED**		3296	542309	545605	74.21	<0.001
	2 Procs used	21	16963	16984		
	3+ Procs used	2	1643	1645		
	1 Procedure (REF)	3273	523703	526976		
GENDER		3242	521844	525086	168.54	<0.001
	Female	842	193137	193979		
	Male (REF)	2400	328707	331107		

Table 4. Drug Overdose Scoring Index (DOSI)

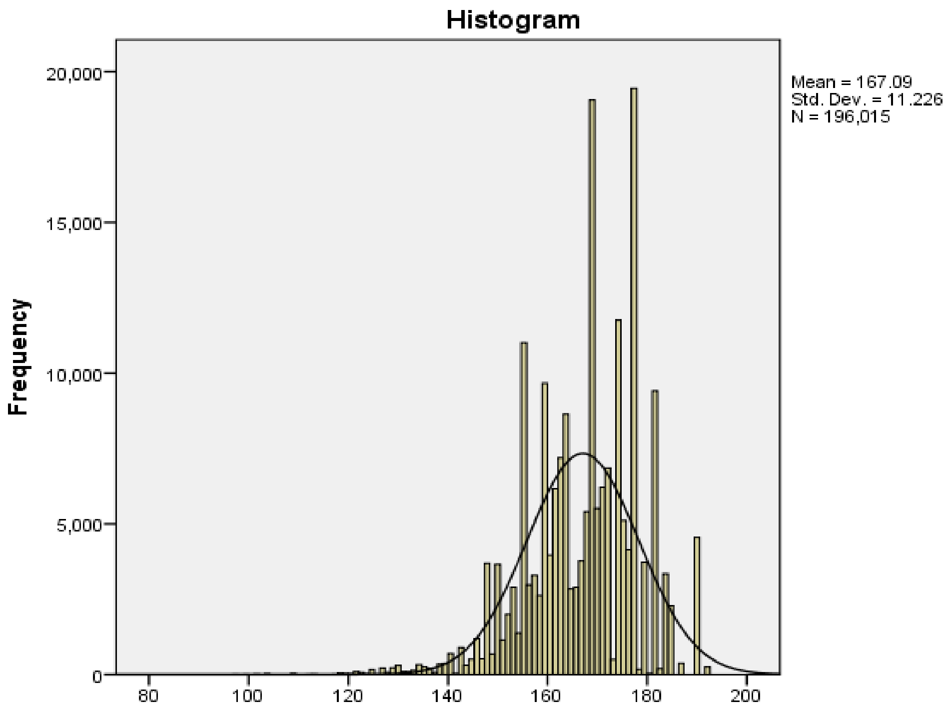
Predictor Variable	β Coefficient	Raw Score	Adj. Score
911 COMPLAINT CALL		DOSI911	DOSI911A
Ingested Poison	3.648	36	65
Traumatic Injury	3.769	38	67
Breathing Problem	3.273	33	62
Chest Pain	4.59	46	75
Heart (non cardiac arrest)	3.511	35	64
Unconscious/fainting	3.644	36	65
Seizure/convuls/stroke/CVA	3.693	37	66
Stabbing/GSW	3.585	36	65
Traffic accident	4.115	41	70
Man down (unk reason)	3.11	31	60
Other complaints	4.402	44	73
Cardiac Arrest (REF)	1	10	39
GENDER		DOSIGEN	DOSIGEN1
Female	0.502	5	34
Male (REF)	1	10	39
EMS LVL		DOSIEMS	DOSIEMS1
BLS, Emerg	-0.285	-3	26
ALS, LV1	0.202	2	31
ALS, LV2	-0.549	-5	24
Paramedic	-1.548	-15	14
BLS (REF)	1	10	39
EMS TIME AT SCENE		DOSITIME	DOSITME1
16-30 Min	-0.365	-4	25
30-45 Min	-1.272	-13	16
45+ Min	-2.862	-29	0
0-15 Min (REF)	1	10	39

Adjusted scores were used in calculating DOSI for DPI(+) cases in ROC analysis.

Table 5. Select calculated DOSI scores for DPI(+) cases

(+) DOSI is >=	Sensitivity	1 - Specificity
100.51	1.000	.990
110.51	1.000	.913
120.01	1.000	.884
130.51	.994	.708
140.01	.985	.623
150.50	.923	.434
156.50	**.814**	**.327**
160.50	.735	.289
170.50	.400	.148
180.00	.104	.041

Figure 1a. DOSI Frequencies for DPI(+) Cases in Developmental Dataset



Statistics

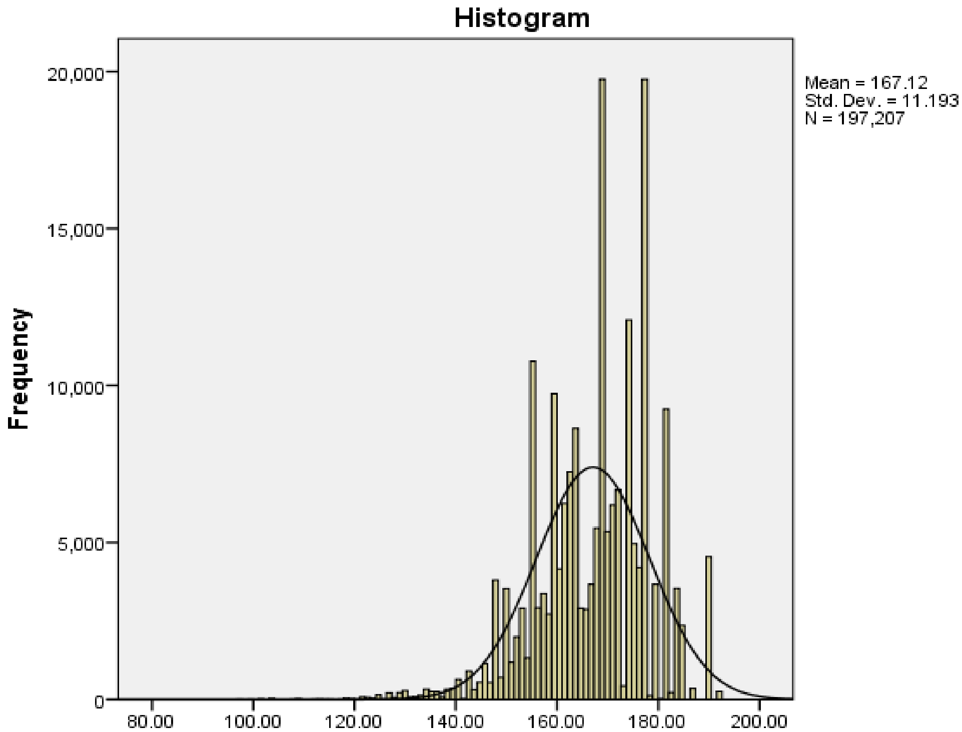
Developmental Predictive Dataset

N	Valid	196015
	Missing	349590
Mean		167.09
Median		168.62[a]
Mode		177
Skewness		-.572
Std. Error of Skewness		.006
Kurtosis		.870
Std. Error of Kurtosis		.011
Range		95
Minimum		97
Maximum		192
Percentiles	25	160.11[b]
	50	168.62
	75	175.31

a. Calculated from grouped data.

b. Percentiles are calculated from grouped data.

Figure 1b. DOSI Frequencies for DPI(+) Cases in Validation Dataset

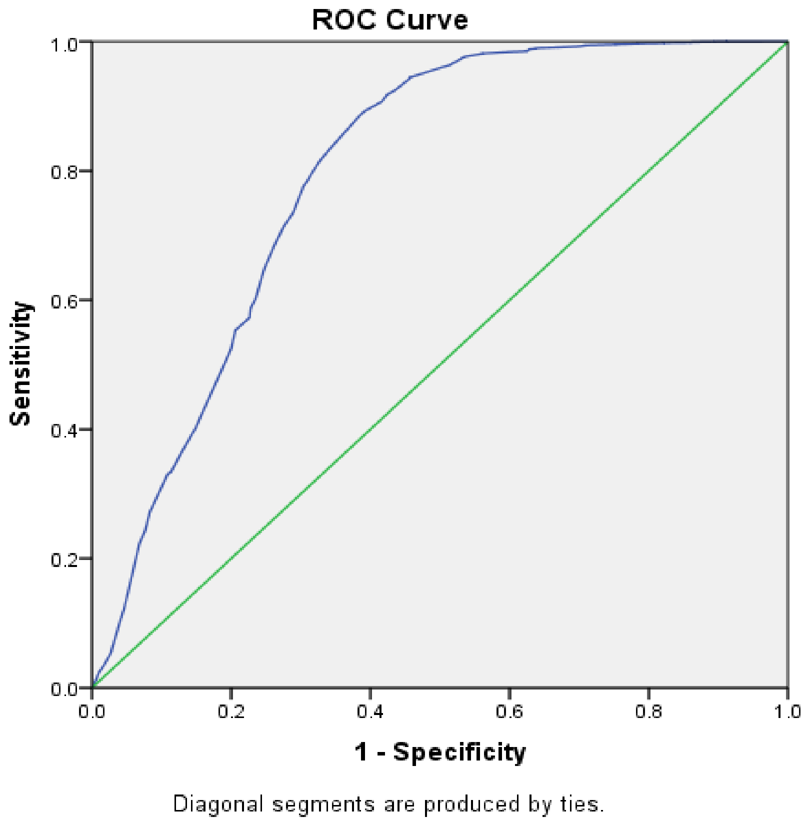


N	Valid	197207
	Missing	349697
Mean		167.1198
Median		169.0000
Mode		169.00
Skewness		-.564
Std. Error of Skewness		.006
Kurtosis		.846
Std. Error of Kurtosis		.011
Range		94.99
Minimum		97.01
Maximum		192.00
Percentiles	25	160.0000
	50	169.0000
	75	175.0000

a. Calculated from grouped data.

b. Percentiles are calculated from grouped data.

Figure 2a. DOSI-Developmental Dataset



Area Under the Curve

Test Result Variable(s): DOSI APPLIED FROM DEVELOPMENTAL DATA SET

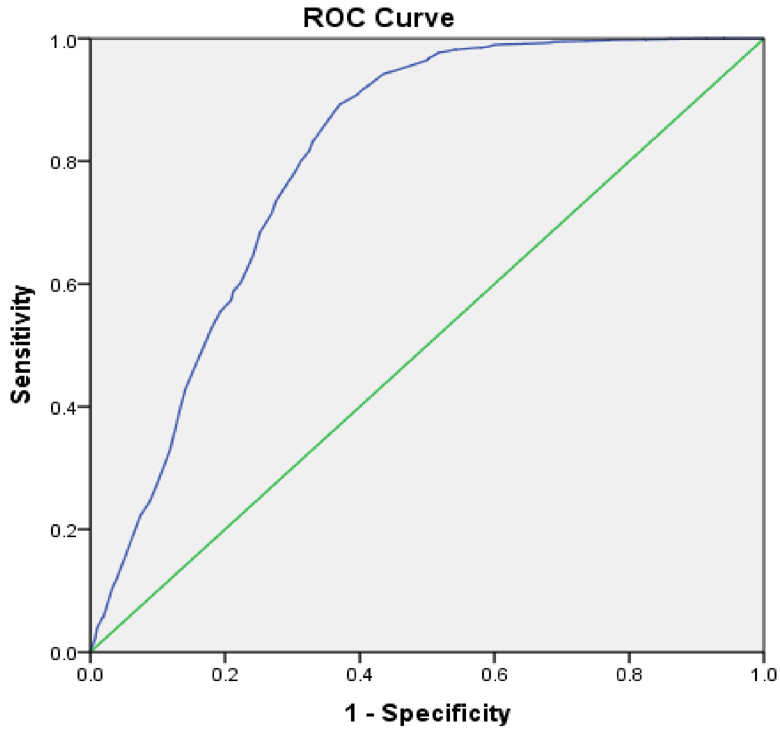
Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.794	.011	.000	.773	.816

The test result variable(s): has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Figure 2b. ROC Curve for DOSI Validation



Diagonal segments are produced by ties.

Area Under the Curve

Test Result Variable(s): DOSI VARIABLE APPLIED TO VALIDATION DATASET

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.802	.011	.000	.780	.825

The test result variable(s): has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5