Second, estimates of %COHb[††], rather than direct measurements (blood analysis), were used to provide indications of %COHb levels. Finally, the convenience sampling method used for vacationers did not provide data to estimate the number of vacationers with increased CO levels.

During the 2003 Memorial Day weekend evaluations, employees with an estimated %COHb of $\geq$5% were advised to exchange jobs with a co-worker assigned away from the channel area; those with $\geq$10% were required to remove themselves from the area immediately and, if symptomatic, advised to seek medical attention. Protective measures recommended for workers also should be recommended for vacationers until measures to reduce ambient CO exposures in the channel are implemented (*6*). Exhaled breath measurements should be used to screen vacationers located in areas with high ambient CO during days of heavy boat use in the channel (particularly during calm wind conditions) (*7,8*).

Persons in communities with lakes and rivers where boats congregate in large numbers should be aware of the dangers of open air, boat-related CO poisoning and the need to evaluate CO exposures during high-traffic periods. Boat manufacturers should improve emission controls to reduce consumer CO exposure. The risk for boat-related CO poisonings should be reduced by considering measures such as limiting the number of boats in certain areas; enforcing a "no idle" policy when boats are stationary; and warning vacationers of 1) the signs and symptoms of CO poisoning; 2) the hazards related to occupying the back of the boat any time the motor is running; and 3) the risk for CO poisoning in areas of boat congestion, especially during calm weather conditions.

[††] An exhaled CO concentration (in ppm) is converted to an estimated level of %COHb by either a calculation or conversion chart. Estimates of %COHb were derived from the ACGIH formula for employee participants and from a conversion chart for vacationers.

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Work-Related Pilot Fatalities in Agriculture — United States, 1992–2001

Aircraft often are used in agriculture to apply pesticides, herbicides, or fertilizers. During 1992–2001, a total of 141 persons died in agriculture-related plane crashes. To characterize aviation fatalities in agriculture, CDC analyzed data on fatal injuries to pilots working in U.S. agriculture during 1992–2001. This report summarizes the results of that analysis, which indicated that agricultural pilots are at increased risk for fatal injury compared with pilots in all other industries. The agriculture aviation profession continues to work to reduce fatalities by recommending continual skill development and by offering training to aerial application pilots.

CDC analyzed data for 1992–2001 (the most recent years for which data are available to CDC) from the Bureau of Labor Statistics' Census of Fatal Occupational Injuries (CFOI). Using death certificates, workers' compensation reports, state and federal agency records, and other supporting documents, CFOI collects data on all fatal occupational injuries in 50 states* and the District of Columbia to determine worker demographics and the circumstances and causes of the fatality. Cases were selected if they occurred in agriculture (Standard Industrial Classification 0110–0783), the occupation was pilot/navigator (Bureau of Census code 226), and the event was an aircraft crash (Occupational Injury and Illness Classification event codes 4600, 4610, or 4690). Fatality rates based on flight hours for 2000 were calculated by using estimates reported by the Federal Aviation Administration (FAA) of hours flown in aerial applications and all other types of flights.

During 1992–2001, a total of 141 pilots/navigators in the agricultural industry died in aircraft-related events. All were male; median age was 44 years. The majority (63%) of cases occurred during May–August. A total of 70 (50%) cases occurred in Arkansas, California, Louisiana, and Texas. Of the 141 fatalities, 100 (71%) were in fixed-wing aircraft, 22 (16%) were in helicopters, and 19 (13%) were in unknown aircraft types. A total of 71 (50%) cases occurred in companies employing $\leq$10 persons; 42 (30%) persons were self-employed or worked in a family business. In 46 (33%) cases,

* Data files provided by the Bureau of Labor Statistics CFOI to CDC do not include New York City.

the company size was not reported. Not all fatalities occurred among pilots; in addition, 31 agricultural workers died as farm workers, farmers, passengers, ground crew, or mechanics and were not included among the 141 pilots/navigators described in this report.

In 2001, the rate of pilot/navigator fatalities in agriculture (one death per 100,000 hours flown) was three times the rate for pilots in other industries. Rates are based on 1,038,346 agricultural aerial application hours and 25,978,449 hours flown by pilots/navigators in all other types of flights in 2001 (*1*).

Narrative descriptions of fatal incidents occurring in agricultural operations were reviewed in the National Transportation Safety Board's (NTSB) Accident Database and Synopses (*2*). The following case reports are representative of fatal crashes in agriculture.

Case Reports

Case 1. In March 1998, a commercial-certified pilot aged 50 years with 14,246 hours of flight time left a private airfield in an agricultural aircraft with a load of defoliant at 5:54 a.m. He took off in clear weather and headed toward a field 3 miles away. A witness reported a rapidly developing fog near the airfield at approximately 5:55 a.m. At 5:58 a.m., the aircraft crashed into trees and hit the ground. NTSB determined that the probable cause was flight into adverse weather conditions (fog), resulting in loss of control caused by spatial disorientation.

Case 2. In July 2000, at approximately 7:45 p.m., an agricultural aircraft struck the ground, killing the commercial-certified pilot. After leaving a grass runway with a full load of herbicide, the pilot had begun spraying a field and made several passes over the area. During a turnaround maneuver, the aircraft climbed and turned to the right; however, the plane did not level out to continue the next pass but instead lost altitude and struck the ground. A satellite tracking device recovered after the crash indicated that most turns were made over a 1,000-foot diameter, but the final one was considerably sharper, with only a 660-foot diameter. NTSB determined that the probable cause was the pilot's failure to maintain airspeed during the sharp turn.

Case 3. In July 1999, at approximately 10:50 a.m., an agricultural aircraft was loaded with fuel and chemical product. The pilot reported that he was taking only a partial fuel load because temperatures were near 80° F (27° C), and the increased heat would reduce aircraft flight performance. The planned application was at 3,000 feet above sea level and required a course reversal over an abruptly rising hill. Witnesses reported that the aircraft made one pass but did not return over the field, and soon after, they saw black smoke rising from the direction of the aircraft's last sighting. The commercial-certified pilot was killed, and the plane was consumed by fire. NTSB determined that the probable cause was a failure to maintain airspeed during course reversal. High temperatures and hilly terrain were contributing factors.

Case 4. In June 2003, at approximately 9:15 a.m., an agricultural helicopter left a local airport to apply product to a cotton field. At approximately 10:00 a.m., after all of the product had been dispensed, the helicopter struck a power-transmission line 30 feet above the ground. The helicopter crashed to the ground and was consumed by the post-impact fire. The pilot had 3,714 total flight hours, of which 1,117 were in helicopters. The probable cause was the pilot's failure to maintain clearance from wires during the flight.

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Editorial Note: Of the 1,190 pilot fatalities that occurred in aircraft-related events during 1992–2001, a total of 141 (12%) involved persons engaged in agriculture. In 2002, the fatality rate per 100,000 workers for pilots and navigators (70) was the third highest in the United States, far exceeding the overall occupational fatality rate of four per 100,000 persons (*3*). Only timber cutters and persons engaged in fishing occupations had higher rates (118 and 71, respectively).

As with other agricultural occupations, pilots are exposed to several hazards, variable weather conditions, and time-dependent tasks. Aircraft performance is affected by density altitude, which is a function of atmospheric pressure, temperature, and altitude. High altitudes, high temperature, and humid air adversely impact aircraft performance. Warm, humid air requires longer take-off distances and results in a reduced rate of climb. Low-level turbulence, wind gusts, and the possibility of fast-forming fog present continual challenges to agricultural pilots who maneuver aircraft close to the ground. Nearly one quarter of aerial-application crashes were related to density altitude (*4*).

Agricultural aircraft also are under stress from high-load factors (gravitational forces). Guidelines regarding spray drift and buffer zones (e.g., setbacks around sensitive areas such as water, aquatic habitats, and residential areas) require pilots to maneuver planes quickly and precisely to avoid off-target spray. Obstructions (e.g., antennas, overhead power lines, trees, fences, and towers) pose additional hazards for agricultural pilots. During 1992–1998, one third of pilot fatalities in the crop service industry resulted from aircraft contact with a tower, power line, or tree (*5*).

The findings in this report are subject to at least four limitations. First, CFOI might not capture all relevant fatalities; incidents might have been coded in CFOI into an industry other than agriculture. Second, neither pilot experience (i.e., hours flown in aerial applications) nor pilot certification levels could be determined consistently. Third, fatality rates were calculated for only 1 year. Finally, hours flown were based on survey responses, which are subject to sampling error and other biases (e.g., subjective recall) (*6*).

Companies engaged in agricultural aerial applications should assess risks and safety measures carefully and provide pilots with periodic safety training. Self-employed pilots must exercise constant vigilance regarding safety risks and actively seek out periodic safety training. Several risk-assessment tools and training resources are available, including FAA's 1) checklist to help in risk assessment and risk reduction of controlled flight into terrain (*7*) and 2) self-administered training tool, "Aerial Decision Making," which systematically defines mental processes used by pilots to choose the best action for a given set of circumstances and outlines steps for good aeronautical decision making (ADM) (*8*). These steps include assessing personal attitudes, learning behavior modifications, recognizing and coping with stress, developing risk-assessment skills, using all available resources, and self-evaluating ADM skills. In addition, the Professional Aerial Applicators Support System, sponsored by the National Agricultural Aviation Association Research Education Foundation, offers skill development courses for aerial application pilots (available at http://www.agaviation.org).

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