



**Institute for Environment
and Health**

**A CONSULTATION ON THE POSSIBLE
EFFECTS ON HEALTH, COMFORT AND
SAFETY OF AIRCRAFT CABIN ENVIRONMENTS**

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1 Introduction

The Institute for Environment and Health (IEH) has conducted a consultation exercise — *‘Consultation on the Possible Effects on Health, Comfort and Safety of Aircraft Cabin Environments’* — on behalf of the Department of the Environment, Transport and the Regions (DETR), with the assistance of the Department of Health (DH), the Civil Aviation Authority (CAA) and the Health and Safety Executive (HSE). The consultation exercise was undertaken as the first part of a response to the House of Lords Science and Technology Sub-Committee inquiry on the topic, held from May to July 2000 (House of Lords, 2000).

The principal objectives of the consultation exercise were to:

- establish the range of potential issues of concern about the possible harmful effects to personal health from the environment in aircraft cabins;
- identify key stakeholders having the potential to contribute towards the development of understanding in the field; and
- provide the Departments with a report assessing the priority areas for further consideration.

The consultation exercise was undertaken both to confirm, independently, the concerns identified by the House of Lords inquiry and to investigate any other potential issues and gaps in knowledge. The involvement of stakeholders throughout the whole process of investigation of a topic of major public concern is in line with the Government’s policy of openness, participation and inclusion.

As part of the exercise, IEH contacted several stakeholders with an interest and involvement in passenger air transport and sought their advice through a consultation exercise conducted by semi-structured telephone interviews, as described in Section 2 of this report. A qualitative analysis of the responses to the consultation exercise is provided in Section 3.

The consultation exercise was followed by a workshop of key stakeholders held at IEH on 30 November 2000. The principal aims of the workshop were to decide the priority concerns and to identify any issues of no real concern. A further objective of the prioritisation exercise was to help the relevant Government departments to decide what further action should be taken to improve knowledge about the impact on health of

aircraft cabin environments. Section 4 summarises the discussion at the workshop. Finally, section 5 presents a summary and the conclusions arising from both the consultation exercise and the workshop.

2 Methodology

2.1 IDENTIFYING STAKEHOLDERS

The consultation exercise to identify issues of concern relating to aircraft cabin environments was carried out through a series of semi-structured telephone interviews. A preliminary list of stakeholders likely to be able to provide relevant input to the topic was initially identified by DETR and DH. This comprised three representatives of aircraft crews, three representatives of constructors and engineers, two representatives of holiday/flight groups, four non-Governmental organisations (NGOs), one passenger representative and two independent researchers. Additional advice on the identification of stakeholders was sought from CAA. Likely stakeholders were also identified from a variety of sources, including the World Wide Web, lists of those people who gave evidence at the House of Lords inquiry and during interviews. The final list of stakeholders identified included representatives of government departments, aircraft crews, passengers, professional organisations requiring staff to travel on business, tour operators, occupational health physicians, travel insurance agencies, airline operators, airline constructors and appropriate special interest groups. A list of stakeholders contacted is presented in Annex 1; it comprises six representatives of aircraft crews, 14 constructors and engineers, six Government departments and authorities, 14 holiday/flight companies, six representatives of insurance companies, nine NGOs, three occupational health specialists from multinational organisations, 4 representatives of passenger groups and 18 independent researchers and consultants. Table 1 presents the numbers of individual stakeholders contacted and interviewed, within the different groups. Key stakeholders were identified through the consultation exercise and invited to a workshop to discuss the results of the exercise (see Annex 2).

Table 1 Stakeholders contacted and interviewed

Stakeholder Groups	Number Contacted	Number Interviewed
Aircraft Crews	6	5
Aircraft Constructors and Engineers	14	9
Government Department and Authorities	13	11
Holiday/Flight companies	14	6
Insurance	6	1
Non-Governmental Organisations	9	4
Occupational Health	3	3
Passenger Representatives	4	3
Independent Researchers and Consultants	18	12
Total	87	54

As shown in Table 1, 87 stakeholders were contacted and 54 interviewed. The remaining 33 were not interviewed for the following reasons:

- ☐ the stakeholders felt they were inappropriate or would not add anything to the consultation (7);
- ☐ it was difficult to arrange a time for the interview (9);
- ☐ it was not possible to talk directly to the appropriate representative of the organisation (10);
- ☐ it was not possible to identify an appropriate representative (6); or
- ☐ the stakeholder declined to give any information at the present time (1).

2.2 DEVELOPING THE CONSULTATION QUESTIONNAIRE

A preliminary consultation questionnaire for use in interviews with stakeholders was developed, based on issues of concern identified by DETR, the published literature and issues raised in the House of Lords inquiry. The consultation questionnaire was piloted using staff from IEH not otherwise associated with the project. Pilot consultations were held through pre-arranged telephone interviews following the proposed interview process. Two types of consultation questionnaire were piloted: one comprised just key questions; the other comprised the same key questions but also incorporated some checklists under each question, indicating areas of concern previously identified. Subsequently, the consultation exercise was further piloted with representatives from CAA.

In the light of the results of the piloting exercises, and taking into account advice from DETR and CAA, a semi-structured format, with key questions and some checklists indicating topics likely to be of concern or interest, was considered to provide the best approach, and this was adopted as the format for the consultation questionnaire used in pre-arranged telephone interviews with stakeholders (see Annex 3).

2.3 TELEPHONE CONSULTATIONS

All stakeholders were contacted first by telephone, during which their willingness to take part in the exercise was confirmed. A follow-up letter and copy of the consultation

questionnaire for use in a telephone interview at an agreed pre-arranged time were then sent.

The telephone consultations were conducted by three principal interviewers. The responses to the questions and additional dialogue were written down by the interviewer during the telephone interview and immediately after the interview a structured report was prepared (see Annex 4).

An announcement was posted on the IEH web site (see Annex 5) to facilitate interviewee confidence in the procedure and in the legitimacy of IEH requests for individuals or organisations to provide information and opinion.

2.4 STATISTICAL ANALYSIS

The consultation exercise utilised qualitative research methodology. Quantitative research aims, through measurement and quantification of the occurrence of events, to test hypotheses and draw conclusions as to the generalisability of the results. In contrast, qualitative research methods aim to make sense of and interpret the nature, strengths and interactions of variables. The analysis of the interview data involved:

- identifying and indexing all themes and concepts;
- examining all data relevant to each theme systematically (i.e. each item of data is checked and compared with the rest of the data – constant comparison); and
- describing the range and nature of the data within each theme and exploring associations between themes (Pope, 2000).

2.5 WORKSHOP

Key stakeholders from the groups listed in Table 1 were invited, together with representatives from DETR, CAA, DH and HSE, to participate in a workshop to identify and prioritise issues relating to aircraft cabin environments of widespread concern and to eliminate any issues of no substantive concern.

For the principal issues of concern identified by the consultation exercise, the workshop participants were asked to:

- decide what priority each issue of concern has relative to the others; and
- give general advice on possible further action.

3 Results of telephone consultation

This section presents a qualitative analysis of the responses from the consultation exercise, which was conducted through telephone interviews with stakeholders who have an interest and involvement in passenger air transport.

3.1 KEY ISSUES

Air travel allows for rapid movement across many time zones in a single flight, with flights lasting from less than one hour to over 14 hours. Commercial transport aeroplanes operate in an external environment that is hostile to human life. Ambient conditions outside the aircraft include very cold temperatures, (-43 C to -65 C), very dry air, too low a level of partial pressure of oxygen to sustain life, periodic episodes of high ozone, and pockets of air turbulence. Cosmic radiation is approximately 100 times higher at typical cruise altitudes than it is at ground level. It is in this harsh environment that an aeroplane must operate, while providing a life-supporting environment inside the aircraft cabin for passengers and crew. The environment must be healthy, safe and comfortable within the constraints of aeroplane design and function. This requires an advanced environmental control system to control the multiple functions of cabin pressurisation, ventilation and temperature control, as well as the provision of air for other pneumatic sources.

The aircraft cabin has a very different environment in comparison with most other forms of transportation. The environment is low in humidity, pressurised to a cabin altitude of between 6000 and 8000 feet above sea level and subject to continuous noise, vibration and accelerations.

In terms of health impacts, many different health effects and exposures related to aircraft cabin environments were mentioned by stakeholders during the consultation exercise as being of some concern. The health effects and exposures mentioned are summarised in Table 2. Each cross in the table represents a concern that was mentioned by at least one stakeholder. In some instances, specific health effects were considered as being linked to specific exposures. Thus a cross in the row 'headache' under the column 'humidity' indicates that at least one interviewee considered that headaches were linked, in some way, to the humidity of the aircraft cabin environment.

Table 2 Health effects and exposures highlighted by interviewees

	Air Flow/Circulation	Air Recycled/Filtered	Cabin Pressure/Altitude	Low Availability of Oxygen	Humidity	Temperature	Hydraulic Fluid & Lubricants	Exhaust Fumes	De-icing Fluids	Ozone	Increased Carbon Dioxide	Increased Carbon Monoxide	Disinsection	Seating	Exercise	Proximity of Passengers	Cosmic Radiation	Jet Lag/Time Zones	Work Patterns	Food & Drink	Noise & Vibration	Dehydration	No Exposure	No Problem	
Headache	x	x	x	x	x		x		x	x	x	x						x			x	x	x		
Nausea	x	x	x	x	x		x		x		x	x						x			x	x	x		
Irritation & Inflammation	x	x	x	x	x		x		x	x			x										x		
Respiratory Effects			x	x	x		x	x	x	x			x											x	
Hypoxia				x																					
Cardiovascular Effects			x	x	x					x				x										x	
Deep Vein Thrombosis			x	x	x									x	x						x		x	x	
Kidney					x																		x		
Dehydration					x	x															x			x	
Infection	x	x			x											x		x	x	x					x
Cancer										x							x	x					x		
Neuropsychological Problems				x			x		x				x						x						
Anxiety & Stress																			x	x				x	
Dizziness/Faintness	x		x				x				x	x						x	x					x	
Twitching/Trembling/Tremors			x				x	x			x	x													
Impaired Vision/Memory																									
Loss			x				x	x			x	x						x						x	
Reproductive Problems																	x							x	
No Problem	x	x					x						x								x				
No Health Symptom																									
Mentioned	x	x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x		x				

In other cases, although interviewees were concerned about particular health effects, they did not link them to particular exposures. These are recorded as crosses in the 'no exposure' column. Similarly, exposures of concern mentioned by at least one interviewee but not linked by them to health effects are recorded under the relevant column in the 'no health symptom measured' row. Thus the symptom 'headache' was mentioned at least once in association with each of a number of exposures (including humidity, low availability of oxygen, jet lag etc.) and was also mentioned at least once without reference to a particular exposure. The concerns mentioned can be considered as falling into five main areas: physical and chemical aspects of air quality, deep vein thrombosis (DVT), infection, cosmic radiation, and jet lag and work patterns. A qualitative analysis of the concerns expressed by interviewees under each of these headings is presented in Section 3.2.

A discussion of concerns expressed, by participants in the study, about safety and comfort is presented in section 3.3 and opinions about provision for passengers with special needs and advice to passengers are presented in sections 3.4 and 3.5, respectively.

3.2 HEALTH IMPACT

3.2.1 Air quality

Many interviewees expressed concerns about the quality of the air circulating in aircraft cabins. These concerns cover both physical and chemical aspects of air quality.

Physical aspects of air quality

Specific concerns about the physical aspects of the air included the amount of air flow, uneven cabin air distribution (perhaps causing pockets of 'stale' air), the proportion of recycled air in the aircraft cabin environment, the effects of altitude, low oxygen availability and the relatively low humidity of the air. Representatives of cabin crew and some NGOs referred to surveys of cabin staff from around the world that have shown symptoms of headaches, nausea, irritation, dizziness, hypoxia and other respiratory effects, dryness, fainting and fatigue to be common (Eng, 1979; CUPA, 1992; Balouet, 1998; Pierce *et al.*, 1999).

Crew representatives believed the amount of airflow in the aircraft cabin is insufficient, and stated that there is no regulation to ensure a minimum amount of outside air flushes into the cabin. About half the air in the cabin environment is recirculated and crews suggested that the amount of outside air input is much less than would occur in a typical office. In contrast, although constructors also said that the air supply is not extensively regulated, they quoted work undertaken in the USA, which demonstrates that the outside air exchange in an airplane is over four times that in a building (Cain *et al.*, 1983; ASHRAE, 1989). A major concern expressed by a majority of interviewees was the potential role of recycled air in the spread of infections (see Section 3.2.3).

Although the percentage of oxygen in cabin air remains unchanged (21%) at all flight altitudes, the partial pressure of oxygen and its availability to the body decrease with increasing altitude. The reduced cabin pressure and hence oxygen availability were believed to contribute to headaches, nausea and respiratory effects, and to cause hypoxia among those suffering from obstructive pulmonary diseases, anaemia or certain cardiovascular conditions. A number of interviewees gave examples of studies that have investigated these issues (Berglund, 1998; Space *et al.*, 2000).

Interviewees were greatly concerned about the relatively low humidity of cabin air, commenting that it can lead to a feeling of dryness and thirst, including dryness of the eyes and mucous membranes of the nose and respiratory tract. Studies were described indicating that symptoms related to relative humidity, such as dry irritated eyes and dry/stuffy nose, are predominant health-related symptoms on long haul flights (Eng, 1979; Rankin *et al.*, 2000). It was also believed that these symptoms indicate a degree of dehydration, and interviewees suggested that this might have a role in the development and progression of deep vein thrombosis and other cardiovascular problems. A few interviewees also mentioned kidney problems as being a possible problem associated with dehydration. It was suggested that humidifiers could be installed into the aircraft, but representatives of aircraft manufacturers said the possibility of increasing humidity is limited owing to the effects of condensation, corrosion and fatigue on the airplane structure. An alternative method suggested was to increase the amount of recirculated air, but this is an issue of concern itself.

Representatives of cabin crew expressed concerns about the combined effect that altitude and air quality may have on the crew and the impact of any such combined effect on their work, which they reported can be fatiguing and stressful for prolonged periods (especially long haul flights).

Chemical aspects of air quality

Several interviewees, particularly representatives of crews but including all groups of stakeholders except aircraft manufacturers, were concerned about the possibility of chemical contamination of the air from lubricating oils and hydraulic fluids (especially the organophosphates they may contain) and from exhaust fumes and de-icing fluids entering through open doors whilst the plane is on the ground. These all contain trace chemicals that are known to be neurotoxins, organ-specific toxicants, carcinogens or irritants. A number of stakeholders referred to published reports (Smith *et al.*, 1997; Balouet, 1998; Van Netten, 1998) on cabin air contamination by such chemicals as well as to company logs and pilot reports that provide evidence that flight deck, cabin crew and passengers may be directly exposed to sufficient airborne chemicals to cause symptoms.

Some NGOs referred to articles and documents that suggest that exposure to fumes in aircraft from hydraulic fluids and lubricants has been associated with acute irritation of the eyes and throat and gastrointestinal, respiratory and nervous system effects, and chronic central nervous system and immunological effects. Neurological or neuropsychological symptoms reported included headaches, dizziness, fainting, blurred vision, disorientation, memory loss and lack of coordination, as well as incapacitating symptoms such as nausea and respiratory difficulties¹ (Rayman & McNaughton, 1983; Tashkin *et al.*, 1983; Van Netten, 1998; Balouet & Winder, 2000; SBAI, 1999).

The issue of organophosphates in oils was raised often, with many references to the recent Australian Senate Inquiry². It was suggested that a monitoring system should be set up similar to that already established for measuring other

¹ ATSB (1997) *British Aerospace Plc BAe 146-300, 10 July 1997* (Preliminary Report 9702276), Canberra City, Australia, Australian Transport Safety Bureau. Available at: <http://www.basi.gov.au/occurs/ob199702276.htm>

² Senate on Rural and Regional Affairs & Transport Legislation Committee (2000) *Air Safety and Cabin Air Quality in the BAe 146 Aircraft*, Canberra, Australia, Parliament for the Commonwealth of Australia. Available at: http://www.aph.gov.au/senate/committee/rrat_ctte/bae/bae.pdf

chemicals. Representatives of aircraft manufacturers said that, to date, there are no reports that organophosphates have been detected in cabin air. Representatives of airlines referred to US studies that have found levels of air pollutants in aircraft cabin environments to be within specified regulations and guidelines, with the occasional exception of ozone (O'Donnell *et al.*, 1991; Spengler *et al.*, 1997; Pierce *et al.*, 1999).

A number of interviewees, did not consider that chemical contamination of air is a problem or that further information is required, and proposed that the symptoms mentioned may be caused by exposure to increased carbon dioxide and carbon monoxide, the reduced availability of oxygen or to other physical aspects associated with flying.

As a proportion of the air is recycled, a filtration system is used to filter out particles, vapours and pathogens. Although concern was expressed by some interviewees about the efficiency and effectiveness of some filters and the maintenance of the filtration systems, others felt that the filters were often of high quality, for example High Efficiency Particulate Air (HEPA) filters, and were similar to those used in hospital operating theatres. However, engineers did point out that any leaks from the engine would reach the cabin because they would not be filtered out.

The practice of disinsection, that is the spraying of pesticides in the enclosed aircraft cabin on arrival in some countries, was of concern to some interviewees, who suggested that this could cause problems for people with respiratory difficulties, especially asthma, and give rise to some neuropsychological problems in the case of repeated exposures. Crew representatives were particularly concerned about such exposure. The potential effect on children and infants should also be considered. Some interviewees felt that there was a lack of standardisation in this practice between airlines. However, airline representatives stressed that the World Health Organization and the International Civil Aviation Organization lay down rules for disinsection; only pesticides that are not injurious to the health of passengers and crew and that cause the minimum of discomfort are permitted. It has recently been reaffirmed that there are still very valid reasons to continue the practice. Nevertheless, it was thought that the necessity of this procedure should be reconsidered.

3.2.2 Deep vein thrombosis

The issue of DVT and other cardiovascular problems in relation to aircraft cabin environments was mentioned by many interviewees and among all categories of stakeholder. It was felt to be a growing concern, partly because an increasing number of anecdotal cases have been reported, and partly because of media attention. It was pointed out by several interviewees that the apparent increase in occurrence of DVT is probably, at least in part, caused by the increasing number of passengers, including a higher proportion of the elderly, on long haul flights. Most interviewees related this health problem to enforced immobility, cramped conditions, seating design and other factors, such as insufficient intake of water and air cabin pressure.

Researchers in cardiovascular medicine interviewed were in no doubt that prolonged periods of immobility are a risk factor for DVT, as has been shown by numerous studies of patients following surgery (Kakkar *et al.*, 1969; Field *et al.*, 1972); it was felt therefore, that long periods of immobility during a flight may conceivably increase the risk of DVT. All stakeholders interviewed suggested that walking about the aircraft would help to reduce the problem, although some pointed out that the potential for injuries caused by unexpected turbulence might outweigh the benefit. However, it has not been established that air travel is any different from any other mode of transportation in terms of immobility and DVT. Several interviewees pointed out that DVT is potentially a general problem of travel in confined spaces, and also occurs after journeys by road and rail (Stack, 1984; Ferrari *et al.*, 1999; Haas, 2000).

The design aspect of seats was highlighted. Factors mentioned included seat pitch and the need to design seats that are ergonomically suitable and also allow increased movement. One haematologist interviewed felt that it is not seat pitch that is the problem, but the fact that passengers (especially economy class passengers) are not able to stretch out their legs under the seat in front.

Dehydration brought about by the low humidity within the aircraft cabin environment, was cited as a possible factor contributing to the development of DVT on board. Haematologists noted that there is evidence that excessive dehydration leads to the thickening of the blood and an increase in its coagulability (Carter, 1994). However, several people were doubtful that the

aircraft cabin environment could actually cause a physiological dehydration. One interviewee estimated that on an average ten-hour flight a passenger would only lose about 100 ml of fluid (approximately 0.2% of total body fluid). Instead it was felt that discomfort of the external nasal passages is the main effect of dryer air. Alcohol is a known diuretic and hence adds to the dehydration experienced by passengers. However, one interviewee pointed out that a diuretic would increase the need to visit the toilet, therefore increasing exercise. Passenger representatives mentioned the fact that the disabled deliberately dehydrate themselves before flying to reduce the number of times they have to visit the toilet, and that they might therefore put themselves at greater risk of DVT.

Predisposition to DVT was felt to be an important consideration in the evaluation of any link between DVT and aircraft cabin environments. Many risk factors for DVT were mentioned, including obesity, hormone therapy, a previous history of DVT or other heart problems, chronic or malignant disease, and recent surgery. These might not necessarily be taken into account when investigating an incident of DVT. Several interviewees discussed how to reduce the potential for DVT, including increasing the awareness of the potential problem among flight companies, aircraft crew and passengers, and developing and delivering appropriate advice on prevention, particularly for those with predisposing factors.

3.2.3 Infection

A proportion of passengers and crew may board an aircraft with an infection, and there have been several case reports of transmission of potentially serious diseases, such as tuberculosis, following a long haul flight (Kenyon *et al.*, 1996). Many interviewees were concerned about the potential for general transmission of infections during flights, whether owing to the proximity of passengers or the recirculation of cabin air.

Some interviewees suggested that sitting in close proximity to an individual with an infection, particularly on a long flight, is the reason for cross-infection rather than the air circulation or recycling. However, engineers pointed out that it is not just proximity in the cabin that is the problem but also in the terminal prior

to boarding, and noted that the risk of infection is no different than on any other form of public transport or in any other public place.

It was suggested that increased travel to foreign countries might increase the possibility of coming into contact with unfamiliar viruses and pathogens, resulting in illness shortly after returning home. Interviewees representing crews also commented that the risk is not unique to long haul flights, because many passengers will connect from these flights onto short haul flights to reach their final destinations.

Around 50% of the cabin air may be recirculated (Carlile, 1996), and a large number of interviewees, across all categories, were concerned that the filters used in the air conditioning units may not completely prevent bacteria and viruses from re-entering the aircraft cabin, thus potentially allowing infections to spread more widely. However, engineers stated that the HEPA filters used, which are changed on a regular basis, remove 99.99% of all microorganisms down to the size of very small viruses. These filters should ensure that bacteria and viruses die very quickly within cabin air, and reports on regular checks of cultures from filters indicate that viable microorganisms are not found (Dechow, 1996). However, one interviewee stated that there is evidence that filters may not stop cross-contamination from one part of the aircraft to another, and that highly contaminated filters have been found, although no published documentation was suggested to substantiate this.

There was some concern that the air circulation might allow microorganisms to pass along the cabin, and incidents have been described where this has happened (Moser *et al.*, 1979). However, engineers pointed out that this could not occur when air conditioning units are operating, owing to the velocity of the air out of the ventilation system and the direction of air movement from above the head down to floor level, where the air is vented.

The effects of jet lag were also likened to those of the common cold, and it was thought this may be the reason why some people feel they have 'caught something' while flying. Interviewees from airlines pointed out that the Centre for Disease Control in Atlanta has studied disease transmission on aircraft and has so far identified only proximity, length of exposure and infectiveness of the patient as the important factors (Kenyon *et al.*, 1996).

3.2.4 Cosmic radiation

At sea-level people are protected to some extent from the sun's radiation because the various layers of the atmosphere absorb it. However, at cruising altitudes these layers are thinner, reducing the protection. Various groups, particularly crew representatives, Government agencies and NGOs, were concerned about cosmic radiation and the possibility that cancer may be associated with prolonged exposure; but studies have not shown an increased risk among aircraft crew for cancers known to be linked with exposure to radiation (Irvine & Davies, 1999; Ballard *et al.*, 2000). It was also pointed out that background radiation in some areas of the UK, such as Cornwall, is likely to be higher than radiation experienced during a flight. One interviewee felt that the greater opportunity for aircraft crew, compared with the general UK population, to spend periods of time in hot sunny countries might increase the risk of some cancers, such as skin cancer.

However, researchers in this field, aircraft crew, and flight companies drew attention to work underway to monitor flight crew's exposure, and Government departments have set up a working group (The Cosmic Radiation Advisory Group; see section 4.4). There are also European Union (EU) regulations (EURATOM, 1996) concerning exposure of flight crew to cosmic radiation.

3.2.5 Jet lag and work patterns

Jet lag, or disruption of the circadian rhythm, is a well-known problem associated with long distance travel, and it has been suggested that an individual needs one day to recover for every time zone crossed (O'Connell, 1997). Thus anyone travelling may feel tired and fatigued after a long flight, until their biological clock adjusts to the new time zone. Several interviewees were concerned that continued travel over long distances without adequate rest periods in between might lead to neuropsychological problems amongst staff, including anxiety, stress, dizziness, faintness, fatigue and tiredness, and might also cause a depressed immune system and an increased susceptibility to infection, gastrointestinal and kidney disruption, and menstrual problems. These symptoms may be exacerbated by long shifts and irregular work patterns.

One interviewee felt that jet lag might contribute to the increased probability of accidents subsequent to the flight, such as road accidents.

It was also a concern of cabin crew that the combined effects of jet lag plus the stresses of the work on their health had not been thoroughly studied (see section 4.5). Other groups were concerned that although cabin crews pass an initial medical test before they start employment, their health is not regularly monitored after this, in contrast to the flight crews who have to pass a medical to enable them to fly.

3.2.6 Other problems

Other problems that might affect health, which were mentioned by interviewees, related to food, drinking alcohol, sanitation, noise and vibration. Although many interviewees were not happy with the general quality of the food, the potential for food poisoning due to poor refrigeration and inadequate reheating on board the aircraft was particularly highlighted. However, UK airlines stressed that they have no major concerns about this and regular checks are in place to ensure that suppliers around the world conform to UK health and safety regulations.

In addition to the dehydrating effect of alcohol, some interviewees were concerned about its psychological effects, particularly when this might lead to a passenger becoming disruptive. Several interviewees mentioned inadequate cleaning of toilets and other communal areas during long haul flights, and also between flights, because of the need for rapid turnaround. Representatives of crew were particularly concerned about the potential contact of crew with infected blood or other bodily fluids. These groups also mentioned noise and vibration as being potential problems for crew, with possible associations with symptoms such as nausea and dizziness, and maybe even long-term deafness. It was felt that it was not just the volume of noise that may be a problem, but also low frequency noise experienced, for example, in the galleys of Boeing 777s. Crews felt that EU regulations that apply on the ground should also apply on an aircraft, and that monitoring procedures should be established. One interviewee felt that more research is needed on the effect of whole body vibration on crew.

3.3 SAFETY AND COMFORT

Table 3 shows the issues of safety mentioned by different stakeholder groups. There was general concern amongst interviewees about the amount of baggage that passengers are allowed to bring into the cabin and where it is stowed. The problem of overloading overhead lockers, with the chance that objects, especially duty free alcohol, may fall out during turbulence, causing injury, was highlighted. It was felt that CAA regulations were not strictly enforced by airlines. Interviewees were also concerned that baggage stowed on the floor might hinder evacuation procedures during an emergency.

There was concern about seating arrangements on aircraft and the possibility of evacuation being hindered. Some interviewees were worried about the number of exits and that some may be blocked by seats.

A major concern for half the stakeholders was the effect of unexpected turbulence on the safety of passengers. During flights, passengers have a tendency to undo their lap belts, and it was felt by interviewees that there should be strong advice not to do so, as there have been incidences of serious injury and even fatalities.

Illicit smoking in the toilets, on non-smoking flights, as a possible cause of fire was also an issue raised. One interviewee suggested that perhaps smokers could be provided with tobacco substitutes during long haul flights. Another potential fire hazard mentioned was the amount of electrical equipment now being installed into seats (videos, cd players, etc).

Several interviewees thought that more medical equipment should be provided, especially on long haul flights, and that staff should receive proper training in its use. The use of telemedicine was also mentioned a number of times as a way of providing assistance when a doctor is not on board.

Although it was not included in the remit of this study the subject of air rage and unruly passengers was a major safety concern amongst all stakeholders.

Table 3 Safety issues mentioned by different stakeholder groups

	Crew Representatives	Constructors & Engineers	Government	Airlines & Holiday Groups	Insurance Companies	Researchers	Non-Governmental Organisations	Occupational Health	Passenger Groups
Turbulence & Seat Belts	x	x	x		x				x
Overhead Lockers	x	x	x	x				x	x
Cabin Baggage	x	x	x	x				x	
Evacuation & Seat Layout	x			x		x	x	x	x
Number of Exits	x	x							
Smoking & Fire Risk		x	x	x			x		x
Medical Equipment				x		x			
Burns (from dry ice, hot drinks)		x	x						x
Crew Fatigue	x		x		x	x			
Air Rage		x	x	x		x			

3.4 PROVISION FOR PASSENGERS WITH SPECIAL NEEDS

Table 4 shows the categories of passengers with special needs mentioned by the different stakeholder groups. The group of users requiring special provision that was most frequently mentioned by interviewees was people with impaired mobility, including wheelchair users and the elderly. Representatives of all the respondent groups mentioned this category, many highlighting the lack of specially adapted toilets for the disabled. It was felt that consideration of special seating arrangements might be necessary for exceptionally tall or large people or those with musculoskeletal problems. Representatives of passenger groups stated that the concerns of the disabled were being examined and a report is due for publication in the near future. However, it was felt that very tall and vary large people are not particularly well looked after, especially the latter who tended to ‘encroach’ into other passengers seats from time to time. Two interviewees suggested that improved provision of special seating and safety belts for children and babies are necessary.

Passengers with specific health conditions were a concern for many interviewees. Concerns were expressed about pregnancy (to ensure no harm to both mother and fetus), respiratory problems (in which case extra oxygen may be required), cardiovascular problems (including a history of or predisposition to DVT), cancer patients, and those with a fear of flying. It was suggested that there should be provision of special equipment, such as Braille reading material and audio equipment, for passengers with visual and hearing impairment.

Some interviewees felt that most airlines were already providing flexible arrangements for a range of passengers with special needs. Several emphasised the importance of passengers taking responsibility both for their own fitness to fly and for notifying airlines of their needs.

Table 4 Categories of passengers with special needs mentioned by different stakeholder groups

	Crew Representatives	Constructors & Engineers	Government	Airlines & Holiday Groups	Insurance Companies	Researchers	Non-Governmental Organisations	Occupational Health	Passenger Groups
Increased risk of DVT/PE ¹	x		x			x			
Other Cardiovascular Disease	x		x					x	x
Respiratory Disease	x	x	x			x	x	x	
Musculoskeletal Problems						x		x	x
Neurological Disorders								x	x
Haematological Disorders								x	x
Tall People		x				x		x	
Large People		x				x		x	
Elderly		x	x				x	x	
Impaired Mobility	x	x	x	x	x	x	x	x	x
Sensory Impairment						x			x
Stretcher-Bound People		x			x		x	x	
Pregnant Women			x	x		x		x	
Children/Babies		x	x						

¹Deep vein thrombosis/pulmonary embolism

3.5 AWARENESS OF ADVICE FOR PASSENGERS

Interviewees suggested that advice should generally be available in airline in-flight magazines and on videos on board, and should cover such topics as what to drink and not to drink (i.e. plenty of water and not too much alcohol), simple exercises to do while seated and, if possible, walking around a little during a long flight. Some airlines do provide this information. However, the majority of interviewees from other groups felt this advice should have initially been given with the tickets or in information that is available to the travel agent. Airlines, Government, CAA and other organisations produce literature on health aspects of flying, but interviewees felt that this might not be comprehensive or readily available. It was suggested the airlines should be more pro-active in providing this literature. Some responsibility should also be placed on the passenger to ensure they are fit to fly, to consult their general practitioner (GP) if they have any worries, and to contact the airline if any special arrangements need to be made for them on the flight (i.e. extra oxygen, leg room, disabled access, etc.).

4 Workshop discussions

This section summarises the discussions at the workshop at which key stakeholders met to consider the results of the consultation exercise described in the previous section. The summaries of the workshop discussions on the main areas of concern are presented in the same order as in the previous section. Although there is inevitably some overlap, in many cases workshop participants were able to provide additional insight into the need for concern.

4.1 AIR QUALITY

It was suggested that an essential measure of success of aircraft travel is that passengers and crew disembark feeling relatively fit and well. Unfortunately there sometimes appears to be an expectation that after a flight, particularly a long haul flight, travellers may feel slightly under the weather, for example a little nauseous, bloated or dehydrated. The challenge is to make the effects of flying comparable with those associated with other forms of transport.

Air travel could be likened to being at high altitude in a dry hot atmosphere. A great deal is known about the individual physical characteristics of cabin air, such as oxygen content, temperature and so on, because such aspects are subject to design specification, and the safe boundaries are regulated. However, the concern is that it may be the combination of these inherent physical and chemical characteristics of aircraft cabin environments that gives rise to mild symptoms of ill health.

Cabin crew and passengers may have different requirements and may respond differently in some respects, for example to the recirculation of cabin air and the impact of altitude. Although in modern aircraft cabin air is changed approximately every three minutes and (it was felt) air is probably 'cleaner' than it is in many operating theatres, there are still concerns about the distribution of air throughout the cabin and the possibility that pockets of stale air may occur. Aircraft generally fly with a cabin pressure equivalent to that occurring at an altitude of between 6000 and 8000 feet and this has to be accepted with the current design of the aircraft. Given that the percentage of oxygen in cabin air is in fact the same as that at ground level, although reduction of pressure due to

the flying altitude may reduce absorption of oxygen, it was felt that a normal healthy passenger sitting at these altitudes should generally feel no ill effects. However, altitude may impact on the physically demanding tasks of cabin crew and this may be an area that would warrant further investigation.

Although the concerns are recognised, it was not clear what evidence there is that there are problems associated with the physical and chemical qualities of cabin air. It was felt that if the engineering controls and design specifications were correct and maintained then there should be few effects on health. It was pointed out that vague symptoms of ill health have been reported among passengers on many types of aircraft and lengths of flights (Balouet & Winder, 2000). These symptoms, for example headaches, are also generally common. It was suggested that research into the health effects of the unique combination of physical and chemical characteristics of cabin air is needed. This could include laboratory based chamber studies, with a range of different values of the important characteristics, in which physiological measurements could be made and symptoms recorded. Other stressors such as shift patterns and jet lag could also be introduced.

Potential microbial contamination of cabin air was discussed. It was felt that methods of measuring this have improved and that contamination may have been underestimated in the past. It was not clear if altitude has an effect on microbial contamination. Endotoxins may cause symptoms such as nausea, headaches and rhinitis, and are also known to interact with certain chemicals. It was pointed out that HEPA filters maintained to a high quality should remove all bacteria, viruses and endotoxins.

The issue of potential chemical contamination of cabin air, in particular from engine fumes and lubricating oils was also discussed. Although organophosphates are a tiny constituent of the oils, this was a concern of several interviewees and those who gave evidence to the House of Lords inquiry (House of Lords, 2000). It was felt that, although some information is available from the oil manufacturers, probably not enough is known about how oil might change under conditions of extreme pressure and heat and what happens if oil seals malfunction. It was suggested that measurements should be made on aircraft and also experimentally; experimental studies could cover a range of scenarios from a complete seal failure to a small leak. Measurements obtained in

this way could then be integrated with what is already known about the toxicological effects of these chemicals, to assess the potential risks to health.

4.2 DEEP VEIN THROMBOSIS

It is not known how common a problem the development of blood clots on the legs is among aircraft passengers; however, in the majority of cases the clots will disappear (O'Shaughnessy & Fitzgerald, 1997). Small clots can be detected but how often these progress to cause more serious problems including swollen legs, clots in the lungs requiring hospitalisation, or mortality is not known. As noted during the consultation exercise (see Section 3.2.2), DVT is not confined to aircraft travel, it is also associated with other modes of transport.

Although a number of possible risk factors were proposed by interviewees, most DVT will occur in those with a previous clot in the leg; other recognised risk factors include concurrent serious medical conditions, such as cancer, heart disease or (possibly) diabetes, and age (Gorman *et al.*, 2000). Other proposed risk factors, including reduced mobility (which the consultation exercise identified as a concern), will only increase risk very slightly. In particular, although also identified as a concern, there is no evidence at present that cramped seating conditions or seat design affect DVT. These are all topics that should be investigated.

At present, knowledge about DVT among aircraft passengers is very limited. Some anecdotal reports and retrospective studies of patients presenting at hospitals with problems associated with DVT are available (Ferrari *et al.*, 1999; Kraaijenhagen *et al.*, 2000). Most of the knowledge about DVT available today comes from studies conducted in the 1970s and 80s on hospital patients admitted for surgical procedures. Among such patients, about one-third in the over 40 age group will develop clots in the legs (Gorman *et al.*, 2000). Treatment with heparin and use of elastic stockings can help reduce the occurrence of the condition (Gorman *et al.*, 2000; Muir *et al.*, 2000). It is known that DVT is associated with stasis, damage to the veins and abnormalities in the blood clotting mechanisms (Freedman, 1998; Van Hylskama *et al.*, 2000). It could be envisaged that stasis and damage to the veins might be associated with seating, for example in aircraft.

Given the current perceptions among the public and other stakeholders about the association of DVT with the aircraft cabin environment, it will be important to conduct research to investigate in detail all the suggested causes. Ideally, studies should be undertaken on large groups, representing the general travelling public rather than specific subgroups, in order to evaluate how common the problem actually is (among travellers in general and aircraft passengers/crew in particular), what causes DVT in travellers, how much each of the known and proposed risk factors for DVT contribute to the overall risk, and what can be done to prevent DVT. This would facilitate the development of methods to identify passengers at most risk and some specific recommendations as to what can be done to reduce their risk. The effectiveness of changes in, for example, seat design, mobility during flight and exercise in counteracting the impact of some of the known risk factors should also be studied.

4.3 INFECTION

As noted in Section 3.2.3, transmission of infection associated with air travel may arise because of the proximity of passengers to each other. Workshop participants also noted that intercontinental travel (and associated contact with infectious agents unfamiliar to a given individual or population) or disease carrying insects entering the aircraft (usually through the cargo hold, which is not disinfected in the same way the aircraft cabin is) may also have some bearing on the transmission of infection. An example of the latter would be 'runway malaria', but in numerical terms this is a very small problem.

Airlines expect passengers not to travel if they have an infectious disease. However, passengers will often not know they are infectious. This may be a particular problem with tuberculosis, which is the most important condition of concern that is transmitted by droplet infection, as people may be infected and asymptomatic. Tuberculosis is most infectious when it is open and cavitating, otherwise it is unlikely to pass from one passenger to another in an aircraft. Although proximity to passengers carrying infections is a concern, as was noted also in the consultation exercise (Section 3.2.3), workshop participants felt that it need be of no greater concern than in any other situation where people are in close proximity, perhaps for prolonged periods. In fact any problems should be reduced in the aircraft cabin environment owing to the rapid exchange of air.

Studies have shown that the limit of transmission of infection from one person to another is probably no more than two to three rows of seats (Kenyon *et al.*, 1996). Cabin crew, in particular, may be exposed to numerous infectious diseases through their contact with large numbers of passengers from numerous and varied locations; however, if a higher than usual level of contact with pathogens does occur among crew this may in fact increase their resistance to infection.

There are concerns about links between air quality and transmission of infection (see Sections 3.2.3 and 4.1); for example, it is possible that failure to use air filtration and circulation systems or breakdown of the systems may increase the likelihood of transmission of infectious disease through the aircraft cabin environment. Regulations about the use of air conditioning systems, especially when the aircraft is on the ground, should be clarified and, where possible, unified. It was noted that monitoring environments (including aircraft cabin environment) for infection just by culturing organisms probably only identifies between 0.5-10% of microbiological agents present. Other monitoring techniques should ideally be included. Symptoms such as rhinitis, headache and nausea, which have been associated with air travel, can all be caused by microbiological contaminants. The presence of microbiological contaminants in the aircraft cabin environment will be largely dependent on the efficiency of the air filtration systems. Despite confidence in the efficiency of current systems (see Section 3.2.3), it might be beneficial to study levels of microorganisms, both during flights when passengers are present and after a flight when the aircraft is empty, to evaluate the efficiency of the filters.

Thus much is already known about both modes of transmission of infectious diseases through the aircraft cabin environment and the likelihood of such transmission. The prime need now is to inform, reassure, where appropriate, and educate passengers (in particular, that those with infectious disease should not travel).

4.4 COSMIC RADIATION

A DETR, CAA working group (The Cosmic Radiation Advisory Group), incorporating representatives from aircraft crews, industry and Government departments as well as scientific experts, has an ongoing remit to monitor the radiation exposure of flight deck crew and to keep up-to-date with advances in knowledge on the health impact of radiation. That radiation is associated with an elevated risk of cancer is recognised. However, the latency between exposure and effect is in the region of 20 years, and over even the last decade work patterns of flight crew have changed considerably, for example in terms of length of flights and latitude of flights. Thus it will be about another 20 years before prospective epidemiological studies being conducted now among flight crew can provide much new information on the health impact of cosmic radiation in this working population.

Much information on the health impact of ionising radiation comes from historical data on the atomic bomb and the nuclear industry. Nonetheless, it should be recognised that the types of radiation from a nuclear blast, the nuclear industry and cosmic radiation are different.

Based on existing studies, the cancer risk associated with cosmic radiation is less than 0.5% (Bagshaw *et al.*, 1996). This is a very small risk relative to the background cancer risk in the general population; for example, four in ten people in the UK are at risk of developing cancer during their lifetime (CRC, 2001). Thus very large studies will be needed to have the power to detect any adverse effect of cosmic radiation; for this reason a pan-European study (European Study of Cancer Risk Among Airline Pilots and Crew; ESCAPE) is currently underway.

There are concerns that only flight crew are routinely monitored for radiation exposure in the UK. Such monitoring is limited by the availability of records, which are not kept in the same way for cabin crew (being potentially a more mobile population) as for flight deck crew. There is thus much less opportunity to study radiation effects in women, as few pilots are women; in contrast among cabin crew women are in the majority. If monitoring and record collection pertinent to epidemiological studies on aircraft travel and cosmic radiation are to be extended to cabin crew in the UK, it would certainly enlarge the available

study population, but requirements to monitor would have to be applied across all airlines, internationally, so that none were unduly disadvantaged by an increased burden of monitoring. Another group that should possibly be studied is frequent flyers. Many people now fly frequently on business, and there is apparently an obligation of the employer, under European law, to conduct risk assessments on persons so employed (EURATOM, 1996). The implications of this regulation and how it should be applied should be evaluated in detail.

4.5 JET LAG AND WORK PATTERNS

To date, studies on the effect of jet lag and shift work patterns on flight crew have focused on performance and therefore the impact on the safety of aircraft and passengers. The topic has been well researched and findings from the studies have been taken into account in the development and implementation of flight time limitation regulations (CAA, 1990). The effects of shift work (in general not just among aircraft crews) on performance have also been well studied. However, as noted in the consultation exercise (Section 3.2.5), less has been done to study the impact of jet lag and shift working on aircraft cabin crew. It is not only performance and therefore safety that might be affected. There are also concerns about the combined effects of jet lag and shift working through changing time zones on the health of crew. Furthermore, it is not known how other factors associated with the particular lifestyle of aircraft crew (such as limited access to fresh air over repeated prolonged periods, work related stress and lack of control over diet, sleep patterns and domestic and social life) may interact with jet lag and shift work to adversely affect health. Jet lag is known to cause circadian dysrhythmia, which may affect, for example, sleep, digestion and hormone rhythms, and this needs to be actively managed (as is the case for all shift workers). The Strathclyde study* highlighted concerns about fertility among aircraft crew, and there have also been studies on fatigue among aircraft crew (Gundel *et al.*, 1995; Samel *et al.*, 1997). It is recognised that although there has been research on some of these individual aspects of employment as aircraft crew, the combination of jet lag, shift work, changing time zones/day light patterns and lifestyle is unique to this particular

* Boyd C & Bain P (1999) *Flying So High with Some Girl in the Sky - Image and Reality of Cabin Crew Work* (Report presented to the Transport and General Workers Union Press Conference, 25th March 1999, London)

occupational group, and as such aircraft crew should ideally be studied in a long-term epidemiological study, perhaps similar to nuclear industry studies, where participants are followed up not just through their working life but for their lifetime.

4.6 SAFETY

The workshop participants considered the issue of safety within the aircraft cabin environment, including whether enough information exists to assess the issues, whether more research is required, and whether changes in practice are indicated.

Among the specific safety issues discussed, a foremost concern was that of turbulence. Clear air turbulence cannot be predicted, and forecasts may not have a high degree of accuracy. Work is in progress to develop methods of detecting turbulence. General practise is to advise passengers to keep their seat belts fastened whilst in flight. At present it is the decision of individual passengers as to whether or not they heed this advice.

As in the consultation exercise (see Section 3.3), the amount and storage of cabin baggage, in particular the use of overhead lockers, was a concern. It was felt that this issue is often a major cause of confrontation between cabin crew and passengers. The passengers are often unwilling to be separated from their property. Another cause of concern is that of duty-free alcohol. The storage of glass bottles of flammable liquid in overhead lockers on an aircraft is a safety issue. This problem may be addressed by having duty-free shops on arrival in airports, so that passengers do not have to bring alcohol on to the aircraft.

It was noted that, originally, luggage space above seating was intended for coats and hats only, but this has now been extended to other baggage. A more logical and safe place to store baggage would be underneath seats. This would need a long-term solution to the problem, with major redesign of the cabin. It was felt that it was important to achieve standardisation across airlines on this issue to prevent unfair competition.

Workshop participants discussed the concerns about seating configuration and emergency evacuation raised by the consultation exercise. This is tightly regulated, although airlines may occasionally make errors. There may be

perceived concerns from the public, but these are not founded on an accurate basis. At present research is being carried out using mathematical models of seating configurations in aircraft cabins.

Onboard medical equipment is another safety area that is tightly regulated. European standards are usually exceeded by UK airlines. The use of ancillary medical equipment and ground-to-air advice could be considered by individual airlines. Medical training for cabin crew needs to be regularly updated in order to maintain competency in their skills. At present ground-to-air advice is provided by some airlines by emergency physicians experienced in aviation medicine. They advise on treatment and decide if a diversion is required. The use of telemedicine was felt to be the way for future provision of emergency medical advice.

4.7 PASSENGERS WITH SPECIAL NEEDS

It was pointed out that DETR have an 'Access to the Sky' Group, which discusses all issues related to disabled people using aircraft. There was a discussion relating to the need of people who are very large and/or tall, and their requirements. It was mentioned that over the past few decades, average sizes have increased, hence there are more people who are larger/taller, who may experience difficulties with standard seat sizes. Although airlines could resolve this by increasing seat sizing and space, this would result in fewer seats, and hence higher fares. Passengers may therefore choose to travel with other airlines. Tall passengers are often accommodated by being given seats in emergency exit rows.

4.8 ADVICE TO PASSENGERS

Throughout the workshop, several points were raised concerning the issue of advice, both to passengers and staff, regarding health and safety in the aircraft cabin environment.

The type of advice required can be broadly subdivided into:

- the advice that passengers need to know to enable them to travel safely and with less risk to health; and
- advice that passengers would like to have.

The provision of advice generally occurs either pre-flight or onboard. In particular, 'at risk' groups need advice prior to flying.

An important point discussed was the issue of who should provide advice to passengers that they can trust to be honest, independent and credible. It was pointed out that different airlines provide advice in their own style (to maintain brand image). It would be beneficial to have the airlines' advice endorsed and it was suggested that the DH might be an appropriate source of endorsement for the information. The production of 'Healthy Flying Guides' could be an option. These would be similar to 'Healthy Eating Guides', and could be made available through GP surgeries, for example.

The difficulties of effective health promotion were considered. The first requirement is for robust scientific evidence on which to base advice. Then, effective information provision is needed, in order to lead to changes in behaviour. The standardisation and consistency of information is thus of prime importance.

As well as catering for 'at risk' groups, it is also necessary to provide advice for the 'worried well', although it was pointed out that this group of passengers is likely to seek out information and go to their GP with questions. It is also necessary to provide advice to GPs so that they may pass this on to patients. As GPs may not have time to read through all the literature they are sent, advice would need to set out key points. As many passengers fly on a reasonably frequent basis (once per year or more), the advice they receive in-flight on one occasion will be of use the next time they fly.

The issue of providing information via the World Wide Web was discussed, especially with the growing numbers of passengers buying tickets online. Information is available on many airlines' websites; this information can be accessed at different levels. From the point of view of the airline, the advantage of the World Wide Web to disseminate health information is that it is easily updated. In contrast, leaflets, once printed must be recalled before new ones can be sent out. However it was recognised that not all passengers have Internet access.

It was suggested that, in addition to research into the physical aspects of aircraft cabin environments, research is required to determine the sources of advice and

information that people would find acceptable, and what motivates them to read it. It is necessary to find a reliable way to provide information at the depth required and to ensure that everyone has access to it. Scientific knowledge is also needed to discount issues and inform the public that they are not a problem.

Overall, the workshop participants concluded that a standardised and effective method for conveying information to passengers about health risks and safety should be developed. A research project in this field would need to ascertain what information should be given and how it should be presented, and evaluate the effectiveness of any advice.

5 Summary and conclusions

Stakeholders with an interest and involvement in passenger air transport were identified and invited to take part in a consultation exercise, conducted through semi-structured telephone interviews with IEH staff, to identify issues of concern about possible harmful aspects of the aircraft cabin environment. The project involved a wide range of stakeholders, and sought opinion as well as factual knowledge and expertise, in keeping with the Government's policy of openness, participation and inclusion when investigating topics of major public health concern.

Starting from an initial list of fifteen stakeholders provided by DETR, 87 stakeholders were identified during the course of the project. In addition to stakeholders in the initial list representing crews, constructors and engineers, holiday/flight groups, non-Governmental organisations, passengers and independent researchers, stakeholders representing insurance companies and occupational health specialists from multinational organisations were also identified during the project. Of the 87 stakeholders contacted, 54 were interviewed by telephone using a questionnaire that had been developed in consultation with DETR and CAA and piloted among IEH staff not otherwise involved in the project. From among the stakeholders interviewed, 23 key stakeholders, representing the various stakeholder groups (except insurance companies), were invited to a workshop to discuss the results of the consultation exercise and prioritise the major concerns identified.

The major concerns identified by the consultation exercise fell into five main areas.

- ☐ physical and chemical aspects of air quality
- ☐ deep vein thrombosis
- ☐ infection
- ☐ cosmic radiation
- ☐ jet lag and work patterns

Taking account of the results of the consultation with stakeholders in air passenger transport (reported in Section 3) and the discussion held at the

workshop (summarised in Section 4), the workshop participants identified and prioritised a number of topics related to the aircraft cabin environment that cause the greatest concern. The three most important concerns, in order of priority, were:

- deep vein thrombosis – the major current health concern for air passengers, owing to recent media interest;
- air quality – of concern especially to airline professionals and experts owing to the lack of knowledge about the combined effects of various aspects to do with air quality and other stressors relevant to flying; and
- provision of advice to passengers – of concern across the board, owing to the desire of individuals to be able to make informed choices.

Concerns about infection, cosmic radiation and jet lag and work patterns were also considered to be very important but to be of lower priority to stakeholders, relative to the first three.

In addition to the identified priority health concerns, concerns about comfort and safety were often thought to be associated with aircraft design (for example quantity and storage of cabin baggage, seat pitch and dimensions, evacuation of the aircraft). There were also concerns that no one body or agency seems to have responsibility for the health and well being of aircraft passengers.

Deep vein thrombosis

In the customers' eyes, this is a major concern, and DVT has received much recent media attention. Concerns included:

- lack of knowledge about how much of a problem DVT really is for aircraft passengers (especially relative to other 'at risk' groups or other passenger groups); and
- lack of knowledge about what differences interventions, such as increased leg movement or exercise, might make to the occurrence of DVT during or shortly after flying.

Air quality

Current knowledge on physical and chemical aspects of aircraft cabin air quality cannot completely resolve a number of concerns, for example about the effects

of temperature, humidity, air circulation, oxygen deprivation or chemical or microbial contamination, even though some concerns may be based on misconceptions. Although much is known about many of these topics individually, there was concern about:

- ☐ the combined impacts of the various aspects of air quality;
- ☐ combined effects of aircraft cabin air and other stressors associated with flying that might have an impact on health and well being (including psychosocial factors);
- ☐ features of aircraft cabin design that affect air quality; and
- ☐ the potential contamination of aircraft cabin air with lubrication oils.

Advice to passengers

The strong and broadly based concerns about the content, quality and availability of advice to passengers on the health aspects of flying had not been anticipated at the outset of this project. Some concerns of both passengers and crew about both health and safety arise because of the lack of detailed and efficient provision of advice and information. Specific concerns focused on:

- ☐ the evaluation and endorsement of advice to passengers, to ensure its consistency and accuracy across information providers;
- ☐ the identification and provision of essential advice and advice that could be accessible to those interested, taking into account the requirements of all passengers, passengers with special needs and crew; and
- ☐ the provision of effective advice in a way that can be responsive to changing knowledge.

Although there are concerns about the provision of advice, *per se*, it is also recognised that the provision of appropriate and effective advice may help allay some of the other concerns about the aircraft cabin environment described in this report.

Infection

Knowledge about the potential transmission of infectious diseases is already well advanced, and many current concerns among stakeholders, for example about transmission of infection through the aircraft cabin environment and

procedures that are in place to minimise it, may arise because of the limited provision of advice and information. There were concerns that the best procedures may not be currently in place to measure microbial contamination in aircraft cabin environments.

Cosmic radiation

As with infection much is already known, and concerns may arise because of the limited provision of information about ongoing research and surveillance initiatives. A considerable amount of long-term research, following the exposure and health of flight crew, is already well established and can be expected to continue. Concerns were expressed that little is known about the impact of cosmic radiation on women, cabin crew or frequent flyers.

Jet lag and work patterns

Safety issues related to jet lag and work patterns are well researched, as is the effect of shift work on health. However, less is known about:

- the health impact of jet lag;
- the health impact of the combination of jet lag and shift work patterns - this is a particular concern among crew; and
- the lack of long-term investigations of airline crew, and in particular cabin crew, on the health impact of jet lag and shift work patterns in these occupational groups.

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Annex 1 List of stakeholders contacted

Aircraft Crews

Association of Flight Attendants
British Air Line Pilots Association
British Airlines Stewards and Stewardesses Association
International Transport Workers Federation
Trade Union Congress
Transport & General Workers Union

Aircraft Constructors and Engineers

Airbus Industrie
Baxter Woodhouse Taylor
Boeing Corporation
Britax Rumbold Ltd
British Aerospace
European Aeronautic defence and Space Company
Envirotech (UK) Ltd
General Aviation Manufacturers & Traders Association
Ministry of Defence (Filters)
Mobil Oil
Normalair-Garrett Ltd
Pall Aerospace
Rolls Royce
Shell Oil Products Ltd

Government Departments and Agencies

Civil Aviation Authority
Department of the Environment, Transport and the Regions, Aviation Directorate
Department of Health
Health & Safety Executive
House of Commons
The Joint Aviation Authorities

Holiday and Flight Companies

Air Canada
Air Tours
British Air Transport Association
Britannia Airways
British Airways
British European
British Midland
International Association of Air Travel Couriers
Qantas
Saga Group Ltd
Thomas Cook
Thomson Holidays
United Airlines
Virgin Atlantic

Insurance Companies

First Assist
Home & Overseas Travel Insurance
Lloyds Aviation Underwriters Association
PPP Health Care Group
Prudential Insurance Corporation
Royal & Sun Alliance

Non-Governmental Organisations

Air Transport Users Council
Aviation Health Institute
Aviation Study Group
Board of Airline Representatives, UK
Environmental Communications
European Regional Airline Association
International Air Transport Association
International Civil Aviation Organisation
Royal Aeronautical Society

Occupational Health

Astra Zeneca
BP Amaco
Glaxo Wellcome

Passenger Representatives

Consumers Association (Holiday Which)
Disabled Persons Transport Advisory Committee
Flight International
International Airline Passengers Association

Independent Researchers and Consultants

Aviation Medicine Consultant
BRE Ltd
Defence Establishment Research Agency
Freeman Hospital
Hospital Doctor Magazine
Human Factors Group, Cranfield University
Independent Consultant
Institute for Aviation Medicine
ICE Ergonomics
Jet Lag Clinic
Lister Hospital
Medical Toxicology Unit, Guy's Hospital
MRC Epidemiology & Medical Care Unit
Mullard Space Science Laboratory
National Radiological Protection Board
Open Ergonomics Limited
Queens Medical Centre
Thrombosis Research Institute

Annex 2 List of workshop participants

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MRC Institute for Environment and Health, 94 Regent Rd, Leicester, LE1 7DD

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Annex 3 Consultation questionnaire



Medical Research Council

**Institute for Environment
and Health**

CONSULTATION ON THE POSSIBLE EFFECTS ON HEALTH, SAFETY & COMFORT OF AIRCRAFT CABIN ENVIRONMENTS

A House of Lords Science and Technology Sub-Committee inquiry identified a need for information of the potential adverse effects on human health of the environment in aircraft cabins. In response to this, the Department of the Environment, Transport and Regions (DETR) and Department of Health (DH), with the assistance of the Civil Aviation Authority (CAA) and the Health and Safety Executive (HSE) have initiated a programme to gather information.

As an initial step in the programme, the DETR and DH have commissioned the Institute for Environment and Health to consult with appropriate stakeholder organisations, to prioritise those issues of particular importance to this area. The consultation exercise has been developed to identify the general areas of concern to individual stakeholders, in relation to both passengers and crew.

You have already been contacted to arrange a date for a telephone interview to consult with you on aircraft cabin environments.

The attached document outlines the topics we wish to cover during the telephone interview. It includes some checklists of some of the issues that have been identified by previous studies. We would not necessarily expect you to have an opinion on all of these, and you may also have other concerns you wish to raise. The interview should last no longer than 30 minutes and will not be taped. We therefore ask the interviewee to speak clearly and not too fast. Any answers that are unclear to the interviewer will need clarification. We would also request any technical jargon be kept to a minimum.

Information in this questionnaire will be treated as strictly confidential and will be used for statistical purposes only.

If there are any problems please contact Jane Stevens on 0116 223 1644.

Thank-you for your time.

Date:
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Time:
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Interviewer:
.....

Interviewee:
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Telephone Number:
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Institution:
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Address:
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Role of Institution:
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Role of Interviewee Within Institution:
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2. (a) What concerns, if any, do you have about safety issues in the aircraft cabin environment?
(b) Do you have any concerns about the likely causes of these safety issues.

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3. (a) What concerns, if any, do you have about comfort issues in the aircraft cabin environment?
(b) Do you have any concerns about the likely causes of these comfort issues?

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4. Are there any individuals or specific health conditions for which you feel special provision should be made within the aircraft cabin environment?

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5. Are you aware of any advice that is available to passengers embarking on a flight, be it short or long haul?

General Practitioners, Insurance Companies, Travel Agents, Airlines, etc.
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6. Are there other areas of concern you wish to raise which we've not already covered?

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7. During this consultation we are contacting people from all areas of the aircraft industry (manufacturers, airlines, crew representatives, regulators, government, passenger groups, scientists, lay people, etc.). Are there any specific groups or individuals you feel we should contact?

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Annex 4 Example of individual consultation report

Consultation on the Possible Effects on Health, Safety and Comfort of Aircraft Cabin Environments

Interview report

Interviewer:	<Name>		
Interviewee:	<Name>	Phone No.	<Details>
Organisation:	<Title>	Position:	<Title>
Address:	<Details>		
Role of organisation:	<Details>		
Date of interview:	<Date>	Time of interview:	<Time>

Question 1: Do you have any concerns about the effects flying might have on the health of passengers and crew?

When this question was asked, the answers related more to question two, than question one. However, on prompting the interviewee felt that a higher level of CO₂ in ACE may be important, although he was unsure how exactly it might affect health. Chemicals in the air may also be a problem, but it is difficult to say what affect they may have on health. Oxygen levels may be important for pregnant mothers and the cabin pressure may be a problem for those with circulatory problems or with inner ear problems (this could lead to burst ear drums). Other problems may be pathogens in the ACE and generally stress, which may lead to violent behaviour.

Question 2: Do you have any idea as to the likely causes of these health problems?

Main areas thought to be of concern were air quality, air exchange rates and ventilation. In particular chemicals in the ACE from emissions from seats and carpets and the use of pesticides were mentioned. Additional concerns were also the oxygen level flying at altitude, the air pressure in the ACE, possible illness being transmitted and stress. These concerns have been obtained from personal experience and background reading. Air quality was re-iterated as a concern and that it is generally dry and stuffy.

Question 3: Do you have any concerns about safety and comfort of aircraft cabin environments?

The interviewee felt that safety was sufficiently regulated and had no real concerns. However, he felt that there was insufficient legroom, which may result in problems for lower limb circulation. He also felt that the lack of space might also be a safety issue for evacuation of people.

Question 4: Are there any groups of individuals for whom you feel special arrangements should be made or who should be advised not to fly?

Pregnant mothers and those with reduced mobility were or concern and special arrangements should be made for them.

Question 5: Are you aware of any advice that is available to passengers embarking on a flight, be it short or long haul?

The interviewee thought that pregnant women were advised not to fly after about the 30th week of pregnancy, or if they did that they required permission from a doctor to fly. However, he had not heard or seen any advice given by plane operators.

Question 6: Are there other areas of concern you wish to raise in the interview which we've not already covered?

No further concerns.

Question 7: Is there specific person you feel we should contact?

The Civil Aviation Authority

Interviewers notes:

None

Annex 5 IEH web site announcement

Consultation on the possible effects on health, comfort and safety of aircraft cabin environments

A House of Lords Science and Technology Sub-Committee inquiry recently identified a need for further study of the potential adverse effects on human health of the environment in aircraft cabins. In response to this, the Department of the Environment, Transport and Regions (DETR) and the Department of Health (DH), with the assistance of the Civil Aviation Authority (CAA) and the Health and Safety Executive (HSE), have initiated a programme to gather information.

As an initial step in the programme DETR and DH have commissioned IEH to consult with appropriate stakeholder organisations in order to prioritise those issues concerning health, comfort and safety that are of particular importance to this area. The consultation exercise has been developed to identify the general areas of concern to individual stakeholders, in relation to both passengers and crew.

The key objectives of the project are:

- to establish the potential areas of concern with regard to adverse health effects of the aircraft cabin environment;
- to identify key stakeholders having the potential to contribute towards the development of understanding in this field; and
- to provide the Departments with a report assessing which of the suggested issues constitute a priority for subsequent detailed consideration.

To meet these objectives, the health impact issues of concern to the public and to representative organisations will be identified and prioritised. The results of the project will be developed and presented in such a way as to inform a subsequent study to identify and assess in detail the evidence available on the priority concerns and, if necessary, recommend future research.