DOT/FAA/AM-20/14

Office of Aerospace Medicine

Washington, DC 20591

DRUG AND ALCOHOL – FORENSIC TOXICOLOGY ANNUAL REPORT 2017

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Final Report

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AM-20/14		

4. Title and Subtitle	5. Report Date
DRUG AND ALCOHOL – FORENSIC TOXICOLOGY ANNUAL REPORT 2017	December 2020
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Cliburn K, Craft K, Hunn H, Thompson K, Ritter R, Saenz S, Angier M, Caldwell D, Griffin A, Hickerson J, Hileman C, Lewis R, Soper J, Williamson K, Kemp P.	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Civil Aerospace Medical Institute P.O. Box 25082 Oklahoma City, OK 73125	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	14. Sponsoring Agency Code

15. Supplemental Notes

This effort was performed in fulfillment of 2018-AAM-611-CHE-10164.

16. Abstract

The Bioaeronautical Sciences Research Branch (BSRB) is a branch of the Aerospace Medical Research Division that includes three teams focused on improving aviation safety through accident investigation. The Autopsy Program Team is an operational team that collects, manages, and maintains all autopsy records from the investigation of fatal aircraft accidents in the United States and supports the aeromedical review of these accidents. The Biochemistry and Forensic Toxicology Research Teams conduct research on accident fatalities and serve as the primary national site for toxicology testing of accidents overseen by federal agencies, including the FAA and the National Transportation Safety Board (NTSB).

In 2017, the BSRB received 297 cases from accidents in various modes of transportation including aviation, highway, marine, and rail. The laboratory received biological specimens from 15 incidents in which the pilot, driver, or primary operator was nonfatal. Toxicological analyses, including carboxyhemoglobin, glucose, volatiles, and drug analyses were performed on cases during the investigation process. Of the 272 cases that had a comprehensive drug screen performed, 142 cases were negative while 130 cases were positive for at least one drug.

This report contains widely requested data on the toxicological findings of the cases handled by the BSRB. This report includes comparisons of data over a five-year period. The aerospace community, including FAA leadership, NTSB personnel, aerospace researchers, forensic toxicologists, and the public will use the findings and trends of this report to assess transportation safety.

	18. Distribution Statement
Forensic Toxicology, Postmortem Toxicology, Civil Aviation Accidents, Surface Accidents, Drugs, Ethanol	Document is available to the public through the National Technical Information Service Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	55	

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Contents

INTRODUCTION

This is the second annual report, reviewing the findings of the Federal Aviation Administration (FAA) while processing postmortem samples from aviators involved in fatal aerospace accidents. This report covers the findings from fatal aerospace accidents that occurred during 2017. This report will cover the characteristics of the accidents that occurred during the timeframe under investigation, including the type of flight, the aircraft, the geographic location of the accident, the medical certification status of the aviators, including any positive findings of drugs or alcohol in the postmortem remains of the aviators. These findings are provided to the National Transportation Safety Board (NTSB) on a continuing basis where they are used by NTSB investigators as a part of their determination of probable cause for fatal transportation accidents. These findings are the result of the efforts of several teams of scientists working at the Civil Aerospace Medical Institute (CAMI). CAMI is the medical certification, education, research, and occupational medicine wing of the Office of Aerospace Medicine (AAM) under the guidance of the FAA Office of Aviation Safety (AVS). CAMI is located at the Mike Monroney Aeronautical Center (MMAC), in Oklahoma City, OK.

The Bioaeronautical Sciences Research Branch (BSRB, AAM-610) is part of the Aerospace Medical Research Division (AAM-600). The mission of AAM-600 is "to develop new and innovative ways to support FAA regulatory and advisory missions to improve the safety of humans in civilian aerospace operations." As such, its goal is to "Continuously maintain the Absorptive Capacity for applying Science, Medicine, Bioengineering, and Technology to unrelentingly enhance human safety."

The BSRB is divided into two sections, Forensic Sciences (AAM-611) and Biomedical Sciences (AAM-612). Forensic Sciences Section is composed of the Forensic Toxicology Research Team and the Biochemistry Research Team. The Functional Genomics and Knowledge Management Research Teams, along with the Autopsy Program Team, make up the Biomedical Sciences Section. The Autopsy Program Team is an operational team that collects, manages, and maintains all autopsy records from the investigation of fatal aircraft accidents in the United States and supports the aeromedical review of these accidents by AAM-600's Research Medical Officer. The Biochemistry and Forensic Toxicology Research Teams conduct research on accident fatalities and serve as the primary national site for toxicology testing of accidents overseen by federal agencies, including the FAA and the NTSB. The AAM-610 organizational chart is presented in Figure 1.

The BSRB is certified in accordance with the International Organization for Standardization (ISO) standard 9001:2008 (July 2015). Additionally, the Forensic Sciences Laboratory is also accredited by the American Board of Forensic Toxicology (ABFT). The mission of the ABFT is to establish standards for the practices of laboratories involved in postmortem toxicology and/or human performance testing. The accreditation process includes an on-site inspection every two years and a thorough review of documentation and procedures in the year between the on-site inspections. Accreditation is also contingent upon the successful performance of proficiency tests provided by the College of American Pathology. ABFT has established a certification program for scientists that are engaged in the practice of forensic toxicology and successfully pass an examination. In 2017, three BSRB employees held certifications as a Fellow of ABFT (F-ABFT) and one employee as a Diplomat of ABFT (D-ABFT).

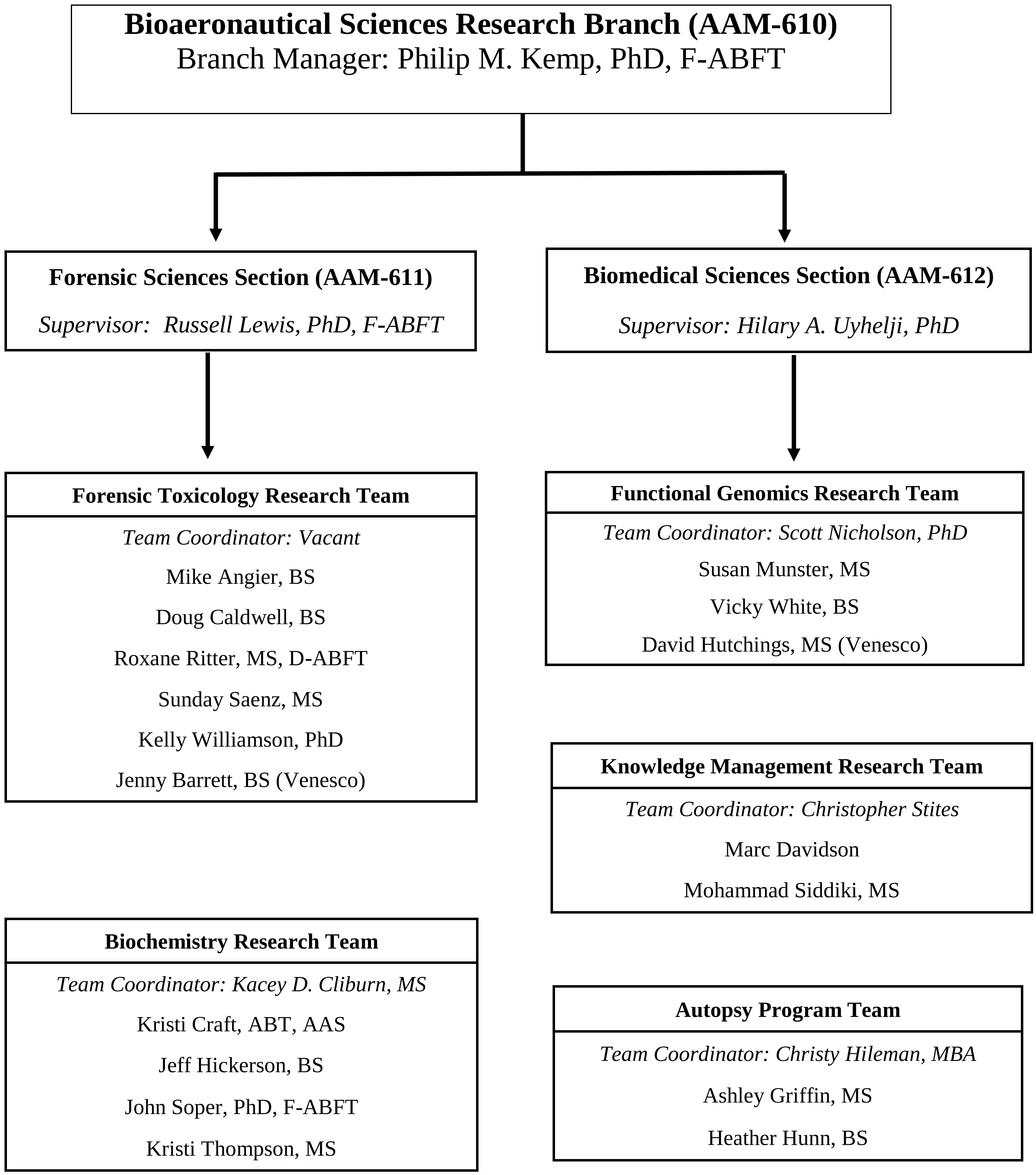

Figure 1. AAM-610 Organizational Chart, as of December 2017.

Autopsy Program Team

The FAA has statutory authority and a congressional mandate to conduct accident prevention and crash injury research by collecting relevant data in the interest of protecting public safety. The Autopsy Program Team at the FAA exists to assist accident investigation with the medical portion of the investigation process. The Autopsy Program Team is involved in all U.S. registered civilian aviation accidents where a fatality occurs. The team works with FAA and NTSB investigators as well as local medicolegal jurisdictions to obtain autopsy and toxicological specimens for each fatal pilot, co-pilot, pilot rated passenger, and/or other passenger that may have had control of the aircraft at the time of the accident. Autopsy and toxicology are an important part of the accident investigation in that they aid investigators in determining what was going on with the airman or occupants at the time of the accident. Results from the autopsy report and toxicology report help to rule out or discover any impairments or incapacitations. The reports also assist in identifying any existing medical conditions that may or may not have been previously disclosed to the FAA's Aviation Medical Examiner (AME).

In 2017, the Autopsy Program Team consisted of three full time autopsy records administrators whose background is in health information management. The Autopsy Program Team has a database, the Medical Analysis and Tracking (MANTRA) Registry, to store all of the information obtained during their role in accident investigation. Others within the FAA use the data contained in this database to conduct research on fatal accidents. The research is intended to improve aviation safety, health, security, and survivability in the aviation community. The research conducted at CAMI brings understanding to aeromedical factors in aviation accidents and studies performance decrements resulting from disease processes to determine their effects on aviation safety. One of the focuses of the research performed at CAMI is to evaluate factors that influence human performance in aviation and communicate that to the aviation community.

Biochemistry Research Team

The Biochemistry Research Team started 2017 with five members: one Research Toxicologists, two Research Chemists, and two Laboratory Technicians. Their functions include, but are not limited to: 1) receiving cases and creation of the initial case folders, 2) accessioning, 3) analytical batch review, 4) completion of the case reports, and 5) research.

After an aviation accident, or other transportation related accident, an autopsy is performed by the local Medical Examiner or Coroner. The FAA provides a leak-proof kit to the local Medical Examiner or Coroner for them to use to collect and then ship the postmortem remains of aerospace accident victims to CAMI. This kit contains multiple vials and containers along with instructions on what biological samples need to be collected for our toxicology analysis, and instructions on how to ship the box back for processing. This kit is euphemistically called a TOX-BOX. Upon request by the NTSB, biological specimens from an accident victim are shipped in a TOX-BOX to the Forensic Sciences Laboratory. Toxicological testing is provided to several agencies, in addition to the FAA and NTSB, including the Federal Railroad Administration, U.S. Coast Guard, and various other U.S. and foreign agencies, including the Royal Canadian Air Force.

Once a TOX-BOX is received, a case is created and given a unique case number. The box contents are videotaped and cataloged as to the specimen types and their weight and any distinguishing characteristics noted, such as putrefaction, charring, debris, limited in volume, etc. Batches are prepared for toxicological testing by transferring aliquots of the biological specimens into test tubes. These batches are created for the analysis of carboxyhemoglobin, alcohols/volatiles, glucose, drugs of abuse, over-the-counter drugs, and prescription drugs. The type of tests requested depends upon the specimens received and/or whether the specimens are suitable for use. Pilot and co-pilot victims receive full toxicological testing. Passenger victims are not tested unless the investigator deems toxicological testing is necessary or there was a fire (ground or in-flight). In the event of a fire, testing for carbon monoxide exposure (carboxyhemoglobin) would be performed. The TOX-BOX is then cleaned, a new kit inserted, and the box is shipped back to the office from which it originated.

Once the initial screening is complete, the results are reviewed and additional testing may be requested depending on the initial findings. After all the testing is complete, the final case reports are then generated, reviewed and approved, and distributed to appropriate agency personnel.

In addition to the processing of case specimens from aviation or surface accidents, the Biochemistry Research Team also conducts research. The Team's research interests include epidemiology studies, prevalence studies of various drug classes, and method development for the analysis of cannabinoids or other emerging substances in postmortem samples. This research helps to identify trends in drug and alcohol use in the fatal pilot population.

Forensic Toxicology Research Team

The Forensic Toxicology Research Team consists of seven members: six Research Chemists and one Biological Science Laboratory Technologist (contractor) who together encompass more than 110 years of experience. Two team members hold Ph.D., two M.S., and three B.S. degrees. Two team members are board certified with the ABFT. In July of 2017, the Forensic Toxicology Team Coordinator was promoted to Forensic Sciences Supervisor, leaving a vacancy on the team for the remainder of the year. The Forensic Toxicology Research Team performs toxicological analysis on biological specimens obtained from transportation accidents. The NTSB, FAA, and local investigators use information gathered from these activities to aid in the determination of a cause of an aviation or other transportation accident.

The Forensic Toxicology Research Team initially screens case specimens for illicit, over-the-counter (OTC), and prescription drugs using immunoassay, gas chromatography-mass spectrometry (GC/MS), liquid chromatography/mass spectrometry (LC/MS), and liquid chromatography/ultraviolet/visible/fluorescence (LC/UV/VIS/FL). Presumptive positives from this screening are re-tested for confirmation and quantification by the Forensic Toxicology Research Team using GC/MS and liquid chromatography/tandem mass spectrometry (LC/MS/MS). Additionally, case specimens are analyzed for ethanol/volatiles, combustion gases, and glucose/HbA1c, if suitable specimens exist. Ethanol and other volatiles are analyzed by headspace gas chromatography (GC-HDSP). Ultraviolet/Visible Spectrophotometry (UV/VIS) and colorimetric tests are used to analyze for carbon monoxide (carboxyhemoglobin) and cyanide.

Sample preparation and handling is required prior to analytical instrument analysis. Biological tissues must be homogenized and then handled alongside the fluid samples. Typical sample preparations include, but are not limited to, solid phase extraction, liquid-liquid extraction, or modified “crash and shoot” methods. Chemists prepare and analyze positive and negative controls for each analysis. For drug confirmation/quantification, calibration curves and controls are prepared for each analysis.

In addition to the analysis of case specimens from aviation or surface accidents, the Forensic Toxicology Research Team also conducts research. The Team’s research interests include method development and validation for current and emerging drugs, postmortem drug distribution and redistribution, and postmortem ethanol formation. This innovative research, in combination with the day-to-day forensic toxicology casework, aids in the development of accident prevention strategies and overall safety improvement to the flying public.

Objectives

The objectives of this report are:

1) to provide descriptive characteristics of all cases received by the laboratory for processing and toxicological analyses,
2) to evaluate aviation accidents in regards to the type of accident, location of the accident, occupant role, and medical certification status,
3) to examine current trends in drug and alcohol usage in the cases received by the laboratory,
4) to contribute to discussions about policy changes regarding drug use, and
5) to educate the pilot population about the dangers of drug use in aviation.

METHODS

Since 1997, a database (ToxFlo™, DiscoverSoft Development, LLC) has been maintained at the Civil Aerospace Medical Institute (CAMI) that includes information relating to the biological specimens received by the CAMI Biochemistry Research Team and the results of the forensic toxicology analysis performed by the CAMI Forensic Toxicology Research Team. Information obtained during the accident investigation is sent to CAMI and recorded in ToxFlo™. The information may include, but is not limited to, the victim's name, date of birth, social security number, and gender. The accident information includes the accident date and location and, if it is an aviation accident, information about the type of operation or aircraft registry. This information may also be obtained from the CAMI Autopsy Program Team's MANTRA database. The pilot's certificate number is obtained from the FAA's Multi-System Access Tool – Airman (MSAT-A). The pilot's medical history, including pilot class and drug history, is obtained from the FAA's Medical Support System-Document Imaging Workflow System (DIWS).

The ToxFlo™ database was searched to establish the number of cases received during the calendar year 2017. Accidents that occurred in 2016, but whose biological specimens were not received by the laboratory until 2017, were included as a part of the data for 2017. The MANTRA database was searched to obtain corresponding information about the fatal aviation accidents. The data collected for aviation cases received by the laboratory included age, fatal or nonfatal status, accident date and location, type of flight, occupant role (pilot, co-pilot, passenger, etc.), and pilot's medical certificate status. The data collected for non-aviation cases received by the laboratory included, age, fatal or nonfatal status, accident date and location, and mode of transportation. Results from the toxicological analyses were collected for all cases, regardless of mode of transportation. The toxicology results were evaluated based on the types of tests that were performed and the number of cases that were positive for drugs, alcohol, carboxyhemoglobin, cyanide, and glucose.

RESULTS

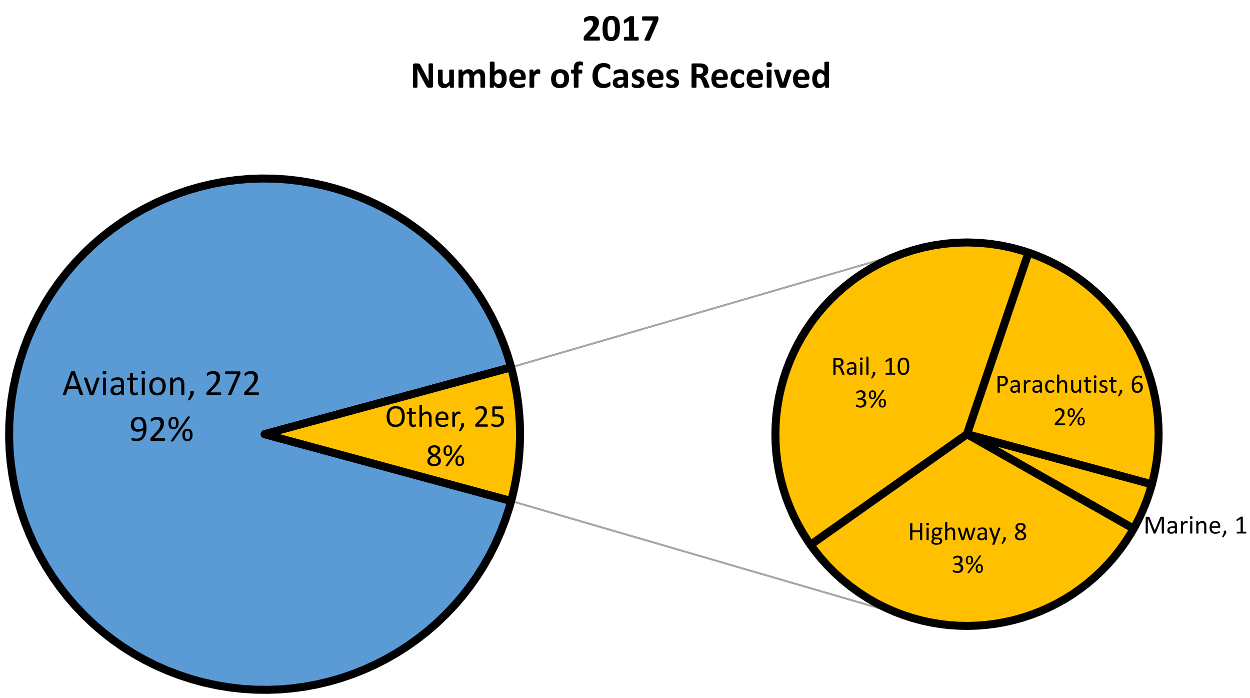

Figure 2. Number of Cases Received by Mode of Transportation.

Table 1. Nonfatal Cases Received by Mode of Transportation.

Mode of Transportation	Number of Cases Received
Aviation	7
Highway	4
Rail	4
Total	**15**

Aviation

The laboratory received biological specimens from 272 individuals involved in 212 accidents.

Table 2. Type of Aviation Accidents.

Investigated by NTSB & FAA	Number of Accidents
General Aviation (14 CFR Part 91)	186
Air Carrier (14 CFR Part 121)	1
Rotorcraft External Load (14 CFR Part 133)	1
Air Taxi and Commercial (14 CFR Part 135)	9
Agricultural (14 CFR Part 137)	6
Non-US, Commercial	1
Total	**204**

Investigated by FAA	Number of Accidents
No Intent to Fly	1
Ground Mechanic	1
Ultralight	1
Total	**3**

Investigated by Other Government Agencies	Number of Accidents
Foreign - Royal Canadian Air Force	1
Military	1
Unregistered Ultralight, Paraglider	3
Total	**5**

Location

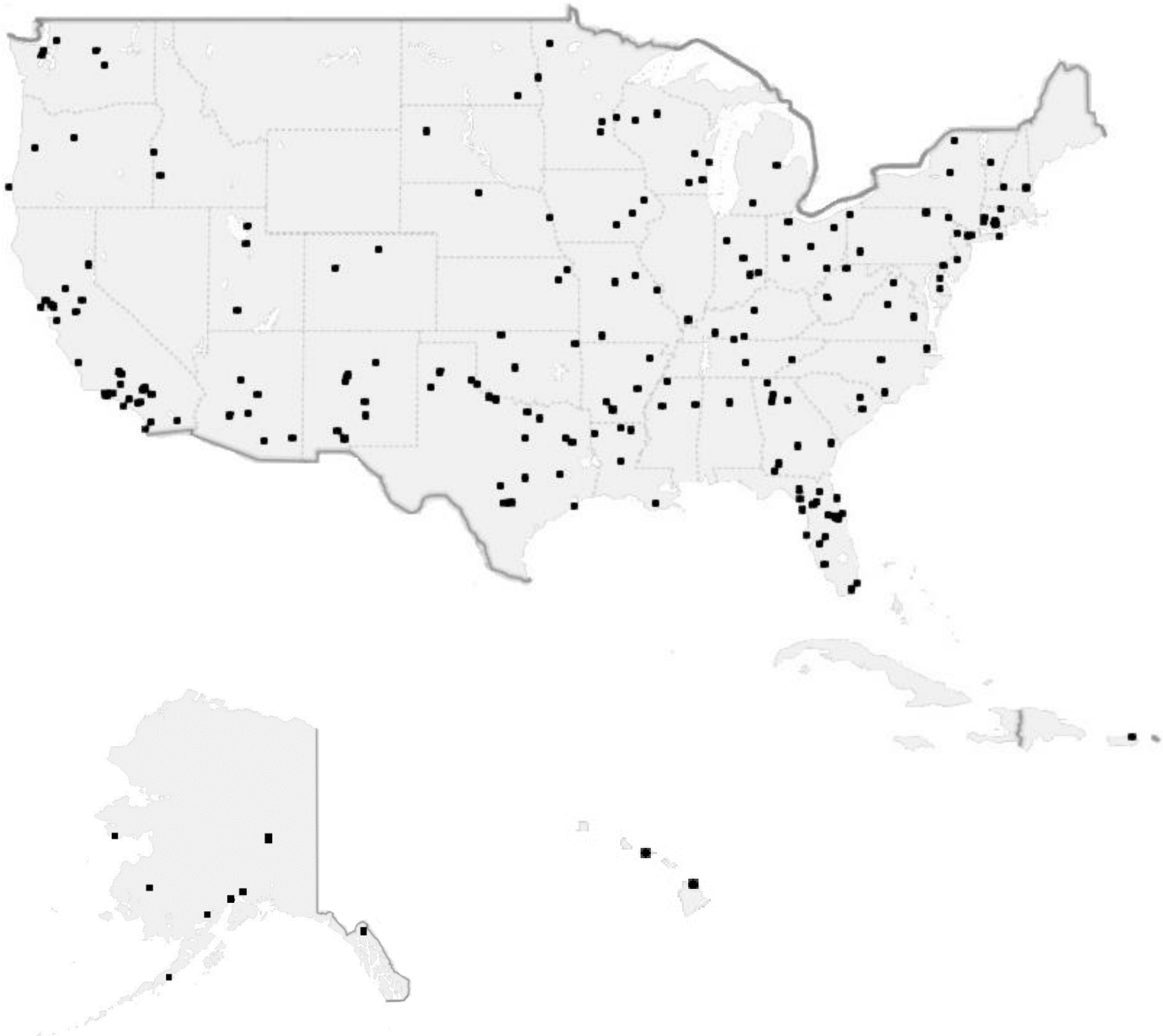

Figure 3. Aviation Accidents Investigated by the NTSB/FAA Classified by Location (N=204).

Month

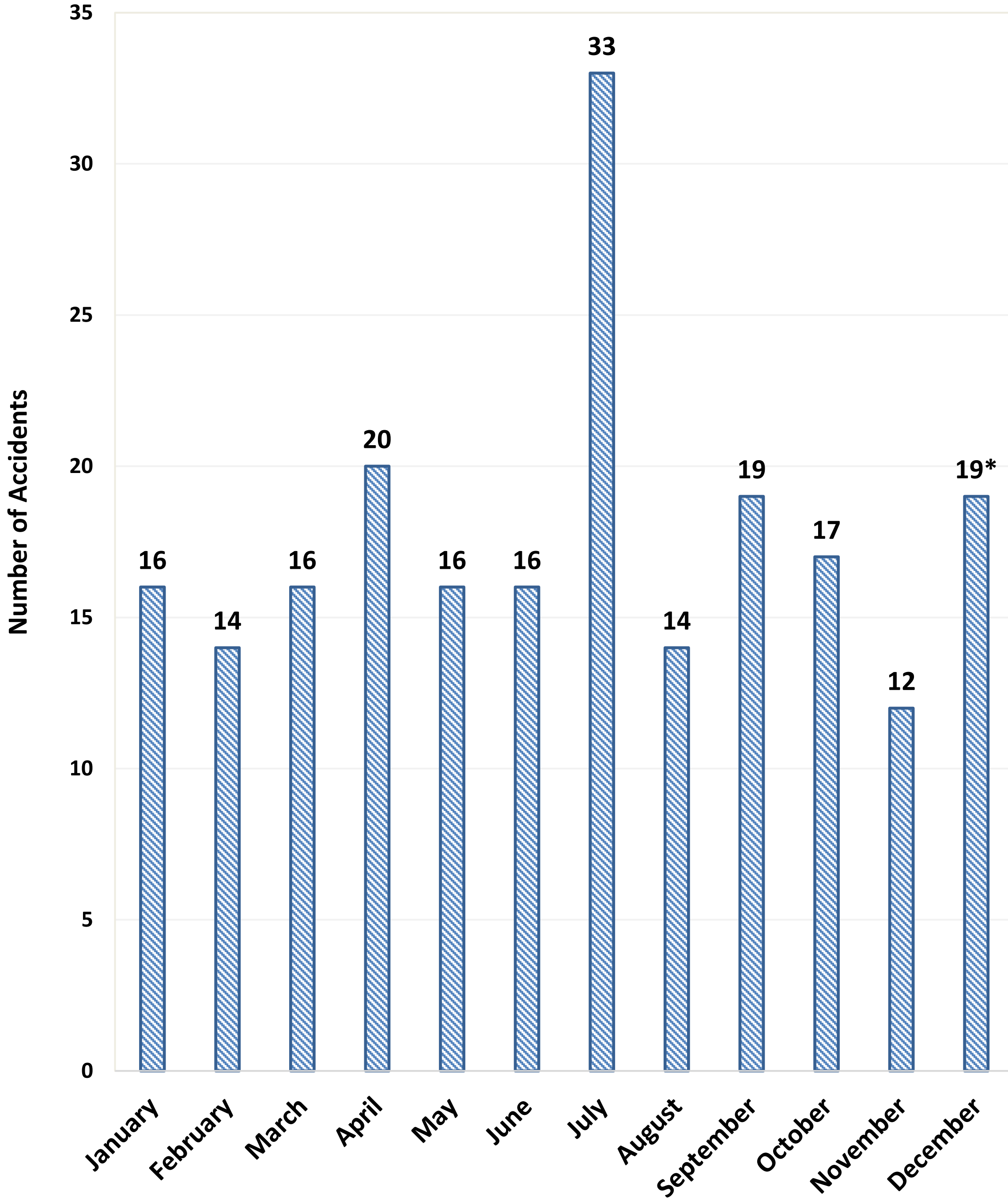

Figure 4. All Aviation Accidents Classified by Month (N=212).

*4 accidents occurred in December 2016, but cases were received in 2017

Day of Week

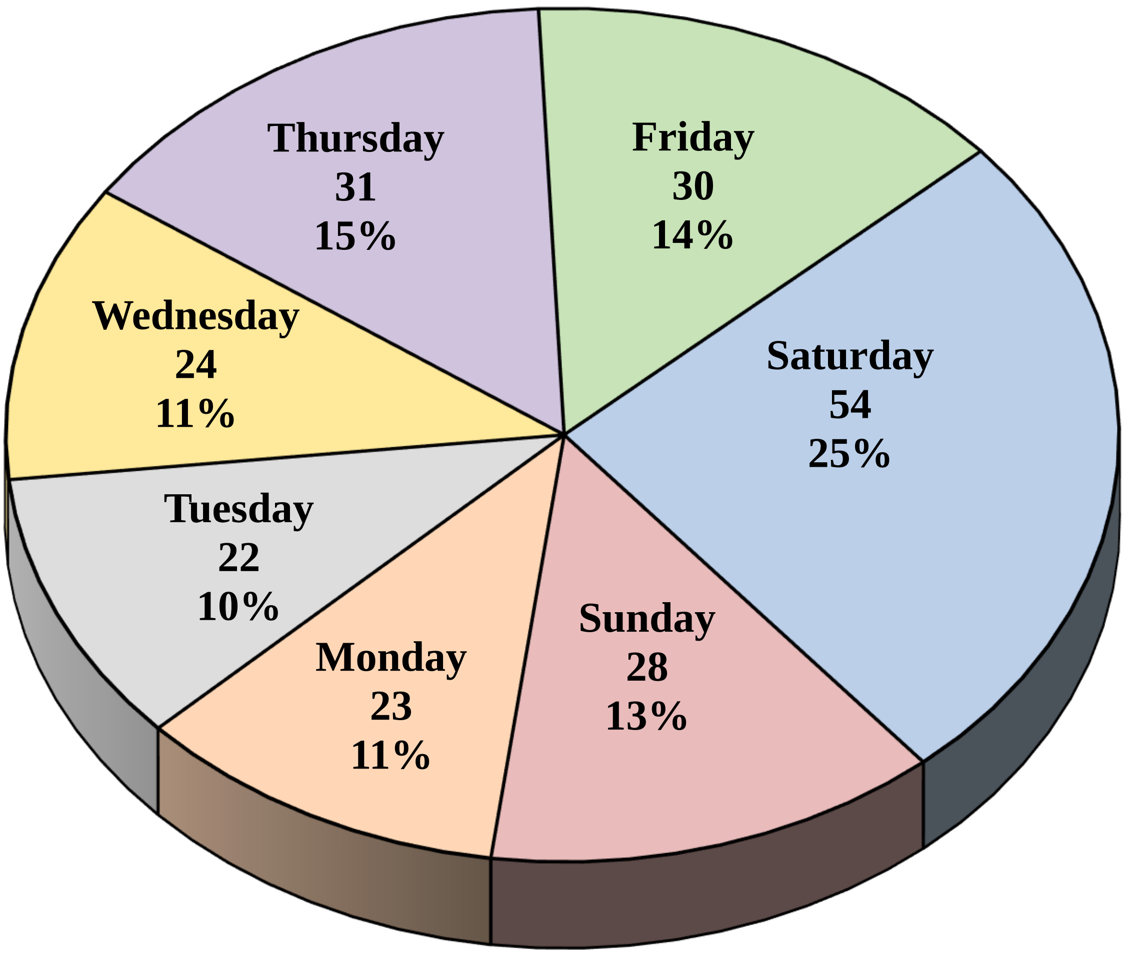

Figure 5. All Aviation Accidents Classified by Day of the Week (N=212).

Occupant Role – Age and Gender

Table 3. Occupant Role and Gender for each Case Received.

	Pilot	Flight *Instructor*	Co-*Pilot*	*Pilot Rated PAX*	*Passenger*	*Ground Crew*	*Medical Crew*
Male	198	16	4	12	20	1	1
Female	3	0	1	3	12	0	1

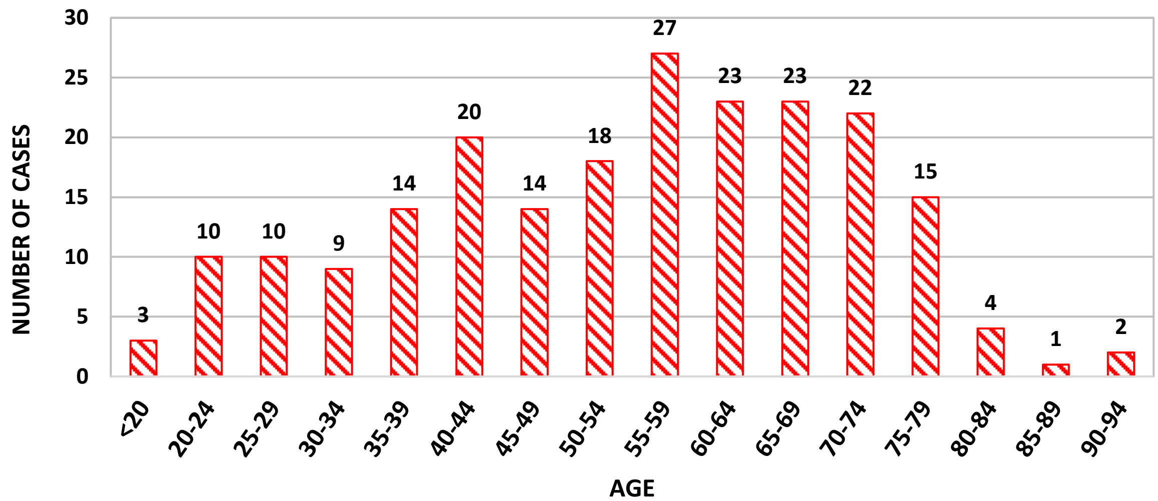

Figure 6. Age (at the time of accident) of Pilots, Co-pilots, Flight Instructors.

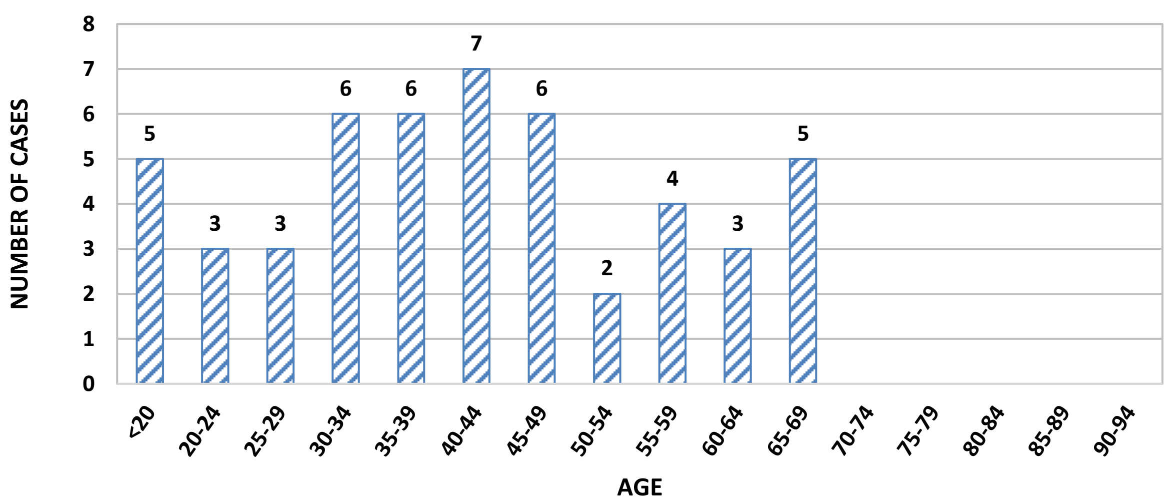

Figure 7. Age (at time of accident) of all Non-pilots.

Medical Certification

The FAA has standards and procedures for a pilot to obtain a medical certificate in order to exercise the privileges of an airline transport, a commercial, or a private pilot (1). The three classes for airmen medical certificates are First-Class Medical Certificates, Second-Class Medical Certificates, and Third-Class Medical Certificates.

The First-Class Medical Certificate is required for Airline Transport Pilots. Airline Transport Pilots are at least 23 years of age and require more flight training than other certificate types. They fly for compensation or hire.

The Second-Class Medical Certificate is required for commercial pilots, flight engineers, flight navigators, and air traffic control tower specialists. Commercial pilots may operate an aircraft that is carrying passengers or property for compensation or hire.

The Third-Class Medical Certificate is required for private pilots, recreational pilots, student pilots, and certified flight instructors. Private pilots must be at least 17 years of age. They cannot act as a pilot in command of an aircraft that is carrying passengers or property for compensation or hire. Recreational pilots must also be at least 17 years of age and are not to carry more than one passenger. Student pilots must be at least 16 years of age. They are not to act as a pilot of an aircraft carrying any passengers or carrying property for compensation or hire.

Sport pilots are not required to hold a valid airman's medical certificate if they have a current valid U.S. driver's license. Any restrictions on their driver's license applies to flying as well.

In 2017, the laboratory received 215 cases involving a pilot, co-pilot, or flight instructor that were flying under US regulations. Of those cases, 183 were operating an aircraft in which a medical certificate was required. The laboratory received 32 cases in which a medical certificate was not required for the pilot to operate the aircraft.

BasicMed

In July 2016, Congress passed the legislation, FAA Extension, Safety, Security Act of 2016 (FESSA) which includes an alternative to 3rd class medical certificates. BasicMed became effective May 1, 2017. BasicMed allows General Aviation private pilots to fly aircraft without holding an FAA issued medical certificate as long as they have a valid driver's license and at least one valid FAA medical certificate at any point after July 14, 2006 (2).

An airman flying under BasicMed must see a state licensed physician and complete a comprehensive medical examination checklist. After the medical exam, they must take a BasicMed Online Medical Course. This course contains several topics regarding fitness for flight including but not limited to warning signs of serious medical conditions, awareness of impairment from prescription and over the counter drugs, the importance of regular medical checkups, etc. (3). There are certain medical conditions that require at least one special issuance before operating under BasicMed, examples of those conditions are mental health disorders, neurological disorders and certain cardiovascular conditions (2).

In addition to the above requirements these airmen cannot fly under BasicMed in aircraft that weigh more than 6,000 pounds, cannot carry more than 5 passengers and the flight cannot be operated for compensation or hire (2).

Table 4. Demographics and Toxicology for BasicMed Pilots (N=8).

	Age	Gender	BasicMed Date	Date of Accident	Days from BasicMed to Accident	Toxicology Results
1	70	M	5/31/2017	6/1/2017	1	Carboxyhemoglobin (55%)
2	78	M	6/14/2017	6/27/2017	13	Negative
3	75	M	5/24/2017	7/15/2017	52	Morphine
4	61	M	7/12/2017	7/31/2017	19	Citalopram, N-desmethyl-citalopram, Metoprolol
5	70	M	5/19/2017	8/9/2017	82	Metoprolol
6	73	M	7/10/2017	9/28/2017	80	Diphenhydramine
7	67	M	6/22/2017	11/7/2017	138	Verapamil, Norverapamil
8	78	M	9/2/2017	12/20/2017	109	Amlodipine, Quinapril

Accidents Requiring Valid Medical Certificate

Of the 215 pilots, co-pilots, and flight instructors received by the laboratory, 183 were involved in an aviation accident in the United States in which a medical certificate was required for operating the aircraft.

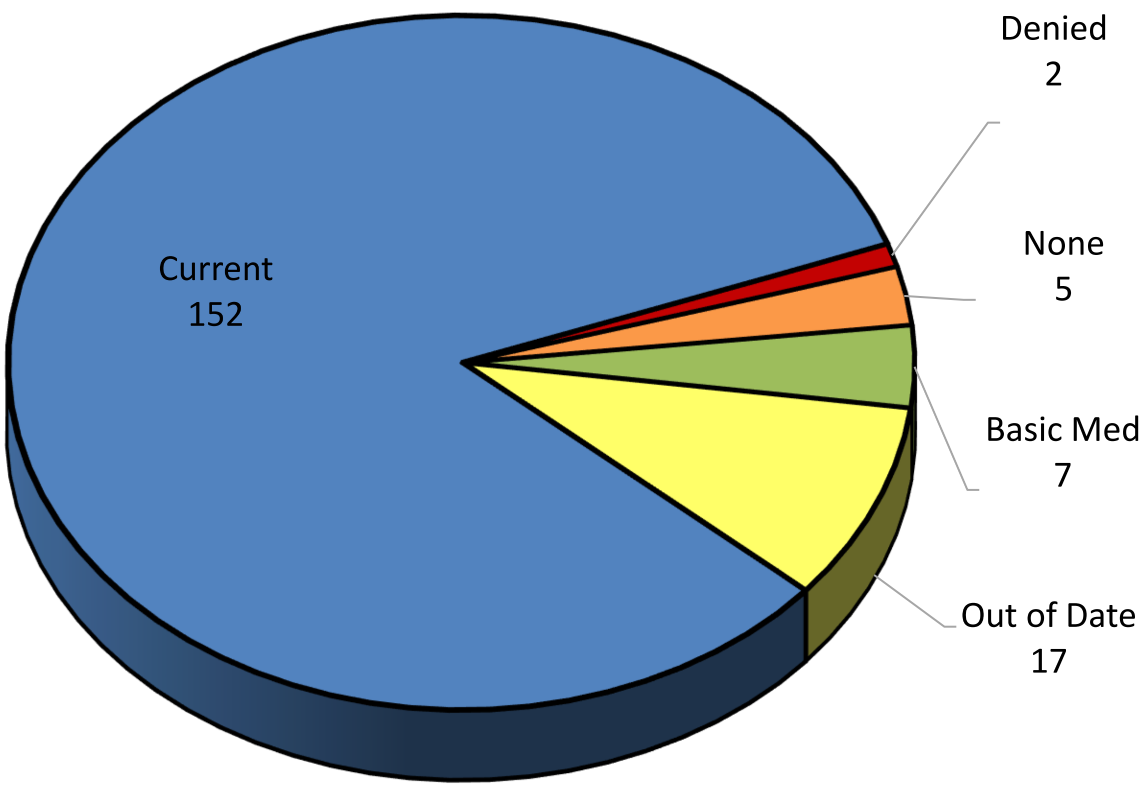

Figure 8. Medical Certificate Status for Accidents Requiring a Valid Certificate.

Accidents Not Requiring Valid Medical Certificate

Of the 215 pilots, co-pilots, and flight instructors received by the laboratory, 32 were involved in an aviation accident in the United States in which a medical certificate was not required for operating the aircraft.

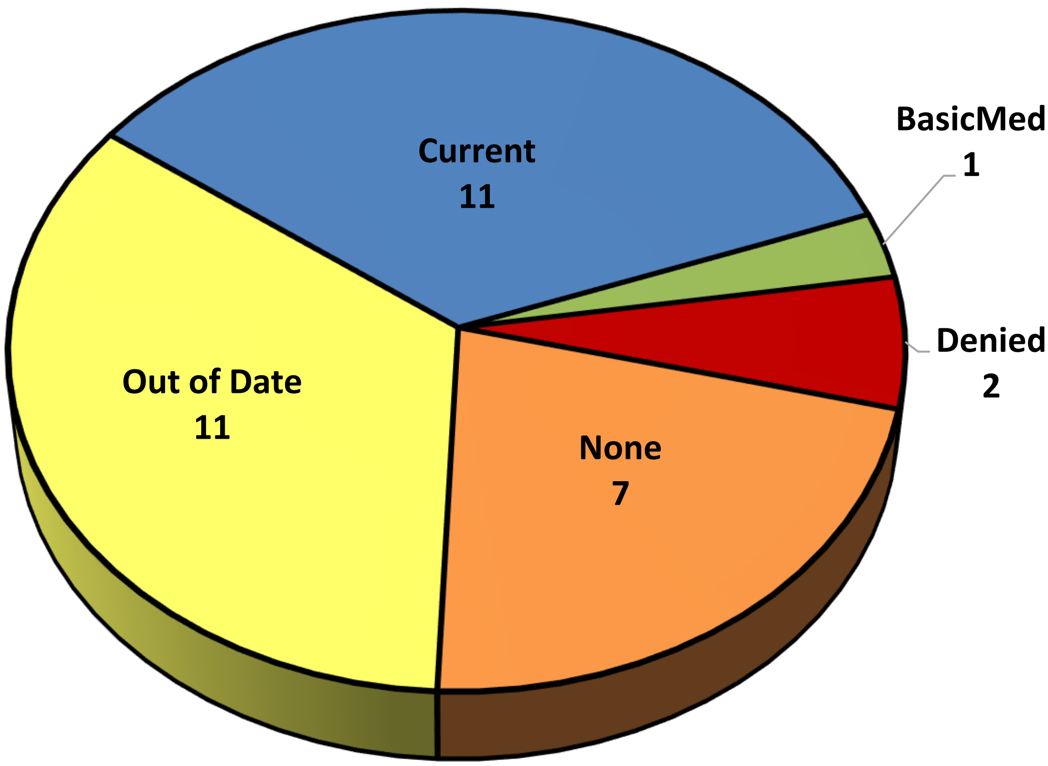

Figure 9. Medical Certificate Status for Accidents Not Requiring a Valid Certificate.

Other Modes of Transportation

In 1967, the NTSB was established by Congress as an independent investigative agency of civilian aviation accidents and major accidents in other modes of transportation, such as highway, railroad, marine, and pipeline. The Safety Board determines the probable cause of each accident and promotes safety recommendations aimed at preventing future accidents. FAA's Forensic Toxicology Laboratory assists in the NTSB investigations by providing toxicological support for non-aviation accidents. The non-aviation accidents that are sent in for toxicological analysis are determined by the NTSB. In 2017, the laboratory received biological specimens from 19 individuals involved in 16 non-aviation accidents investigated by the NTSB.

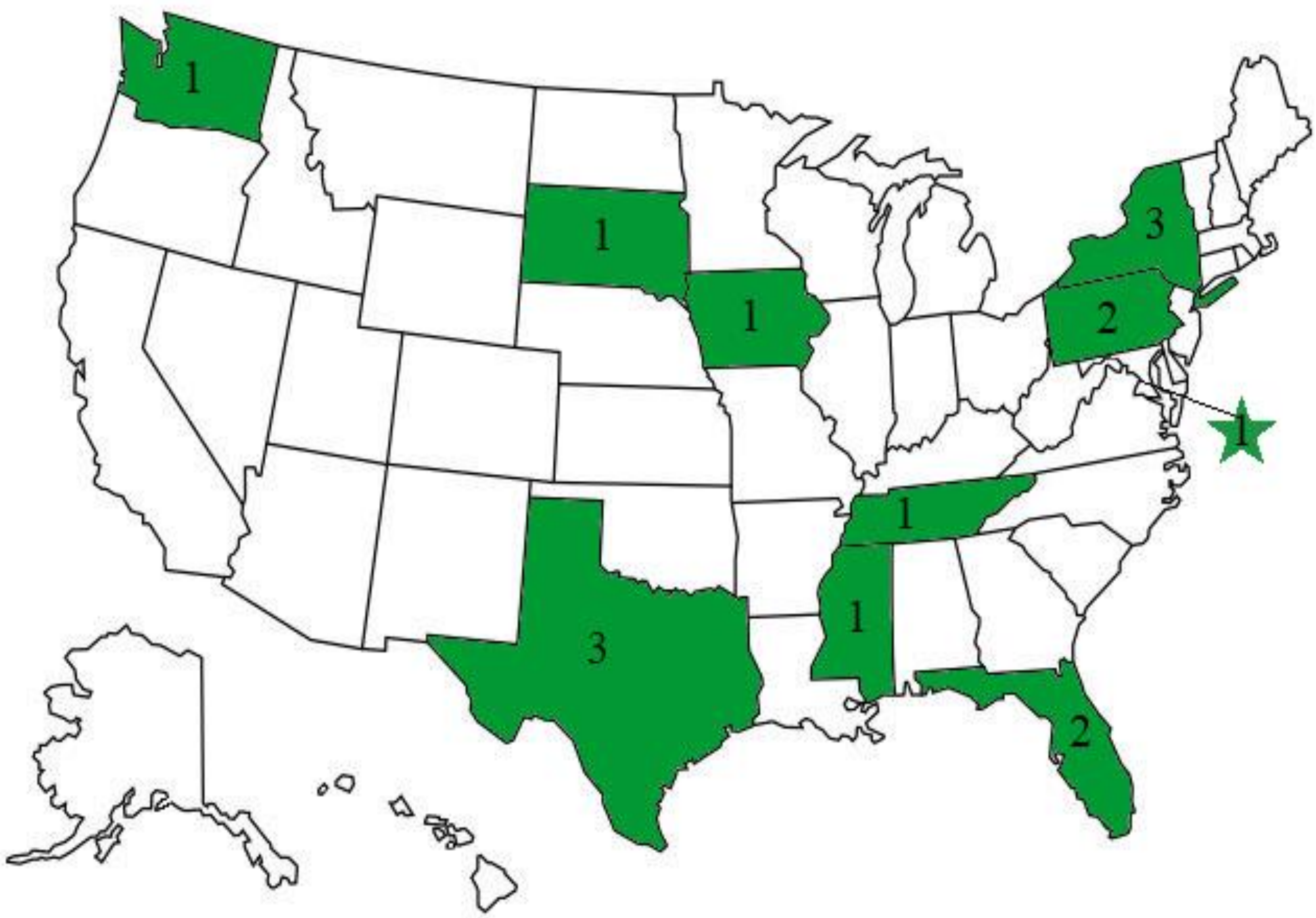

Figure 10. Non-Aviation Accidents Classified by Location (N=16).

Month

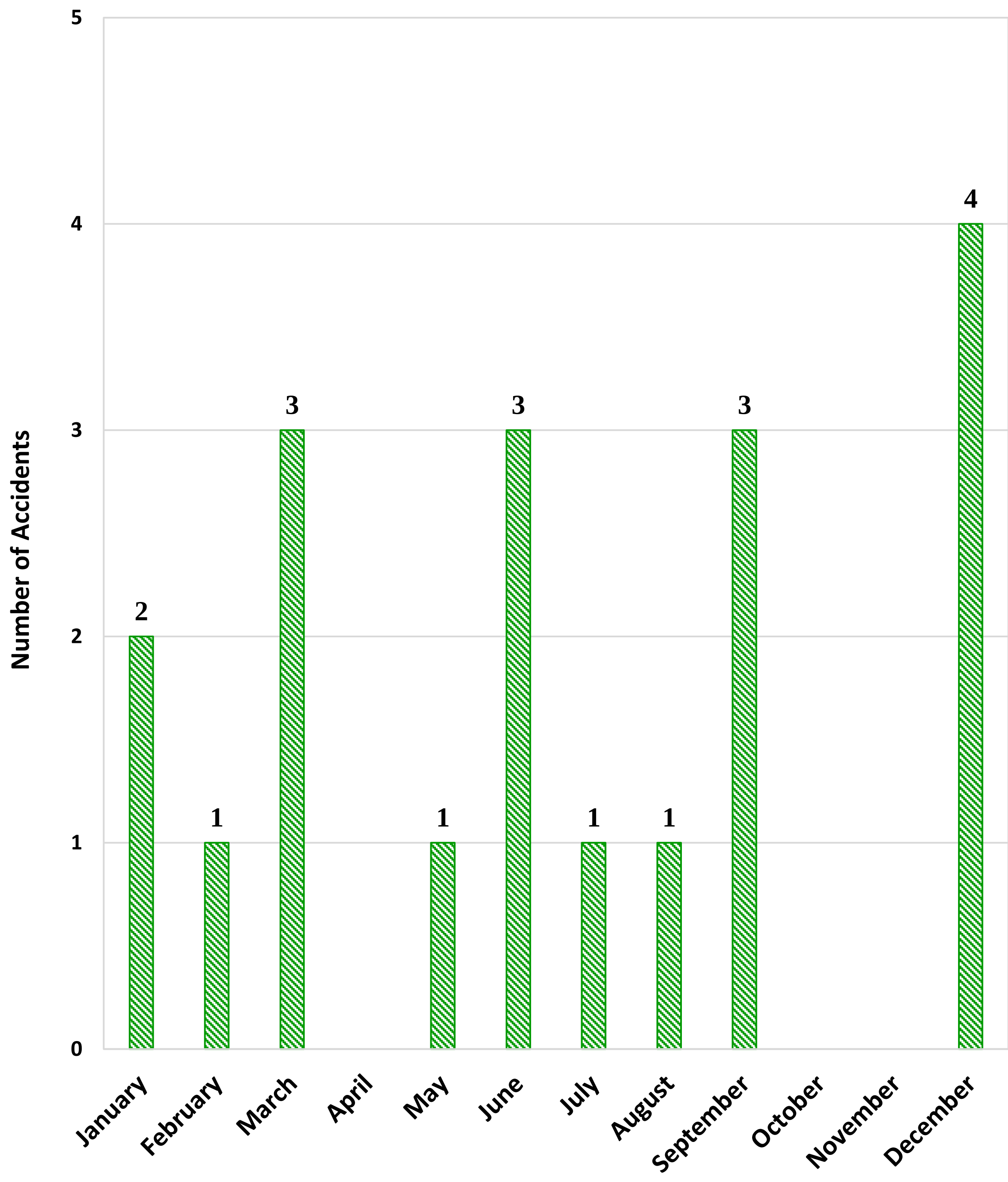

Figure 11. Non-Aviation Accidents Classified by Month.

Day of Week

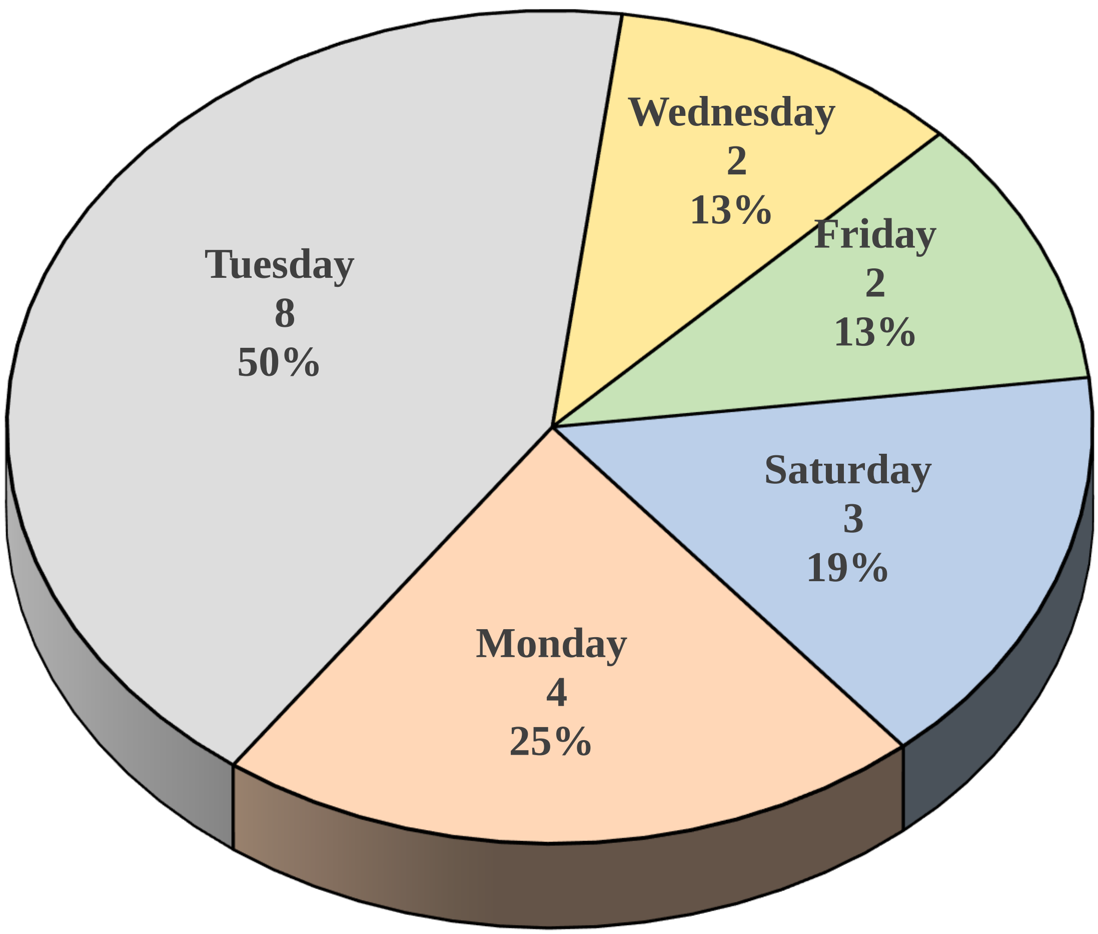

Figure 12. Non-Aviation Accidents Classified by Day of Week.

Fatality Status

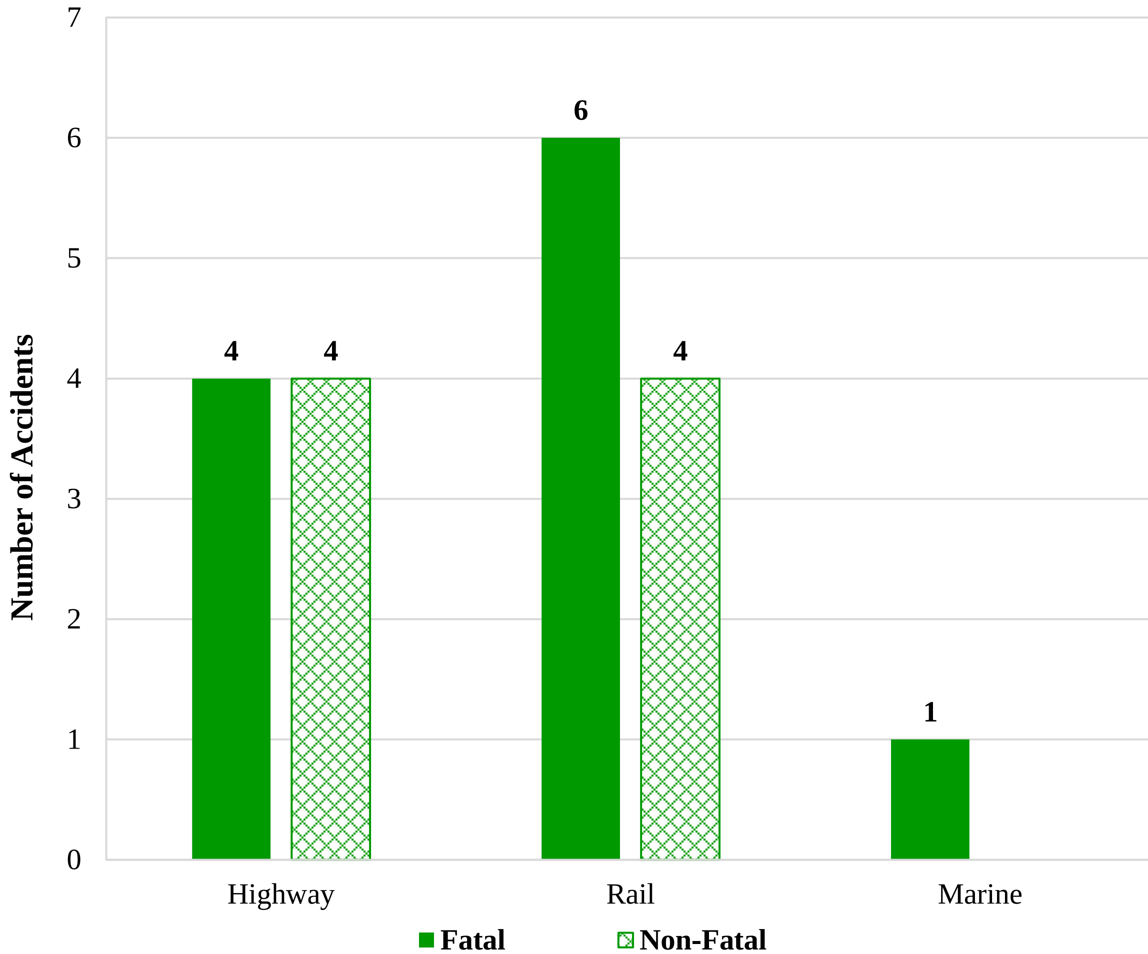

Figure 13. Fatality status of non-aviation cases.

Age

Table 5. Descriptive Statistics of Age for Non-Aviation Cases.

Number of Cases	Average Age	Range	Median	Standard Deviation
16	47.6	19 – 75	49	17.2

Toxicology

In 2017, toxicological analyses were performed on 273 of the 297 cases the laboratory received. Twenty-four cases had no analyses performed due to lack of sufficient specimens, condition of specimens, or a request from the investigator in charge of the case indicating no toxicology testing was needed. The results from the toxicology tests performed are summarized in this section, and includes all modes of transportation, as well as fatal and nonfatal cases.

Carboxyhemoglobin (COHb): The laboratory tested 164 cases for the presence of carboxyhemoglobin. This test is performed on a blood sample; thus, if there was no blood received with the case, the test was not performed. The laboratory reports any carboxyhemoglobin result greater than or equal to 10%. In 2017, 6 cases tested positive for carboxyhemoglobin.

Cyanide: A test is performed for cyanide on any case that is positive for carboxyhemoglobin or at the request of the investigator-in-charge. The laboratory performed a cyanide analysis on 7 cases in 2017.

Glucose: The laboratory tested 169 cases for the presence of glucose. This test is performed on urine and/or vitreous humor samples. The laboratory does not report glucose results that are less than 100 mg/dL in urine or 125 mg/dL in vitreous humor. In 2017, glucose-positive results were reported in 2 cases.

Hemoglobin A1c: A test is performed for hemoglobin A1c on any case that has a glucose result greater than 100 mg/dL in urine or 125 mg/dL in vitreous humor or by special request from the NTSB or FAA Investigator. The test is performed on blood and the laboratory tested 3 cases for hemoglobin A1c in 2017.

Volatiles: The laboratory tested 266 cases for the presence of volatile substances, including ethanol, methanol, isopropanol, and acetone. This test may be performed on vitreous humor, urine, blood, bile or any tissue sample. An ethanol result greater than or equal to 10 mg/dL is reported by the laboratory. In 2017, 46 cases had a positive ethanol result.

Drugs: The laboratory tested 272 cases for the presence of illicit, prescription, and over-the-counter medications. The test may be performed on urine, blood, or tissue samples. In 2017, 130 cases were positive for one or more drugs.

Toxicology Testing Flow Chart

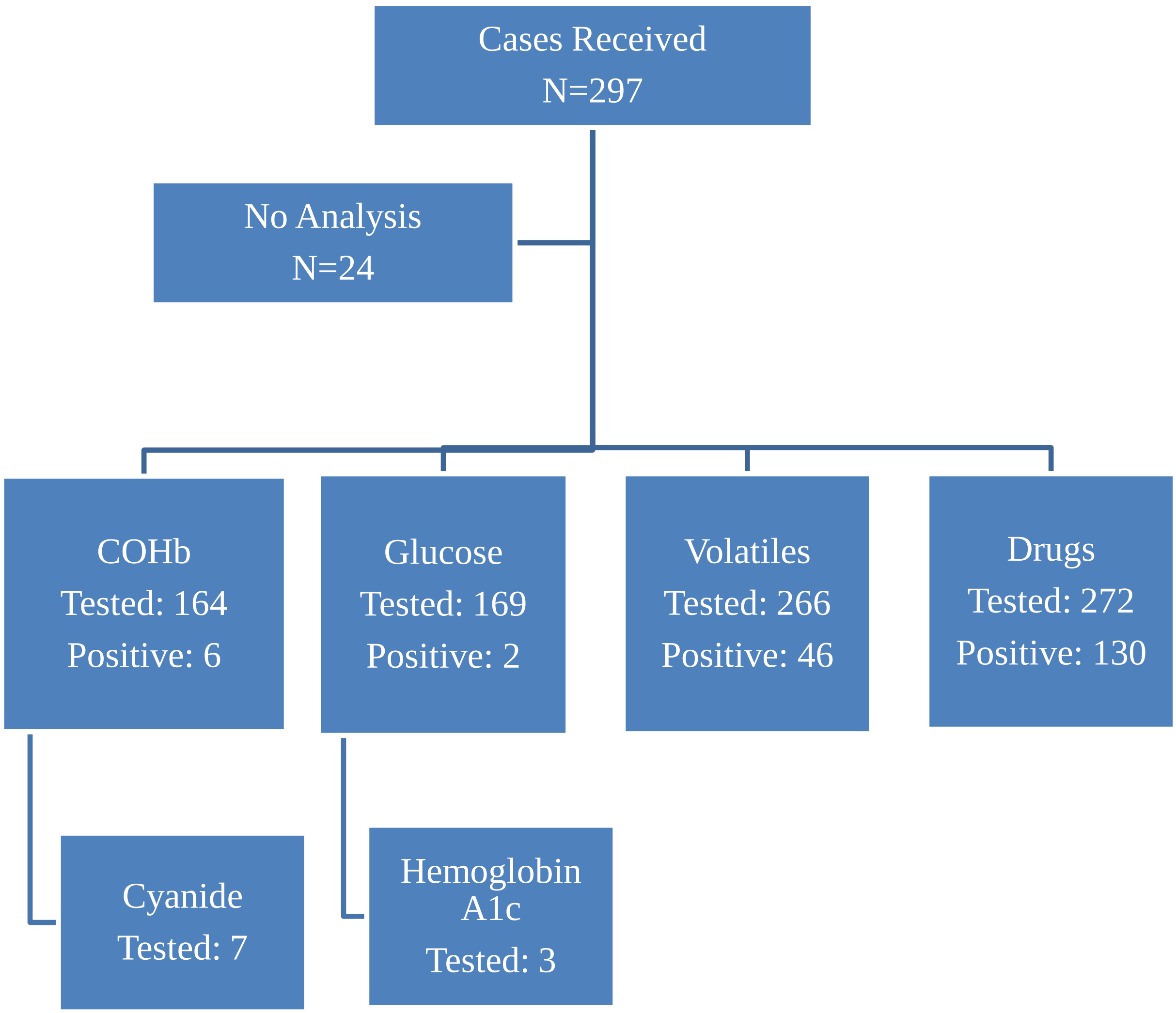

Figure 14. Number of Cases and Positives for each Toxicology Analysis Performed.

Carboxyhemoglobin

Carbon monoxide (CO) is a byproduct of incomplete combustion. It is a toxic gas which can occur as a result of a fire. Carbon monoxide binds with hemoglobin forming carboxyhemoglobin, which interferes with the transportation of oxygen in the body. Carboxyhemoglobin levels can cause various symptoms ranging from headache to death (4).

Table 6. Carboxyhemoglobin Levels and Symptoms (4).

Percentage	Symptoms
10-20%	Headache, flushed skin, and/or shortness of breath with moderate exercise
20-30 %	Throbbing headache, memory and/or judgement impairment, confusion, irritability, emotional instability, and/or rapid fatigue
30-40%	Severe headache, visual disturbances, nausea, vomiting, dizziness, and confusion
40-50%	Hallucinations, abnormally rapid breathing, and/or ataxia
>50%	Lethal with symptoms of syncope, coma, tachycardia, incontinence, convulsions, discoloration of skin, loss of reflexes, respiratory paralysis, and/or death

Cyanide

Cyanide gas (CN^-) can be produced by the burning of carbon and nitrogen containing materials (4). Hydrogen cyanide (HCN) is the fastest acting form of the gas. CN^- binds to an enzyme in the electron transport system, interrupting the electron transport cycle which is the central pathway for energy generation necessary for life. Inhalation of a large amount of HCN is fatal in less than one minute (5). Symptoms from oral or dermal exposure depend on variables such as the extent, rate, and site of absorption of the cyanide. The onset of symptoms is slower with this type of exposure. Headache, dizziness, and rapid breathing occur immediately after exposure. The symptoms increase to slowed respiration, gasping breaths, erratic cardiac rhythms, hypotension, coma, seizures and death (4).

Table 7. Carboxyhemoglobin and Cyanide Results for 2017.

	Specimen	Carboxyhemoglobin (%)	Cyanide (µg/mL)
1	Blood (Heart)	27	0
2	Blood	21	0
3	Blood	Unsuitable	0
4	Blood (Cavity)	55	0
5	Blood	18	3.6
6	Blood (Heart)	11	0
7	Blood	20	0

Glucose and Hemoglobin A1c

Blood glucose concentrations can be elevated in people with diabetes mellitus. The specimen of choice for postmortem glucose concentrations is vitreous humor or urine, since postmortem blood glucose concentrations have been shown to drop rapidly after death. However, these specimens also suffer from the loss of glucose after death. The laboratory does report glucose results that are equal to or greater than 100 mg/dL in urine or 125 mg/dL in vitreous humor.

Glycolated hemoglobin (HbA1c) is a good measure of long-term glucose control and can be used to evaluate the glucose over a 3 to 4 month average (4). Postmortem HbA1c levels greater than 6.0% have been found to be correlated with a history of diabetes and with abnormal glucose levels determined in urine and vitreous humor. The determination of postmortem HbA1c levels can be helpful in determining medical impairment or incapacitation in aviation accidents (6). Results from 2017 are found in Table 8.

Table 8. Glucose and Hemoglobin A1c Results.

	Specimen	Glucose (mg/dL)	Hemoglobin A1c (%)
1	Urine	110	
	Blood		5.1
2	Urine	24	
	Blood (Cavity)		7
3	Urine	119	
	Blood (Aortic)		4.9

Ethanol

Ethanol, commonly referred to as alcohol, is frequently detected in forensic toxicology casework. Alcohol can decrease inhibitions, diminish attention and judgment, slow information processing, and cause drowsiness and slurred speech. As blood alcohol increases, the signs and symptoms of intoxication/impairment are more pronounced (4). In 2017, the federal limit for blood alcohol concentration for driving in all 50 states was 80 mg/dL or 0.08 % w/v. The federal limit for blood alcohol concentration for pilots is 40 mg/dL. The National Highway Traffic Safety Administration (NHTSA) performed a Drug and Alcohol Crash Risk Study in 2012 and found that drivers with an alcohol concentration at the 0.08 level were 4 times more likely to be involved in a crash compared to sober drivers (7).

Interpretation of postmortem ethanol concentrations can be a challenge since bacteria and putrefaction processes may lead to the production of ethanol after death. It is important that forensic laboratories perform ethanol analyses on multiple biological specimens to help establish whether the blood alcohol concentration is a result of antemortem ingestion or postmortem production. The BSRB routinely analyzes more than one biological specimen if the ethanol result is greater than 10 mg/dL in the initial test.

In 2017, the laboratory reported ethanol at greater than 10 mg/dL in 46 cases (Figure 9). Only 10 of those cases were received with a blood specimen. The rest of the ethanol results were in tissues, such as liver, lung, kidney, spleen, muscle, brain, or heart.

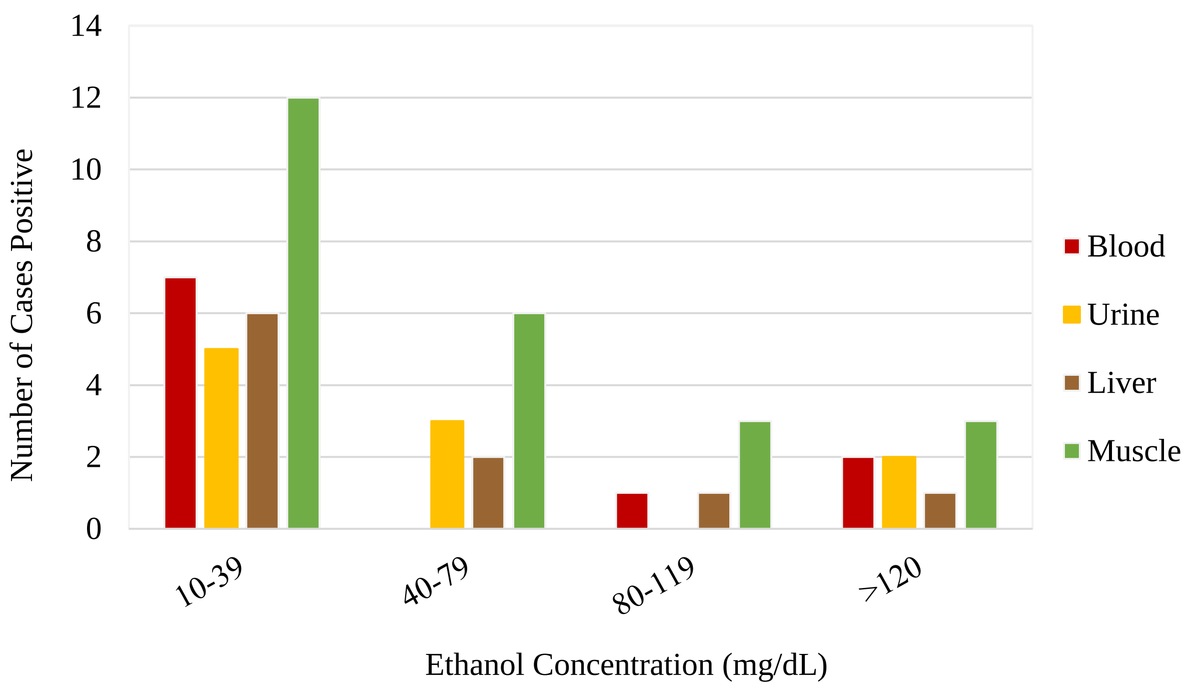

Figure 15. Ethanol Results for Blood, Urine, Liver, and Muscle.

Drugs

The laboratory detects a variety of drugs that includes OTC, prescription (Rx) medications, and substances that are controlled by the federal government (CS). In 2017, the laboratory reported 124 different drugs and metabolites found in 130 cases (Tables 10-11, Figure 15). Any drug that is reported by the laboratory is confirmed by more than one test and is typically confirmed in more than one biological specimen, if available.

Of the 130 drug-positive cases, 64 cases were positive for OTC medications, 41 cases were positive for CS drugs, and 84 cases were positive for RX drugs. Poly-drug use is a common finding in cases received by the BSRB with 82 cases positive for two or more drugs and 28 cases positive for five or more drugs.

Pilot safety is a high priority for the FAA, thus the FAA provides information to airmen of the potential adverse effects of medications. During the medical certificate examination, the physician, known as an Airmen Medical Examiner (AME), has the responsibility to inform airmen of any effects of medications that the applicant is taking and to counsel the airman regarding the use of medications. There are certain medications that, if used by the airman, the AME should not issue the applicant a medical certificate without clearance from the FAA. Other medications can seriously cause decrements in pilot performance and the AME should advise airmen not to fly while taking these medications (8). In 2017, there were 104 pilots, co-pilots, or flight instructors positive for one or more drugs. Of these 104 cases, 70 held a valid medical certificate, 6 were flying under BasicMed and 28 had no medical certificate or it was expired.

In this report, the drugs reported by the laboratory are categorized by the common or brand name, type of drug, and as potentially impairing. Drugs were identified as potentially impairing if the drug has an FDA warning regarding adverse effects associated with use that might impair a pilot's judgement, decision-making, or reaction time. It is recognized that other drugs in Table 10 and 11 may have impairing effects but have no official warning. Metabolites are also listed as potentially impairing, if the parent drug is identified as potentially impairing. All illegal substances are classified as potentially impairing.

Table 9. OTC Drugs Identified by the Laboratory in 2017.

Drug Identified	Common Brand or Trade Name	Drug Type	Potentially impairing
Acetaminophen	Tylenol, Paracetamol	Nonsedating Pain Reliever	
Albuterol	ProAir HFA	Asthma Medication	
Azacyclonol	Metabolite of Allegra	Nonsedating Allergy Medicine	
Cetirizine	Zyrtec	Sedating Antihistamine	✓
Chlorpheniramine	Chlor-Trimeton	Sedating Antihistamine	✓
Desloratadine	Clarinex, metabolite of loratadine	Nonsedating Antihistamine	
Dextromethorphan	Robitussin	Nonsedating Cold/Cough Medicine	
Dextrorphan	Robitussin and metabolite of dextromethorphan	Nonsedating Cold/Cough Medicine	
Diphenhydramine	Benadryl, Unisom, Nytol	Sedating Antihistamine	✓
Doxylamine	Aldex, Unisom, NyQuil	Sedating Antihistamine	✓
Famotidine	Pepcid	Antacid	
Fexofenadine	Allegra	Nonsedating Allergy Medicine	
Ibuprofen	Advil, Motrin	Nonsedating Pain Reliever	
Loratadine	Claritin	Nonsedating Antihistamine	
Naproxen	Naprosyn, Aleve	Nonsedating Pain Reliever	
Norpseudoephedrine	Metabolite of pseudoephedrine	Nonsedating Cold/Cough Medicine	
Omeprazole	Prilosec	Heartburn Medication	
Oxymetazoline	Oxymetazoline	Nonsedating Cold/Cough Medicine	
Pheniramine	Avil	Sedating Antihistamine	✓
Phenylpropanolamine	Phenylpropanolamine	Decongestant	
Pseudoephedrine	Sudafed	Nonsedating Cold/Cough Medicine	
Ranitidine	Zantac	Nonsedating Stomach Aid	
Salicylate	Metabolite of aspirin	Blood Thinner	

Table 10. RX Medications Identified by the Laboratory.

Drug Identified	Common Brand or Trade Name	Drug Type	Potentially impairing
Alfuzosin	Uroxatral	Urinary Retention	
Amlodipine	Norvasc	Cardiovascular	
Atenolol	Tenormin	Cardiovascular	
Atorvastatin	Lipitor	Cholesterol lowering	
Atropine	Atropen	Life-saving Medication	
Baclofen	Lioresal, Gablofen	Muscle Relaxant	
Benazepril	Lotensin	Cardiovascular	
Bupropion	Wellbutrin, Zyban	Antidepressant	✓
Bupropion Metabolite	Metabolite of Wellbutrin, Zyban	Antidepressant	✓
Carvedilol	Coreg	Cardiovascular	
Chlorthalidone	Thalitone, Hygroton	Cardiovascular	
Citalopram	Celexa	Antidepressant	✓
Clopidogrel	Plavix	Blood Thinners	
Colchicine	Colcrys, Mitigare	Anti-inflammatory	
Desipramine	Norpramin	Antidepressant	✓
Desmethylsertraline	Metabolite of Zoloft	Antidepressant	✓
Desmethylsildenafil	Metabolite of Revatio, Viagra	Erectile Dysfunction Drug	
Desmethylvenlafaxine	Metabolite of venlafaxine	Antidepressant	
Donepezil	Aricept	Neurologic Drug	✓
Etomidate	Amidate, Hypnomidate	Anesthetic	
Flecainide	Flecainide	Cardiovascular	
Fluconazole	Diflucan	Antifungal	
Fluoxetine	Prozac, Rapiflux, Sarafem	Antidepressant	✓
Furosemide	Lasix	Diuretic	
Gabapentin	Neurontin	Anti-Seizure	✓
Glyburide	Glynase	Diabetes Drug	
Hydrochlorothiazide	Microzide	Diuretic	
Hydroxychloroquine	Plaquenil	Anti-parasite	
Imipramine	Tofranil	Antidepressant	✓
Irbesartan	Avapro	Cardiovascular	
Laudanosine	Metabolite atracurium/cistracurium	Life-saving Medication	
Levamisole	Ergamisol	Antiparasitic Drg	
Levetiracetam	Keppra	Anti-Seizure	✓
Lidocaine	Lidoderm, Xylocaine	Cardiovascular	
Lisinopril	Prinivil, Zestril	Blood Pressure Medication	
Losartan	Cozaar	Cardiovascular	

Table 10 Continued. Rx Medications Identified by the Laboratory.

Drug Identified	Common Brand or Trade Name	Drug Type	Potentially impairing
Metoclopramide	Reglan	Acid Reflux Medication	
Metoprolol	Lopressor, Toprol	Cardiovascular	
Minoxidil	Loniten	Cardiovascular	
Desmethylcitalopram	Metabolite of Celexa	Antidepressant	✓
Nordiazepam	Nordaz, Metabolite of Valium	Benzodiazepines	✓
Norfluoxetine	Metabolite of fluoxetine	Antidepressant	✓
Nortriptyline	Pamelor, Aventyl	Antidepressant	✓
Norverapamil	Calan SR, Isoptin SR, Verelan	Cardiovascular	
Ondansetron	Zofran	Antinausea	
Paroxetine	Paxil	Antidepressant	✓
Phendimetrazine	Phendimetrazine	Anorectic	
Phenmetrazine	Preludin	Anorectic	
Phenobarbital	Solfoton	Anticonvulsant	✓
Phentermine	Adipex-P, Lomaira	Anorectic	
Pioglitazone	Actos	Diabetes Drug	
Pravastatin	Pravachol	Cholesterol lowering	
Primidone	Mysoline	Anticonvulsant	✓
Propofol	Diprivan	Anesthetic	
Propranolol	Inderol	Cardiovascular	
Quinapril	Accupril	Cardiovascular	
Quinine	Qualaquin, Quinamm	Antimalaria	
Rosuvastatin	Crestor	Cholesterol lowering	
Sertraline	Zoloft	Antidepressant	✓
Sildenafil	Revatio, Viagra	Erectile Dysfunction Drug	
Simvastatin	Zocor, FloLipid	Cholesterol lowering	
Sitagliptin	Januvia	Diabetes Drug	
Sotalol	Betapace, Sorine	Cardiovascular	
Tadalafil	Cialis, Adcirca	Erectile Dysfunction Drug	
Trazodone	Oleptro, Desyrel	Psychotropic Drug	✓
Triamterene	Dyrenium	Cardiovascular	
Valsartan	Diovan	Cardiovascular	
Vardenafil	Staxyn, Levitra	Erectile Dysfunction Drug	
Venlafaxine	Effexor	Antidepressant	✓
Verapamil	Calan SR, Isoptin SR, Verelan	Cardiovascular	
Warfarin	Coumadin	Blood Thinners	
Yohimbine	Aphrodyne, Yocon	Erectile Dysfunction Drug	
Ziprasidone	Geodon	Antipsychotic	✓

Table 11. CS Identified by the Laboratory in 2017.

Drug Identified by Laboratory	Common Brand or Trade Name	Drug Type	Potentially impairing
Alprazolam	Xanax	Benzodiazepines	✓
Amino-clonazepam (7-)	Metabolite of clonazepam	Benzodiazepines	✓
Amphetamine	Adderall, Metabolite of methamphetamine	Illicit	✓
Anhydroecgonine Methyl Ester	Metabolite of cocaine	Illicit	✓
Benzoylecgonine	Metabolite of cocaine	Illicit	✓
Butalbital	Fiorinal	Migraine Treatment	✓
Clonazepam	Klonopin	Benzodiazepines	✓
Cocaine	Cocaine	Illicit	✓
Dihydrocodeine	Metabolite of hydrocodone	Opioid	✓
Ecgonine Methyl Ester	Metabolite of cocaine	Illicit	✓
Fentanyl	Sublimaze	Opioid	✓
Hydrocodone	Lortab, Vicodin, Norco	Opioid	✓
Hydromorphone	Dilaudid, Metabolite of hydrocodone	Opioid	✓
Hydroxyalprazolam (Alpha-)	Metabolite of alprazolam	Benzodiazepines	✓
Hydroxymidazolam (Alpha-)	Metabolite of midazolam	Benzodiazepines	✓
Ketamine	Ketalar	Anesthetic	✓
Methamphetamine	Methamphetamine	Illicit	✓
Midazolam	Versed	Benzodiazepines	✓
Morphine	Avinza, Kadian, MS Contin	Opioid	✓
Norfentanyl	Metabolite of fentanyl	Opioid	✓
Norketamine	Metabolite of Ketalar	Anesthetic	✓
Oxazepam	Serax, Metabolite of Valium	Benzodiazepines	✓
Oxycodone	Percocet, Roxicet, Tylox	Opioid	✓
Oxymorphone	Opana, Metabolite of oxycodone	Opioid	✓
Temazepam	Restoril, Metabolite of Valium	Benzodiazepines	✓
Tetrahydrocannabinol	Marijuana, Marinol	Illicit	✓
Tetrahydrocannabinol Carboxylic Acid	Metabolite of marijuana	Illicit	✓
Zolpidem	Ambien	Sleep Aid	✓

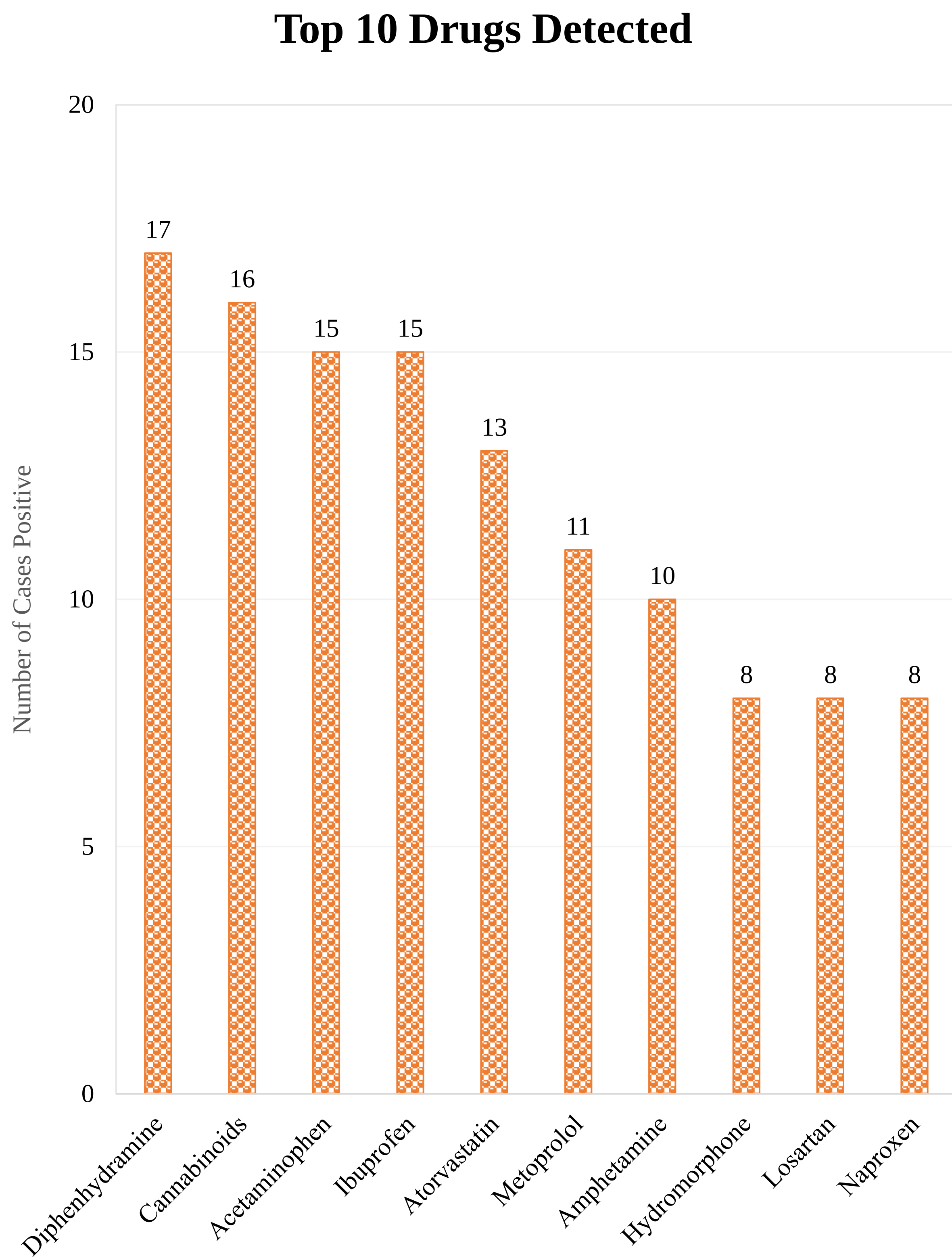

Figure 16. Most Common Drugs Detected.

Medical Certificate – Reporting of Drugs by the Airman

Airmen are required to report current medications, prescription and nonprescription, on each application for medical certification. According to the Guide for Aviation Medical Examiners (8,9), AMEs are advised about two medication issues:

1. Medications for which the AME should not issue (Do Not Issue – DNI) applicants without clearance from the FAA.
2. Medications for which the AME should advise the airmen not to fly (Do Not Fly – DNF) and provide additional safety information for the applicant.

In 2017, the laboratory received biological specimens from 215 pilots, co-pilots, and flight instructors, who had been involved in fatal accidents. Of these cases, 163 held a current medical certificate which required the airman to disclose medical conditions and current medications on their application. Sixty-six of the 163 airmen were positive for one or more drugs. The medications reported by the airman on the medical certificate application were compared to the toxicological findings for each airman. More than half (N=34) of the 66 airmen did not report any drug or medication. While 32 airmen reported taking a medication, the drug detected by the laboratory may not have been the drug the airmen reported.

Some medications detected by the laboratory in these 66 airmen fall under the DNI list identified in the FAA's Medications and Flying Brochure. Those detected include angina medications, anticholinergics (oral), controlled substances, diabetic medications, hypertensive (centrally acting), psychiatric or pscyhotropic medications, over-active-bladder medications, seizure medications, smoking cessation aids, and weight loss medications. The most common class of drugs detected by the laboratory and not reported by the airman on their application was controlled substances (N=16) and psychiatric or pscyhotropic medications (N=12).

Diphenhydramine

Diphenhydramine has been the most common drug identified by the laboratory for more than five years. Diphenhydramine is an antihistamine found in more than 50 different OTC and Rx medications, and is used to relieve symptoms of allergy, hay fever, and the common cold. Normal side effects of diphenhydramine use includes drowsiness, dizziness, headache, irritability, decreased coordination and dry mouth/nose/throat/eyes.

The normal dosage range for diphenhydramine is 25 to 50 mg every 4 – 6 hours. Single dosage and continuous dosage result in blood concentrations ranging from 50 – 100 ng/mL. Toxic levels range from 1000 – 2000 ng/mL, with comatose/fatal levels rising above 5000 ng/mL (10). Seventeen cases were positive for diphenhydramine in 2017, with a range of concentration 35 – 540 ng/mL. Sedative effects can be expected with blood concentrations above 50 ng/mL (11). Diphenhydramine found at sedating levels in pilots involved in civil aviation accidents is of concern to the FAA. Findings reported by the laboratory are used to create and refine policies issued by the FAA regarding use of the medication.

Use of more than the recommended amount of diphenhydramine can increase side effects to a noticeable degree and the individual may be perceived as drunk. Geriatric use of diphenhydramine can increase side effects at normal dosage (12). Diphenhydramine can cause central nervous system depression which can impair driving or the operation of heavy machinery; therefore, the FAA advises that pilots should wait 30 hours after the last dosage of diphenhydramine before piloting an aircraft (9).

In 2017, the laboratory reported diphenhydramine in 17 cases (Table 13). The average age of airmen who tested positive for diphenhydramine was 56.5 yrs (range: 28 – 89 yrs). Their fatal accidents were distributed throughout the year in 2017, with 3 accidents occurring in the spring, 5 in the summer, 5 accidents in the fall, and 4 fatal accidents occurring in the winter. The majority of these cases were also positive for substances other than diphenhydramine.

Table 12. Cases Positive for Diphenhydramine.

Case	Age	Date	Toxicological Findings
1	28	1/27/2017	Diphenhydramine, Acetaminophen, Ketamine, Norketamine
2	69	3/4/2017	Diphenhydramine, Atorvastatin, Clonazepam, 7-aminoclonazepam, Hydrocodone, Dihydrocodeine, Nortriptyline, Temazepam
3	51	4/18/2017	Diphenhydramine
4	67	4/24/2017	Diphenhydramine, Amphetamine, Clonazepam, 7-aminoclonazepam, Cocaine, Benzoylecgonine, Ibuprofen, Methamphetamine, Paroxetine, Phenylproanolamine, Quinine
5	62	6/11/2017	Diphenhydramine, Lidocaine, Ketamine, Norketamine
6	41	7/2/2017	Diphenhydramine
7	56	7/8/2017	Diphenhydramine, Chlorpheniramine, Loratadine, Desloratadine
8	51	8/8/2017	Diphenhydramine
9	28	8/16/2017	Diphenhydramine
10	29	9/5/2017	Diphenhydramine, Ibuprofen
11	73	9/28/2017	Diphenhydramine
12	66	10/4/2017	Diphenhydramine, Acetaminophen, Benazepril, Colchicine, Donepezil, Hydroxychloroquine, Naproxen, Rosuvastatin
13	60	10/17/2017	Diphenhydramine
14	89	11/22/2017	Diphenhydramine, Ibuprofen
15	65	12/16/2017	Diphenhydramine, Acetaminophen, Atorvastatin, Famotidine, Ranitidine, THCCOOH, 11-OH-THC
16	55	12/18/2017	Diphenhydramine, Hydromorphone, Lidocaine, Metoclopramide, Naproxen, Ondansetron, Oxycodone, Oxymorphone
17	70	12/23/2017	Diphenhydramine, Atorvastatin, Gabapentin, Loratadine, Losartan, Metoprolol, Sotalol, Warfarin

Marijuana

According to the National Institute on Drug Abuse (NIDA), 46.2% of individuals 26 or older have used marijuana in their lifetime (14). Marijuana is often used for its euphoric effects and medicinal properties, but numerous studies have shown that the use of marijuana impairs an individual's ability to efficiently complete everyday tasks by impairing memory and concentration and by increasing reaction time (4). An individual who operates a motor vehicle while smoking marijuana has a 2-fold increase of being involved in a motor vehicle accident (15). The impairment associated with marijuana use has become a worldwide public safety concern, especially due to the legalization for medicinal and/or recreational use in many states. As of December 2017, eight states (Alaska, California, Colorado, Maine, Massachusetts, Nevada, Oregon, Washington) and the District of Columbia had legislation allowing recreational marijuana use for residents 18 and older. The legal limit for THC while operating a motor vehicle varies by state from zero tolerance to per se laws of 2 or 5 ng/mL; however, the FAA has zero tolerance and does not permit safety-sensitive transportation employees, which includes pilots, to use marijuana recreationally or medicinally under 49 CFR Part 40, at 40.151(e) (16,17).

One of the primary cannabinoid compounds that is responsible for these side effects is Δ^9-tetrahydrocannabinol, or THC. This lipophilic compound is quickly metabolized into 11-hydroxy-tetrahydrocannabinol (11-OH-THC), which has also been found to be psychoactive, and further metabolized into the inactive metabolite 11-nor-Δ^9-carboxy-tetrahydrocannabinol (THCCOOH), which can be detected for an extended period of time. (4).

Marijuana use is determined by detection and reporting of THC and/or THCCOOH. THC/THCCOOH, also referred to as cannabinoids, was the most commonly found controlled substance by the laboratory in 2017 with 16 cases being positive for cannabinoids (Tables 13, 14). In December 2017, the laboratory added the detected and quantitation of 11-OH-THC and two cases had positive results in urine. The average age for these cases was 52.0 yrs (range: 20 – 70 yrs). For the 13 aviation cases that were positive for cannabinoids, 9 accidents occurred in the same state as the departure point (Table 14). Of all the departure locations, California was the only state at the time of the accident that had legalized marijuana for recreational purposes. Connecticut, Pennsylvania, and Arizona had legalized medical marijuana at the time of these accidents.

Table 13. Demographics for Marijuana-Positive Aviation Cases.

Case	Age	Gender	Month	Departure Point	Accident Location
1	36	M	January	Texas	Arkansas
2	61	M	January	California	California
3	56	M	January	Arizona	Arizona
4	55	M	March	California	California
5	60	M	April	South Carolina	South Carolina
6	35	M	May	Canada	New York
7	49	M	April	Missouri	Missouri
8	57	M	June	California	California
9	52	M	July	Pennsylvania	Pennsylvania
10	70	M	July	Georgia	Florida
11	65	M	July	Connecticut	New Hampshire
12	46	M	December	California	California
13	65	M	December	Indiana	Indiana

Table 14. Quantitative Results (ng/mL) of Marijuana-Positive Cases.

Case	THC					THCCOOH						
	Blood	Liver	Lung	Kidney	Muscle	Blood	Urine	Liver	Lung	Kidney	Muscle	Brain
1								82.7				2.2
2	ND					6.0						
3	10.9[a]		271.6			15.1[a]	1117.8		22.9			
4	4.0[a]	10.3				7.1[a]	305.3	51.4				
5	3.1					66.2						
6	7.1[b]					20.2[b]	2263.1					
7	18.5[a]	37.4				25.3[a]	308.7	343.8				
8	1.9[a]	21.8	666.3			19.3[a]		198.0	34.6			
9	17.9	11.4	106.9			1.9	19.2	19.6	2.5			
10		NS	D	NS			116.2	D	D	D		
11	19.1[a]					47.0[a]	1285.3					
12		NS			108.3		184.3	63.7			4.5	
13			296.5	366.0					76.6	451.1		
14	3.2[a]					49.1[a]						
15	ND					16.3[c]	84.5					
16	ND					2.4[a]	46.6					

[a] Cavity Blood, [b] Peripheral Blood, [c] Heart Blood, D = Detected, ND = Not Detected, and NS = Sample Not Suitable for Analysis

Methamphetamine/Amphetamine

Methamphetamine and amphetamine are central nervous system sympathomimetic stimulants that are used medically for the treatment of attention deficit hyperactivity disorder (ADHD), attention deficit disorder (ADD), narcolepsy, and weight control. Smoked, insufflated, injected, or swallowed, they are abused for stimulant effects that produce euphoria, alertness, feelings of well-being, and high energy. Mild side effects may include hyperactivity, rapid speech, and depressed appetite. Side effects that are more serious include hypertension, tachycardia, agitation, paranoia, and delusions. Higher doses may lead to life-threatening symptoms including hyperthermia, seizures, cardiorespiratory depression and death. Following methamphetamine use, both methamphetamine and amphetamine are detected in biological fluids and tissues. If only amphetamine is detected, the use of amphetamine or a drug that metabolizes to amphetamine (e.g., fenethylline, lisdexamfetamine) is suspected.

From 2008 - 2017, the laboratory reported 43 cases positive for methamphetamine and amphetamine, amphetamine only, or methamphetamine only (Figure 17). In 2017, there were 3 cases positive for methamphetamine with amphetamine, and 7 cases positive for amphetamine only. The total positives for the year (N=10) and the total amphetamine only cases for the year (N=3) were the most that the laboratory had reported in a year for the previous ten-year period.

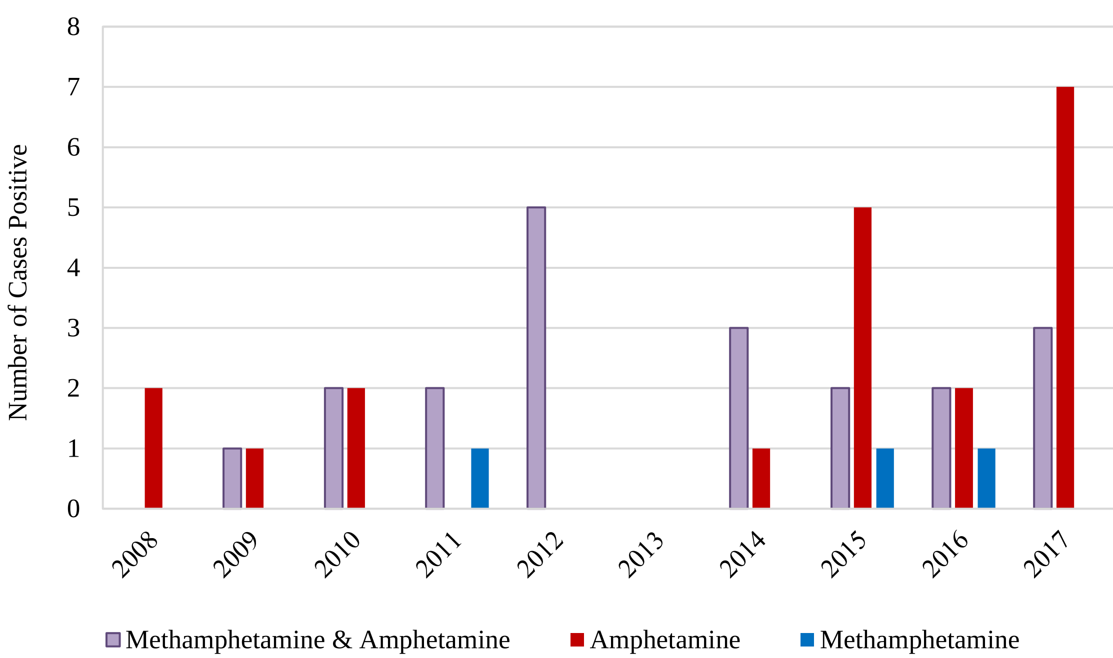

Figure 17. Ten-Year Period for Methamphetamine and Amphetamine Positive Cases.

Five-Year Comparisons

The AAM-600 Research Division, the NTSB, and the FAA use comparisons across a five-year period to monitor accident and drug trends for aviation accidents in the United States (19-22). The NTSB uses data about the prevalence of OTC, prescription, and illicit drug use from fatally injured pilots to recommend safety improvements for pilots. The following graphs and figures show the trends observed by the laboratory across the five-year period beginning in 2013 and extending through 2017.

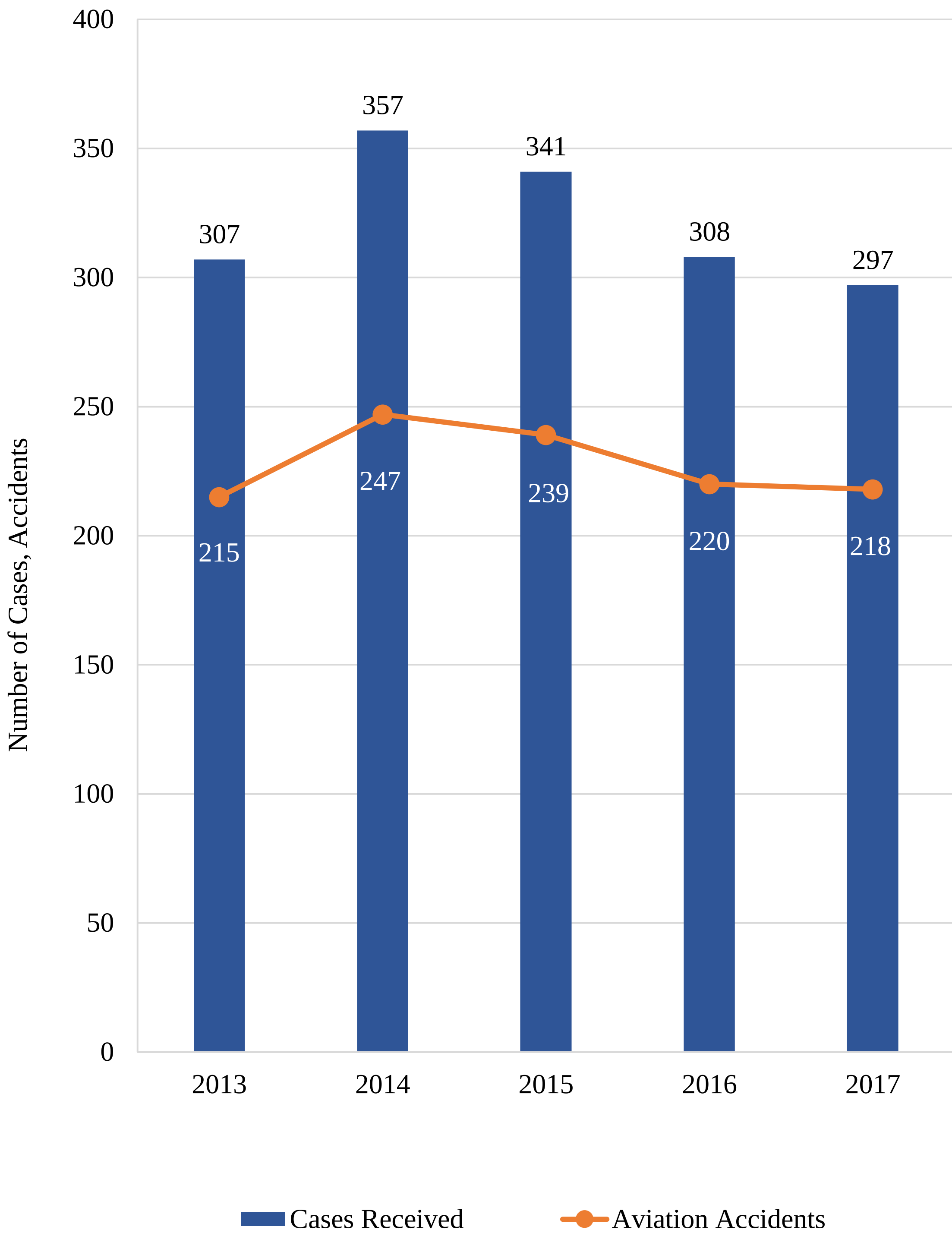

Figure 18. Five-Year Comparison: Number of Cases Received and Aviation Accidents.

Table 15. Five-Year Comparison: Types of Cases Received.

Mode of Transportation	2013	2014	2015	2016	2017
Aviation	294	336	325	285	271
Highway	3	13	5	12	8
Rail	1	1	10	8	10
Marine	7	7	0	1	1
Military	0	0	0	1	1
Parachutist	2	0	1	1	6
Total	**307**	**357**	**341**	**308**	**297**

Table 16. Five-Year Comparison: Number of Nonfatal Cases Received.

Mode of Transportation	2013	2014	2015	2016	2017
Aviation	16	23	25	12	7
Highway	2	3	3	6	4
Rail	1	0	3	2	4
Marine	6	7	0	1	0
Total	**25**	**32**	**31**	**21**	**15**

Table 17. Five-year Comparison: Descriptive Statistics for Age of all Cases Received.

Age Statistics	2013	2014	2015	2016	2017
Average	52.2	52.2	52.6	53.0	51.8
Median	54	53	54	56.5	54
Minimum	6	9	9	9	12
Maximum	82	88	89	90	90

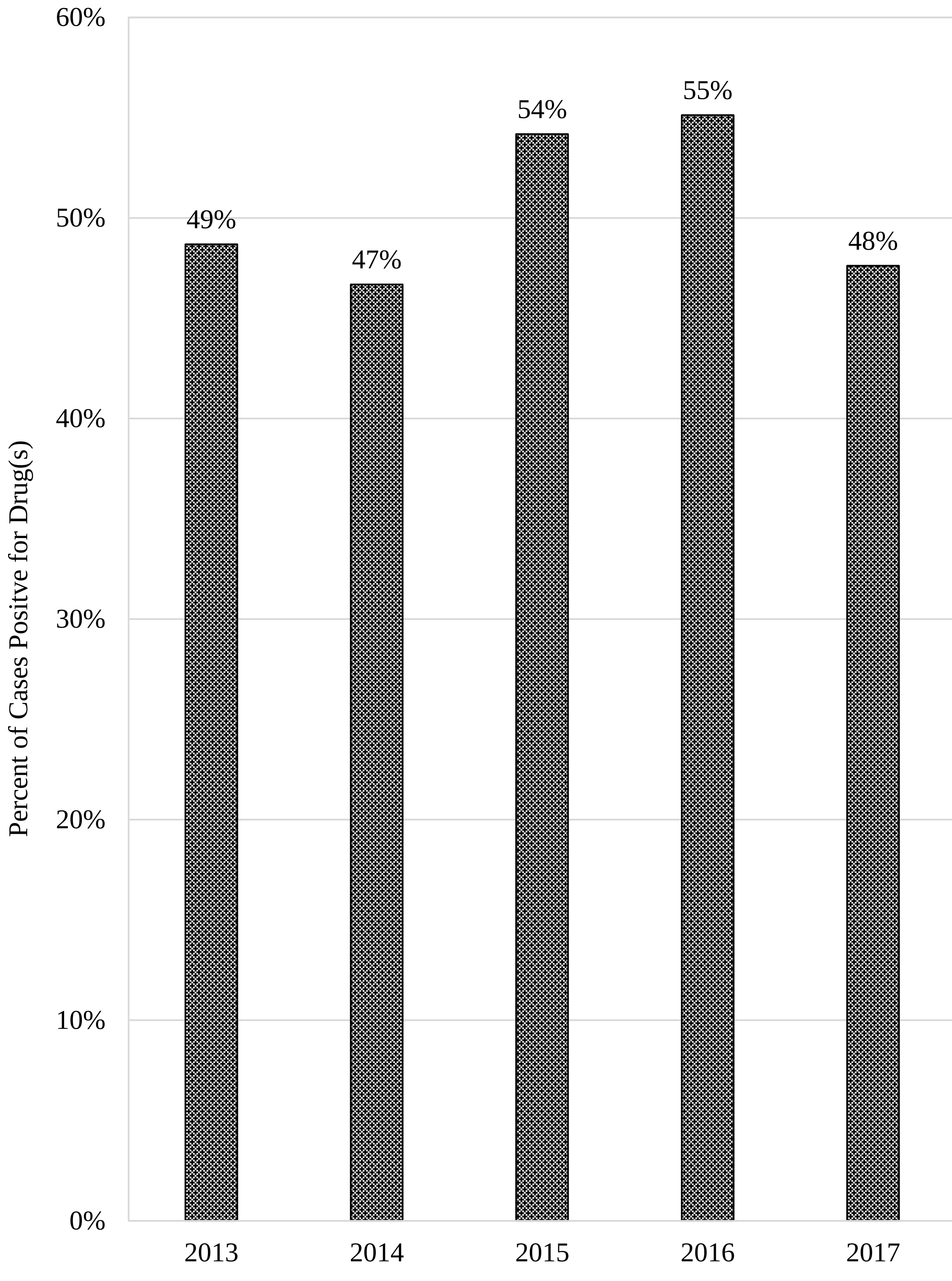

Figure 18. Five-Year Comparison: Percent of Cases Positive for at least One Drug.

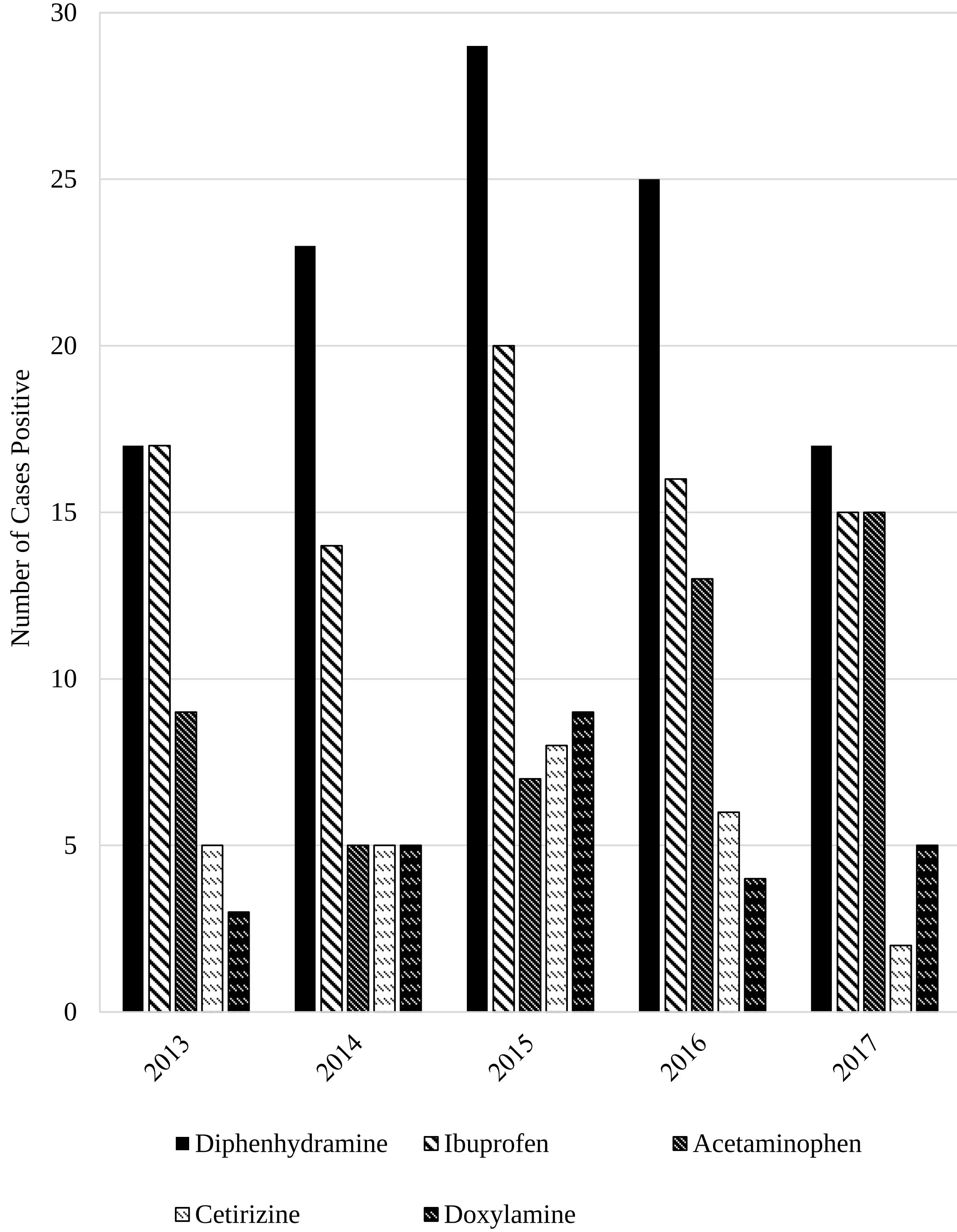

Figure 19. Five-Year Comparison: Prevalence of Common OTC Medications.

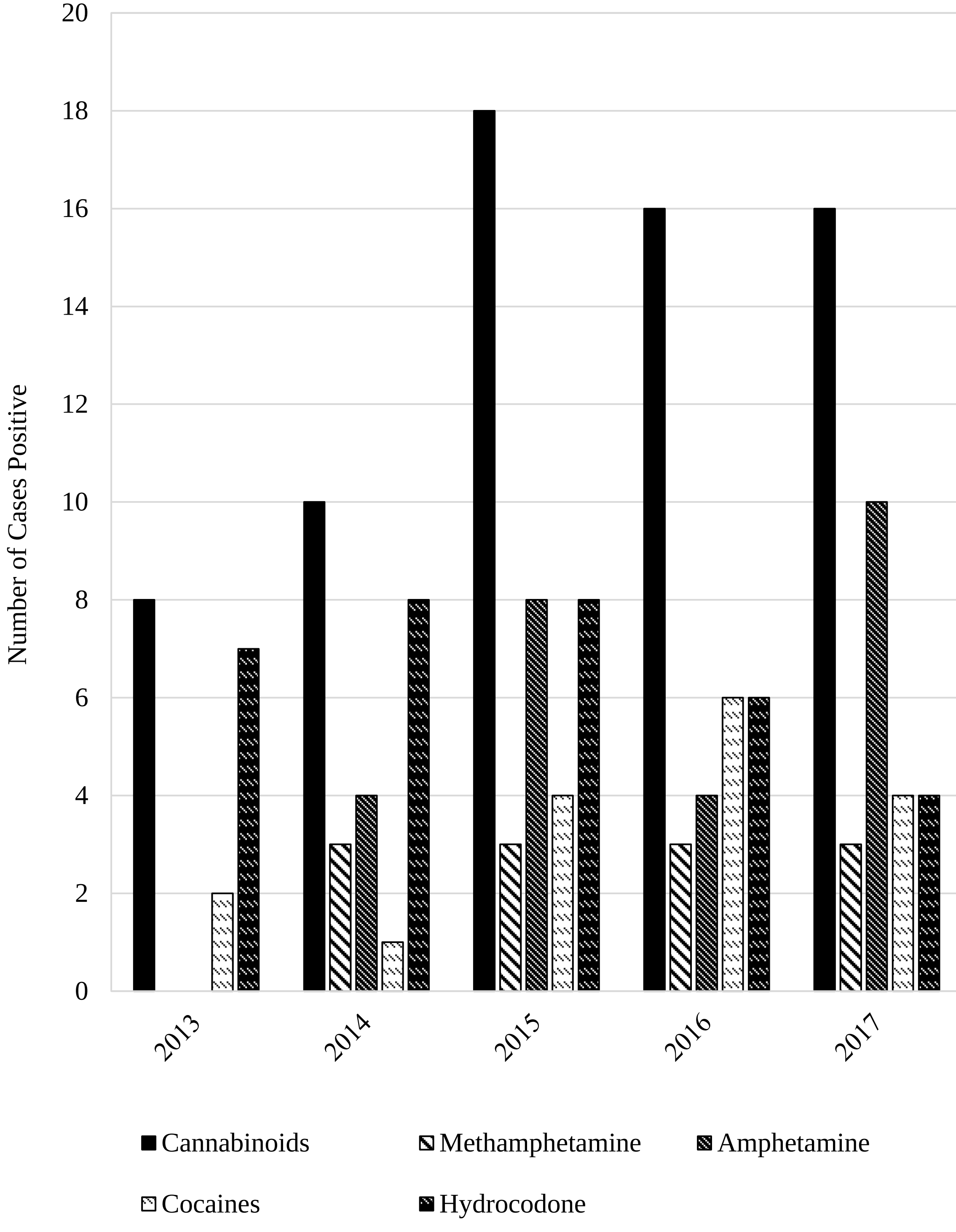

Figure 19. Five-Year Comparison: Prevalence of Common Controlled Substances.

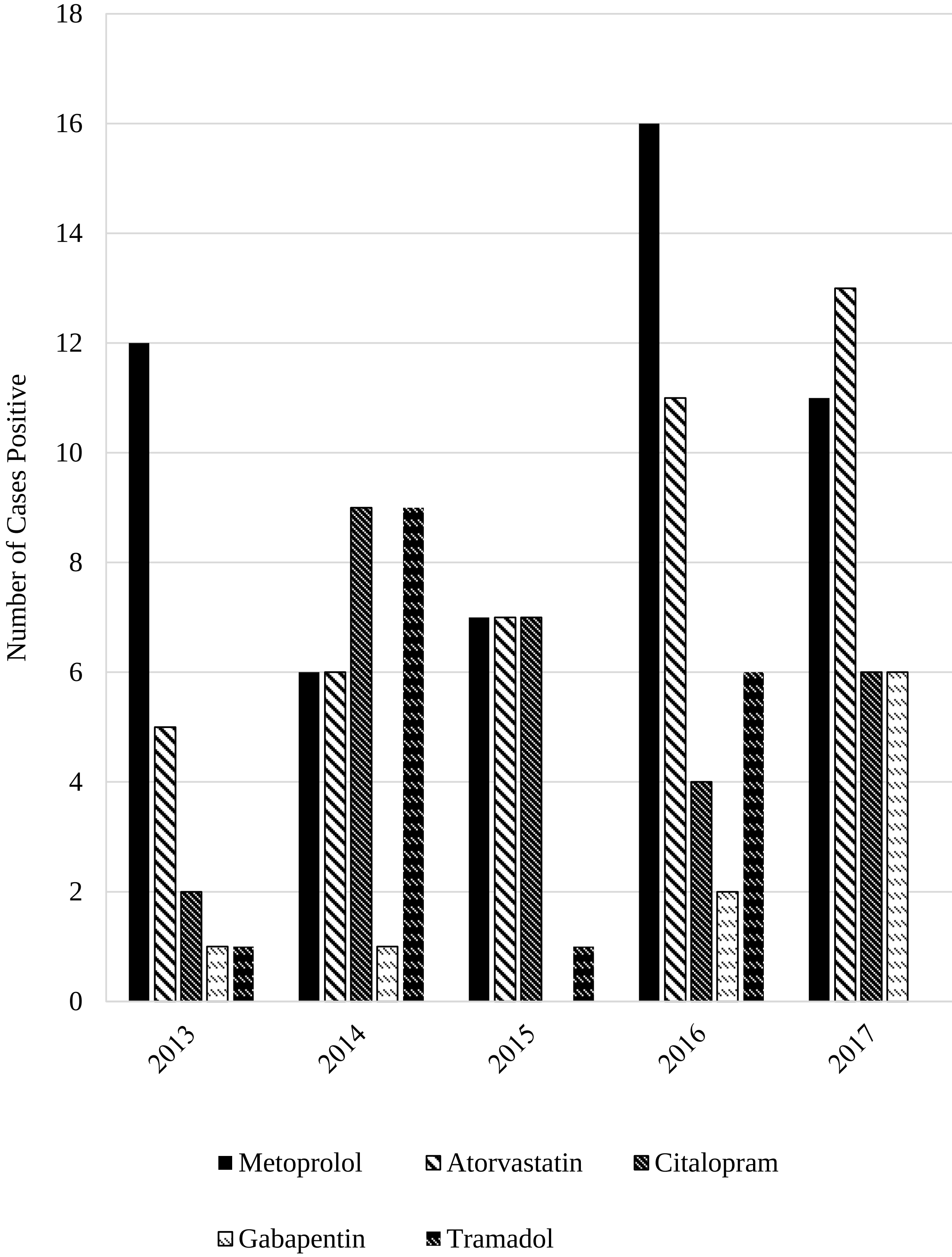

Figure 20. Five-Year Comparison: Prevalence of Common Rx Medications.

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