EXECUTIVE SUMMARY

Public health impact of large airports

Civil aviation
Civil aviation represents a growing industry and most economists expect this growth to continue. It is developing into a truly global industry, with a few conglomerates of airlines serving a world-wide network of large 'hub' airports. In 1997 the scheduled airlines carried 1,5 billion passengers and 26 million tons of freight. The economic gains of the aviation industry and the possibility of reaching far away locations may be beneficial for health and quality of life, probably mainly so for affluent populations in the industrialised parts of the world. However, aviation affects the environment both globally and locally in a negative sense and consequently has also negative impacts on health.

Request and report
This report responds to a request of the Ministers of Health, of Transport and of the Environment of the Netherlands Government to assess the health impact of large airports._ The request was related to the public and political debate about the future of the Dutch aviation infrastructure and about the expansion of Amsterdam Schiphol airport in particular, although a specific assessment for the Dutch National Airport was not called for. To prepare the report the President of the Health Council appointed an international committee of experts.
Three case studies were carried out to provide the committee with background material on the way public health plays a role in airport development. The cases chosen were; a new passenger terminal at London Heathrow, Munich International Airport that opened at a new location in 1992, and the planning process for an airport in Berlin, to replace the three existing airfields in the beginning of the next century. The committee was also informed on the progress with the health impact assessment studies at Amsterdam Schiphol.
The committee focused on the public health impact of local changes in environmental factors. 'Public health impact' has been defined by the committee as to include impacts on 'quality of life'. Effects of aviation on climate and thereby health and indirect positive and negative public health effects through economic mechanisms, transport possibilities and tourism are outside the scope of the present report.

Airport operations system
The committee has approached the relationship between airport operations and public health in an integrative manner. It evaluated public health impacts in airport operations systems encompassing the area up to a few tens of kilometres distance from the airport. Apart from the direct aviation related operations the system also includes the activities of businesses that are attracted to the airport region, as well as the infrastructure necessary to serve to airport, other businesses and the residential locations in the area. Even when airports are originally located in remote areas, then over of the years the airport region becomes more and more urbanised and settled with freight handling industries, catering and hotel activities, high-tech industries and offices that prefer to be located close to the airport.
The impacts of all these activities within an airport operations system on public health are only partly specific for the system. Aircraft noise, kerosene odour and aircraft crash risk are specific factors. Air pollution, landscape changes by transport infrastructure, road traffic and industrial noise and occupational health risks are, however, also encountered in other urbanised and industrialised settings.

Environment and public health
The committee has considered the impact of several environmental factors on health separately:

- air pollution
- noise
- accidents
- soil and water pollution at the airport
- importation of infectious diseases
- appearance of the environment
- occupational health risks at the airport.

In the concluding chapters the committee has tried to integrate these findings and suggests approaches for improving public health protection.
Does the airport operations system affect public health? This central question is answered by the committee with; yes. Considering the relationship between environmental factors and public health, infringements on the

quality of life, such as sustained odour and noise exposure, also have a potential of causing clinically observable disease in the long run. This depends on a variety of factors such as individual susceptibility, social-economic status and life style, and the simultaneous exposure to a variety of environmental factors. Some of these factors may aggravate the public health effects, but others could reduce or offset them. The relationships between environment and health are fraught with uncertainties, not in answer to the question about whether factors such as environmental noise and air pollutants do affect public health negatively, but to the questions as to what extent and which population groups are most vulnerable.
In determining the impact of environmental factors the committee uses classification schemes for:

- evidence for the causal relationship between the exposure to an environmental factor and a public health effect
- severity of the effect (slight, moderate, severe)
- number of people affected.

The classes for causal evidence are; sufficient, limited or inadequate evidence, or evidence for the lack of a causal relationship. Severe effects seriously impair day-to-day functioning and usually require professional medical care. A public health effect is rated as 'slight' if the impact on daily functioning is not very significant, or is reversible, or has a small effect in the long run. Moderate effects are in between these two extremes. The number of affected people can only be very roughly indicated. Classes are: susceptible individuals, specific subgroups, substantial part of the exposed population, and are only given if the causal relationship is deemed to be supported by sufficient evidence.

Air pollution
The contributions from aircraft, other airport operations, road traffic to or from the airport or to other destinations to the public health effects of air pollution in an airport operations system are intricately mixed. This is due to the spread of air pollutants in the atmosphere by dispersion processes, whereas total pollution is also determined by sources outside the system, possibly far away. The important conclusion is that air pollutant levels around large airports are similar to those in urbanised areas and are to a large extent determined by road traffic emissions. At such concentrations public health effects are to be expected, even though the concentrations are generally below official guideline values.
The present understanding of air pollution effects is that exposure will impair respiratory functions, for most people in a reversible way. Effects become more invalidating in the case of sustained exposure. The table below lists the effects of air pollution for which there is sufficient scientific evidence for a causal relationship:

Response	severity 1	number affected 2
premature death (response after an episode in susceptible groups)	***	*
aggravation of respiratory and cardiovascular disorders after an episode (resulting in hospital admissions)	***	*
affected lung function after an episode	*	?
premature death (decrease in life expectancy) due to chronic exposure	***	*
reduced lung function due to chronic exposure	**	**
increase in chronic respiratory conditions (bronchitis) due to chronic exposure	**	**
odour annoyance from chronic exposure	*	***

1 * = slight, ** = moderate, *** = severe

2 * = susceptible individuals, ** = specific subgroups, *** = substantial part of exposed population

Effects, related to an air pollution episode, for which there is limited evidence are respiratory symptoms and aggravation of asthma. These effects are rated by the committee as slight and severe, respectively. Epidemiological studies of the prospective, cohort and case-control variety have linked long-term exposure to air pollution with survival, increased lung cancer mortality, reduced lung function and increases in chronic respiratory conditions, especially bronchitis. The committee rates this evidence as sufficient, even though more work need to be done to elucidate exposure-response relationships and to what extent the effects observed are due to exacerbation of existing disorders. There is to date only inadequate evidence to link long term exposure to community air pollution to the prevalence of allergy ands asthma. As yet no airport specific carcinogenic compounds have been identified.

The number of epidemiological studies on air pollution and public health near airports are scarce. Morbidity and mortality levels, related to diseases that may be air pollution related, do not appear to differ between airport regions and cities. A study at Amsterdam Schiphol has provided evidence for a decrease in the prevalence of respiratory complaints with increasing distance from the airport. To what extent air pollution levels and other factors play a role is subject of further study.
Chronic exposure to odour has been reported to induce, apart from annoyance, a variety of moderate somatic and psychosomatic effects. The evidence for a causal relationship is rated as limited.
With respect to controlling air pollution the committee notes that in most industrialised nations industrial and road traffic sources of air pollution are subject to regulatory control, contrary to aircraft emissions. An integrated approach to combat air pollution is at odds with a system in which one important source, *i.e.* aircraft emissions, is exempt from such control.

Noise
Aircraft noise is one of the most noticeable environmental factors of airport operations and is specific to the system. Although there are other noise sources in the system, noise from aircraft taking off and landing, from aircraft braking and taxiing at the airport and from aircraft engine testing are dominant ones. At the airport, noise from ground traffic can be considerable and will in particular affect airport workers. In the vicinity of an airport one will usually find residential locations where air traffic noise is a dominant source of environmental noise exposure. Aircraft noise levels are determined by the position of the runways and the flight patterns. Outdoor aircraft noise exposure in residential areas around large airports may exceed 60 and occasionally 70 dB(A) (day-night or day-evening-night exposure level).
Hearing impairment is a well-documented effect of noise exposure. In an airport operations system it is of concern at operations at the airport, especially in ground handling and in engine testing. Only in very exceptional cases will environmental noise exposure induce hearing loss. The other effects for which there is sufficient evidence for a causal relationship with noise exposure are listed in the table below. Effects are only observed in exposed populations at noise levels above the observation threshold. 'Sleep disturbance' in the table denotes a conglomerate of effects, including awakening, sleep stage and sleep pattern changes, heart rate changes, and effects on mood the next day. Limited evidence exists for the effects of night-time noise exposure on performance the next day and changes in hormone levels.

response	severity 1	number affected 2	observation threshold
hypertension	**	**	eq. outdoors sound level (06-22 h) of 70 dB(A)
ischaemic heart disease	***	*	eq. outdoors sound level (06-22 h) of 70 dB(A)
annoyance	*	***	outdoors day-night level of 42 dB(A) 3
sleep disturbance	**	***	depending on effect, indoors SEL of 35-50 dB(A) 4
performance at school	**	**	eq. outdoors sound level (school hours) of 70 dB(A)

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3 threshold for 'high annoyance'; the day-night level is the equivalent sound level over 24 hours, with the sound levels during the night (period of 23-07 h) increased by 10 dB(A).

4 SEL is the equivalent sound level during the noise event normalised to a period of one second

A variety of other effects has been linked to noise exposure, such as decreased general performance, biochemical effects, deterioration of the immune system, decrease in birth weight, psychiatric disorders and negative effects on psycho-social well-being. The committee considers the evidence for the causal relationship of these phenomena with noise exposure to be limited. With the exception of psychiatric disorders (severe), and effects on birth weight and psycho-social well-being (moderate), the committee rates the other effects as slight. There is evidence that congenital effects do not result from the exposure of pregnant women to environmental noise.
The understanding of the committee is that, hearing impairment excepted, the public health effects of noise depend on both the (psychological) appraisal of the noise exposure by the organism and the vegetative reactions induced. Some of the somatic and psychosomatic effects, such as hypertension and cardiovascular disease may be a direct consequence of this processing of noise exposure by the organism, others are possibly a consequence of noise-related annoyance. Annoyance is defined here as a feeling of resentment, displeasure, discomfort, dissatisfaction or offence which occurs when an environmental factor interferes with a person's thoughts, feelings or activities.
Noise exposure is only one of the determinants of annoyance. Studies have shown that aircraft noise is more annoying than road and rail traffic noise at the same day-night exposure levels. Aircraft noise-induced

annoyance is influenced by the degree of anxiety associated with the possibility of aeroplane crashes. Other so-called non-acoustical factors that modify annoyance are the degree of openness on the part of the airport authorities or the government concerning the developments at the airport and the way in which the authorities enforce environmental standards. These latter factors can work both ways, i.e. they can be instrumental in reducing (more openness, strict enforcement) or increasing annoyance.
Recent studies appear to confirm older work on the negative impact of aircraft noise on the cognitive abilities of children. The committee deems this to be a subject that warrants further study to elucidate exposure-response relationships and to assess the possible long term impacts.

Safety
Aircraft crashes come first to mind when mentioning safety in relation to airport operations. However, accidents, such as fires, may also occur (and have occurred) at fuelling operations and aircraft maintenance. Fires not related to fuelling can have severe consequences, especially those at the air, rail and bus passenger terminals. Also terrorist actions have been recognised as a serious risk associated with airports. Elsewhere in the airport operations system traffic accidents, accidents at industries, fires, etcetera can occur.
The present report focuses on aircraft crashes. The landing and takeoff stage are the most critical parts of a flight as far as crash risk is concerned. The probability of an accident further depends on the type of aircraft, its weight and its state of maintenance and the weather conditions. The management quality of the systems and organisations involved in aviation and in accident control, and the quality of the managed personnel are components determining the accident risk. This holds for flight personnel, air traffic control, airlines and rescue and other safety services alike.
In the past decades world-wide, on average, 50 crashes occurred per year, resulting in about 1500 fatalities per year, among which 35 individuals of the general population. These data show that the primary victims are the crew and passengers. The services of the large airlines are associated with considerably less fatalities per aircraft hour than, e.g., general aviation (non-commercial aviation). Aircraft crashes are rare events given the large number of flights. At present the crash frequency in the vicinity of a large airport is roughly one to two crashes per ten million movements (takeoffs and landings). This implies that a rough estimate of the average crash rate in the vicinity of larger airports is one to two per decade.
Using the evidence, severity and number affected classifications accidents do occur (sufficient evidence), the health consequences are always severe and the whole population in the airport operations system is at risk, be it that only a small number of people will be actually affected.
The individual risk levels for people living, working and travelling in the vicinity of a large airport are low (being hit by a crashing aircraft is a very extraordinary event) and will vary strongly geographically depending on the flight paths. Calculated individual risks (probability per year of dying due to an accident at a given location) exceeding 1 per 10 thousand per year are confined, within the airport territory, to places close to the runways. Locations with calculated individual risks between 1 per 100 thousand and 1 per million per ear that encompass residential zones, have been identified around large airports. In the Netherlands around industrial installations new houses would only be allowed in zones with individual risk levels not exceeding 1 per million per year.

Soil and water pollution
Leaking underground storage tanks and pipes, fuel spillage or leakage during ground handling of aircraft, washing of aircraft and vehicles and fire-training for which flame-retardant chemicals are used, are sources of water and soil pollution at airports. If policies to prevent such pollution are in force and effective, the public health impact is minor. A pollution pathway specific for airports is related to de-icing operations to prevent, for safety reasons, the formation of ice on aircraft parts and runways. Effects on humans due to exposure to all these compounds appear to be unlikely in practice.

Importation of infectious diseases by air traffic
World-wide air traffic increases the potential for transmission of infectious diseases from one country to another. An example is 'airport malaria', that occurs when mosquitoes infected with *Plasmodium falciparum*, originating at airports in regions where malaria transmission frequently occurs, contaminate people around airports elsewhere. The number of documented cases at present is small, but giving the growth of air transport the committee recommends airport authorities and airline companies to be vigilant.

Occupational health risk
In general the nature of the work in the vicinity of the airport is not expected to have characteristics specific to the airport operations system. This is different for work at the airport and for the operation of aircraft, although for aviation ground personnel only the incidence of musculo-skeletal disorders appears to be higher than what might be generally expected. Accident mortality among pilots is increased, but flight crew mortality from other causes is not exceptionally different from what would be expected. Fatigue and job stress would be expected among air traffic controllers and flight crew, but research data do not point to specific problems. Although activities within the airport operations system do affect occupational health, the situation is not out of line with the situation in comparable industries.

Comprehensive public health impact assessment

Environmental factors in an airport operations system operate in a cumulative way: people are exposed to, e.g., air pollution, noise and accident risk at the same time. People living in the vicinity of airports are not able to avoid exposure when performing everyday activities such as working, shopping, going to school, etcetera. Furthermore, the factors interact; for example anxiety related to aircraft crashes may enhance noise-induced annoyance and vice-versa. Other factors will modify the cumulative impacts. The visual appearance of the environment may act both in a positive and a negative sense, depending, e.g., on how well the traffic infrastructure has been embedded in the natural landscape. The availability of facilities, such as shops, public transport, parks, schools, will influence the way people rate their living environment and will also influence the public health impacts of factors that primarily or partly act via psycho-social mechanisms, such as noise and odour. Measures that increase the perceived control of people over their living environment may be beneficial in this respect.

Published results of comprehensive assessments of the public health impact of large airports, that would have allowed a definitive and complete answer to the Ministers' request, are lacking. In fact, the health impact assessment study in progress at Amsterdam Schiphol is an exceptional example of what, in the opinion of the committee, should be normal practice. On the basis of such studies measures to safeguard public health effectively and efficiently can be implemented. The committee strongly recommends that public health impact assessment, to guide the further international development of the civil aviation system, become the norm instead of the exception.

Way ahead

Airport and aviation development affect the lives of many people. Decisions to be taken are of a strategic nature and therefore require carefully and specifically designed procedures in which all stakeholders involved, including the people living in the vicinity of the airport in question, play a role. Although differing views on the significance of health and health effects, including impacts on quality of life, will make it difficult to reach consensus on the necessity and desirability of developments, a decision making structure in which those views can be discussed and are accounted for is preferable to autocratic decision making. The nature of the decisions to be made also require that mobility policies have to be discussed with the aim to let air transport be an integrated part of a sustainable mobility strategy.

Two approaches to reduce public health risk can be distinguished. On the one hand environmental quality standards can be set on a geographical basis ('zoning') and enforced by the government. In a different approach stakeholders 'negotiate' a comprehensive package of measures in which the negative effects of factors like noise, apart from being reduced by exposure limiting measures, are offset by improvements in the natural landscape, the quality of facilities in residential areas and an open communication between all parties concerned about developments at the airport and elsewhere in the system and about the measures taken to reduce noise exposure and air pollution. In practice a mix of both approaches will probably be used, depending on the prevailing political culture.

Aviation technology will have to innovate if the growth in air transport continues at its present rate. Already now large airports are congested and accident and near-accident frequencies might rise. Furthermore new technology is needed in order to lessen the public health impact of the expanding airport activities or in any case not aggravate it. The committee recommends that the technology development is accompanied by a technology assessment process that explicitly considers the short and long term environmental and health impacts of changes in technology.

Given the many parties involved in an airport operations system and given the interactions between different measures to reduce public health effects, the committee recommends that all developments are monitored and assessed on their public health consequences in an integrated manner. How such an integrated risk management structure reaches this goal is to be decided through the political process, but in order to be effective all parties involved should support such a structure and be willing to provide the necessary data in good time.