Convergent Validity of Drug Data Sources among Motor Vehicle Fatal Crash Victims in Maryland

Submitted by:
Johnathon Ehsani and Jeffrey Michael
Johns Hopkins University
Bloomberg School of Public Health
Johns Hopkins Center for Injury Research and Policy

BACKGROUND

Accurate and reliable information on drug use by road users is essential to inform safety policy in Maryland. There are two primary repositories of drug test information from fatal motor vehicle crashes in Maryland: (1) the Fatality Analysis Reporting System (FARS), a national crash database managed by the US Department of Transportation, and (2) the Maryland Medical Examiner.

Drug data in FARS are collected for public health surveillance purposes at a population level. Toxicology data from the Medical Examiner data are collected as part of a protocol to determine the cause and manner of death for an individual. In addition, the Medical Examiner serves a public health surveillance role by identifying injury trends and emerging infectious diseases that may pose risks to the public.

Neither the FARS nor the Medical Examiner data collection protocols were created for the specific purpose of collecting accurate and reliable information on drug use by road users. For example, one limitation of the FARS data is that until 2018, the FARS database restricted the number of drugs that can be reported to three. A key limitation of the Medical Examiner data is that it excludes testing for any cannabinoids such as those resulting from the use of cannabis. Because FARS and the Medical Examiner data are optimized as surveillance systems and utilize information from a range of sources, they may lack the precision of a reference laboratory for measurements of impairing drugs.

PURPOSE

In this study, we tested the convergent validity of drug data in the FARS and Medical Examiner data by comparing them with drug test results for a sample of cases conducted by an external reference laboratory (Immunalysis Corporation). Immunalysis has been used as a reference laboratory for large driver safety studies including the National Roadside Survey, a study conducted by the National Highway Traffic Safety Administration for measuring drug use by a sample of drivers in traffic.

If we find differences between the Immunalysis data and FARS drug data, this may indicate systematic inaccuracies in the primary data, collection, or interpretation of source information. If we find that the drug information differs between Medical Examiner and Immunalysis, this may indicate the need to investigate differences in testing thresholds, panels and protocols. If the Medical Examiner and Immunalysis data are consistent with one another but differ from FARS, this may indicate that the Medical Examiner data could be used as a reference for ongoing checks of the FARS data as improvements are pursued.

METHODS

We used probabilistic linkage to match FARS and Medical Examiner cases and compare matched cases by individual drug group for motor vehicle crash victims in Maryland between March 2011 to May 2018. Details of this method has been published in prior work linking the FARS and Medical Examiner data.[1] Case ID information was used to match these linked cases with the Immunalysis sample that was collected during the same period. Based on the detailed list of tested drugs, they were grouped to match the substance categories in Medical Examiner and FARS datasets.

Statistical Analysis:

Substance class positivity was tabulated in 3 datasets and the proportions were compared between Immunalysis and FARS as well as Immunalysis and Maryland Medical Examiner data. Given that Immunalysis was the reference dataset, agreement metrics were calculated by comparing FARS and Medical Examiner datasets to the Immunalysis sample.

The primary aim of the analysis is to measure agreement between the overlapping positive substances of drug categories in (1) matched FARS and Immunalysis datasets, and (2) the matched Medical Examiner and Immunalysis datasets. It should be noted that agreement could only be calculated where both datasets reported the presence of the substance.

In the matched FARS and Immunalysis cases, these substances were:

1. Stimulants, and
2. Opioids.

In the matched Medical Examiner and Immunalysis cases, these substances were:

1. Stimulants
2. Opioids
3. Antidepressants, and
4. Benzodiazepines

The comparison metrics included percent agreement, percent positive and negative findings, chance corrected Cohen's kappa statistic, Brennan and Prediger's, Krippemdorff's alpha and Gwet's AC statistics. Stata 18 statistical software program was used for all calculations.[2] Agreement values are benchmarked as follows: 0.4 to 0.6 indicates moderate agreement, 0.6 to 0.8 – substantial agreement and 0.8 to 1 – almost perfect agreement.[3,4]

A secondary aim was to identify if the matched cases included in the Immunalysis sample were systematically different to the unmatched cases. These findings are presented in Appendix I and II.

RESULTS

Agreement between matched FARS and Immunalysis cases:

Table 1: Substance comparison and measures of agreement for Stimulants and Opioids between FARS and Immunalysis on the records included in both datasets (n = 404)

Substance Class	Opioids	Stimulants
Percent Agreement*	95.8	93.6
Percent Positive in both datasets	9.4	7.4
Percent Negative in both datasets	86.4	86.1
Measures of Agreement	Value (Agreement Benchmark Interval Note)	
Cohen's Kappa	0.79 (Almost Perfect)	0.66 (Moderate)
Krippendorff's Alpha	0.79 (Substantial)	0.66 (Moderate)
Brennan and Prediger	0.92 (Almost Perfect)	0.87 (Almost Perfect)
Gwet's AC	0.95 (Almost Perfect)	0.92 (Almost Perfect)

* *Percent agreement is defined as the proportion of the total cases where both FARS and Immunalysis reports have the same value (either positive or negative for the substance)*

When comparing the matched cases in FARS and Immunalysis datasets, the agreement was almost perfect for Opioids, but moderate for Stimulants.

Agreement between matched Medical Examiner and Immunalysis cases:

Table 2: Substance comparison and measures of agreement between ME and Immunalysis on the records included in both datasets (n = 476)

Substance Class	Opioids	Stimulants	Antidepressants	Benzodiazepines
Percent Agreement*	96.0	92.4	94.8	96.9
Percent Positive in both datasets	9.0	3.2	1.9	1.9
Percent Negative in both datasets	87.0	89.3	92.9	95.0
Measures of Agreement	Value (Agreement Benchmark Interval Note)			
Cohen's Kappa	0.80 (Substantial)	0.43 (Fair)	0.40 (Fair)	0.53 (Fair)
Krippendorff's Alpha	0.80 (Substantial)	0.42 (Fair)	0.39 (Fair)	0.53 (Fair)
Brennan and Prediger	0.92 (Almost Perfect)	0.85 (Almost Perfect)	0.90 (Almost Perfect)	0.94 (Almost Perfect)
Gwet's AC	0.95 (Almost perfect)	0.91 (Almost Perfect)	0.94 (Almost Perfect)	0.97 (Almost Perfect)

* *Percent agreement is defined as the proportion of the total cases where both ME and Immunalysis reports have the same value (either positive or negative for the substance)*

When comparing the matched cases in Medical Examiner and Immunalysis datasets, the agreement was almost perfect for Opioids, but fair for Stimulants, Antidepressants, and Benzodiazepines.

Interpretation and Discussion

Our results indicate that when records are compared across different datasets, the positivity proportions were rather similar, and did not vary greatly depending on the data sources (i.e., FARS, Immunalysis, or Medical Examiner).

Comparison of FARS and Immunalysis datasets, the agreement was almost perfect for Opioids. Similarly, comparison of the Medical Examiner and Immunalysis, the agreement was almost perfect for Opioids.

Comparing FARS to Immunalysis data, agreement was moderate for stimulants. Comparing Medical Examiner to. Immunalysis datasets agreement was only fair for stimulants, antidepressants and benzodiazepines.

In terms of the available data, Medical Examiner dataset contained the most detailed information, including not only the name of the substance, but also the type of specimen (e.g., blood, urine etc.), location (e.g., heart, peripheral blood abdominal cavity etc.) and concentration. However as noted previously, the Medical Examiner data did not include information on cannabis use.

Conclusion

The objective of this project was to test the convergent validity of the drug data in the FARS and Medical Examiner sources by comparing them with drug test results for a sample of cases conducted by an external reference laboratory (Immunalysis). We found that agreement between the data sources was high, moderate, or fair, depending on the substance classes.

For FARS data there were two classes of substances that were available to be compared to Immunalysis: opioids and stimulants. For opioids, agreement was close to perfect. For stimulants, FARS data had moderate agreement with Immunalysis. This indicates that where drug data are available in FARS, they represent a reliable source of information. However, the data categories that are not included in FARS represent a gap that needs to be addressed.

With the exception of cannabis, the agreement between Medical Examiner and Immunalysis was high or fair, suggesting the ME data represent a reliable source of drug data for deceases drivers in Maryland. The ME data could be used directly as a source for drug use among deceased drivers, and/or could be used as an ongoing reference point as efforts are made to identify and resolve inaccuracies in the FARS data. Discussions with Medical Examiner may lead to strategies for further use of their data in driver safety studies and for the adoption of routine testing for cannabis.

APPENDIX I

The analysis in Appendix I quantifies the prevalence of substances in the Immunalysis and FARS datasets and tests if there are significant differences between the matched and unmatched cases. The purpose of this step is to determine whether the matched cases between Immunalysis and FARS are a reasonable representation of the cases in the complete datasets.

A. Comparison of Immunalysis data (n = 501) to FARS data (n = 4805).

Table 1 number of positive cases by the medication classes in FARS and Immunalysis datasets. After merging the datasets, where were 404 records present in both datasets, 107 were only in the Immunalysis dataset.

Table 1: Substance Positivity Status* from the Immunalysis dataset

		Record Status			
		Immunalysis only (unmatched cases)	FARS and Immunalysis (matched cases)	Total	p-value
Substance Class		N=107	N=404	N=511	
Cannabis	Absent	92 (86.0%)	340 (84.2%)	432 (84.5%)	0.64
	Present	15 (14.0%)	64 (15.8%)	79 (15.5%)	
Cannabinoids	Absent	107 (100.0%)	404 (100.0%)	511 (100.0%)	
	Present	0	0	0	
Stimulants	Absent	101 (94.4%)	357 (88.4%)	458 (89.6%)	0.069
	Present	6 (5.6%)	47 (11.6%)	53 (10.4%)	
Benzodiazepines	Absent	104 (97.2%)	386 (95.5%)	490 (95.9%)	0.44
	Present	3 (2.8%)	18 (4.5%)	21 (4.1%)	
Opioids	Absent	95 (88.8%)	358 (88.6%)	453 (88.6%)	0.96
	Present	12 (11.2%)	46 (11.4%)	58 (11.4%)	
Antidepressants	Absent	106 (99.1%)	395 (97.8%)	501 (98.0%)	0.39
	Present	1 (0.9%)	9 (2.2%)	10 (2.0%)	

* *Presented are substance classes and positivity in the Immunalysis dataset only.*

Table 1 shows the substance frequency in the Immunalysis dataset. Table 1 shows that cannabis is the most frequently reported substance in the Immunalysis dataset (15.5% of all cases), followed by opioids (11.4%) and stimulants (10.4%). Immunalysis toxicology testing did not include alcohol or ethanol as one of the substances.

The results indicate that there are no significant differences in the proportion of the positive cases for the records Immunalysis cases that were in the unmatched and matched Immunalysis/FARS cases.

B. Comparison of FARS data (n = 4805) to Immunalysis data (n = 501)

Table 2: Substance Positivity Status from the FARS dataset

Table 2 number of positive cases by the medication classes in FARS and Immunalysis datasets. After merging the datasets, where were 404 records present in both datasets, and 4,401 records were only in the FARS dataset.

		Record Status			
Substance Class		**FARS only (unmatched) N=4,401**	**FARS and Immunalysis (matched) N=404**	**Total N=4,805**	**p-value**
Alcohol	Absent	2,833 (64.4%)	256 (63.4%)	3,089 (64.3%)	0.69
	Present	1,568 (35.6%)	148 (36.6%)	1,716 (35.7%)	
Cannabinoid	Absent	4,399 (100.0%)	404 (100.0%)	4,803 (100.0%)	0.67
	Present	2 (0.0%)	0 (0.0%)	2 (0.0%)	
Stimulant	Absent	4,012 (91.2%)	365 (90.3%)	4,377 (91.1%)	0.58
	Present	389 (8.8%)	39 (9.7%)	428 (8.9%)	
Opioids	Absent	3,964 (90.1%)	357 (88.4%)	4,321 (89.9%)	0.28
	Present	437 (9.9%)	47 (11.6%)	484 (10.1%)	
Hallucinogen	Absent	4,326 (98.3%)	395 (97.8%)	4,721 (98.3%)	0.44
	Present	75 (1.7%)	9 (2.2%)	84 (1.7%)	
Depressant	Absent	4,248 (96.5%)	387 (95.8%)	4,635 (96.5%)	0.45
	Present	153 (3.5%)	17 (4.2%)	170 (3.5%)	
Inhalant	Absent	4,398 (99.9%)	404 (100.0%)	4,802 (99.9%)	0.60
	Present	3 (0.1%)	0 (0.0%)	3 (0.1%)	
PCP	Absent	4,329 (98.4%)	391 (96.8%)	4,720 (98.2%)	0.021
	Present	72 (1.6%)	13 (3.2%)	85 (1.8%)	
Anabolic Steroid	Absent	4,401 (100.0%)	404 (100.0%)	4,805 (100.0%)	
	Present	0	0	0	
Other Drug	Absent	3,483 (79.1%)	314 (77.7%)	3,797 (79.0%)	0.50
	Present	918 (20.9%)	90 (22.3%)	1,008 (21.0%)	

[*] *Presented are substance classes and positivity in the FARS dataset only.*

Table 2 shows the substance frequency in the FARS dataset. Alcohol was found in 35.7% of cases. Opioids and stimulants were reported for 10.1% and 8.9% of cases, respectively.

The results indicate that with the exception of PCP, there are no significant differences in the proportion of the positive cases for the records FARS cases that were in the unmatched and matched Immunalysis/FARS cases.

APPENDIX II

The analysis in Appendix II quantifies the prevalence of substances in Immunalysis and Medical Examiner datasets and tests if there are significant differences between the matched and unmatched cases. The purpose of this step is to determine whether the matched cases between Immunalysis and Medical Examiner are a reasonable representation of the cases in the complete datasets.

A. Comparison of Immunalysis data (n = 501) to Medical Examiner data (n = 5,652).

Table 3 number of positive cases by the medication classes in the Immunalysis and Medical Examiner datasets. After merging the datasets, where were 476 records present in both datasets, 35 – only in the Immunalysis dataset.

Table 3: Substance Positivity Status from the Immunalysis dataset*

		Record Status		Total	p-value
Substance Class		Immunalysis only (unmatched cases) N=35	Immunalysis and Medical Examiner (matched cases) N=476	N=511	
Cannabis	Absent	31 (88.6%)	401 (84.2%)	432 (84.5%)	0.49
	Present	4 (11.4%)	75 (15.8%)	79 (15.5%)	
Cannabinoids	Absent	35 (100.0%)	476 (100.0%)	511 (100.0%)	
	Present	0	0	0	
Stimulants	Absent	33 (94.3%)	425 (89.3%)	458 (89.6%)	0.35
	Present	2 (5.7%)	51 (10.7%)	53 (10.4%)	
Benzodiazepines	Absent	35 (100.0%)	455 (95.6%)	490 (95.9%)	0.20
	Present	0 (0.0%)	21 (4.4%)	21 (4.1%)	
Opioids	Absent	30 (85.7%)	423 (88.9%)	453 (88.6%)	0.57
	Present	5 (14.3%)	53 (11.1%)	58 (11.4%)	
Antidepressants	Absent	34 (97.1%)	467 (98.1%)	501 (98.0%)	0.69
	Present	1 (2.9%)	9 (1.9%)	10 (2.0%)	

* *Presented are substance classes and positivity in the Immunalysis dataset only.*

Table 3 shows the substance frequency in the Immunalysis dataset. Table 3 shows that cannabis is the most frequently reported substance in the Immunalysis dataset (15.5% of all cases), followed by opioids (11.4%) and stimulants (10.4%). Immunalysis toxicology testing did not include alcohol or ethanol as one of the substances.

The results indicate that there are no significant differences in the proportion of the positive cases for the records Immunalysis cases that were in the unmatched and matched Immunalysis/Medical Examiner cases.

B. Comparison of Medical Examiner data (n = 5,652) to Immunalysis data (n = 501).

Table 4 number of positive cases by the medication classes in the Medical Examiner and Immunalysis datasets. After merging the datasets, where were 476 records present in both datasets, and 5,652 records only in the Medical Examiner dataset.

Table 4: Substance Positivity Status from the Medical Examiner dataset

		Record Status			
		Medical Examiner only (unmatched cases)	**Medical Examiner and Immunalysis (matched cases)**	**Total ME**	**p-value**
Substance Class		**N=5,652**	**N=476**	**N=6,128**	
Stimulants	Not tested/Negative	5,520 (97.7%)	461 (96.8%)	5,981 (97.6%)	0.26
	Positive	132 (2.3%)	15 (3.2%)	147 (2.4%)	
Benzodiazepines	Not tested/Negative	5,507 (97.4%)	464 (97.5%)	5,971 (97.4%)	0.95
	Positive	145 (2.6%)	12 (2.5%)	157 (2.6%)	
PCP	Not tested/Negative	5,620 (99.4%)	472 (99.2%)	6,092 (99.4%)	0.45
	Positive	32 (0.6%)	4 (0.8%)	36 (0.6%)	
Opioids	Not tested/Negative	5,146 (91.0%)	424 (89.1%)	5,570 (90.9%)	0.15
	Positive	506 (9.0%)	52 (10.9%)	558 (9.1%)	
Antidepressants	Not tested/Negative	5,281 (93.4%)	442 (92.9%)	5,723 (93.4%)	0.63
	Positive	371 (6.6%)	34 (7.1%)	405 (6.6%)	
Other	Not tested/Negative	5,363 (94.9%)	453 (95.2%)	5,816 (94.9%)	0.79
	Positive	289 (5.1%)	23 (4.8%)	312 (5.1%)	
Alcohol	Not tested/Negative	3,565 (63.1%)	292 (61.3%)	3,857 (62.9%)	0.45
	Positive	2,087 (36.9%)	184 (38.7%)	2,271 (37.1%)	

[*] *Presented are substance classes and positivity in the Medical Examiner dataset only.*

Table 4 shows the substance frequency in the Medical Examiner dataset only. Alcohol was the most frequent substance found in 37.1% of cases. Stimulants were the next frequent (9.1%) followed by antidepressants at 6.6%.

The results indicate that there are no significant differences in the proportion of the positive cases for the records Immunalysis cases that were in the unmatched and matched Immunalysis/Medical Examiner cases.

References:

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