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Guidelines Enable Health Authorities to Assess Risk Of Tuberculosis Transmission Aboard Aircraft

Based on eight investigations, U.S. health authorities believe that the risk is low for transmission of tuberculosis aboard transport-category aircraft. Nevertheless, the World Health Organization will publish new guidelines by late 1998 for assessing the need to notify passengers and crewmembers who may have been exposed to a person with active TB.

FSF Editorial Staff

Since March 1995, U.S. airlines and state health departments have used guidelines distributed by the U.S. Centers for Disease Control and Prevention (CDC) to assess and to respond appropriately to instances in which airline passengers have been identified as having active tuberculosis (TB). The Global Tuberculosis Program of the World Health Organization (WHO) also expects to complete by the end of 1998 international guidelines regarding what is known about the risk of TB transmission aboard transport-category aircraft. (See "Investigations Suggest Practical Tuberculosis Measures for Airline Personnel," page 3.)

CDC said that in the last 10 years, TB has re-emerged as the deadliest infectious disease and one of the world's leading causes of death — nearly three million deaths annually.[1] In 1993, WHO officials said that TB is a global health emergency.[2]

TB is an airborne, potentially fatal disease that is preventable and curable for people who receive adequate health care. TB transmission — or spread of infection — may occur when a person inhales TB bacteria from microscopic-sized droplets carried through the air. Typically, coughing or sneezing by a person with active TB expels these bacteria into the air, but the disease has not been considered highly contagious among adults who have healthy immune systems. One reason is that most airborne droplets containing TB bacteria are too large to pass beyond the human body's defenses and reach the deepest areas of the lungs where infection can occur, said CDC. TB transmission typically occurs only after weeks or months of close, indoor contact with a person whose active TB has not been controlled by medications.[3]

Researchers who investigated the risk of TB transmission aboard airline flights studied only the few known instances of a passenger with active TB. The reason is that only people with active TB are capable of transmitting TB to others. Physicians diagnose active TB by symptoms, X-rays and laboratory tests. The American Lung Association said that a person with *active* TB may have any, all or none of the following symptoms: a cough that will not go away, feeling tired all the time, weight loss, loss of appetite, fever, coughing up blood and night sweats. By contrast, TB *infection* can be diagnosed by a tuberculin skin test (TST) but normally has no symptoms and, for about 90 percent of otherwise healthy adults in the United States, does not develop into active TB. Anyone with TB infection is at risk for developing active TB, however, and needs medical care. This distinction between active TB and TB infection is important to keep the risk in perspective, health authorities said.[4]

Researchers typically look for *TST conversion* as evidence that TB transmission probably occurred within a specific time period. Conversion means that a person had a negative TST result after the exposure, then had a positive TST result that meets the researchers' criteria when retested at a date more than 12 weeks after exposure. Assessing TST conversion also involves considering any other known source of exposure and factors that may complicate the diagnosis of TB infection. Regardless of TST-conversion status, physicians consider the person's medical history and risk factors before prescribing medications to prevent TB infection from developing into active TB.[5]

CDC said, "In the United States, an estimated four [percent] to six percent of the total population is TST positive [shows TB infection when tested with a TST], and in developing countries, the estimated prevalence of [TB infection] ranges from 19.4 percent (in the Eastern Mediterranean region) to 43.8 percent (in the Western Pacific region)."[6]

CDC said that in 1996 among U.S. adults with TB infection, active TB will develop in five percent to 15 percent during their lifetimes. The remainder will have no TB symptoms and will not transmit TB infection to other people. The risk that TB infection will progress to active TB in infants and children is substantially greater than for older people, however, said CDC.

"Active TB disease can be severe in young children," said CDC. "Without appropriate therapy, infants less than two years of age are at particularly high risk for developing life-threatening [types of TB]."[7]

People with TB infection know their status only because the infection has been diagnosed, typically by a TST. After TB infection has been diagnosed, a physician may prescribe medications to prevent development of active TB.

TB Remains a Global Health Emergency

In 1996, 3.8 million TB cases were reported to WHO; reports in 1997 estimated that about one-third of the world's population of 5.9 billion, including 15 million U.S. residents, has TB infection and is at risk of developing active TB in the future, said CDC.[8]

In 1998, scientists said that a major advance in genetic understanding of TB bacteria should accelerate the development of safer, more effective chemotherapy and vaccines by the early 21st century. Scientists reported that the complete genome sequence [genetic structure] of the best-characterized strain of *Mycobacterium tuberculosis* has been determined and analyzed to improve their biological understanding of the organism, including characteristics such as slow growth, dormancy and mutation to resist antibiotics.[9] CDC said that a comprehensive worldwide plan is needed to apply this knowledge, with special focus on a new vaccine to prevent people with TB infection from developing active TB.[10]

Outbreaks of multidrug-resistant tuberculosis (MDR-TB) have caused sickness and death in many countries since the 1980s, said CDC. Curing — when possible — a person who develops MDR-TB also is far more costly and difficult than typical TB drug therapy, said CDC. An October 1997 WHO report said that seven countries — Argentina, Dominican Republic, Ivory Coast, Estonia, India, Latvia and Russia — are emerging MDR-TB "hot zones."[11]

"This report provided the first scientific evidence for what we most feared but could not previously prove: The world again faces the specter of incurable tuberculosis."

Research for the WHO report, *Anti-Tuberculosis Drug Resistance in the World*, was conducted by WHO, CDC and the International Union Against Tuberculosis and Lung Disease. WHO said that the report was based on investigation of quality control and proficiency testing performed by 22 laboratories worldwide and surveys of 50,000 TB patients in 35 countries.

In each of these countries, the disease is often resistant to the commonly prescribed drugs, isoniazid and rifampin, said WHO officials. Thus MDR-TB is incurable in anyone who does not receive the most sophisticated and expensive health care, said WHO. The investigation said that even if such health care is available, MDR-TB can make treatment 100 times more expensive than normal — up to US$250,000 per patient.

"This report provided the first scientific evidence for what we most feared but could not previously prove: The world again faces the specter of incurable tuberculosis," said Michael Iseman, M.D., of the University of Colorado (U.S.) and the National Jewish Medical and Research Center. "Today in the developing world, MDR-TB is usually a death sentence."

CDC said that occasional outbreaks of MDR-TB have occurred since today's primary anti-TB medications were

Investigations Suggest Practical Tuberculosis Measures for Airline Personnel

Airlines typically learn that a passenger had active tuberculosis (TB) weeks after a flight. This circumstance makes it impossible for airline personnel to respond while the passenger is traveling, said Cris Bisgard, M.D., medical director of Delta Air Lines. (It is important to distinguish between *active* TB, which enables a person to transmit TB infection to others, and TB *infection*, which can be diagnosed by a tuberculin skin test [TST] but normally has no symptoms and may never cause active TB in a healthy person.)

Bisgard said, "I find it reassuring that the public health community has endorsed the appropriateness of current notification guidelines for these situations, even though they are rare."[1]

A researcher at the U.S. Centers for Disease Control and Prevention (CDC), who was involved in investigations of the risk of TB transmission aboard aircraft, said that guidelines based on research will increase worldwide understanding of this issue. For reasons often noted by U.S. researchers — such as the difficulty of identifying and communicating with passengers after a flight, and the resources required to accomplish those tasks — some airlines have been reluctant to handle TB notifications, said Ida M. Onorato, M.D., chief of the Surveillance and Epidemiology Branch in CDC's Division of Tuberculosis Elimination.

"All airlines have [internal] guidelines for dealing with acutely ill passengers and guidelines for medical problems aboard aircraft," Onorato said. "Education about the risk of TB transmission aboard aircraft using CDC guidelines will be important to help airlines and health authorities to make decisions and take appropriate steps."[2]

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U.S. epidemiological investigations since 1992 have provided data to support the current CDC guidelines. One consensus recommendation was that physicians should discourage any patient from using public transportation until medical treatment for active TB has eliminated the likelihood of infecting other travelers.[3]

One study said, "To prevent exposures to TB aboard aircraft, when travel is necessary, persons known to have [active] TB should travel by private transportation (i.e., not by commercial aircraft or other commercial carrier). … [A negative result on a lab test ordered by the physician for patients taking TB medications] virtually precludes potential for transmission. Decisions [by the physician] about a TB patient's infectiousness and ability to travel should be made on an individual basis."[4]

Resources of CDC and the World Health Organization help local health authorities and airlines provide practical guidance for airline employees who might encounter a person who has symptoms of active TB.

Before a flight or during a flight, said Delta's Bisgard, airline personnel occasionally may be able to involve health care professionals in decisions about how to assist an acutely ill passenger or to attempt preventive measures.

"I can't remember a case where cabin-crewmember assistance to a passenger known to have active TB actually occurred aboard an airplane," said Bisgard. "In virtually all these cases, the airline is notified by health authorities about two weeks to six weeks after a flight that a passenger with active TB was aboard. It's very rare to find out while the passenger is on the airplane."

Bisgard said that ideally, airline personnel would be aware — before a flight — of any seriously ill passenger who wishes to travel. Then an ill passenger could be assessed individually in light of legal requirements as well as sound public health practices, he said.

"We have to be extraordinarily careful in the United States, for example, to comply with the Air Carrier Access Act," said Bisgard. "The conditions under which an airline can deny boarding are clearly delineated. We can deny boarding to someone who has a serious contagious disease, but it has to be both serious and contagious. A common cold is an infectious disease, but we cannot deny boarding for that reason. To deny boarding related to suspicion of active TB, we would have to be able to document that the individual has active TB. Someone could have had active TB, but have started antimicrobial treatment so that he or she is not contagious. Then we could not deny boarding.

"If someone arrived at a Delta Air Lines gate who appeared to be seriously ill — maybe coughing blood — the gate agent could call our medical advisory service. The gate agent would ask the medical-advisory-service physician on duty to contact the passenger's physician to confirm that the individual has been cleared for this flight and should not pose a risk of serious contagious disease. If the person had lung cancer, for example, that would explain the coughing. In that case, we would be required to board the person."

After an ill passenger is aboard an aircraft, flight attendants and flight crews may have limited options for assisting the introduced in the 1940s, but the first documented outbreak did not occur until 1970. In the 1990s, however, multidrug-resistant mutants of TB bacteria have caused concern worldwide, said CDC. [12]

Tuberculosis Has Afflicted People Since Ancient Times

TB has afflicted people since the time of ancient Egyptian and Greek civilizations, said CDC. During the last two centuries, the disease was associated with urban crowding and malnutrition, and more than 25 percent of Europe's people died of TB during the 1800s. In the United States, approximately 20 percent of deaths were caused by TB in the early 1800s, but mortality from TB declined throughout the century. By the late 1800s, physicians understood that TB was infectious and isolated patients in treatment centers for rest, enhanced nutrition and surgical procedures to close lung cavities caused by TB. Effective anti-TB medications substantially reduced TB in the U.S. by the middle of the 20th century, said CDC.[13]

From 1953 to 1984 TB rates in the United States declined steadily, then increased from 1985 until 1992. This resurgence of TB and the changing nature of TB in the United States prompted a re-evaluation of strategies to eliminate the disease, including revision of medical guidelines in the mid-1990s, said CDC.

WHO officials said that when MDR-TB affects regional centers of travel, emigration and international economic activity, little can be done to prevent people who have MDR-TB infection from traveling to other nations. Some of these people later may develop active MDR-TB, said WHO. Immigrants must provide evidence that they do not have active TB before travel, but visa requirements for tourists, business travelers and students are less restrictive, said U.S. health authorities.[14]

WHO said that the report documented for the first time a link between poor-quality treatment of TB and the spread of MDR-TB. Conversely, where a medical strategy known as directly observed therapy, short course (DOTS), is used, the level of TB drug resistance is low, but only about one TB patient in 10 TB patients has access to DOTS, the organization said.

Inconsistent or partial treatment of TB is the root cause of MDR-TB, said WHO, and many patients fail to take all their medicines consistently because of the extended treatment period or because they believe that they no longer have the disease. In addition, some doctors and health workers prescribe the wrong drugs or the wrong combinations of drugs, said WHO.

"MDR-TB is an airborne bacterium that is spread just as easily as regular TB. An individual who is sick with any strain of [active] TB will infect between 10 people and 20 people each year with that same strain," said Paul Nunn, M.D., chief of the Tuberculosis Research and Surveillance Unit of the WHO Global Tuberculosis Program. The United States is not immune to MDR-TB, said WHO, citing a separate 1997 CDC investigation that found MDR-TB in 42 states. WHO said that effective TB control that cures patients has proved successful in preventing MDR-TB in targeted areas of Algeria, Chile, Korea, Tanzania and the United States.

WHO said that DOTS combines five elements to focus on curing every case: national commitment, case detection through examination of sputum under a microscope, directly observed short-course treatment, regular drug supplies and monitoring systems with evaluation of treatment outcome for every patient. After active TB patients have been detected using microscopy services, health and community workers and trained volunteers observe and record patients swallowing the correct dosage of anti-TB medicines, and document that the patient has been cured, said the organization.[15]

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Kenneth G. Castro, M.D., director of CDC's Division of Tuberculosis Elimination, said, "In 1996, 3.8 million [TB] cases — 887,731 from areas with DOTS — were reported to WHO. … One hundred eighty-one countries and territories (97 percent of the global population) have reported on the status of DOTS to WHO. … Approximately 32 percent of the global population live in areas where DOTS is available. Twenty countries have adopted DOTS since the 1996 survey, and an additional nine percent of the global population were benefiting from it. … In summary, TB remains an important public health problem in many areas of the world where DOTS has not been implemented. Because treatment outcomes were better in countries where DOTS has been used, the strategy needs to be expanded rapidly, and new tools to facilitate its implementation need to be developed."[16]

WHO data from 1995 showed that 95 percent of active-TB cases and 98 percent of deaths from TB occurred in developing countries. WHO said that TB-control work in the following 13 countries largely will determine whether the global effort to control and eliminate this disease will succeed or fail: Bangladesh, Brazil, China, Democratic Republic of the Congo (formerly Zaire), Ethiopia, India, Indonesia, Mexico, Pakistan, Philippines, Russia, South Africa and Thailand. These countries had nearly 75 percent of the world's TB cases in 1997, said WHO.[17]

International travel and migration trends have changed significantly the demographics of people who develop active TB in some parts of the world, said CDC.

person or reducing or preventing prolonged close contact with other passengers, which CDC considers an important risk factor in TB transmission.

"If a passenger's illness is noticed in flight, it's a little bit late," said Bisgard. "If flight attendants notice health conditions that cause concern, we want them to call our medical advisory service and let a physician get involved. In the case of TB-like symptoms, the physician may advise flight attendants to move the ill passenger to a part of the cabin as far as possible from other passengers, and to have the passenger remain seated in that area. International sanitary regulations describe the specific circumstances in which an airline captain would have to notify health authorities at the next port that an airline passenger may have a serious infectious disease."

CDC's aircraft-related TB guidelines do not address existing health and safety practices in aircraft cabins, Bisgard said. But by the early 1990s, many airlines already had begun following the U.S. Occupational Health and Safety Administration (OSHA) guidelines developed for health care workers, adding universal precautions to subjects covered in flight-crew and flight-attendant training, and providing universal-precautions kits on airplanes in 1993. Both actions were taken voluntarily by airlines as a good operating practice, he said.

(Universal precautions define medically appropriate ways to use gloves, masks, eye protection and other equipment to prevent health-care workers and others from directly contacting blood or other body fluids while providing health care to anyone. Universal precautions were adopted during the 1980s in the context of preventing transmission of the human immunodeficiency virus [HIV] in health-care settings.)

Some universal-precautions kits contain OSHA-approved, disposable respirators (masks) that cover the mouth and nose, Bisgard said. This type of respirator may provide some protection from TB — which normally is transmitted by weeks or months of exposure to airborne bacteria in a confined space — although U.S. health regulations require more effective dust/mist respirators or high-efficiency particulate air (HEPA) respirators for health-care workers in hospital TB isolation rooms.

Ideally, a physician or other health care professional would provide guidance on appropriate use of respirators by airline personnel, and when appropriate, by ill passengers — especially if a specific situation has not been covered in airline training. Some medical studies suggest that health-care professionals consider factors such as a patient's health status and symptoms of anxiety — including patients who have active TB — before wearing respirators.[5]

Medical authorities believe that preventive health care for people who have TB infection and timely treatment for people who develop active TB remain the best ways to prevent transmission of this disease.

Bisgard said that continuing health education for airline personnel about infectious diseases such as TB, and the associated risk of exposure, should be handled with sensitivity to the limited knowledge and fears that most people have. Accurate information helps to overcome myths about human health and daily exposure to bacteria and viruses in every environment, he said.

Candace Kolander, coordinator of air safety and health for the Association of Flight Attendants (AFA), said that AFA has been among the groups working with health researchers who study disease transmission aboard aircraft. AFA has a particular interest in TB, but the subject has not received a high priority in flight-attendant training that typically covers first aid and basic instruction on universal precautions, said Kolander.

"Some carriers do provide more than minimal training on universal precautions," said Kolander. "It can't be assumed, however, that flight attendants have training on subjects such as airborne and bloodborne pathogens; we do not. There needs to be more extensive training. We carry spill kits — also called pick-up kits or clean-up kits — that typically contain a biohazard bag, latex gloves, surgical masks, spatula and a solution to absorb potentially infectious substances."[6]

When flight attendants encounter an ill passenger, radio communication with medical personnel on the ground may or may not be possible, she said. More commonly, the flight attendant would notify the captain aboard the flight about a seriously ill passenger, then make a call for medical assistance from a passenger-physician, Kolander said, and the captain would decide whether to divert the flight or take other appropriate action.

Medical authorities believe that preventive health care for people who have TB infection and timely treatment for people who develop active TB remain the best ways to prevent transmission of this disease. Effective health education for people who have active TB — persuading them to avoid public contact until medications eliminate their ability to infect others — also is critical.[7]

A 1996 study co-authored by Onorato said, "Practical considerations would require patients to seek advice regarding their infectious state and ability to travel rather than airline personnel making assessments at the airport gate. Nonetheless, some persons will still travel despite their being classified as infectious."[8]

Two researchers, who investigated the microbiological composition of aircraft cabin air on 36 U.S. flights from 1987 to 1994, said, "Obviously an exposure to a passenger who

"In 1997, nearly 40 percent of new U.S. cases [of active TB] occurred in persons born in other countries," said CDC in an August 1998 report. "Like Canada and several European countries, the United States is expected soon to have more TB cases among foreign-born persons than native-born persons."[18]

Countries Adapt TB-control Efforts To Local Needs

Strategies for coping with TB vary somewhat among countries, depending on the prevalence of the disease in different segments of the population and health-care resources, said CDC and WHO.

CDC said that in the United States, for example, the risk for TB infection in the overall population is low, so the primary strategy for disease prevention and control is to minimize the risk of transmission by the early identification and treatment of patients with active TB. The second-most-important strategy, CDC said, is the identification of people with TB infection and, if indicated, the use of drug therapy to prevent TB infection from progressing to active TB.[19]

In other parts of the world, TB programs also focus on identifying and treating people with active TB, but a vaccine known as BCG (bacille Calmette-Guérin) also is widely used for children. CDC said that the use of BCG vaccine has been limited in the United States because its effectiveness in preventing TB is uncertain, and vaccination interferes with the later identification and treatment of people who may have TB infection.

People with impaired immunity also are more likely to have a weakened response to a TST — and this condition makes it difficult for physicians to identify TB infection and decide whether or not to initiate TB preventive therapy, said CDC. (The flight-related investigations of TB, for example, said that some passengers' previous vaccination with BCG or immune-system problems made it difficult to determine whether or not they had TB infection.)

Investigating TB among Airline Passengers Has Limitations

Various constraints limit what can be learned from epidemiological investigations of airline passengers for evidence of TB transmission aboard a flight. CDC said that the limitations include the inability to contact all passengers; response rates dependent upon passenger and crewmember cooperation; the commitment of public health resources for follow-up efforts; and limited ability to assure a uniform quality of TST procedures and interpretation of test results. Incomplete or insufficient locating information in airline records presently precludes the notification of all passengers, said CDC, although passenger records of frequent-flier programs have been useful.[20]

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CDC said, "Investigations [of TB transmission aboard aircraft] … are subject to two substantial constraints. First, because the investigation may be initiated several weeks to months following the time of the flight and exposure (see "Future Aircraft Cabin-air Standard Will Apply Latest Research," page 9), passengers may not be readily located. With the exception of persons who are enrolled in frequent-flier programs, airline companies do not routinely maintain residence addresses or telephone numbers for passengers. Second, the time elapsed between the flight and when public health authorities and airline companies become aware of an exposure and when passengers are notified and are tested limits the use of TSTs to assess for conversion."[21]

These limitations make it difficult for scientists to determine the precise source of TB infection among airline passengers with absolute certainty. Results of investigations, therefore, use careful wording to indicate that infection *probably* occurred or *probably* did not occur, based on the available evidence.

After a 1994 investigation that concluded passenger-to-passenger TB transmission probably had occurred during an airline flight, for example, some physicians said that they did not believe that this conclusion was warranted. These physicians said that comparison of strains of bacteria would more accurately determine or rule out the source of infection.

Jose M. Aguado, M.D., Jose T. Ramos, M.D., and Carlos Lumbreras, M.D., of Madrid, Spain, said, "The only way to prove [that MDR-TB can be transmitted in an airplane] would be to demonstrate by a molecular biologic method that the same strain of [MDR-TB] that infected the index patient [the passenger known to have active TB] produced tuberculosis in [another] passenger or crewmember on the flights."[22]

The authors of this investigation said in response to this comment that their conclusions "met the commonly accepted criteria for inferences in epidemiology" and that the suggested research technique — commonly called DNA fingerprinting — would have required a specimen from a passenger who developed active TB after a specific airline flight.[23]

is frequently coughing or sneezing with a URI [upper respiratory infection] or active tuberculosis represents an egregious set of circumstances. The problem then is not the transportation mode per se but the irresponsibility of the individual who knowingly exposes his or her fellow passengers to infection."[9]

In cases where patients do not follow treatment plans, laws in some U.S. states empower health authorities to take measures that include temporary quarantine of patients who have active TB, said CDC. Recourse to these laws, while unusual, shows the seriousness of preventing TB transmission and underscores the need for airline personnel to involve health care professionals if possible when there is concern about a passenger's health.[10]

After studying hospital outbreaks involving TB transmission to health care workers, various medical authorities have recommended preventive measures. Although hospital environments are not directly comparable to aircraft cabins, medical authorities sometimes have cited parallel issues.

Hospitals should perform a TB risk assessment and develop a TB infection-control plan, one study said.[11] The known risks of TB transmission aboard aircraft have been described by CDC, which has distributed summaries with TB exposure-notification guidelines to airlines and state health departments. CDC and state health authorities can advise airline medical staffs regarding any encounter with a passenger who may have active TB. This communication enables health authorities to become involved in the early identification, treatment and isolation of people with TB — the first step in typical hospital TB infection-control plans.

Hospitals also have introduced effective environmental controls, such as ventilation, HEPA filters and/or ultraviolet germicidal irradiation. Some medical researchers said that transport-category aircraft typically provide air-exchange rates comparable to or greater than hospital TB-case isolation rooms, and some provide HEPA air filters (or other types) that remove contaminants from recirculated air.[12]

Hospitals specify appropriate respiratory protection for health care workers who provide care for infectious TB patients (dust/mist respirators and particulate respirators such as HEPA masks). These respirators normally would not be available to airline personnel, but disposable respirators in universal-precautions kits may be useful in reducing the exposure of crewmembers or passengers to airborne bacteria (airline personnel should follow the specific recommendations of airline medical consultants).

Most important, hospitals provide TB training for health-care workers, education, counseling and screening, plus periodic evaluation of the effectiveness of all these measures. Airlines may not have an equivalent need for TB education, but information about TB from WHO, CDC and similar sources could be added during the revision of training materials to help aircraft crewmembers, gate agents and other personnel to anticipate passenger needs and respond appropriately.

Education for airline personnel also should include reminders about simple, but important, health practices — such as covering the nose and mouth when coughing or sneezing, obtaining a TB skin test at least once a year (or according to applicable airline policy) for early detection of TB infection and timely medical care, and accepting personal responsibility to maintain good health — especially immune-system health — through adequate nutrition, rest, exercise and regular health assessments by medical professionals.[13]♦

— FSF Editorial Staff

Flight-related TB Guidelines Rely on Investigations

The WHO guidelines, incorporating the CDC's work, will help airlines and health authorities determine when to notify airline passengers and crewmembers that they may have been exposed during a flight to a person with active TB. (CDC's guidelines recommend text for letters that inform people in a sensitive and careful manner about the possible risk, and advise them to obtain a TST and to receive follow-up health care if necessary.)

Work toward a consensus recommendation for worldwide airlines and health authorities advanced in May 1998 during a WHO meeting in Geneva, Switzerland. Draft recommendations for handling situations involving passengers with potentially active TB then were circulated for review by health and aviation specialists, said a WHO representative.

Luigia Scudeller, M.D., of WHO's Global Tuberculosis Program, said, "In cooperation with a number of external consultants, a WHO writing committee is preparing a set of guidelines to be distributed worldwide to airline companies, health authorities, physicians and other interested parties. The guidelines will describe the problem of TB transmission on aircraft and provide guidance on procedures to follow when a case of active TB with a history of air travel is diagnosed. They will incorporate the CDC guidelines. A draft of the document is presently under revision, and we expect the final document to be published by the end of 1998."[24]

Cris Bisgard, M.D., medical director of Delta Air Lines, said that he believes the question of whether TB can be transmitted aboard aircraft has been answered. The consensus of airlines and the public health community is that transmission is possible, but that aircraft cabins are not conducive to TB transmission, said Bisgard.[25]

"We had a theoretical belief that the risk of TB transmission should be less on an aircraft than in other settings," said Bisgard. "The investigations that CDC performed actually showed that even when you expose people to a person with [active] TB for more than eight hours on an airplane, the probability of transmission is extremely low."

CDC's current notification guidelines for TB aboard aircraft have served U.S. airlines for three years, said Bisgard, a member of the WHO writing committee. CDC developed these guidelines after reviewing recent U.S. epidemiological investigations.

Bisgard said, "In essence, WHO is taking the CDC guidelines and globalizing them. It was felt that they had worked so well in the U.S. that we could incorporate the same kinds of procedures and they would work for any airline in the world. We're just finishing up the first draft in [mid-August 1998]. It will be sent to TB experts around the world, and the International Civil Aviation Organization will be one of the reviewers. They will propose changes, then the guidelines will be put together and published by WHO."

"We know that there have been cases where state health authorities have determined, with the airline, that notification was appropriate, and other times when it was unnecessary."

Six investigations in the early 1990s — considered as a group to develop CDC guidelines — sought to determine whether TB transmission had occurred on transport-category aircraft, and if so, how transmission most likely occurred. In four of the investigations, researchers said that transmission of TB probably did not occur aboard the airline flights conducted while a person with active TB was aboard.

One investigation, however, said that TB probably was transmitted by one passenger with active TB to four other passengers during an 8.6-hour flight from Chicago, Illinois, U.S., to Honolulu, Hawaii, U.S.[26]

Another investigation said that a flight attendant with active TB probably transmitted TB to two co-workers during lengthy periods of contact aboard many aircraft over several months. The investigation involving the flight attendant did not find evidence of TB transmission to any passengers, but the data were inconclusive, said the researchers.

The possibility that TB could be transmitted during the relatively brief duration of an airline flight — even a flight more than eight hours long — was surprising to some physicians.

Steven R. Mostow, M.D., professor of medicine and infectious disease at the University of Colorado (U.S.) Health Sciences Center, and a member of the influenza and pneumonia advisory committee of the American Thoracic Society, said, "I was surprised at how many passengers on the flight to Honolulu were infected. TB is not that transmissible among people who have normal immune response, and eight hours or nine hours is a very short exposure time. Normally when we see TB outbreaks among [such] people, transmission occurs only after months of exposure. TB is not a highly contagious disease for people with normal immune systems; immunodepressed people are easier to infect."[27]

Kris Moore, M.D., M.P.H., assistant state epidemiologist in the Minnesota (U.S.) Department of Health, said that CDC has done sufficient work to demonstrate that transmission has occurred aboard aircraft and to provide guidance about the specific circumstances in which it occurred. Moore is a co-author of one of the flight-related TB investigations, a member of the executive committee of the Council of State and Territorial Epidemiologists (CSTE), and CSTE's lead consultant for infectious disease.[28]

"Based on the CDC guidelines, most [U.S.] state health departments now notify the airline if a case of active TB is found," said Moore. "There has not been a systematic effort to collect this data, however, and no more investigations have been conducted to see how many people converted [changed from a negative TST result after exposure to a positive TST result in a specified period of time]. Now the basic process is for health departments to recommend that TST testing be done, and if any passengers have a positive test result, they may want to take the standard prophylactic therapy [six months to 12 months of medications to decrease the risk of developing active TB in the future]."

CDC no longer collects national data on transmission of TB aboard aircraft, said Ida M. Onorato, M.D., chief of CDC's Surveillance and Epidemiology Branch, Division of Tuberculosis Elimination. U.S. state health departments have performed TB contact investigations of airline passengers, but CDC has not been involved in such investigations since the mid-1990s, Onorato said.

"These investigations have occurred very rarely, so national statistics have not been compiled," Onorato said. "Airline-related notification is now a matter of follow-up by state tuberculosis programs. Recommendations have been made, and local and state health departments contact CDC periodically about their work, but now it's a TB-control issue. We know that there have been cases where state health authorities have determined, with the airline, that notification was appropriate, and other times when it was unnecessary."[29]

Future Aircraft Cabin-air Standard Will Apply Latest Research

Tuberculosis (TB) is an airborne disease, and discussion of the risk of TB transmission — or spread of infection — aboard aircraft leads to questions about cabin-air quality. During the last 10 years, U.S. research on cabin-air quality has been prompted by concerns other than TB, such as complaints of discomfort and unexplained health symptoms from some passengers and crewmembers.

Several investigations in the 1990s by the airline industry, the U.S. government, academic researchers and independent interest groups have focused on airborne microbiological concentrations and other air-quality measures aboard transport-category aircraft. Basic measurements, such as carbon dioxide levels, typically surpassed U.S. regulatory requirements. More investigations are under way, however, and a new industry standard for cabin-air quality is under development.[1] The medical director of one U.S. airline said that typical aircraft environmental-control systems (ECSs) are designed, maintained and operated to provide a healthy supply of air to crewmembers and passengers.

Cris Bisgard, M.D., of Delta Air Lines, said, "If you compare air quality in an aircraft cabin to a standard office building, the airplane has far more air exchanges per hour than an office, and the air that comes into the aircraft cabin is sterile. Cabin air that is recirculated through a [high-efficiency particulate air (HEPA)] filter compares to recirculated air used in operating rooms and infectious-disease containment facilities."[2]

Continuing cabin-air research and the new industry standard should help settle debates about cabin-air quality by the early 21st century.

Some medical researchers who investigated the risk of transmission of TB aboard transport-category aircraft during the early 1990s said that ECSs probably helped to prevent the spread of airborne bacteria that cause TB infection.[3] Although ECSs are designed to meet the standards of worldwide aviation authorities, airlines and aircraft manufacturers have been challenged by various interest groups in recent years to re-examine these standards and conduct research to determine whether ECSs cause discomfort, fatigue and various health symptoms that occasionally have been reported by passengers and crewmembers. Continuing cabin-air research and the new industry standard should help settle debates about cabin-air quality by the early 21st century.

Aircraft ECSs Balance Several Requirements

Aircraft ECSs provide functions that include fresh-air supply, cabin-air circulation, cabin heating, cabin cooling, cabin pressurization, and lavatory and galley vents. In addition to normal cabin-air quality requirements, aircraft flight decks have special ECS-related operational and safety requirements, such as adequate cooling of equipment and removal of smoke or vapors. These requirements are met by systems that provide 100 percent outside air, recirculation systems with filtration, and/or higher rates of air exchange than needed in the cabin.

Components of recent transport-aircraft ECS designs have been engineered to provide a high-quality fresh-air environment, cabin pressure at or below 8,000 feet above sea level, and a comfortable temperature. The source of fresh air is the atmosphere outside the aircraft. Outside air is compressed by the turbine engines and a portion — bleed air — is diverted via the pneumatic system to air-cycle machines (packs), which cool the air.

The temperature of bleed air typically is 482 degrees Fahrenheit (250 degrees Celsius) and it is then cooled to about 234 degrees Fahrenheit (112 degrees Celsius) at a pressure of 450 pounds per square inch (32 kilograms per square centimeter).[4] Bleed air is cooled and the pressure is reduced to make it suitable for the aircraft cabin. Each pack is a collection of heat exchangers, turbines, compressors and other components that take bleed air from the turbine-engine compressors and condition it for distribution to the main deck and flight deck. This cooled air is ducted to an air-mix chamber. From the air-mix chamber, the air is directed to various cabin zones within the airplane. Figure 1 (page 11) shows the basic components of a ventilation system that mixes outside air with recirculated air passed through filters.

Early jet airliners used 100 percent outside air. This type of system continually exhausts all cabin air through outflow valves while the cabin is pressurized and replenishes the cabin with outside air.

Beginning in the 1970s, designs with air recirculation were developed to make airplanes more fuel efficient. On airplanes with air recirculation, some of the air exiting the cabin is filtered and reintroduced into the air-mix chamber. The rest of the air exiting the cabin is ducted overboard. Because outside air supplied to the cabin is taken from the aircraft's engines, any reduction in bleed-air usage increases the engine's efficiency and reduces fuel consumption and operating costs.

Typical cabin-air filters trap nearly all airborne particles. Filters also may be designed to remove from recirculated cabin air specific aerosols (liquid droplets) that could contaminate bleed air in case of a malfunction, such as a pinhole leak of hydraulic fluid from an engine or auxiliary power unit (APU). Nevertheless, engine and APU fluids can

No public health statistics exist linking people with active TB to airline travel, said health authorities. But based on informal exchanges of information, the consensus of organizations such as WHO's Global Tuberculosis Programme, CDC's Tuberculosis Elimination Program and CSTE is that documented cases of airline travel by people with active TB have occurred infrequently. Delta's Bisgard, for example, estimated that known cases of passengers traveling with active TB occur twice a year on large airlines. Ken Shilkret, manager of the Tuberculosis Program of the New Jersey (U.S.) Department of Health and Senior Services, said that his state considers cases of airline travel by people with active TB once or twice a year.[30]

The report of a 1996 investigation, co-authored by Onorato, said, "Tuberculosis is acquired through inhalation of [tuberculosis bacteria] in aerosolized respiratory secretions from infectious persons who cough, talk or sneeze. ... Risk of infection increases with proximity and duration of exposure to the source patient. Although the duration of a single flight is a relatively brief period of exposure to become infected with [tuberculosis bacteria], conditions in a confined aircraft cabin may increase the risk of transmission from [patients with active TB]. … In this study, the airflow systems … operated during the entire flight and exceeded the recommended minimum air exchanges in rooms for patients hospitalized with tuberculosis. … The risk of tuberculosis transmission in this study does not appear greater than in other confined spaces."[31]

In the six flight-related investigations cited by CDC's guidelines, researchers typically identified, to the extent possible, passengers and crewmembers with TB infection, then narrowed their lists to those who did not have TB infection previously and who had a minimal chance of exposure from a source other than the flight. Researchers typically said that they documented that transmission probably had occurred if a physician confirmed TST conversion by multiple TSTs 12 weeks or more after the flight, verified exposure to the passenger with active TB, and determined that there had been no prior TB infection and no other plausible explanation, such as BCG vaccination.

To a limited extent, these epidemiological investigations also considered whether the aircraft environmental-control systems (ECSs) — which include fresh-air supply and cabin-air circulation functions — had affected the risk of TB transmission. Some researchers and other physicians said that the investigation results showed that ECS designs probably helped to prevent the dispersion of TB bacteria.

Mostow of the University of Colorado said that he believes aircraft ECSs are a factor. Mostow's concern is not that cabin airflow could carry TB bacteria to other people. He said that airflow always should be sufficient to dilute the bacteria — a basic strategy employed in hospitals.[32]

"Air circulation is significant," said Mostow. "The way we reduce risk of infection in an operating room or isolation room is to ensure enough airflow to dilute any bacteria or viruses. My sense is that airflow or air exchange is more important than filtration aboard aircraft. Filtration is helpful and will reduce risk of TB transmission, but reducing airflow will increase the risk. A combination of increasing airflow and filtration with adequate filters should reduce the risk."

CDC Cites Investigations of Aircraft-related TB Transmission

From January 1993 through February 1995, CDC and U.S. state health departments completed investigations of six instances in which passengers or a flight crewmember traveled on commercial aircraft with active TB.

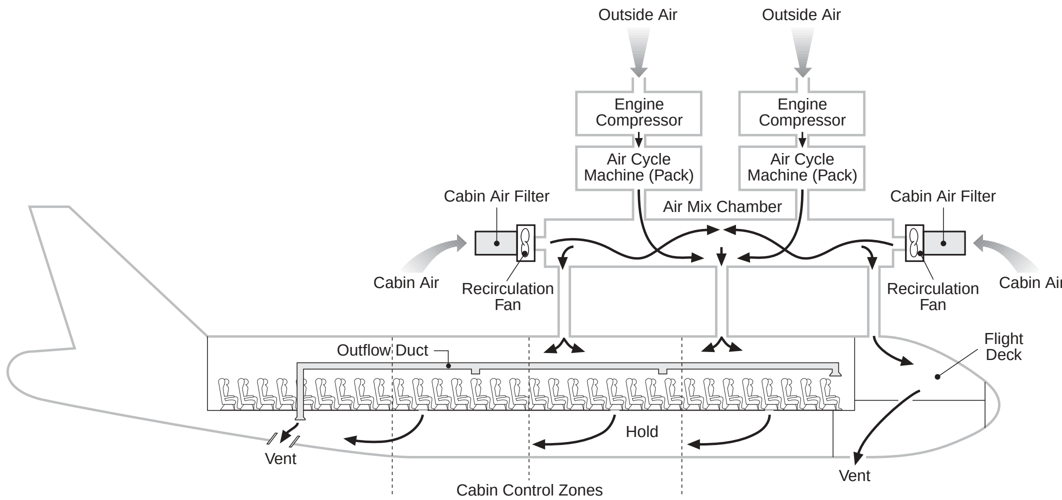
CDC said, "All six of these [investigations] involved … [active-] TB patients … who were highly infectious at the time of the flight(s). In two instances, [TB bacteria] isolated from the patients was resistant to both isoniazid and rifampin [commonly prescribed drugs]; organisms isolated from the other cases were susceptible to all antituberculosis medications. In addition, in two instances, the index patients [passengers with active TB] were aware of their TB at the time of travel and were in transit to the United States to obtain medical care. However, in none of the six instances were the airlines aware of the TB in these passengers."[33]

In each situation, said CDC, the airlines cooperated with U.S. health authorities, who conducted TB contact investigations. The investigations typically involved communicating with passengers and flight crewmembers, testing them for TB infection and TST conversion, interviewing those with a positive TST result, evaluating the probability that TB infection was caused by exposure on the flight, and counseling people who had a positive TST result about appropriate medical care.

- The investigation that provided the strongest evidence of passenger-to-passenger TB transmission involved a 32-year-old Korean woman with active MDR-TB. In this case, TB transmission probably occurred for four U.S.-born passengers on the May 1994 flight and may have occurred for two other passengers seated in the same section of an aircraft with the passenger who had active TB. The proximity of people and the 8.6-hour flight duration from Chicago, Illinois, U.S. to Honolulu, Hawaii, U.S. were significant. "Those seated within two rows were at greatest risk," said the report.[34]

  The report said, "Among the six persons with positive tuberculin skin tests, four had been seated within two rows of the index patient [the passenger with active TB], and the two seated toward the front of the rear cabin section reported having frequently visited friends seated very near the index patient and having used the lavatory close to her seat. As of February 1996, all six

Typical Transport-category Aircraft System with Fresh-air Supply and Cabin-air Recirculation



Note: A separate vent system directs air overboard from lavatory and galley areas.

Source: Derived from an illustration provided by Pall Corp.

Figure 1

burn in the high temperatures of the bleed-air system, and smoke and odors can be circulated in the airplane cabin. Air filters do not remove vapors, but separate odor-removal filters help eliminate specific gaseous contaminants in some designs. During ground operations, the APU provides bleed air for ECS functions, or an external ground air-conditioning unit may supply preconditioned air.

Engineers who designed air-recirculation systems sought to balance cabin-air quality and greater fuel efficiency. Their work responded to concerns about rising fuel prices and fuel availability, affordable airline-ticket prices, depletion of natural resources and environmental issues. The same concerns changed engineering priorities for homes, appliances, motor vehicles, manufacturing plants and office buildings.

In one 1987–1994 investigation of the microbiological composition of cabin air on 45 flights, the researchers said, "Because the high compressor temperatures effectively kill any living organism in the intake air, the air supply is virtually sterile as it enters the cabin air-distribution system. Cabin air is compressed from ambient air at high altitudes. The low humidity at altitude means that the moisture content in the air supply is also quite low. Relative humidities approximate those found in the U.S. southwestern deserts — commonly 10 percent to 20 percent. Such low humidities do not favor microbiological growth."[5]

The researchers said that normal airline-cabin air-exchange rates in 1994 typically ranged from 15 per hour to 20 per hour, which compared to 12 air exchanges per hour in a typical office building and five air exchanges per hour in a typical home.

The researchers said, "The microbiologic flora [organisms] within an airline cabin under cruise conditions almost certainly cannot come from external air. Instead, [they are] supplied by the occupants and by those residual organisms present on cabin furnishings at the beginning of each flight. … The amount of contamination is relatively small. It is normally an order of magnitude less than that found on city buses and streets. … Microbiological concentrations appear to be related to [passenger] activity within the cabin."

Air-recirculation systems were developed primarily to improve fuel economy, but have several benefits that airlines consider in choosing equipment, including lower operating costs, increased range, reduced emission of exhaust gases into the atmosphere, slightly higher cabin-air humidity and lower ozone concentrations in some situations.[6]

Aircraft with air-recirculation systems have been designed to provide comfortable airflow to the cabin with recirculation fully turned on, continuously mixing equal amounts of fresh air and filtered cabin air, then pumping it overboard through outflow valves. Flight crews typically can select 100 percent outside air temporarily to increase the rate of air exchange for comfort during some operating conditions, to remove odors or to purge smoke or vapors.

On a medium-capacity transport aircraft, one pack is designed to maintain the required fresh-air supply with [people who had positive TSTs] remained free of signs and symptoms of active tuberculosis [approximately 21 months after their flight to Honolulu].”

The report said that the woman’s relatives believed that she was not taking anti-TB medicine, and that the woman had been treated for TB in Korea as an adolescent and in Japan within the previous two years. The woman died of pulmonary hemorrhage and respiratory failure after her second flight to Honolulu.

About the time of her first flight to Honolulu and the U.S. mainland, where she visited friends for one month, the report said that she was reportedly coughing and lethargic. By the time of her return flight to Honolulu, the woman’s symptoms had worsened: she had progressive cough, lethargy, shortness of breath, fever and night sweats, and was coughing blood. CDC later tested a 21-month-old child in one household who had a TST conversion 17 weeks after the traveler’s month-long visit.

CDC said, “[This case] involved a highly infectious passenger, a long flight and close proximity of contacts [passengers] to the index patient. … These findings are consistent with previous reports of the transmission of other airborne pathogens on commercial aircraft, such as measles, influenza, and smallpox virus. … In our investigation, the absence of passengers with skin-test conversions in other cabin sections of the aircraft on [the second flight to Honolulu] is further evidence [that TB bacteria] were not transmitted through the aircraft’s air-recirculation system.”

- The other investigation in which TB transmission probably occurred aboard an aircraft involved a flight attendant who had a positive TST in 1989 but had not received preventive therapy, said CDC. CDC said that a relative of the flight attendant had died of TB during that time period. “While working on numerous domestic and international flights from May 1992 through October 1992, she developed a progressively [more] severe cough, and TB was diagnosed in November 1992,” said CDC.

  The CDC investigation found that two flight crewmembers probably were infected by the flight attendant, and that close contact with the flight attendant for more than 12 hours was associated with the TB transmission. The investigation was inconclusive as to whether any passengers were infected by the flight attendant.[35]

- One investigation found no evidence of TB transmission to passengers or crewmembers after a passenger with active TB traveled in the first-class section of an aircraft on a nine-hour flight from London, England, to Minneapolis, Minnesota, in December 1992. The researchers said, “This investigation required more than 600 hours of personnel time at the Minnesota Department of Health and lasted three months. Direct costs to [the department] in personnel time, phone calls and materials exceeded $25,000.”[36]

- One investigation found no evidence of TB transmission to passengers or crewmembers after a passenger with active TB traveled on a 30-minute flight from Mexico to San Francisco, California, U.S. in March 1993 [the Mexican city where the flight originated was not reported].[37]

- One investigation involved a passenger with active TB who traveled on an 8.5-hour flight from Frankfurt, Germany, to New York City, New York, U.S., and for 1.5 hours on a flight from New York City to Cleveland, Ohio, U.S., in March 1993. The report said, “The five passengers who were TST converters had been seated in sections throughout this plane. Because none of the U.S.-born passengers on this flight had TST conversions, the investigation indicated that, although transmission could not be excluded, the positive TSTs and conversions probably were associated with prior [TB infection], a boosted immune response from prior exposure to TB or prior BCG vaccination.”[38]

- One investigation found that, although transmission of TB during flights could not be excluded, the positive TSTs may have resulted from prior TB infection. The traveler was a U.S. citizen with active TB and an underlying immune disorder who had been a long-term resident of Asia, said the report. The passenger traveled on a three-hour flight from Taiwan to Tokyo, Japan, a nine-hour flight to Seattle, Washington, U.S., a three-hour flight to Minneapolis, and a one-half-hour flight to another city in March 1994.[39]

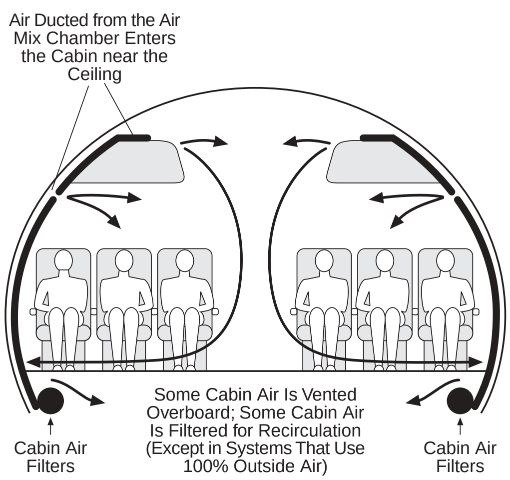
- Since these six investigations cited by developers of CDC’s notification guidelines, another investigation, begun in July 1994 and reported in November 1996, said that although the possibility of transmission could not be excluded, there was a low likelihood of TB transmission during two other U.S. airline flights, each approximately 1.25 hours in duration. The investigation found that three passengers on one flight and two passengers on the other flight later tested positive for TB infection, but all these people had risk factors that made it unlikely that transmission occurred aboard the aircraft.[40]

- Another investigation — not among the six cited by CDC’s guidelines — also concluded that TB transmission probably did not occur aboard two flights, but transmission could not be ruled out. The report said, “Although 34 contacts [passengers and crewmembers] had positive TST adequate heating and cooling, and a second pack is provided for reliability and redundancy, but can be used for faster cooling or ventilation rates. In some large aircraft, two packs are needed to provide proper airflow, and a third pack provides redundancy and gives the flight crew the ability to provide faster-than-normal air exchanges or temperature adjustments.

Some epidemiological investigations of aircraft-related TB transmission said that typical patterns of cabin airflow apparently help to dilute and filter out airborne bacteria.[7] Air from the air-mix chamber commonly enters near the cabin ceiling, circulates around the cabin and exits near the cabin floor. Much less air moves along the length of the inside of the cabin. Research generally shows that cabin airflow patterns do not entirely eliminate the risk that airborne bacteria will travel from one section to another, but cabin-air circulation, in combination with air filtration, significantly reduces the likelihood.[8] Figure 2 shows the dominant airflow pattern in typical transport-category aircraft.

The preliminary findings of a 1994 investigation by the Department of Environmental Health at the Harvard University School of Public Health, for example, said, "Reduced amounts of outdoor air [aboard the aircraft studied] do not necessarily translate to poor air quality and increased risk of disease. Air cleaning and removal of pollutants mitigate some of the effects of decreasing dilution air. Even with recirculating ventilation systems, oxygen is not depleted, nor does carbon dioxide increase to levels that interfere with respiration. Of concern, however, is the adequacy of the strategies used (i.e., recirculation and filtration) to offset the effects on air quality of reducing the amount of outdoor air produced. … It is evident from our investigation that aircraft ventilation systems [were] not balanced by sections of the cabin."[9]

Dominant Cabin Airflow Pattern in Transport-category Aircraft



Source: Derived from an illustration provided by Pall Corp.

Figure 2

Researchers said that the preliminary bacteria-related conclusions of the investigation, which should not be considered comprehensive, were that more work is needed to characterize exposure to infectious agents in aircraft cabins; airborne bacterial concentrations were slightly higher in airport terminals than during any of 22 flight segments, except three samples taken during deboarding; that overall bacterial counts on airplanes with recirculating air-handling systems tended to be higher than those with 100 percent outside air; and that bacteria recovered were those typically shed from human skin and mucous membranes, and levels were within the range commonly seen in public environments such as schools and office buildings.

"Low fresh-air supply during boarding resulted in elevated [carbon dioxide] levels," the Harvard researchers said. "When passengers and crew are subjected to these conditions for an extended period of time, discomfort symptoms will be experienced. Exposures to airborne dust, biological agents and organic compounds are expected to be highest during this time. The airlines should investigate procedures to improve ventilation during boarding and other ground activities."

Latest Cabin-air Filters Eliminate TB Bacteria

Joe Lundquist, vice president-technology development at Pall Corp., a major U.S. manufacturer of air-filtration systems for large-aircraft ECSs, said that in recent years there has been a trend toward reducing the amount of outside air entering the cabins of transport-category aircraft.[10]

Fuel savings have encouraged manufacturers and airlines to design systems that meet cabin air-quality requirements while using a combination of outside air and recirculated cabin air, said Lundquist. An analysis by Pall found that airlines save approximately US$60,000 (in 1992 dollars) in fuel per year for a medium-sized aircraft that uses cabin-air recirculation, based on 1992 data provided to Pall by Boeing Commercial Aircraft Group and McDonnell Douglas (The Boeing Co. merged with McDonnell Douglas Corp. in 1997).

Recirculation systems reduce fuel costs, said Lundquist, but require adequate air-filtration systems to reduce the exposure of passengers and crew to microbes and other particulate pollutants. People traveling within a cabin generate dust and fibers (and cigarette smoke in aircraft where smoking is allowed), as well as bacteria and other microorganisms. Cabin air-filtration systems — whether certified to HEPA standards or previous standards — have been designed to enhance passenger and crew health and comfort by controlling these contaminants, he said.

"The efficiency of our HEPA aircraft filters compares very well with HEPA filters we manufacture for use by hospital patients," Lundquist said. "There is no way to prevent transmission of some diseases aboard aircraft, but we can reduce the probability of someone becoming ill if they are sitting far away reactions or conversions, it is unlikely their reaction is due to exposure to the passenger with [active] TB on the two flights. … Since two [TST-] positive contacts had no other identified risk factor, TB transmission on board the aircraft could not be excluded. … Boosted immunologic responses to tuberculin from prior BCG vaccination or prior exposure to TB in endemic countries could explain the apparent TST conversions in our study. … The risk of tuberculosis transmission does not appear greater than in other confined spaces." In this investigation, the Russian passenger with active TB began a March 1993 trip in Moscow, Russia, and was aboard one flight from Frankfurt to New York City and another flight from New York City to Cleveland. Researchers focused on the last two flights in their epidemiological investigation.[41]

CDC said, "Two of these [six] investigations indicated that transmission occurred … from flight attendant to other flight crew and … from passenger to passenger. In [one investigation], transmission occurred on the return to Hawaii, when the index passenger was most symptomatic and on the longest flight. All persons with TST conversions were seated in the same section of the aircraft as the index passenger, suggesting that transmission was associated with seating proximity. Because the origins of all [non-U.S.]-born passengers were countries in which TB is endemic and/or where BCG vaccine is routinely used, TST results from these passengers do not reliably represent recent infections."[42]

CDC Provides Guidelines for TB-exposure Notification

CDC said that the risk for TB transmission on an aircraft does not appear to be greater than in other confined spaces. Because current evidence indicates low risk for transmission of TB on aircraft, CDC said, the need for notification of passengers and flight crewmembers should be guided by the following three criteria:

- "First, the person with TB was infectious [had active TB] at the time of the flight. [CDC said that people are most likely to be infectious who, at the time of the flight, are symptomatic with positive acid-fast bacilli smears from sputum or bronchoscopy specimens; have cavitary pulmonary TB (active TB diagnosed in the lungs) or laryngeal TB (active TB diagnosed in the larynx); have positive cultures for *M. tuberculosis* (bacteria identified in a laboratory); are symptomatic with a cough; or are not receiving treatment for (active) TB or treatment has been started but they have not responded to treatment.] Evidence of transmission to household [contacts] and other close contacts also indicates infectiousness;

- "Second, exposure was prolonged (e.g., the duration of flight exceeded eight hours [of cumulative exposure]); [and,]

- "Third, priority should be given to notifying passengers and flight crew who were at greatest risk for exposure based on proximity to the [passenger known to have had active TB] (for example, depending on the aircraft design, proximity may be defined as [being seated] or working in the same cabin section as the infected passenger)."[43]

CDC recommended the following guidelines for coordinated decisions and TB contact notifications:

- "Notification should be conducted by the airline in coordination with local and state TB-control programs;

- "Those who are notified should be encouraged to seek a medical evaluation to determine whether they have been infected with [TB] and to assess the need for preventive therapy; [and,]

- "In all situations, the appropriate health department(s) and the airline medical consultant(s) should determine whether passengers and/or flight crew should be notified, and who [among them] should be notified."

CDC said that in all the aircraft-related TB investigations to date, a state health department was informed about an airline crewmember's or a passenger's diagnosis of active TB before the airline received this information. CDC said that whenever health departments learn that a flight crewmember or a passenger has active TB, they should call the involved airline's medical consultant or other designated person. CDC recommended the following procedures for notification:

- "When the airline is informed first — e.g., by the person with TB or by the private physician treating the person — the airline should obtain the physician's name and address. The airline should then call the state health department in the state in which the person with TB resides or is being treated to provide the information about the person with TB and the treating physician's name and address; [and,]

- "Based on this information, the state health department and the airline should work together to determine who should be notified and how notification will occur. Notification of passengers and flight crew should be done by the airline in cooperation with the health department. Airlines should call or send [letters] to all [people] who can be located to explain the potential exposure, give recommendations for the passenger or crewmember, and provide telephone numbers for them to call if they have further questions. … It is also advisable to include some basic information about TB with the letter [such as educational materials from state health departments]."[44]

CDC said that in most situations, health authorities discover an airline-related TB case weeks or months after a flight. The delay impairs the ability of health departments to identify from an infectious passenger. A HEPA recirculation filter will help to prevent other passengers from getting ill."

Lundquist said that HEPA filters on transport-category aircraft remove particles with an efficiency higher than 99.97 percent at 0.3 micron (one micron is one-thousandth of a millimeter), significantly reducing the level of airborne-particulate contamination. HEPA filters provide the microbial equivalent of outside air to the passenger cabin, he said. The average bacterium has a diameter of about one micron, and strains of *M. tuberculosis,* which cause TB infection, range from 0.2 to one micron in diameter, Lundquist said. (By comparison, the diameter of an average human hair is about 75 microns.)

"Some people today want 20 cubic feet [0.6 cubic meter] per minute of outside air per passenger, but there is a two percent to four percent increased cost of fuel per year if you don't recirculate cabin air," Lundquist said. "The advantage of a recirculation system aboard an aircraft is that you can filter the air so that what comes out the filter actually is cleaner than bleed air. Secondary benefits of recirculating through a filter are that normally low relative humidity increases a small amount for greater comfort and reduces ozone levels."

Because of the physical properties of airborne particles, Lundquist said, HEPA filters also remove particles smaller than the openings between fibers of filter material. Viruses are 10 times to 100 times smaller than bacteria, for example, but research shows that they are trapped by HEPA filters.

"In HEPA design, there is a 'most-penetrating particle size' at which the filter is least efficient," Lundquist said. "Some viruses get very close to molecular level in size. But when viruses are bombarded by air molecules, they move laterally, not in a straight line. The more lateral motion, the higher the rate of filter efficiency because if a particle touches any fiber in the filter as it passes through, it will be captured. That means we can filter out particles even smaller than 0.3 microns. That is why the HEPA filter is 99.9995 percent efficient for viruses, even though they are smaller than bacteria."

Adsorbent chemicals, built into filters or installed separately, are used in some cabin-air systems for removal of odors and gases.

Scientists first realized that cabin-air filtration could be effective because of U.S. Department of Transportation (DOT) research about the effects of tobacco smoke aboard U.S. aircraft, he said.

"We looked at the dispersion of nicotine [from cigarette smoke in aircraft cabins]," said Lundquist. "This data told us how readily something airborne will disperse up and down the aisle, what we call diffusional transport. We found that the circulation of air [from] ceiling to floor is so much greater than along the length of the cabin … it is the dominant airflow pattern. That was great news. There was not a lot of axial mixing — nicotine levels varied by a ratio of 400 to one in different parts of the cabin. This told us that improved filtration of cabin air would be a benefit. We then did some mathematical studies and used the DOT nicotine-dispersion data, working with Boeing on committees of the American Society of Heating, Refrigerating and Air-Conditioning Engineers [ASHRAE]. We proved analytically that a better filter would reduce the dispersion of contaminants throughout an aircraft."

The circulation of air [from] ceiling to floor is so much greater than along the length of the cabin … it is the dominant airflow pattern.

In early 1998, United Airlines became the first major airline to announce plans to install HEPA filters throughout the airline's fleet.[11] Other airlines also have been specifying HEPA filters for new aircraft in recent years and retrofitting some aircraft, he said. Other recent-generation filters have provided similar benefits in cabin-air quality, Lundquist said, but HEPA technology has become the "gold standard" because of the preference for this technology in health care. HEPA filters typically are disposable.

Among other advances in aircraft ECS designs recently described by aircraft manufacturers are distribution systems with more main-deck air-distribution zones; ventilation rates that can be regulated based on passenger density in different zones; normal and high-flow operating modes for rapid cabin-clearing of cigarette smoke or odors, if needed; and ECSs that use 100 percent outside air more efficiently than previous designs.

Hospitals also generally choose from two basic types of ventilation systems for dilution and removal of contaminated air: single-pass systems and recirculating systems, said one study of mathematical models for medical-facility environments.

The report said, "In single-pass systems the supply air is uncontaminated, fresh outside air, and after it passes through the ventilated area, 100 percent of that air is exhausted to the outside. In a recirculating system, a small portion of the exhaust air is discharged to the outside and is replaced with fresh outside air, which mixes with the portion of exhaust air that was not discharged to the outside. A minimum of six [air changes per hour] is recommended for TB isolation rooms and treatment rooms. Where feasible, this airflow rate should be increased to 12 [air changes per hour] or more, and in areas where the nature of work is exceptionally hazardous, such as autopsy rooms, airflow rates of 15–25 air changes per hour have been recommended. … HEPA filtration units or ultraviolet germicidal irradiation can be used as a supplement to ventilation control measures in settings where adequate airflow cannot be provided with the general ventilation system alone."[12] These rates compare to typical people who have evidence of TST conversion. CDC said that notification should begin as soon as the health department and the airline determine that notification is appropriate.

CDC said, "The suggested procedures apply to all domestic and [non-U.S.] airline carriers. However, these recommendations were developed in the context of the TB prevention and control activities in the United States and may not be directly applicable to countries where TB risks or control strategies are different."

Airline's TB Notification Uses CDC Guidelines

In February 1998, a Scottish television documentary raised public awareness of the risk of TB transmission aboard transport-category aircraft by focusing on one eight-hour flight.[45] The January 1997 flight was not among those investigated by medical researchers to determine the probability of TB transmission. The flight provides an example, however, of how airline medical personnel and health authorities have applied CDC's guidelines, and how TB notification by an airline may affect some passengers with TB infection.

A few weeks after the flight, medical authorities in New Jersey, U.S., determined that a TB-clinic patient probably had active MDR-TB while on this flight from Europe to the United States. New Jersey medical authorities said that they consulted with the non-U.S. airline, and that the airline agreed to follow CDC guidelines to notify passengers and crewmembers about their possible exposure, and to recommend medical attention.

In the television program, two physicians at the Glasgow Royal Infirmary, Glasgow, Scotland, said that two Scottish passengers on the flight later had positive TSTs. These passengers said that they believed that TB transmission had occurred while they were aboard the airplane. After consultation with New Jersey physicians, the Scottish physicians prescribed medications that would prevent the development of active MDR-TB. One of the physicians later said that this preventive treatment was recommended for several reasons.

Mark Cotton, M.D., of the Glasgow Royal Infirmary, said, "The prevalence of TB in Scotland is extremely low. In general, to diagnose [TB] infection in countries where BCG [vaccination] is common, we take a cutoff of 10 millimeters [of induration (palpable swelling) on the arm where a TST injection is given] in nonvaccinated [adults] and 15 millimeters in vaccinated [adults]. There are unlikely to be any [TST] reactions attributable to BCG over 15 millimeters in adults vaccinated as children.[46]

"We saw three individuals [who had been aboard the flight], none of whom had spent time in a high-prevalence country, had a contact with a known case of TB, or socialized together, although they did work for the same media company (not in the same office). They had all been vaccinated as children more than 20 years ago; two out of the three had reactions over 20 millimeters — this can only reflect TB infection and probably relatively recently. While the chances of acquiring infection on such a flight must be low, the chances that our patients were infected this way, or while in New York, must be significant. Information showing that no other passengers [on this flight] seemed to have been infected might have led us to downgrading our risk assessment for our patients. The more difficult situation is those [adults] with known previous [TB] contact [such as] residence in a high-prevalence country … whether a positive [TST] reaction represents recent infection, or infection several years ago, is impossible to know."

__CDC said that notification should begin as soon as the health department and the airline determine that notification is appropriate.__

In the epidemiological investigations of the early 1990s, U.S. researchers said that transmission of TB aboard the flights studied was unlikely among passengers with positive TST results if they had other risk factors. Those with other risk factors included passengers who were vaccinated with BCG; passengers born in countries or residents of countries with a high prevalence of TB; and passengers continually exposed to populations in which TB prevalence is high.

New Jersey health officials found that the patient with active MDR-TB had taken TB medications in another country for two months before traveling to the U.S., said Shilkret, the state TB program manager. The state health department's involvement began when the patient — a visitor to the U.S. from Monrovia, Liberia — requested medical care at a TB treatment center in Newark, New Jersey. The patient told health care workers that active TB had been diagnosed in Liberia in October 1996 and that TB medications had been taken since that time, said Shilkret.[47]

The Newark TB treatment center confirmed a diagnosis of active MDR-TB based on chest X-rays and lab tests, notified New Jersey health officials and initiated a TB contact investigation about two weeks after the patient arrived, said Shilkret. During a medical interview, the patient reported recent air travel.

"The patient was not asked about air travel until active TB was suspected," said Shilkret. "The patient then claimed to have been asymptomatic and to have had no cough on the flight." Travel by a person with active TB aboard a nonstop flight of eight hours duration, however, prompted a call to the airline for discussion of the CDC criteria for notification of other passengers and flight crewmembers.

aircraft systems that provide approximately 20 air exchanges per hour.

Future Standard to Define Cabin-air Quality

In the United States, Federal Aviation Regulations (FARs) Part 25.831 says, "Under normal operating conditions and in the event of any probable failure conditions of any system which would adversely affect the ventilating air, the ventilation system must be designed to provide a sufficient amount of uncontaminated air to enable the crewmembers to perform their duties without undue discomfort or fatigue, and to provide reasonable passenger comfort. For normal operating conditions, the ventilation system must be designed to provide each occupant with an airflow containing at least 0.55 pounds [0.25 kilograms] of fresh air per minute. Crew and passenger compartments must be free from harmful or hazardous concentrations of gases or vapors."

FARs also specify cabin-air limits for carbon monoxide (not more than one part in 20,000 parts of air), carbon dioxide (not more than 0.5 percent by volume, sea level equivalent, during flight) and ozone concentrations (not more than 0.25 parts per million by volume, sea level equivalent, at any time above 32,000 feet, or 0.1 parts per million, sea level equivalent, time-weighted average during any three-hour interval above 27,000 feet).

In Europe, the Joint Aviation Requirements (JARs) include the following standards for aircraft ventilation. JARs Part 25.831 says, "Each passenger and crew compartment must be ventilated and each crew compartment must have enough fresh air (but not less than 10 cubic feet [0.28 cubic meter] per minute per crewmember) to enable crewmembers to perform their duties without undue discomfort or fatigue." Advisory Circular-Joint (ACJ) 25.831 (a) says, "The supply of fresh air in the event of the loss of one source, should not be less than 0.4 pounds [0.18 kilograms] per minute per person for any period exceeding five minutes. However, reductions below this flow rate may be accepted provided that the compartment environment can be maintained at a level which is not hazardous to the occupant."

"Each passenger and crew compartment must be ventilated and each crew compartment must have enough fresh air to enable crewmembers to perform their duties without undue discomfort or fatigue."

JARs Part 25.831 says, "Crew[-compartment] and passenger-compartment air must be free from harmful or hazardous concentrations of gases or vapors. In meeting this requirement, the following apply: (1) Carbon monoxide concentrations in excess of one part in 20,000 parts of air are considered hazardous. For test purposes, any acceptable carbon monoxide detection method may be used. (2) Carbon dioxide in excess of 3 percent by volume (sea-level equivalent) is considered hazardous in the case of crewmembers. Higher concentrations of carbon dioxide may be allowed in crew compartments if appropriate protective breathing equipment is available. [Yves Morier, regulations director of the Joint Aviation Authorities (JAA), said that JAA has proposed an amendment to adopt the text of FARs 25.831 (b) (2) regarding carbon dioxide concentration during flight.[13] JAA received public comments in June 1998 and expects to finalize the amendment in early 1999, said Morier.[14] The effective date of the amendment to the FARs regarding carbon dioxide concentration was Jan. 2, 1997.]

"There must be provisions made to ensure that the conditions prescribed [regarding carbon monoxide and carbon dioxide] … are met after reasonably probable failures or malfunctioning of the ventilating, heating, pressurization or other systems and equipment." ACJ 25.831 (c) says, "To avoid contamination the fresh-air supply should be suitably ducted where it passes through any compartment inaccessible in flight. Where the air supply is supplemented by a recirculating system, it should be possible to stop the recirculating system and [1] still maintain the fresh-air supply prescribed, and [2] still [avoid contamination of the air supply by suitable ducting where it passes through any compartment inaccessible in flight]."

JARs Part 831 says, "Except as provided in [the following paragraph] … means must be provided to enable the occupants of the following compartments and areas to control the temperature and quantity of ventilating air supplied to their compartment or area independently of the temperature and quantity of air supplied to other compartments and areas: (1) the flight-crew compartment; (2) crewmember compartments and areas other than the flight-crew compartment unless the crewmember compartment or area is ventilated by air interchange with other compartments or areas under all operating conditions.

"Means to enable the flight crew to control the temperature and quantity of ventilating air supplied to the flight-crew compartment independently of the temperature and quantity of ventilating air supplied to other compartments are not required if all the following conditions are met: (1) The total volume of the flight-crew [compartments] and passenger compartments is 800 cubic feet [22.4 cubic meters] or less. (2) The air inlets and passages for air to flow between flight-crew and passenger compartments are arranged to provide compartment temperatures within five degrees Fahrenheit [2.8 degrees Celsius] of each other and adequate ventilation to occupants in both compartments. (3) The temperature and ventilation controls are accessible to the flight crew."

In 1994, Alan R. Hinman, M.D., M.P.H., director of the National Center for Prevention Services at the U.S. Centers

"The airline refused to release the passenger list to the local TB-treatment center, but agreed to follow CDC's protocol for notifying passengers and crewmembers," said Shilkret. "We didn't learn the results of this notification. The airlines don't go that far under the recommended notification process."

Shilkret said that the state health department handles local cases of active TB in a different manner, relying on its own resources, procedures and follow-up using the guidelines of CDC's Division of Tuberculosis Elimination. He said that it is important to keep the few known cases involving airline travel in perspective relative to the day-to-day work of a state TB program in the United States.

"I would be surprised if airline travel comes up as an issue more than once or twice a year in New Jersey," said Shilkret. "Even then, the flights have been less than eight hours long, so we don't get involved in follow-up. By comparison, each year approximately 2,000 people are evaluated for TB in New Jersey, which yields about 750 active-TB cases. Approximately 1,200 initial and follow-up interviews are conducted to determine the source and/or spread of infection among approximately 4,000 named contacts. As a state, we have had a good track record of following up TB contacts — examining 98 percent of them to provide health education and medical services for active TB and TB infection."

U.S. laws require that all people seeking to immigrate have a chest X-ray for TB screening, and anyone diagnosed with active TB in another country must obtain an approved physician's certification of effective treatment before permission will be granted to immigrate to the United States, said Shilkret. Immigrants with abnormal chest X-rays must be examined by a physician or in a clinic under New Jersey health laws, he said. TSTs are required for children who move to New Jersey from other U.S. states or countries under regulations for schools. Health authorities strongly recommend preventive therapy for children with TB infection but not active TB, said Shilkret.

Airline Association Suggests Passenger-notification Process

The International Air Transport Association (IATA) has published a nonbinding recommended practice, effective June 1, 1998, for member airlines to consider in assessing and responding to any report that a passenger with an infectious disease traveled on a specific flight. The recommended practice provides guidelines concerning passenger notification and related issues that airlines should consider in developing their own policies and procedures. The association's Inflight Services Department will continue to refine these guidelines periodically by issuing supplemental materials, said Wanda Potrykus, corporate communications manager of IATA.[48]

The guidelines first suggest that IATA's member airlines advise the public not to travel with an infectious disease because of the possibility of exposing other people.

"[Member airlines] should inform passengers through their public relations, literature, inflight magazines, etc. that passengers who know they have an infectious disease should not travel by air, as they can expose other passengers and crewmembers to such infectious disease," said IATA.[49]

Upon receiving a postflight report about a passenger with an infectious disease, member airlines should cooperate with the health authority and notify the airline's medical department or medical advisor, said IATA. The association said that health authorities first should use immigration records to determine the names and addresses of arriving passengers who may have been exposed to the infectious disease.

If the health authority is unable to determine from immigration records the names of passengers who may have been exposed to the infectious disease, IATA said that the member airline then should obtain a formal request for a list of passengers. IATA said that the health authority's formal request should contain the following details:

- Full name, nationality and permanent address of the passenger with the infectious disease;
- Names of people who traveled with this passenger;
- Airline flights, dates of travel, origin/destination of the passenger with the infectious disease, duration of flight, and seat number;
- Confirmation of the communicable disease (including mode of transmission, incubation period, period of communicability, susceptibility and control measures);
- Distance from the passenger with the infectious disease at which other passengers could have been infected;
- Confirmation of posting on a WHO Internet bulletin board;
- Endorsement by a competent national authority to proceed with contact-tracing [notification] of other passengers and/or preventive therapy;
- Commitment to contact-trace all at-risk passengers; and
- How information will be distributed to health authorities in the originating and intermediate countries involved.

"After the [member airline] verifies that it did in fact transport the [passenger with an infectious disease], and if the health for Disease Control and Prevention (CDC), responded to questions about aircraft air quality before an aviation subcommittee of the U.S. House of Representatives. Hinman said that CDC's National Institute for Occupational Safety and Health (NIOSH) had applied extensive experience from investigating indoor environmental quality under the health hazard evaluation (HHE) program to study cabin-air quality in transport-category aircraft.

"In 1991, in response to a request by the Association of Flight Attendants [AFA], NIOSH conducted an HHE to investigate potential causes of headache, dizziness, blurred vision, mental confusion and numbness reported by employees [of one U.S. airline]," Hinman said. "NIOSH assessed cabin air quality and reviewed employee medical records and company incident logs to determine whether toxic gases or lack of oxygen caused these symptoms. Measurements of levels of carbon monoxide, ozone, carbon dioxide, nitrogen dioxide, oxygen, temperature, humidity, total particulate and volatile organic compounds did not reveal an environmental cause for the symptoms reported. Review of employee medical histories also did not indicate a work-related etiology [cause or origin] for these illness incidences. NIOSH recommended that the airline continue to monitor cabin air for carbon monoxide levels and that further investigation should examine the roles of other environmental, ergonomic and psychosocial occupational stressors."[15]

A 1994 study commissioned by the Air Transport Association of America (ATA) collected cabin-air-quality data during flights aboard two types of transport-category aircraft designed to use 100 percent outside air and two types of transport-category aircraft designed to use a combination of outside air and cabin air recirculated through filters.

The study evaluated contaminants (respirable particulates, biological organisms [bacterial and fungal] and volatile organic compounds) and environmental parameters (such as carbon dioxide levels, relative humidity, temperature and noise). The study said, among other findings, that the aircraft environments reviewed were relatively free of dust and other particles that are likely to cause health effects; that levels of airborne microorganisms were well below NIOSH-recommended levels; and that no bacterial or fungal respiratory pathogens were isolated by a medical laboratory that studied air samples.[16]

Since the NIOSH health-hazard evaluation and the ATA study, however, AFA has continued to monitor reports of health symptoms from its members and to discuss with airlines, aircraft manufacturers and engineering groups a new standard for cabin-air quality.

"AFA is still very interested in the issue of air quality," said Candace Kolander, AFA's coordinator for air safety and health. "Complaints from flight attendants vary over time, but air quality remains high on the priority list of issues for AFA."[17]

General public interest in aircraft-cabin air quality has not abated since the mid-1990s, said Tony Giometti, ASHRAE's public relations manager. Representatives of flight-attendant unions from the United States and Canada, manufacturers, engineers and other groups participated in sessions on this topic during the society's June 1998 meeting in Toronto, Ontario, Canada.[18]

The focus of attention, Giometti said, has been work on ASHRAE's proposed Standard 161P, Air Quality Within Commercial Aircraft. A 20-member standards committee comprises representatives of airlines, aircraft manufacturers, airline pilots, flight attendants, environmental-control-system engineers, scientists, the traveling public and other knowledgeable individuals and interest groups, he said. ASHRAE expects that work on the proposed standard, begun in June 1995, will require another two years.[19]

ASHRAE Standard 161P will apply to commercial passenger air-transport aircraft certified under FARs Part 25. The standard will define the requirements for air quality in air-carrier aircraft that carry 19 or more passengers, and will specify methods for measuring and testing air quality to verify compliance. The society believes, however, that it may prove difficult to satisfy every person who has expressed concern.

"Considering safe operation of the aircraft, the diversity of sources and contaminants in aircraft-cabin air, and the range of susceptibility in the population, compliance with this standard will not necessarily ensure acceptable aircraft-cabin air quality for everyone," ASHRAE said.[20]

Part of the problem has been a common tendency to ignore significant differences between "moving" and "built" environments, ASHRAE said. The committee developing the proposed standard for cabin-air quality believes that the amount of air provided per cubic foot per minute and the number of air changes per hour are not directly comparable between aircraft and buildings, for example. Giometti said that additional ASHRAE research on cabin-air quality is under way.♦

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authority requests a list of other passengers who could have been infected, the [member airline] should attempt to compile a list of such passengers, including the contact information which is available, and seat numbers," said IATA. "The [member airline] could, depending on the circumstances and/or local regulations, contact the crewmembers who may have been exposed to the infectious disease, and offer necessary diagnostic procedures and/or treatment, or handle as deemed appropriate by the [member airline] concerned."

The guidelines said that member airlines should comply with local, national or international laws or regulations that prohibit disclosure of a passenger list or seat-assignment data (such as privacy/confidentiality laws and data-protection laws).

Member airlines also should advise the health authority, said IATA, when the airline's data are inadequate — for example, when passenger data no longer are available, limiting information to names and possibly telephone numbers recorded when passengers made flight reservations.

"When a [member airline] is advised by a health authority that it may have transported a passenger with an infectious disease … it shall cooperate with such health authority, with the understanding that it is not the [member airline's] responsibility to trace and notify other passengers who may have been exposed to the infectious disease," said IATA. "The health authority should exonerate the [member airline] of any liability or responsibility, or costs, that could result from notifying other passengers."

Epidemiologists Monitor Resources Required for Notifications

Some U.S. epidemiologists believe that there are opportunities to handle flight-related TB notifications more effectively by tracking and sharing information. CSTE, for example, said in 1995 that the following improvements should be considered:

- Standardized protocols for notifications to maximize the use of limited resources and to collect information;
- Assistance to health departments that have limited resources to consult with airlines or to conduct written TB notifications, especially states that have direct flights arriving from TB-endemic areas; and,
- Adoption of flight-related TB-notification guidelines worldwide so that airlines and health authorities have consistent roles. [50]

Worldwide distribution in 1999 of the WHO guidelines to airlines and health authorities will provide a risk-assessment tool and notification guidance. Discussion of the guidelines will encourage a common understanding and a balanced perspective of the possibility of TB transmission in air travel.♦

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