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23 years of toxicology testing fatally injured pilots: Implications for aviation and other modes of transportation

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ABSTRACT

Use of over-the-counter, prescription, and illicit drugs is increasing in the United States (US). Many of these drugs are psychoactive and can affect the user's ability to safely operate a vehicle. However, data about drug use by vehicle operators is typically limited to a small proportion of operators and a short list of drugs. For instance, required testing for commercial vehicle operators following most accidents is limited to a urine test for 11 drugs. By comparison, the Federal Aviation Administration (FAA), routinely tests fatally injured pilots' blood and tissues for hundreds of compounds. This study used the results from these tests to assess drug use in aviation.

Methods: Using matched data from the FAA's Civil Aerospace Medical Institute toxicology database and the National Transportation Safety Board's (NTSB's) aviation accident database, this study examined trends in the prevalence of over-the-counter, prescription, and illicit drugs identified in toxicology tests of fatally injured pilots between 1990 and 2012.

Cases that failed to match or where toxicology testing had not been performed were excluded. Pilots identified by the NTSB investigation as being the "flying pilot" at the time of the accident and results from blood or tissues were included. Toxicology results for ethanol and other alcohols were not included. Positive test results were categorized by drug type and potential for causing impairment. Analysis used SPSS Version 19.1 to perform linear by linear chi-squared statistics.

Results: The study included 6677 pilots or 87% of the eligible subjects. The large majority were male (98%) and flying general aviation operations (96%) at the time of their fatal accident. There were increasing trends in pilots' use of all drugs, potentially impairing drugs, drugs used to treat potentially impairing conditions, drugs designated as controlled substances, and illicit drugs. The most common potentially impairing drug pilots had used was diphenhydramine, a sedating antihistamine that is an active ingredient in many over-the-counter allergy formulations, cold medicines, and sleep aids in the US. Although evidence of illicit drug use was found only in a small number of cases, the percentage of pilots testing positive for marijuana use increased during the study period, mostly in the last 10 years.

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1. Introduction

In the United States (US), over-the past few decades the overall use societal use of drugs has been increasing, including over-the-counter and prescription medications as well as the illicit use of drugs (use of illegal drugs and the mis-use of medications). Between 1999 and 2011, an increasing proportion of adults reported taking prescription medication and the proportion that reported regularly taking at least five prescription drugs increased by over 80% (Kantor et al., 2015). Sales of prescription opioids quadrupled between 1999 and 2010 (Frenk et al., 2015). In addition, over-the-counter drug sales nearly tripled between 1990 and 2012 (Consumer Healthcare Products Association, 2015). A 2012 survey found that 23.9 million respondents had used illicit drugs during the previous month with an overall annual use rate of 9.2% among the US population ages 12–64, up from 8.3% in 2002 (SAMHSA, 2013). Marijuana was the most commonly reported illicit drug followed by the nonmedical use of prescription drugs, such as opioids and benzodiazepines. The highest illicit drug usage rates were reported in adults ages 18–25, but the trends indicated increasing illicit drug use rates for all age groups surveyed. For the 25–64 years old age group, deaths due to unintentional overdose (most commonly on prescription medications) now account for more deaths than motor vehicle crashes (Centers for Disease Control and Prevention, 2013).

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Although many medications and illicit drugs have significant psychoactive effects that may impair an individual's alertness, response time, executive functioning, or judgment, few analyses of the effects of use or misuse of medications or illicit drugs directly address their effects on the risk of crashes (Elvik, 2013; Avalos et al., 2014; Roth et al., 2014; Corsenac et al., 2012; Li et al., 2013).

In most modes of transportation, data about drug use by vehicle operators are limited to a small proportion of operators and a relatively short list of drugs. Among fatally injured non-commercial drivers, rates of toxicology testing vary among the States from 0 to 100%, and the types of specimens, specific tests performed, number of drugs that can be identified, and cut-off values for reporting positives vary widely (NHTSA, 2012). US federal regulation requires that commercial operators involved in serious transportation accidents have their urine tested for 11 specified substances (Title 49CFR Part 40). In contrast, since 1990 pilots fatally injured in domestic civil aviation accidents have routinely had toxicology testing that can identify approximately 1300 different substances.

The work reported here was performed as part of a study by the National Transportation Safety Board to examine trends in toxicology findings among fatally injured pilots (NTSB, 2014).

1.1. Background

In the US, pilots must have a medical certificate to fly (with some exceptions for gliders, balloons, and very light aircraft). However, federal regulations require all pilots to fly only when they are medically fit and to self-restrict from flying when they are aware of a medical condition or are using a drug that may negatively affect their performance. (Title 14Code of Federal Regulations Section 61.53(a)). In addition, pilots may not fly while using any drug that affects his or her "faculties in any way contrary to safety" (Title 14CFR Section 91.17).

The National Transportation Safety Board (NTSB) investigates all civil aviation accidents in the US to determine the probable cause of the accident and makes safety recommendations aimed at preventing a recurrence. Following its investigation into a fatal aviation accident in 1983 when a cargo aircraft crashed during a landing attempt at Newark International Airport, the NTSB determined physiological and psychological factors, including the use of marijuana and phenylpropanolamine, impaired the flight crew's decision-making and flying abilities (NTSB, 1984). As a result of that investigation and recommendations from the NTSB, the FAA established the capability to perform state-of-the-art toxicological tests on the blood, urine, and tissue of pilots involved in fatal accidents to determine the levels of licit and illicit drugs. Since 1990, the FAA toxicology laboratory has tested available biological specimens from every fatally injured pilot.

2. Methods

For this study, data from the NTSB's aviation accident database were matched with available testing results from the FAA's toxicology database for all domestic US civil aviation accident investigations between 1990 and 2012 in which the flying pilot died. Matching was performed using the accident date, location, and aircraft information. The combined dataset was used to assess the prevalence and patterns of over-the-counter, prescription, and illicit drugs used among study pilots. The available data were not sufficient to compare the drugs identified with toxicology tests to any drugs the pilots had reported to the FAA during medical certification exams.

Toxicology database records from the FAA include a unique case number for each person tested, the drug or substance identified, the bodily tissue or fluid tested, the type of test performed, and the quantity measured in the specimen, if appropriate. The FAA toxicology database also includes pilot and accident details that can be matched to NTSB aviation accident database records. SPSS Version 19 was used to perform analyses of independence and trends using the chi-squared statistic.

2.1. Inclusion criteria

Study cases were limited to pilots who died as a result of an aviation accident, were identified in the NTSB aviation accident database, and had available test results in the FAA toxicology database. For cases involving multi-pilot crews or with more than one pilot on board, only the pilot identified as the pilot flying the accident aircraft by the NTSB accident investigation was included in the study dataset to avoid including toxicology findings from pilots who were on board the accident aircraft but intentionally not flying the aircraft because of their drug use or medical condition. Pilot fatalities determined to have resulted from intentional acts were excluded from study analyses because they are not indicative of typical flight operations and are routinely excluded from safety measures such as accident rates.

This study included toxicology results from pilots' blood and tissue specimens only; substances identified in urine but not in other specimens were excluded. Toxicology results not related to drug use, such as carbon monoxide and cyanide levels, were also excluded. The FAA toxicology lab can identify more than 1300 substances, some of which are metabolites of other identified compounds. To avoid over-counting the number of drugs identified in a pilot, an equivalence list was developed for metabolites and any duplicates were removed. In addition, if a specific drug was identified in multiple specimens for a pilot, it was counted as a single positive finding. A copy of the list of equivalents is available in Appendix A. Reporting cut offs vary according to the type of body fluid or tissue tested and by the individual drug or metabolite identified. In general, cut offs are quite low—in the range of 1–10 ng/ml for many compounds.

Toxicology results for ethanol and other alcohols were excluded because ethanol and other alcohols can be produced by microbial action in body tissues after death (Kugelberg et al., 2007). In some cases, study pilots received postaccident medical care before they died. Drugs that are only available in intravenous forms and are routinely used during resuscitation attempts were excluded. In addition, any other drugs (such as morphine, fentanyl, or phenytoin (also known as Dilantin)) that may have been used during postaccident treatment were not analyzed in this study unless accident details indicated a pilot had used the drug(s) before the accident.

2.2. Drug categories

Drugs identified at least once by the FAA's toxicology tests were grouped based on their chemical structure, usual use, or effects into categories. Each was then classified as to whether or not it was: potentially impairing; indicated the presence of a potentially impairing condition; was identified as a controlled substance; or was illicit (see Appendix A for details). Potentially impairing drugs were defined as those that carry a warning regarding effects associated with routine therapeutic use (such as sedation, hallucinations, or behavior changes) that could impair a pilot's judgment, decision-making, or reaction time or those that carry a warning regarding driving or operating machinery. Illicit drugs were also included as potentially impairing.

Drugs identified as indicating a "potentially impairing condition" were limited to those used to treat neurologic conditions (such as epilepsy, migraine headaches, or Parkinson's disease), cardiovascular drugs primarily used to treat arrhythmias, opioid