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(updated ...)

SMOKING AND COMMERCIAL AIRCRAFT

Summary of conclusions

The present situation regarding smoking on board aircraft can be summarised as follows:

- Attempts by individual airlines and by governments to introduce smoking bans have generally been unpopular with a significant proportion of airline customers.
- Smokers, although in most countries a minority, nevertheless are a significant proportion of the adult population (in the EC, for example, there are an estimated 100 million smokers).
- The available data do not convincingly establish the claim that exposure to other people's tobacco smoke causes disease in nonsmokers.
- Tobacco smoke has not been shown to be a major contributor to poor cabin air quality; indeed, inadequate ventilation allowing a build-up of substances from many different sources, together with low humidity, have been suggested to be the major causes of air quality problems on board aircraft.
- Available data suggest that on board aircraft factors such as low humidity and poor ventilation, which permits a build-up of substances from a variety of sources, along with high levels of substances such as ozone, are in fact the major contributors to passenger discomfort and resulting complaints attributed to ETS.
- In the majority of studies measurements of ETS constituents in non-smoking sections on board aircraft shows them to be low, indicating that exposure to ETS is also low.
- It has been estimated that a nonsmoker seated in a nonsmoking section would have to take thirteen 28-hour round-trip flights from New York to Tokyo to be exposed to the nicotine equivalent of smoking a single cigarette;

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- A thorough review of the causes of fires on board aircraft does not provide evidence for the claim that cigarettes represent a major fire hazard, or that cigarettes are a significant contributor to aircraft fires over the past 30 years

It is therefore difficult to justify banning smoking on board aircraft. The system of providing both smoking and nonsmoking sections ensures that all passengers are catered for, and has worked well for many years The insistence of pressure groups on aircraft smoking bans not justified by scientific evidence is yet another indication of the continuing attempts by these groups to undermine the traditional relationship between smokers and nonsmokers based upon common sense, tolerance and courtesy

Introduction

Airline passengers and flight attendants are increasingly complaining about eye irritation, headaches, nose and throat irritation and breathing discomfort as a result of flying. Tobacco smoke has been pointed to as one visible component of air on board aircraft, and therefore has been suggested to be the major cause of these symptoms This, along with reports about the claimed effects of environmental tobacco smoke (ETS) on health, has led to the banning of smoking on board commercial aircraft in many countries around the world

For many years now, air travellers have been provided by almost all airlines with the choice of seating either in smoking or nonsmoking sections of the aircraft. Although this approach has worked well over the years, many airlines are considering banning smoking on board their aircraft, and many governments are proposing legislation to institute such bans formally. Such bans abandon any effort to accommodate the preferences of both smokers and nonsmokers, and instead merely impose, without convincing scientific justification, a radical "solution" favoured by some anti-smoking activists.

More importantly, efforts to ban smoking on board aircraft in no way address fundamental concerns about cabin air quality that have been raised by many groups over the years. By focusing solely on environmental tobacco smoke, critical constituents of the aircraft cabin environment such as ozone, cosmic radiation, low humidity and microbial aerosols are being ignored, as are problems with aircraft ventilation or filtration Whilst many see banning smoking as a "quick fix" for a difficult problem, responsible regulatory action in this area depends on careful consideration of the

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complex mix of elements in cabin air, rather than focusing on any single source of indoor air constituents

In the last 20 years, there have been a number of studies published dealing with various components of in-flight cabin air. Many of these studies have included measurements of concentrations of one or more components used as markers for ETS. In all of these published studies, the reported levels of ETS markers were far below general occupational standards. In addition, these studies consistently support the proposition that exposure to ETS constituents in nonsmoking sections of aircraft cabins is low. Although some nonsmoking passengers may report being annoyed by exposure to ETS even at these low levels, the data strongly suggest that these symptoms and related passenger discomfort can be alleviated by addressing poor ventilation, low humidity, and a build-up of substances such as ozone in the cabin

Air Quality Problems on Board Aircraft

Just as in the case of "sick buildings", the lack of adequate ventilation in aircraft can reduce air quality by permitting constituents which may have a negative impact on air quality to accumulate. These constituents include carbon dioxide produced by human breathing and dry ice in airplane galleys, atmospheric ozone; fibres and dust; nitrogen oxides; volatile organic compounds from fuel, cleaning fluids and other sources, and bacteria, fungi and viruses from food and passengers.

The ventilation system that is intended to dilute these substances generally utilises outside, fresh air brought through the engines. The air is frequently recycled, however, mixing the fresh air with "used" air from the cabin.

In the United States, ASHRAE (the American Society of Heating, Refrigeration and Air-Conditioning Engineers) has established ventilation standards for buildings. It recommends a minimum amount of 20 cubic feet per minute (cfm) of fresh air per person. However, the US National Academy of Sciences in 1986 observed that in a typical Boeing 747 flight, passengers in economy received less than 7 cfm of fresh air - just over 1/3 of the standard recommended for buildings. The rest of the air was recycled from the cabin. In first class, because of the smaller density of passengers, fresh air was provided at the rate of 30-50 cfm per passenger, whilst, in the cockpit, fresh air was provided at the rate of 150 cfm.

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Most aircraft today would be adequately ventilated if their systems were allowed to operate at capacity But because reducing ventilation saves fuel, the systems are increasingly being cut back to use more recycled air and less fresh air. In response to the fuel crisis, McDonnell Douglas issued a report in 1980 contending that reducing fresh air cabin intake in its DC-10s by 50 per cent would save 0.8 per cent on fuel costs, and that the airlines could save a maximum of 62,000 gallons of fuel per year by installing recycled air systems in their aircraft However, a closer examination shows the savings from reduced ventilation to be minimal For example: on board the average Boeing 747 aircraft, increasing ventilation from 10 cfm to a minimum recommended rate of 20 cfm per passenger on a five-hour flight on board a full plane would result in a total cost increase for that flight of US $ 240, or approximately 60 cents per passenger.

Poor ventilation (e g insufficient outside air in the overall mix) results in a build-up of carbon dioxide, which makes the cabin stuffy and can cause headaches and lethargy. The *US National Academy of Sciences*, in its 1986 report, stated that carbon dioxide levels on aircraft well in excess of limits recommended by ASHRAE and NIOSH (the US National Institute for Occupational Safety and Health) had been found, studies on Lufthansa showed levels more than twice the standard when operating air packs at 50 percent capacity Similarly, the US Department of Transport, in a study carried out in 1989 (see *Nagda et al. 1991*), noted that on 87 out of 92 flights studied, the average carbon dioxide levels exceeded ASHRAE standards Thus, overall air quality inevitably suffers as a result of poor ventilation and chemical constituents build up to levels that can cause discomfort.

Most review studies have reported that, with few exceptions, low humidity levels and high ozone concentrations were the most likely causes of the most commonly reported symptoms by passengers and flight attendants. The relative humidity level in the atmosphere is between 70 to 80 percent, although most people are comfortable when the relative humidity is as low as 30 percent. However, on commercial aircraft where the relative humidity levels were monitored by the US FAA, the *National Academy of Sciences* reported that relative humidity levels found on board aircraft were extremely low, ranging from 2 to 23 percent. When the relative humidity is less than 30 percent, people commonly experience symptoms which include dry mucous membranes and irritation of the skin, respiratory tract and eyes. Passengers on flights of 3-4 hours in the 5-10 percent humidity range can experience irritation of the eyes, throat and lungs.

Outside air at typical flight altitudes has very low moisture to begin with. Once brought on board and treated by engine compressors, low aircraft cabin humidity levels result.

People are more subject to viral infections in environments of low humidity, so planes can become highly infectious places if the ventilation system is inefficient Bacteria and fungal spores are also carried by air and may lodge in seat fabric, staying active for days

According to the NAS report, eleven percent of flights monitored by the FAA violated FAA standards for ozone levels, with average levels well beyond the FAA limits of 0 25 parts per million and levels on some flights more than eight times higher than those recommended Excess ozone exposures, even at levels below this maximum, have been associated with eye, nose and throat discomfort, persistent coughing, and breathing difficulties

Environmental Tobacco Smoke

Environmental tobacco smoke is produced when tobacco products are smoked. ETS is a combination of exhaled mainstream smoke (the smoke that is exhaled after a puff is taken) and sidestream smoke (the smoke that comes off the burning end of the cigarette between puffs). Before exposure occurs, both forms of smoke undergo a variety of changes - often referred to as "ageing" Even more significantly, ETS is progressively diluted in the air until it is removed from the environment by ventilation or is adsorbed onto surfaces Like all other forms of smoke, ETS is comprised of gases and particles

Banning airline smoking on the basis of the claim that ETS causes disease in non-smokers cannot be justified by the available data. Indeed, the majority of the epidemiological (statistical) studies (which typically involve non-smoking wives of smokers) do not even report an overall statistically significant association between exposure to ETS and disease

A number of studies have been carried out that measure levels of nicotine in the air on board aircraft, to give an indication of the levels of ETS present and the extent to which ETS influences overall air quality. The results are summarised in Table 1.

A number of authors have attempted to compare their measurements of nicotine in the air with the amount that the average smoker takes in from smoking one cigarette. *Oldaker and Conrad (1987)*, reporting on measurements on U.S. domestic flights of typically 55 minutes duration, estimated that non-smoking passengers were on average exposed to the equivalent of nicotine of smoking 0.0082 cigarette per flight in the smoking section of the aircraft or to 0.0041 cigarette per flight in the non-smoking

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section. A passenger in the non-smoking section would therefore have to take a 2-hour round-trip twice a week for the entire year to be exposed to the amount of nicotine equivalent to smoking one cigarette Applying the same assumptions to New-York-Tokyo data, published in *Crawford (1989)*, it would take thirteen 28-hour round-trip flights from New York to Tokyo for a passenger in the non-smoking section to be exposed to the amount of nicotine equivalent to smoking one cigarette. This amounts to well over one-quarter of a flight attendant's average annual in-flight time

Studies have also reported on measurements of levels of respirable suspended particles (RSPs) in the air Respirable particles are particles that are small enough to be inhaled into the lower airways of the human lung. Such particles are not unique to ETS and occur in significant quantities on board aircraft from a variety of sources other than ETS. Some studies have therefore measured ultraviolet particulate matter (UVPM), which is believed to give a more accurate reflection of the portion of RSPs from ETS Since UVPM may arise from sources other than ETS, measurements of UVPM may still overestimate the RSP that can be attributed to ETS Nevertheless, the results of studies reporting such measurements are summarised in Table 2; the differences in both RSP and UVPM between smoking and non-smoking sections of aircraft suggest that present policies of seating segregation work effectively

Some studies have measured levels of nicotine in the body fluids of flight attendants and passengers *(Foliart et al, 1983; Mattson et al, 1989)*. One such study *(Foliart et al, 1983)* concluded that physiological effects were "unlikely" from the low levels of nicotine observed

Holcomb in 1988, reviewed the available data from all of the above studies and concluded that

> "The available scientific evidence does not support the prohibition of smoking on commercial aircraft The data that are available reveal low concentrations of substances that can be traced to ETS .. The available data also suggest that factors or substances other than ETS may be major contributors to subjective complaints of discomfort by passenger and flight crew. "

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Fire Safety on Board Aircraft

A review of the causes of aircraft fires between 1962 and 1992 (using 63 different data sources representing the most comprehensive and authoritative aviation accidents and incident compilations, sources which are widely used by aviation safety professionals and the world aviation technical community and which include technical and research papers prepared by fire safety experts) indicates that, over the 30-year period, records were produced documenting 5980 accidents and incidents, less than 4 % of which involved fire as the principal factor. The great majority of fires involved engine/power plant fires and smoke/fire originating in the electrical system. However, of some 250 in-flight fire occurrences, only one has ever been officially attributed to a fire started by a passenger's cigarette. In that case, the aircraft was a Russian-built Ilushyn IL-18 aircraft which did not incorporate advanced fire resistant materials or have stringent in-flight regulations regarding cabin safety.

Two additional cases, although not confirmed or stated in official reports of findings, may have involved the careless use of cigarettes or matches or causes of ignition unrelated to smoking. However, in one of these cases, the failure of the airline to comply with even the minimal requirements for fire protection was considered to be the primary causal factor

Competitive and Economic Considerations

The number of airlines which have found it necessary to rescind smoking bans on board their aircraft because of passenger preference, indicates the extent to which airline passengers believe that the policy of provision for both smokers and nonsmokers is the correct one.

A number of individual airlines (Virgin Atlantic, Lufthansa, Turkish Airlines, Qantas, Swissair, Lauda Air, Guernsey Airlines and KLM) have decided not to go ahead with such bans. Guernsey Airlines commented that it felt it would be wrong to impose a ban when approximately one-third of British adults smoke. Smoking has been reinstated in some countries where airline smoking bans were introduced by government legislation. In December 1990, for example, the Brazilian Supreme Court of Justice overturned the legislated smoking ban on domestic flights of two hours or less. Smoking is now permitted on a segregated basis

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In addition to reasons of passenger preference, bans on smoking by individual airlines (e g SAS) have on occasion been rescinded for reasons of competition and economics, motivated by the fear that smoking passengers will simply select another airline. Bans on domestic flights in individual countries or within regions have also caused concern because of the possibility that passengers who wish to smoke may switch to other means of transportation

The competitive disadvantage for Canadian carriers was cited as one reason for a 'phased in' approach rather than a total ban on long-haul international flights in 1990 The Canadian government also made it clear at that time that it would be promoting a world-wide ban by pressing the issue at the International Civil Aviation Organisation (ICAO). With the United States, Australia and others, it sponsored a 1992 resolution calling for a total ban by ICAO members by 1996 The progressive ban on designated flights by Canadian carriers was to have been completed by July 1, 1993. However, citing "limited designation of smoking sections as the only way for Canadian carriers to compete in markets such as the Orient" the Canadian government postponed the total ban until July 1, 1994

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TABLE ONE

AVERAGE CONCENTRATIONS OF NICOTINE ON BOARD AIRCRAFT

AUTHORS	NICOTINE ug/m³ SMOKING SECTION	NICOTINE ug/m³ NON-SMOKING SECTION	NICOTINE ug/m³ WHOLE AIRCRAFT
Muramatsu et al 1984			15 2
Muramatsu et al 1987	13 5	5 3	
Oldaker & Conrad 1987	8 2	5 5	
Drake & Johnson 1990	10-48	2.54	
Malmfors et al 1989	41 0 business 32 0 tourist	5 0 21 0	
Mattson et al 1989	17 0	14.0	
Oldaker et al 1990	10 6	2.3	
Nagda et al 1990	13-43	0.05	
Ogden et al 1989	25 0	6 8	

TABLE TWO

AVERAGE CONCENTRATIONS OF RESPIRABLE SUSPENDED PARTICLES (RSP) AND ULTRAVIOLET PARTICULATE MATTER (UVPM) ON BOARD AIRCRAFT

AUTHORS	RSP ug/m³ SMOKING SECTION	RSP ug/m³ NON-SMOKING SECTION	UVPM ug/m³ SMOKING SECTION	UVPM ug/m³ NON-SMOKING SECTION
Oldaker et al 1990	39.0	15.0	26.0	7.0
Malmfors et al 1989	250 business 220 tourist	60 160		
Drake & Johnson 1990	37 5	13.48	23.9	6.69
Nagda et al 1990	175.8	35.0		

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