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Use of multiple data sources to identify specific drugs and other factors associated with drug and alcohol screening of fatally injured motor vehicle drivers

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ABSTRACT

Objective: Drugged driving crashes have significantly increased over the past two decades. The objectives of this study were to identify and characterize the drugs present in motor vehicle driver fatalities using multiple surveillance data sources; assess concordance of the data sources in identifying drug presence; and identify demographic and crash factors associated with drug and alcohol screening in fatally injured motor vehicle drivers.
Methods: Fatality Analysis Reporting System (FARS), Collision Report Analysis for Safer Highways (CRASH), and mortality data sets were linked; drug screening and positive drug screens were identified. Chi-square and conditional logistic regression were performed.
Results: The use of FARS data identified the majority of positive drug screens in the linked data set. Supplementation of FARS data with death certificate and CRASH data increased identification of specific drugs and drug classes detected among fatally injured motor vehicle drivers, although there was a low concordance among the data sources. Alcohol and depressants such as alprazolam had the highest frequencies among fatally injured drivers. Speeding, lack of occupant restraints, young age, commercial truck drivers, and speeding were all factors associated with increased odds of the fatally injured driver being drug or alcohol screened.
Conclusions: These findings indicate that FARS drug information data may be strengthened through increased autopsy and consultation with medical examiners to better understand and interpret decedent toxicology testing results, and that states with low driver drug testing rates should consider mandatory driver drug testing in fatal crashes.

1. Introduction

Drug-involved motor vehicle crashes have significantly increased over the last two decades, posing serious safety concerns to the general motoring public on roadways in the United States (Rudisill et al., 2014; Brady and Li, 2014). Both licit and illicit drugs present in drivers involved in fatal and nonfatal crashes have been identified, including marijuana, stimulants, narcotics, and depressants (Li et al., 2013; Bunn et al., 2013). Prescription opioid detection among drivers in fatal motor vehicle crashes, especially oxycodone, more than tripled between 2001 and 2016 (Rookey, 2018). Not only have single drugs been identified in drugged drivers in fatal motor vehicle crashes, the presence of multiple drugs (three or more) has more than doubled among drivers in fall motor vehicle crashes, increasing from 11.5% of all fatal motor vehicle crashes in 1993 to 21.5% of all fatal crashes in 2010 (Wilson et al., 2014).

Identification of specific drugs among drugged drivers in motor vehicle crashes may require analysis of additional, and alternative, data sources to supplement traditional data sources, such as the Fatality Analysis Reporting System (FARS) data, that is routinely used to assess drugged driving in fatal motor vehicle crashes in the United States. In a Norwegian study on the prevalence and concentrations of specific drugs among older suspected drugged drivers, ethanol, zopiclone, and diazepam were most frequently detected among older drivers through retrospective analysis of blood samples (Høiseth et al., 2017). In a literature review of 14 databases, specific drugs associated with an increased risk for a motor vehicle crash were buprenorphine, codeine, dihydrocodeine, methadone, tramadol, levocitirizine, and diazepam, among others.

There are a number of limitations when assessing drug involvement

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in fatal motor vehicle crashes using FARS data. Presence of drugs among drugged drivers may not always represent impairment due to the identified drug in drivers (Compton and Berning, 2009) using FARS data. Differences among states in drug testing procedures have been identified, such as type of test, testing cut-offs, biological sample to be tested, and who is tested (Berning and Smither, 2014). Regarding who is tested after a fatal crash, state drug testing rates are highest for those fatalities where the driver died at the scene (71%) and where the fatally injured driver was determined to be at fault in the crash (64%) (Slater et al., 2016). Romano et al., (2017) have suggested that the FARS database may be useful to assess the contribution of drug to fatal crash risk but is not suitable to identify trends in drug use or to obtain precise motor vehicle crash fatality risk estimates.

Linked and multiple data sets may provide a more comprehensive picture regarding the identification of drugs present among drivers and/or passengers in fatal motor vehicle crashes. Using emergency department (ED) data involving drug use (Drug Abuse Warning Network data), and FARS data, Mattson et al., (2015) showed that both data sets displayed similar temporal patterns for substance-impaired underage youth- involved fatal motor vehicle crashes but at different magnitudes. Romano et al., (2014) and Li et al., (2013) had differing results on the contribution of drugs to crash risk using FARS data and U.S. National Roadside Survey (NRS) data, that Romano et al., (2017) attributed to limitations in the FARS and NRS data due to state drug testing differences, failure to account for demographics in risk estimates, and self-selection bias in the NRS. Concordance of motor vehicle crash, ED, and inpatient hospitalization data was assessed by Bunn et al., (2013) who found Collision Report Analysis for Safer Highways (CRASH) data a better data source for identifying drugs in injured drivers compared to ED data, and that inpatient hospitalization data was the better source for identifying drugs in injured drivers compared to CRASH data. The authors concluded that surveillance data from multiple data sets is necessary to identify the presence of drugs among injured drivers.

Comprehensive drug (including alcohol) screening of fatally injured drivers is not routinely or universally performed (Slater et al., 2016) in all states. Universal standardized drug screening (followed by confirmatory testing if warranted) of fatally injured drivers to obtain specific drug and drug combination results on presence and concentrations (where possible) can inform new and emerging drug testing (Fassette and Martinez, 2016); improve assessment of the contribution of specific drugs to fatal crash risk (Romano et al., 2017); inform law enforcement of drugged-driving offenses and increase law enforcement presence in drugged-driving corridors (Veisten et al., 2013); and inform public health-related safe driving interventions (Benotsch et al., 2015). FARS data is based on multiple data sources (CRASH, death certificate, medical, toxicology testing, and medical examiner records) and is routinely analyzed for drug-related driving studies. FARS data may not capture and identify all drugs present in drivers fatally injured in motor vehicle crashes, and additional data sources may be needed to comprehensively identify the specific drugs and drug categories among fatally injured drivers in motor vehicle crashes. Mortality data may be a useful data source to supplement FARS data and identify the specific drugs listed on the death certificates of fatally injured drivers. CRASH data also may provide additional data on the drugs, circumstances, and other human and vehicular factors that were involved in or contributed to the fatal crash.

The objectives of this study were to 1) identify and characterize the specific drugs and drug categories present in motor vehicle driver fatalities using multiple surveillance data sources (FARS, CRASH, and mortality data) in Kentucky, a state where at least 50% of fatally injured drivers are drug tested (Rudisill et al., 2014); 2) assess concordance and use of CRASH, FARS, and mortality data sources in identifying drug presence in motor vehicle driver fatalities; and 3) identify demographic and crash factors associated with drug and alcohol screening in fatally injured motor vehicle drivers.

2. Methods

2.1. Study population and data

The study population was all drivers (Kentucky residents as well as non-residents) who died in a motor vehicle crash in Kentucky between January 1, 2010 and December 31, 2014.

Data for the present study were obtained from three sources. CRASH electronic files for years 2010–2014 were provided by the Kentucky State Police Records Section, and included all reported crashes that occurred on public roadways in Kentucky. These files contained all motor vehicle collision information but excluded some personal identifiers. Kentucky electronic death certificate records for 2010–2014 were obtained from the Office of Vital Statistics within the Kentucky Department for Public Health at the Kentucky Cabinet for Health and Family Services. Death certificate records contain all personal identifiers. FARS data was obtained from the National Highway Traffic Safety Administration FARS website. FARS data for each individual year for years 2010–2014 was downloaded from the ftp site ftp://ftp.nhtsa.dot.gov/fars/.

This study is part of the broad spectrum of the drugged driving, drug overdose prevention, and Kentucky Occupational Safety and Health Surveillance programs, and was approved by the University of Kentucky Institutional Review Board.

2.2. Data linkage

Of the 3529 crash fatalities in FARS data, 3521 CRASH fatalities, and 223,621 total deaths in Kentucky from 2010 to 2014, there were 2499 drivers in FARS electronic records, 2501 drivers in CRASH electronic records, and 3882 motor vehicle crashes in death certificate records that were selected for inclusion in the record linkage process (Fig. 1).

The CRASH, FARS, and death certificate databases were linked by exact matching on combinations of common data elements. All 2499 FARS driver records were matched to a unique CRASH driver record, using an exact matching process that included 16 matching passes using various combinations of 12 common data elements (crash day, crash month, crash year, crash hour, crash county, death day, death year, death month, death day, vehicle information number, driver age, driver gender, driver ejection status). Next, of the 2499 linked FARS and CRASH records, 2235 (89%) were linked to a Kentucky death certificate record, using an exact matching process that included 17 matching passes using different combinations of 11 common data elements (crash year, crash month, crash day, death year, death month, death day, decedent date of birth, decedent gender, decedent race, decedent ethnicity, work-related indicator).

The final linked FARS-CRASH-death certificate datasets for 2010–2014 included 2235 linked records with drivers identified in all three data sources. Approximately 11% (n = 264) of driver fatalities were lost through linkage; nearly all of them did not have a matching death certificate record. The most likely explanation for the lost cases is that the drivers were hospitalized and died out of state, and Kentucky Vital Statistics did not receive copies of death certificates from the states of death.

2.3. Identification of drug screening and positive drug results

Evidence that fatally injured motor vehicle drivers were screened for drugs or alcohol was identified through analysis of relevant data elements in each data source. In FARS, evidence of drug or alcohol screening was identified through analysis of the data elements “Drug Test Status” and “Alcohol Test Status”. In death certificate records, evidence of drug or alcohol screening was identified through relevant ICD-10-CM codes (F11.0-F19.0 and T36-T50 codes for drugs, and F10.0, T51.0, and T51.9 codes for alcohol) and through mentions of specific

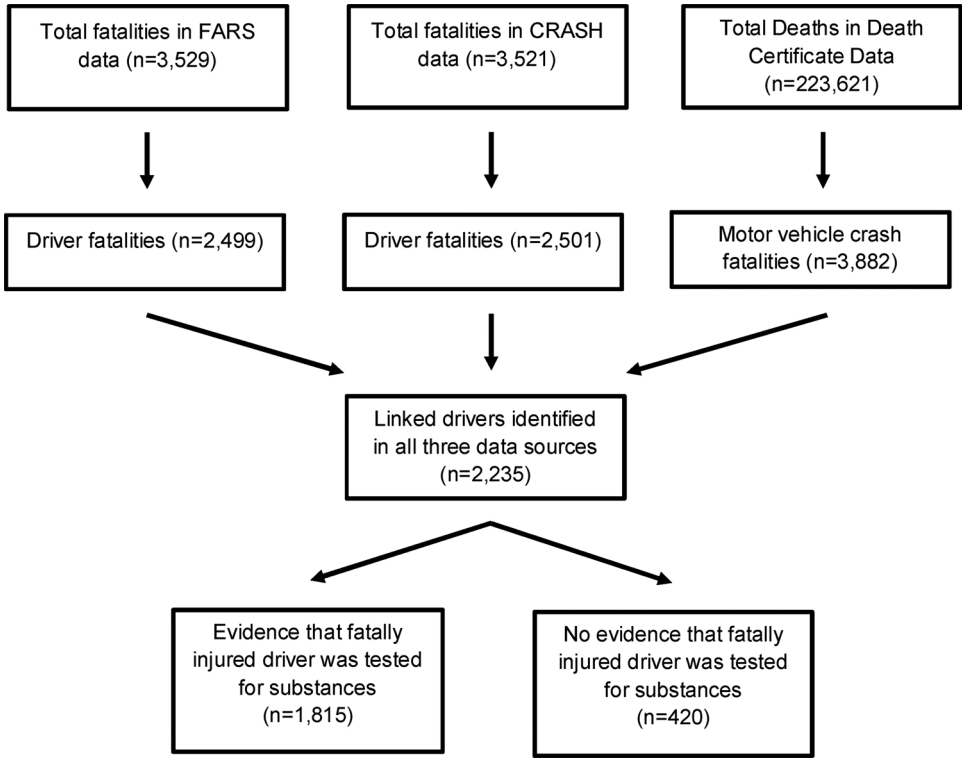

Fig. 1. Linkage of CRASH, Fatality Analysis Reporting System (FARS), and Death Certificate Data to Identify Motor Vehicle Drivers Fatally Injured in Kentucky Crashes, 2010–2014.

drug and/or drug class names in the literal text data elements that document the cause of death and cause of injury. The literal text scan was accomplished using a tool created by the Council of State and Territorial Epidemiologists (CSTE, 2016). Identification of drug screening in the CRASH database was based on the investigating officer's indication that the fatally injured driver underwent laboratory testing for alcohol, drugs, or both alcohol and drugs. Identification of specific drugs present in fatally injured drivers was based on analysis of CRASH and death certificate data.

If there were no positive or negative drug screen findings recorded in any of the three data sets through analysis of the relevant data variables above, the fatally injured driver was presumed not to have been tested for drugs. It is possible (not probable) that the fatally injured driver could have been tested for drugs and that the positive or negative finding was not recorded in the relevant data variable(s) in any of the three data sets.

Positive drug results were identified through analysis of a literal text data element for drug and alcohol test results on the CRASH database; the" Drug Test Results" data elements on the FARS database, and the same codes and text, used for identifying drug or alcohol screening, on death certificate records.

2.4. Demographic characteristics of fatally injured drivers

Demographic characteristic data variables (gender, age [categorized into 10-year intervals], restraint use, and occupant presence) in the final linked data set were derived from FARS data (restraint use, and occupant presence) and from death certificate data (gender, and age). Occupant presence was determined with the "Number of Occupants" data element, which was identical to the number of passengers in the vehicle.

2.5. Collision characteristics

Collision characteristic data elements in the final data set were derived from CRASH data (human factors, land use, and vehicle type), and death certificate data (location of death, and death certificate certifier [authorized person that signed death certificate]). Determination of fault was derived from the CRASH data based on unit number. Unit number 1 is customarily considered the vehicle at fault based on the responding officer's opinion (Bunn et al., 2017).

2.6. Statistical analysis

Chi-square tests were used to examine differences among individual demographic characteristics and vehicle crash characteristics, compared to the percentage of fatally injured drivers who were drug or alcohol screened or not. Descriptive statistics are presented as frequencies (%) for specific drugs or drug type(s).

Bivariate and multivariate logistic regression were utilized to test for differences between the proportion of fatally injured drivers who were drug or alcohol screened and demographic and collision characteristics. A final multivariate logistic regression model was conducted using predictors that presented the greatest impact in bivariate analysis results, including a) suspected driving under the influence (yes vs. no); b) age as a continuous variable; c) passenger vs. no passenger; d) vehicle type (commercial truck vs. all others); e) death certificate certifier (coroner vs. physician and others), and f) human factors (speeding vs. all others). Kappa statistics were conducted to measure agreements for drug classes between two databases and among the three databases.

Statistical tests were two-sided at the 0.05 significance level. All analyses were performed in SAS version 9.4 (SAS Institute, Cary, NC).

3. Results

Of the 2235 total linked cases, male drivers were fatally injured more often compared to female drivers (73% male vs. 27% female), but there was no significant difference between the genders for drug or alcohol screening (approximately 81% of both male and female fatally injured drivers were drug or alcohol screened) (Table 1). Of the linked

Table 1
Demographic and Behavioral Characteristics of Motor Vehicle Drivers Fatally Injured in Kentucky Crashes by Drug or Alcohol Screening Status, 2010–2014.

Demographic Characteristics	Drug or Alcohol Screening Performed n (Column%/Row%)		Total	P-Value
	Yes	No		
Gender				
Male	1,318 (73%/81%)	307 (73%/19%)	1625	$p = 0.84$
Female	497 (27%/82%)	113 (27%/19%)	610	
Age (years)				
16-24	347 (19%/86%)	58 (14%/14%)	405	$p < .01$
25-34	360 (20%/88%)	47 (11%/12%)	407	
35-44	341 (19%/88%)	45 (11%/12%)	386	
45-54	309 (17%/85%)	56 (13%/15%)	365	
55-64	225 (12%/77%)	66 (16%/23%)	291	
65 +	226 (13%/61%)	145 (35%/39%)	371	
Missing	7	3	10	
Restraint Use				
Yes	598 (33%/76%)	187 (45%/24%)	785	$p < .01$
No	1,217 (67%/84%)	223 (56%/16%)	1,450	
Occupant Presence in Vehicle				
Yes	422 (23%/88%)	59 (14%/12%)	481	$p < .01$
No	1,393 (77%/79%)	361 (86%/21%)	1,754	
Total	1,815	420	2235	

fatally injured driver cases, the driver age groups most frequently involved in fatal crashes were the 25–34 age group (20%) followed by the 16–24 year age group (19%) and the 35–44 year age group (19%). The age groups with the lowest proportions of drivers in fatal crashes were the 55–64 year age group (12%), and the 65 + age group (13%). The age group most frequently drug or alcohol screened was the 25–34 age group (88% of this age group was drug or alcohol screened) followed by the 35–44 age group (88%). The age group least frequently drug screened was the 65 + age group; only 61% of the 65 + age group was drug or alcohol screened. Fatally injured drivers who were not using occupant restraints at the time of the fatal crash represented the proportion of drivers most frequently involved in fatal crashes (65%) and most frequently drug or alcohol screened (84% of the fatally injured drivers who were not restrained were drug or alcohol screened). Fatally injured drivers in fatal crashes most frequently did not have a passenger present in the vehicle. If passenger(s) were present, fatally injured drivers were more frequently drug or alcohol screened compared to those without passengers (88% compared to 79%).

Passenger vehicle drivers were the vehicle drivers most often involved in fatal crashes, followed by light truck drivers and motorcycle drivers (Table 2). Not surprisingly, commercial truck drivers were the vehicle drivers most frequently drug or alcohol screened (92% of fatally injured commercial truck drivers were drug or alcohol screened); fatally injured motorcycle drivers were least frequently drug or alcohol screened (78%)). Fatally injured drivers tended to be at fault in the fatal crash, although at-fault status did not significantly affect whether or not the driver was drug or alcohol screened. Of those who were drug or alcohol screened, drivers most frequently died at the crash scene (68%) compared to those who died in the hospital (27%) or in transport (1%), whereas, of those who were not drug or alcohol screened, fatally injured drivers most frequently died at the hospital (70%) compared to those who died at the crash scene (26%). The drivers who died at the crash scene were most frequently drug or alcohol screened (92%) compared to those who died in transport (82%). Those who died in the hospital were least frequently drug or alcohol screened (63%).

Most the fatally injured drivers had their death certificates certified by a coroner or deputy coroner (Table 2). If the coroner or deputy coroner certified the driver death, the driver was more frequently drug or alcohol screened compared to those drivers whose death certificate was certified by physicians and others (83% of the drivers whose death was certified by a coroner was drug or alcohol compared to 37% certified by a physician and others). The majority of the fatal driver crashes occurred in rural land use areas; there was no significant difference between rural and urban areas for drug or alcohol screening of the fatally injured drivers. There was a higher frequency of fatally injured drivers with a human factor of alcohol listed in the FARS record compared to those with a human factor of drug(s), or alcohol and drugs together. All of the fatally injured drivers with a human factor of drug (s) listed were drug or alcohol screened compared to 94% of those with a human factor of alcohol, or of both alcohol and drugs (95%). Of the fatally injured drivers who were drug or alcohol screened, 13% had a human factor of “not under proper control” listed, 13% had “speeding” listed, and distraction/inattention was listed for 12%. Fatally injured drivers were more frequently drug or alcohol screened when speeding was involved (89%) and when multiple human factors were involved (speeding, sleepiness/fatigue, and distraction/inattention (89%).

The adjusted odds were 4.66 (95% CI: 2.87–7.55) higher for a driver to be drug or alcohol screened when drug or alcohol human factors were listed (Table 3). Age (adjusted OR = 0.98; CI: 0.97-0.99)was protective factor for drug or alcohol screening of fatally injured drivers. Lack of restraint use(adjusted OR = 1.30; CI: 1.02–1.64), presence of a passenger (adjusted OR = 1.91; CI: 1.39–2.62), driving a commercial truck (adjusted OR = 3.76; CI: 1.32–10.72), having a coroner or deputy coroner certify the death (adjusted OR = 7.76; CI: 4.86–12.39), and speeding (adjusted OR = 1.65; CI: 1.08–2.52) were all associated with increased odds for a fatally injured driver to be drug or alcohol screened.

Of the total number of fatally injured drivers with positive drug or alcohol screens (based on combined data from all three data sets) (n = 1066), alcohol was most frequently screened (58%), followed by depressants (31%), cannabinoids (24%), and narcotics (22%) (Table 4). Of the total number of linked injured driver fatalities (n = 2235), approximately one-quarter had positive alcohol results (28%), 15% had positive depressant results, 11% were positive for cannabinoids, and 11% were positive for narcotics; very few drivers were positive for stimulants or hallucinogens. Of the fatally injured light truck drivers with positive alcohol or drug screens, the pattern of detected drugs was similar (39% had positive alcohol results, 20% had positive depressant results, and 12% had positive narcotic results (data not shown).

The specific drug identified in fatally injured drivers (based on death certificate and CRASH data) with the highest frequency was alcohol (n = 188 or 18% of all fatally injured rivers with positive drug or alcohol results) (Table 5). The prescription drug, hydrocodone, was identified in 28 (3%) fatally injured drivers with positive drug screens;

Table 2
Collision Characteristics of Motor Vehicle Drivers Fatally Injured in Kentucky Crashes by Drug or Alcohol Screening Status, 2010–2014.

Collision Characteristics	Drug or Alcohol Screening Performed n (Column%/Row%)		Total	P-value
	Yes	No		
Vehicle Type				
Passenger Vehicle	1,060 (58%/82%)	228 (54%/18%)	1,288	$p = 0.03$
Light Truck	317 (20%/81%)	86 (21%/19%)	457	
Commercial truck	45 (3%/92%)	4 (1%/8%)	49	
Motorcycle	290 (16%/78%)	84 (20%/23%)	374	
Other	49 (3%/73%)	18 (4%/27%)	67	
Subjective Determination of Fault				
Yes (Unit 1)	1524 (84%/82%)	337 (80%/18%)	1,861	$p = 0.07$
No (Other Unit)	291 (16%/78%)	83 (20%/22%)	374	
Location of Death				
At Crash Scene	1,242 (68%/92%)	110 (26%/8%)	1,352	$p < .01$
In Transport	14 (1%/82%)	3 (1%/18%)	17	
At Hospital or Emergency Department	495 (27%/63%)	295 (70%/37%)	790	
Unknown	64 (4%/84%)	12 (3%/16%)	76	
Certifier				
Coroner and Deputy Coroner	1,780 (98%/83%)	361 (86%/17%)	2,141	$p < .0001$
Physician and Other	35 (2%/37%)	59 (14%/63%)	94	
Land Use				
Rural	1,444 (80%/82%)	318 (76%/18%)	1,762	$p = 0.08$
Urban	370 (20%/78%)	102 (24%/22%)	472	
Missing	1	0	1	
Human Factors				
Alcohol Only	294 (16%/94%)	18 (4%/6%)	312	
Drug Only	52 (3%/100%)	0 (0%/0%)	52	
Alcohol and Drug	37 (2%/95%)	2 (1%/5%)	39	
Human Factors but Alcohol or Drug				
Speeding	227 (13%/89%)	29 (7%/11%)	256	*p = 0.00*
Sleepiness/Fatigue	24 (1%/83%)	5 (1%/17%)	29	
Distraction/Inattention	221 (12%/76%)	71 (17%/24%)	292	
Multiple of Above	16 (1%/89%)	2 (1%/11%)	18	
Not Under Proper Control	238 (13%/78%)	69 (16%/23%)	307	
Other	356 (20%/76%)	112 (27%/24%)	468	
None	350 (19%/76%)	112 (27%/24%)	462	
Total	1,815	420	2235	

Table 3
Crude and Adjusted Odds Estimates, and 95% Confidence Limits (in Parentheses) for Drug or Alcohol Screening among Fatally Injured Drivers in Kentucky Crashes, 2010–2014.

	Crude Odds Ratio Estimate (95% Confidence Limits)	Adjusted Odds Ratio Estimate (95% Confidence Limits)
Human Factors Related to Alcohol or Drugs (Yes vs. No)	5.35 (3.37, 8.50)	4.66 (2.87, 7.55)
Age	0.97 (0.97, 0.98)	0.98 (0.97, 0.99)
Unrestrained vs. Restrained	1.64 (1.32, 2.04)	1.30 (1.02, 1.64)
Occupant vs. No Occupant	1.85 (1.38, 2.49)	1.91 (1.39, 2.62)
Vehicle Type (Commercial truck vs. All others)	2.64 (0.95, 7.39)	3.76 (1.32, 10.72)
Certifier (Coroner and Deputy Coroner vs. Physician and Others)	8.32 (5.39, 12.83)	7.76 (4.86, 12.39)
Human Factors (Speeding vs. All Others)	1.93 (1.29, 2.88)	1.65 (1.08, 2.52)

Table 4
Identification of Drugs in Fatally Injured Motor Vehicle Drivers in Kentucky Crashes by Drug or Alcohol Screening Status, 2010–2014.

Drug Class	Positive Drug or Alcohol Screening n (Column %/Row%)		Total Number of Fatally Injured Drivers
	Yes	No	
Alcohol	614 (58%/28%)	1621 (73%)	2235
Depressant	326 (31%/15%)	1909 (85%)	2235
Cannabinoid	251 (24%/11%)	1984 (89%)	2235
Narcotic	237 (22%/11%)	1998 (89%)	2235
Stimulant	92 (9%/4%)	2143 (96%)	2235
Other	67 (6%/3%)	2168 (90%)	2235
Hallucinogen	7 (1%/0%)	2228 (100%)	2235
Total	1066	749	2235

alprazolam was identified in 22, and tetrahydrocannabinol was identified in 21 cases. Methadone was identified in 11, and oxycodone, amphetamine, and benzodiazepine were identified in nine fatally injured drivers each. Methamphetamine was detected and identified in seven decedents, and cocaine and clonazepam were identified in five decedents each.

The concordance among all three data sources was assessed to determine whether all three data sources were able to identify the drug classes detected in fatally injured drivers, and whether the analysis of FARS data alone was sufficient to identify drug classes (Table 6). FARS data was the best source for identifying drug classes; of all cases with positive drug screen results in at least one data source, 99% could be identified from FARS alone, 28% from CRASH alone, and 11% from death certificates alone (data not shown). Total positive agreement among all three data sources was extremely low; the best agreement was between FARS and death certificate data (22% positive agreement

Table 5
Identification of Specific Drugs in Fatally Injured Motor Vehicle Drivers in Kentucky Crashes using Death Certificates and CRASH Data, 2010–2014.

Drug Class	Specific Drugs	Positive Drug or Alcohol Testing Results (n = 1066)
Alcohol	ETHANOL	188 (18%)
Narcotic	HYDROCODONE	28 (3%)
Depressant	ALPRAZOLAM	22 (2%)
Cannabinoid	TETRAHYDROCANNABINOL	21 (2%)
Narcotic	METHADONE	11 (1%)
Narcotic	OXYCODONE	9 (1%)
Stimulant	AMPHETAMINE	9 (1%)
Stimulant	METHAMPHETAMINE	7 (1%)
Stimulant	COCAINE	5 (1%)
Depressant	CLONAZEPAM	5 (1%)
Depressant	DIAZEPAM	< 5
Narcotic	CODEINE	< 5
Narcotic	FENTANYL	< 5
Narcotic	HEROIN	< 5
Narcotic	HYDROMORPHONE	< 5
Cannabinoid	CANNABINOIDS	< 5
Narcotic	BUPRENORPHINE	< 5
Narcotic	MORPHINE	< 5
Depressant	TEMAZEPAM	< 5
Other	OTHER	22 (2%)

for alcohol, 12% agreement for stimulants, 7% agreement for narcotics, and 6% agreement for depressants). The lowest positive agreement was between CRASH data and death certificate data (3% agreement for alcohol, and fewer than five cases that agreed on identification narcotics or stimulants).

FARS data did not capture 11% of the total narcotic cases, 3% of the cannabinoid cases, 3% of depressant cases, or 12% of other drug class cases (Table 6). Supplementation of FARS data with death certificate data and with CRASH data increased the capture of total narcotic, and depressant drug class cases. Death certificate data added three alcohol cases (< 1% of all alcohol cases), 15 narcotic cases (6% of all narcotic cases), 6 depressant cases (2% of all depressant cases), and three other drug and alcohol class cases each (5% of all other drug class cases). Supplementation of FARS data with CRASH data added eight alcohol cases (1% of all alcohol cases), 10 narcotic cases (4% of all narcotics cases), seven cannabinoid cases (3% of all cannabinoid cases), and five other drug class cases (8% of all other drug class cases).

4. Discussion

Results of this study showed that supplementation of FARS data with additional data sources such as death certificate data, and CRASH data, increased identification of specific drugs and drug classes detected among fatally injured motor vehicle drivers. While the majority of the positive drug screen results in the linked data set were derived from the FARS data, death certificate and CRASH data supplementation increased "other drug class" detection by 12%, narcotics detection by 11%, and depressant detection by 3%. The concordance among the data sets was low suggesting that FARS data may not need to be combined with death certificate and CRASH data on a routine basis to identify drug involvement among fatally injured motor vehicle drivers. Combining data sources, though, can be useful to help identify specific drugs among fatally injured drivers, address underreporting of the total number of fatally injured drivers with drugs present in their system at the time of the crash, improve assessment of the contribution of drugs to fatal crash risk, and identify additional risk factors for drugged driving.

The findings from this study on risk and protective factors associated with fatal motor vehicle driver crashes are in agreement with a number of studies that used FARS data alone. The presence of drugs in drivers was associated with increased drug screening in fatal crashes similar to other studies that found an association between drug use and fatal crashes (Li et al., 2013; Romano et al., 2014; Li et al., 2013; Liu et al., 2016). Comparable to our results involving crashes with multiple vehicle types, non-restraint use and speeding have been associated with fatal passenger vehicle driver crashes, (Liu et al., 2016). Similar to our finding of higher drug detection frequencies among younger fatally injured drivers, Wilson et al., (2014) found that drugs were detected most often among younger fatally injured motor vehicle drivers. Comparable to the low frequency of drugs detected in commercial vehicle drivers in our study, Reguly et al., (2014) found a low frequency of opioid analgesics among commercial truck drivers in fatal crashes. In fatal passenger vehicle crashes, Huang et al., (2016) found that the presence of injured young passengers was associated with driver drug screening that correlates with our finding that the presence of passengers in fatal motor vehicle crashes involving multiple vehicle types was associated with increased driver drug or alcohol screening. Last, the older the fatally injured driver, the less likely the odds that the driver was drug or alcohol screened (Liu et al., (2016), similar to our results.

The addition of CRASH data and death certificate data to the FARS data set provided additional information on risk and protective factors by confirming and elucidating crash circumstances (e.g., crash

Table 6
Concordance between Fatality Analysis Reporting System (FARS), CRASH, and Death Certificate (DC) Data in the Identification of Drug Classes among Fatally Injured Motor Vehicle Drivers in Kentucky Crashes, 2010–2014.

Drug Class	Total	FARS	DC	CRASH	Total Positive Agreement between FARS, and CRASH Data	Total Positive Agreement between CRASH, and DC Data	Total Positive Agreement between FARS, and DC Data	Total Positive Agreement between FARS, CRASH, and DC Data	Kappa
Alcohol	614	603 (98%)	139 (23%)	69 (11%)	61 (10%)	20 (3%)	136 (22%)	20 (3%)	0.1561
Narcotic	237	210 (89%)	33 (14%)	18 (8%)	6 (3%)	2 (1%)	16 (7%)	0 (0%)	0.0552
Cannabinoid	251	244 (97%)	7 (3%)	19 (8%)	12 (5%)	1 (0%)	7 (3%)	1 (0%)	0.0352
Depressant	326	317 (97%)	26 (8%)	12 (4%)	9 (3%)	0 (0%)	20 (6%)	0 (0%)	0.0304
Stimulant	92	90 (98%)	13 (14%)	6 (7%)	6 (7%)	1 (1%)	11 (12%)	1 (1%)	0.1513
Other type	67	59 (88%)	3 (5%)	6 (9%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)	0.0046

Drug Class	Total	FARS (Not Found)	DC Only	CRASH Only	Both DC and CRASH
Alcohol	614	11 (2%)	3 (27%)	8 (73%)	0 (0%)
Narcotic	237	27 (11%)	15 (56%)	10 (37%)	2 (7%)
Cannabinoid	251	7 (3%)	0 (0%)	7 (100%)	0 (0%)
Depressant	326	9 (3%)	6 (67%)	3 (34%)	0 (0%)
Stimulant	92	2 (2%)	2 (100%)	0 (00%)	0 (0%)
Other type	67	8 (12%)	3 (38%)	5 (63%)	0 (0%)

description and crash location is listed in a text line within death certificate data), and identifying specific drugs. Enhanced identification of the specific drugs involved in fatal crashes can inform new and emerging morbidity (drug screening performed in hospitals after crashes and drug screening in association with drug overdoses) and mortality (postmortem) drug screening that can inform both public health (community substance use prevention interventions and safe driving interventions) and public safety (drug enforcement and highway safety) responses. Combined data sources can also examine additional potential risk and protective factors such as education, ethnicity, country of birth, contributing causes of death, etc.

According to the Kentucky FARS section (personal communication with Kentucky State Police), after a fatal driver crash, the coroner usually collects a biological sample and sends it for toxicology testing; if the driver was alive after the crash and dies days later, the biological sample could be collected by the responding law enforcement officer (instead of the coroner) and submitted to the Kentucky State Police laboratory. After the driver death, the FARS analyst contacts the coroner, investigating agency, and the toxicology-testing laboratory for toxicology testing results. Driver toxicology testing results also are searched for in the Kentucky State Police laboratory database. Requests are sent to the toxicology-testing laboratory and to the investigating agency for toxicology testing updates two times per year. If toxicology testing results are received, they are entered into the FARS database. If a FARS reporting agency states that the individual was not tested, the FARS database entry will be “not tested”. If no response is received by the FARS reporting agencies by the end of the calendar year, the driver’s FARS entry is listed as “not tested.”

There may be a number of reasons for incomplete FARS data. The FARS analyst’s interpretation and coding of drug data may be subjective (U.S. Department of Transportation, 2017). If the FARS analyst does not have access to the medical examiner report with the medical examiner’s medical opinion on drug cut-offs and comparative therapeutic levels, there may be personal interpretation and coding of FARS drug data (U.S. Department of Transportation, 2017). In addition, the FARS analyst could enter “unknown if tested” or “not tested” codes for some cases in the FARS database, when coroner-requested drug screening was performed on the decedent but the results were not transmitted to the FARS analyst. In addition, biological samples may not be available for all fatal driver crashes. Those that died in the hospital may not have had biological samples drawn for toxicology testing, and those that died many days after the crash may not have had a biological sample collected. There also may be instances when a coroner was not able to collect a biological sample due to the condition of the body.

One-quarter of the fatally injured drivers had alcohol present in their system at the time of death (28%); 15% had depressants (e.g., alprazolam), and 11% each had cannabinoids, and narcotics (e.g., hydrocodone, and oxycodone). The percentages of alcohol and “other drugs” in the fatally injured drivers in our study are lower than the results of Brady and Li (2014), who assessed alcohol and other drug presence trends in fatally injured drivers in six states (not including Kentucky), but similar to what Li et al., (2013) reported when assessing at-fault drivers for alcohol and marijuana positivity. In Kentucky, all drivers in fatal crashes should be toxicology tested. Kentucky State Police crash investigation policy states, “when a collision involves a fatality…, the investigating officer shall request alcohol/drug testing of all involved drivers. If an operator is deceased, the investigating officer shall make the request known to the coroner before removal of the body from the scene, as well as requesting a full autopsy be performed.” Kentucky Revised Statute (KRS) 189 A.105 states, “… if the incident involves a motor vehicle accident in which there was a fatality, the investigating peace officer shall seek such a search warrant for blood, breath, or urine testing unless the testing has already been done by consent.” Drug screen results were available for approximately three-quarters of the fatally injured drivers (82% of at-fault drivers and 73% of not-at-fault drivers). The lower percentages of alcohol and drugs present in fatally injured drivers in this study may represent drivers who died en route to the hospital or later at the hospital and who did not have a biological sample collected directly after the crash. Only about two-thirds of our linked fatally injured drivers who died at the hospital were drug or alcohol screened compared to 92% of those who died at the scene, and 82% of those who died in transport.

The majority of motor vehicle driver deaths were certified by coroners or deputy coroners. Coroners are authorized by statute to certify manner and cause of death as well as to sign death certificates. KRS 72.025 states that when an individual dies in a motor vehicle crash, a postmortem examination will be performed, although the elements of a post mortem exam are not defined in the statute. If an autopsy is performed by a medical examiner on a decedent, toxicology testing is usually performed, and a suggested cause and manner of death is provided by the medical examiner to the coroner that contains information on drugs if contributing to the cause or manner of death. The coroner completes the death certificate with the medical examiner- suggested cause and manner of death. It is common practice of medical examiners and coroners not to list drugs as contributing factors for motor vehicle driver deaths on death certificates. Of the 2235 fatally injured driver linked records, 622 had autopsies performed (30%). Of the drivers with positive drug or alcohol screens, one-third were autopsied. Autopsy of fatally injured drivers and consultation of the FARS analyst with a medical examiner in autopsied cases may enhance understanding and interpretation of the driver toxicology testing results (including drug therapeutic levels) for improved input of drug information into the FARS database.

Regarding vehicle type, our finding that commercial truck drivers had increased odds for alcohol and drug screening compared to all other vehicle types was not surprising. According to the Federal Motor Carrier Safety Administration §382.303, a commercial motor vehicle driver is required to be post-accident drug tested when a fatality is involved, regardless of whether or not a citation was issued to the commercial motor vehicle driver. Very few commercial truck drivers had positive drug or alcohol screens in this study (only 2.5% of the total positive drug screen linked cases), indicating that FMCSA’s commercial vehicle driver random drug testing policy is working (§382.305). The unique finding of this study was that motorcycle drivers were drug or alcohol screened less frequently compared to other vehicle drivers. The reason for this finding is unclear but since motorcycle drivers are exposed directly to the environment without the protection of a vehicle; it may be that biological samples were more difficult to collect from motorcycle drivers after a fatal crash due to the body not being intact.

Limitations in the current study are noted. First, similar to the use of FARS data alone, the identification of specific drugs among fatally injured motor vehicle drivers using multiple data sources could only detect and identify presence of the substances not determine impairment of the driver at the time of the fatal crash. Second, there could be drug-testing differences between cases due to condition of body at time of death, biological sample obtained, and variances in post-injury survival periods; one advantage of this study was that motor vehicle crash driver postmortem samples in the state were analyzed by a single laboratory, unless they died in the hospital where the decedent could have been tested at the hospital. Last, the data results from this study may not be appropriate for determining trends and risk estimates since driver impairment could not be determined and confirmed.

5. Conclusion

The use of multiple data sources identified alcohol and depressants with the highest frequencies among fatally injured drivers. Lack of occupant restraints, young age, commercial truck drivers, and speeding were all factors associated with increased odds of the fatally injured driver being drug or alcohol screened. These findings indicate that FARS drug information data may be strengthened through increased autopsy and consultation with medical examiners to better understand

and interpret decedent toxicology testing results. States with low driver drug testing rates should consider mandatory driver drug testing in fatal crashes.

Disclosure

None of the authors have a conflict of interest.

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