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Alcohol Violations and Aviation Accidents: Findings from the U.S. Mandatory Alcohol Testing Program

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Abstract

Introduction: Mandatory alcohol testing has been implemented in the U.S. aviation industry since 1995. This study documents the prevalence of alcohol violations and the association between alcohol violations and aviation accidents among aviation employees with safety-sensitive functions.

Methods: Data from the random alcohol testing and post-accident alcohol testing programs reported by major airlines to the Federal Aviation Administration for the years 1995 through 2002 were analyzed. A violation was defined as an alcohol level of ≥ 0.04% or a refusal to submit to testing. Relative and attributable risks of accident involvement associated with alcohol violations were estimated using the case-control method.

Results: During the study period, random alcohol testing yielded a total of 440 violations, with an overall prevalence rate of 0.09% and a prevalence rate of 0.03% for flight crews. Alcohol violations were associated with an increased yet not statistically significant risk of accident involvement (odds ratio 2.56, 95% confidence interval 0.81–7.08) and were attributed to 0.13% of aviation accidents.

Discussion: Alcohol violations among U.S. major airline employees with safety-sensitive functions are rare and play a negligible role in aviation accidents.

Keywords

accident; alcohol; aviation; epidemiology; occupational safety

The relationship between alcohol consumption and occupational mishaps has been studied extensively. Much of the experimental research on alcohol's effects on safety performance was conducted in the aviation field using flight simulators. Based on a review of over 100 studies, Cook (4) summarized the specific domain-relevant functions impaired at different blood alcohol concentrations (BACs). Alcohol at the level between 0.01% and 0.03% can impair the performance of flight tasks such as terrain separation, aircraft descent, and angular acceleration (2,9). Piloting skills impaired at modest alcohol levels (0.03% to 0.05%) include tracking radio signals, managing heavy workload conditions, vectoring airport traffic control, observing and avoiding air traffic, and performing linear acceleration (4). In an experiment conducted in actual flights involving 16 instrument-rated pilots, Billings et al. (2) found that major performance errors increased progressively with BACs and that when BACs reached the level of 0.12%, over 50% of the pilots lost control of the aircraft.

In addition to the acute effects, alcohol may have significant carry-over effects (also called “late effects,” “hangover effects,” and “post-alcohol impairment”) on piloting skills. One of the well-documented carry-over effects of alcohol is positional alcohol nystagmus, which can occur 34 h after alcohol consumption (11) and be aggravated by high altitude and angular acceleration (8). Positional alcohol nystagmus has been implicated in several aviation crashes

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and remains a concern for flight safety (5). Other carry-over effects on performing flight tasks, such as takeoff heading, landing heading, instrument landing system localizer, and glide-slope deviation, have been reported in pilots 8 to 14 h after they had consumed alcohol (13,14).

While experimental research is instrumental for understanding alcohol's effects on safety performance, epidemiological studies have provided empirical data for delineating the role of alcohol in aviation accidents. Since the 1964 landmark report by Harper and Albers (6), in which over one-third of the pilots who were fatally injured in general aviation accidents and tested for alcohol had elevated BACs, numerous studies have documented the magnitude and temporal trend of alcohol involvement in fatal aviation accidents. Due to intensified education programs and policy interventions, the prevalence of alcohol involvement in fatal general aviation accidents has decreased considerably in the past four decades, from over 30% in the early 1960s to about 8% in the 1990s (3,6,10). It is noteworthy that alcohol-related accidents are largely limited to general aviation. Alcohol as a contributing factor has not been implicated in any fatal accident of U.S. major airlines and in less than 3% of fatal commuter air carrier and air taxi accidents (1,3). Most studies examining the role of alcohol in aviation accidents are based on post mortem toxicological data. Information about the prevalence of alcohol violations among pilots who are not involved in accidents or who are involved in nonfatal accidents has been lacking. As a result, the causal association between alcohol violations and aviation accidents has not been established based on empirical data.

Following the Omnibus Transportation Employee Testing Act of 1991, the Department of Transportation (DOT) established comprehensive protocols for drug and alcohol testing [Procedures for Transportation Workplace Drug Testing Programs (49 CFR Part 40)]. The DOT regulation entails the standards and requirements on all aspects of drug and alcohol testing. Individual operational agencies of the DOT issued additional rules to facilitate the implementation of 49 CFR Part 40 in the respective industries. Consequently, the Federal Aviation Administration (FAA) established the Anti-drug and Alcohol Misuse Prevention Programs for Personnel Engaged in Specified Aviation Activities. As part of the federal aviation regulations, the alcohol misuse prevention program (Appendix J to 49 CFR Part 121) is designed to “help prevent accidents and injuries resulting from the misuse of alcohol by employees who perform safety-sensitive functions in aviation.” In the alcohol misuse prevention program, the FAA has specified the rules and procedures for alcohol testing in the aviation industry. Major airlines (Part 121 certificate holders), commuter air carriers and air taxi operators (Part 135 certificate holders), and air traffic control facilities that are not operated by the FAA are required to implement the alcohol misuse prevention program in employees with safety-sensitive functions. Employees with safety-sensitive functions refer to flight crewmembers, flight attendants, flight instructors, aircraft dispatchers, aircraft maintenance personnel, ground security coordinators, aviation screeners, and air traffic controllers. These employees are subject to a variety of alcohol testing programs, including random testing and post-accident testing. For random testing, employers are required to select and test a minimum percentage of employees with safety-sensitive functions each year. The minimum annual testing rate by default is 25%, which can be changed by the FAA based on the violation rate detected through random alcohol testing in the past year for the entire industry. Actual minimum annual testing rates designated by the FAA were 25% for the years 1995–1997 and 10% for the years 1998–2002. All employees whose performance of a safety-sensitive function may have contributed to the accident are required to submit to alcohol testing within 2 h of the accident. An accident is defined as an event associated with the operation of an aircraft resulting in any loss of human lives, serious injury, or substantial damage to the aircraft. Using data from mandatory alcohol testing programs, this study aimed to examine the prevalence of alcohol violations and the relationship between alcohol violations and accident involvement in flight crew and other aviation employees with safety-sensitive functions working for major airlines.

METHODS

Data for this study came from the annual reports of alcohol testing results submitted to the FAA by major airlines. Alcohol tests under the federally mandated testing programs are conducted by certified technicians using devices approved by the National Highway Traffic Safety Administration. The FAA defines a positive result as an alcohol concentration ≥ 0.02 g $\cdot$ 210 L^{-1} of breath, which is equivalent to a BAC $\geq 0.02\%$. Employees who test positive are required to submit to a confirmation test within 30 min of the initial screening test. A violation is defined as an alcohol concentration of 0.04% or greater as indicated in both the screening and confirmation tests. Refusal to submit to a test is treated as a violation. Information for each test is recorded by an alcohol-testing technician using standard procedures and data forms. Employers must maintain alcohol-testing records for at least 5 yr and submit annual reports of alcohol testing results to the FAA according to the alcohol information management system instructions.

The outcome measure of primary interest is the violation rate, a percentage computed by dividing the number of violations detected in random alcohol testing by the total number of random alcohol tests. The violation rate from random alcohol testing is a measure of the point prevalence of alcohol violations among aviation employees. Chi-square tests were used to assess the statistical significance of differences in violation rates across occupations and time periods.

Data from random testing and post-accident testing provided a unique opportunity for assessing the causal relationship between alcohol violation and the risk of accident involvement. The association between alcohol violations and aviation accidents was assessed using the case-control method, with employees who were tested post-accident serving as the cases and those who were selected for random testing as controls. The association between alcohol violations and accident involvement was measured by the odds ratio (OR), computed based on the following formula (12):

$$\text{Odds Ratio} = (a \times d) / (b \times c), \quad (1)$$

where a denotes the number of violations detected in post-accident testing; b, the number of violations in random testing; c, the number of post-accident tests that did not show a violation; and d, the number of random tests that did not show a violation. The OR is an approximate estimate of the risk ratio if the data meet two conditions: unbiased subject selection for alcohol testing and the rarity of the outcome (i.e., accident). The first condition requires that all employees with safety sensitive functions have the same chance of being selected for random testing and all employees who are involved in accidents have the same chance of being selected for post-accident testing. The second condition entails that the occurrence of aviation accidents is a rare phenomenon.

The role of alcohol violations in aviation accidents was further examined by estimating the attributable risk in the population (7) using the formula below:

$$\text{Attributable Risk} = [p \times (OR - 1)] / [1 + p \times (OR - 1)], \quad (2)$$

where p is the violation rate detected in random testing. The attributable risk represents the proportion of all aviation accidents that are due to alcohol violations. The study protocol was reviewed and approved via exemption by the institutional review board of the Johns Hopkins University School of Medicine.

RESULTS

During 1995 through 2002, major airlines reported a total of 511,745 random alcohol tests to the FAA. Of these tests, 329 had BACs of $\geq 0.04\%$ and 111 were not carried out because the

employees refused to be tested, yielding an overall prevalence rate of 0.09%. Prevalence rates of alcohol violations varied significantly with occupation, ranging from 0.03% for flight crews to 0.19% for non-federally employed air traffic controllers (Table I; $p < 0.001$). Because of their large populations, maintenance personnel and flight attendants together accounted for 78% of all alcohol violations detected through random testing. The prevalence of alcohol violations detected from random testing increased from 0.07% during 1995–1997 to 0.11% during 1998–2002 ($p < 0.001$) when the annual testing rate decreased from 25% to 10% (Fig. 1).

The association between alcohol violation and accident involvement was assessed by contrasting random testing data with post-accident testing data. Of the 1821 post-accident tests performed during the study period, 4 (0.22%) had BACs of $\geq 0.04\%$. The estimated OR of accident involvement associated with alcohol violations was 2.56 (95% confidence interval 0.81–7.08). Given the estimated OR (2.56) and violation rate from random testing (0.09%), the proportion of aviation accidents attributable to alcohol violations was estimated as 0.13%.

DISCUSSION

Substance abuse has long been a concern for occupational safety. As part of the "War on Drugs" effort, the federal government established the Drug Free Work-place Program in 1986, making provisions for testing employees with safety-sensitive functions for illicit drugs (i.e., marijuana, cocaine, amphetamines, phencyclidine, and opiates). Alcohol, however, was not included in the drug-testing program until 1995, when the Omnibus Transportation Employee Testing Act of 1991 was implemented. Adding alcohol to the drug-testing program was prompted by a few highly publicized transportation accidents in which alcohol was implicated as a contributing factor (e.g., the 1989 Exxon Valdez oil spill in Alaska, the 1990 conviction of three Northwest Airlines pilots, and the 1991 New York subway crash).

The FAA-directed alcohol-testing programs cover over half a million employees in the aviation industry. Our analysis of the alcohol testing data sheds light on the magnitude of alcohol violations in U.S. major airline employees with safety-sensitive functions. The results of the study indicate that alcohol violations among U.S. major airline employees with safety-sensitive functions are rare, at the rate of 0.09%. The prevalence of alcohol violations is especially low among flight crewmembers.

Random testing serves primarily as a preventive measure through its deterrent effect, which is presumably a function of the testing rate. Although the exact relationship between testing rate and deterrent effect is unknown, it is conceivable that the deterrent effect would increase as the testing rate rises, and vice versa. The alcohol testing data from the FAA have made it possible to empirically assess the relationship between testing rate and the deterrent effect. Results of this study indicate that lowering the annual testing rate from 25% to 10% was associated with a significant increase in alcohol violations. While the finding affirms that the deterrent effect of random testing diminishes as the testing rate decreases, it is probable that a small portion of the observed increase in alcohol violations during 1998 and 2002 was due to confounding effects from extraneous variables, such as demographic changes in aviation employees. In the absence of data on employee characteristics and drinking behavior, it is impossible to make an inference with certainty that the increase in violation rates during 1998 and 2002 was caused solely by the reduction in annual testing rates.

In addition to its purported deterrent effect, random testing provides much needed data for answering important research questions. In this study, analysis of random testing data helped us estimate the point prevalence rates of alcohol violations among U.S. major airline employees with safety-sensitive functions by occupation and over time. The results of the study are

valuable for monitoring alcohol violations in aviation employees and for program evaluation and policy reform. Moreover, the random testing data fill an important information gap for assessing the role of alcohol violations in aviation accidents. By contrasting the random testing data with post-accident testing data, we estimated that the odds of accident involvement for employees with BACs of ≥ 0.04% are more than twice the odds for their sober counterparts. The estimated OR did not reach statistical significance mainly due to the modest number of post-accident alcohol tests. The relative contribution of alcohol violations to aviation accidents as measured in population attributable risk, however, is very small; we estimate that only 0.13% of all aviation accidents were attributed to alcohol violations.

This study has several data limitations. First, the findings are limited to aviation employees of major airlines covered by the mandatory alcohol testing program and thus may not be applicable to other aviation employees (e.g., air traffic controllers employed by the FAA) and other flight operations (e.g., air taxis and general aviation). Second, the annual reports of alcohol testing results compiled by the FAA are aggregated by occupation and testing program. Demographic data such as employee's age, gender, and race would be valuable for understanding the epidemiologic patterns of alcohol violations but are lacking. Finally, alcohol violations are defined based on BACs ≥ 0.04% or employee's refusal to submit to testing. Information about the actual alcohol testing results for the violation cases is not available in the FAA's data system. Including the refusals in the violation counts may also lead to an overestimation of the prevalence rate of alcohol violations.

Despite these limitations, this study provides important data for understanding the magnitude of alcohol violations in U.S. major airline employees with safety-sensitive functions. The heightened relative risk of accident involvement accorded to alcohol violations suggests that alcohol misuse appears to be a valid risk factor for aviation accidents. The tiny population attributable risk of alcohol violations indicates that, in reality, alcohol misuse as a contributing factor has been virtually eradicated from U.S. major airline accidents. The FAA's alcohol misuse prevention program is likely to have played a role in effectively maintaining the prevalence of alcohol violations in aviation employees at very low levels and minimizing alcohol involvement in aviation accidents.

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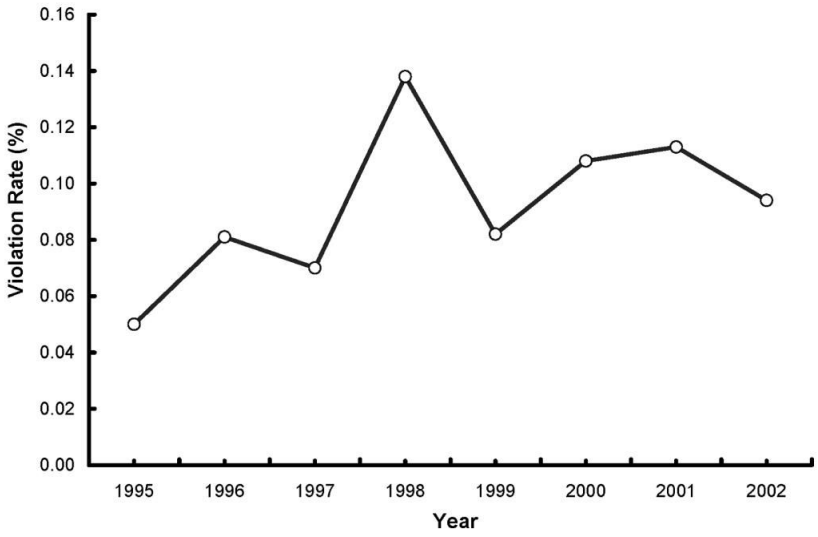

Fig 1.
Prevalence rates of alcohol violations among U.S. major airline employees with safety-sensitive functions, 1995–2002.

TABLE I

PREVALENCE RATES OF ALCOHOL VIOLATIONS BY OCCUPATION AMONG U.S. MAJOR AIRLINE EMPLOYEES WITH SAFETY-SENSITIVE FUNCTIONS, 1995–2002.

Occupation	Number of Random Tests*	Number of Violations	%
Flight Crew	108,407	29	0.03
Flight Attendants	142,068	82	0.06
Flight Instructors	2,944	2	0.07
Aircraft Dispatchers	15,678	13	0.08
Maintenance Personnel	200,602	173	0.09
Aviation Screeners	22,537	15	0.07
Ground Security Coordinators	18,461	13	0.07
Air Traffic Controllers	1,048	2	0.19
TOTAL	511,745	329	0.06

* Excluding 111 refusals to submit to testing. Information about occupation was unavailable for these refusals.