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Health Impact Assessment Schiphol airport
Overview of results until 1999

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This investigation has been performed by order and for the account of the Ministry of Housing, Spatial Planning and the Environment, the Ministry of Transport, Public Works and Water Management, and the Ministry of Health, Welfare and Sport within the framework of project 441520, Health Impact Assessment Schiphol Airport.

Preface

This background paper provides an overview of the current results of the Health Impact Assessment Schiphol (HIAS) research programme. It is written to meet two goals:

1. To inform the participants of the Workshop on Large Airports and Public Health in March 1999, organised by the Health Council of the Netherlands.
2. As a HIAS progress report for the Evaluation and Monitoring Programme for Schiphol (EMSO).

The research programme consists of a series of studies with different designs. Since most of the reports on these studies are in Dutch, the outline and results of the various reported and ongoing studies of this programme are summarised. Several of the more complex studies are still ongoing, or in the final stages of reporting. In this background paper, results are described for each separate health end-point that is subject of study instead of by the separate studies. More information about the research programme can be obtained through:

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Abstract

This report provides an overview of the current results of the Health Impact Assessment Schiphol (HIAS) research programme. This programme consists of a series of studies with different designs. Results are described for each separate health end-point instead of by the separate studies: annoyance, cardiovascular diseases, sleep disturbance, respiratory diseases, perceived health, neurobehavioral effects, birth weight and perception of risks and residential satisfaction. Several of the more complex studies are still ongoing, or in the final stages of reporting. These concern a study of respiratory complaints in children in relation to air pollution and another of aircraft noise and sleep disturbance in adults. Based on the results of the HIAS a monitoring system will be developed to study the health status of the population periodically in relation to possible further expansion of the airport.

Samenvatting

Als vervolg op de gezondheidskundige evaluatie voor de iMER Schiphol in 1993 (*Fase I*) voert het RIVM in opdracht van het Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, het Ministerie van Verkeer en Waterstaat en het Ministerie van Volksgezondheid, Welzijn en Sport verder onderzoek uit naar de gezondheidseffecten van milieuverontreiniging gerelateerd aan vliegverkeer. Het onderzoek is onderdeel van het Evaluatie en Monitoringsprogramma Schiphol. Dit rapport geeft een uitgebreide samenvatting van de stand van zaken en huidige resultaten van de Gezondheidskundige Evaluatie Schiphol (GES). Het rapport is geschreven voor twee doeleinden:

- Informeren van de deelnemers aan een workshop 'Large Airports and Public Health' in maart 1999. Deze workshop werd georganiseerd door de Gezondheidsraad op verzoek van de Minister van Volksgezondheid Welzijn en Sport.
- Voortgangsrapportage ten behoeve van het Evaluatie en Monitoringsprogramma Schiphol en Omgeving (EMSO).

Het vervolgonderzoek (*Fase II*) bestaat uit de volgende onderdelen:

- Onderzoek met bestaande gezondheidsregistraties gericht op het gebruik van medicijnen (slaap- en kalmeringsmiddelen en CARA-middelen), geboortegewicht en hartvaatziekten en luchtwegaandoeningen.
- Eenmalig onderzoek in de woonomgeving naar de huidige gezondheidstoestand van omwonenden van de luchthaven gericht op slaapverstoring, cognitieve prestaties, hinder, ervaren gezondheid en risicobeleving en luchtwegaandoeningen.

In dit rapport zijn de resultaten beschreven per gezondheidsparameter in plaats van per onderzoek.

De vervolgonderzoeken die zijn uitgevoerd in het kader van GES, (*Fase II*) bevestigen de resultaten uit *Fase I* en overige studies dat hinder en indicatoren voor hartvaatziekten en slaapverstoring gerelateerd zijn aan de belasting door vliegtuiggeluid rond de luchthaven Schiphol. De gevonden associatie tussen ervaren gezondheid en vliegtuiggeluid is nieuw. Voor luchtwegaandoeningen werd een relatie gevonden met afstand tot de luchthaven. Door gebrek aan gedetailleerde gegevens over luchtverontreiniging door vliegtuigen kan de relatie met afstand echter niet zondermeer worden toegeschreven aan luchtverontreiniging door vliegtuigen. Uit de pilot studie naar effecten van vliegtuiggeluid op cognitieve prestaties en gedrag bij kinderen blijkt dat het gebruikte testinstrumentarium grotendeels geschikt is voor dit type onderzoek. Conclusies of vliegtuiggeluid het functioneren van kinderen kan beïnvloeden zijn op basis van dit verkennend onderzoek niet mogelijk. Een relatie tussen blootstelling aan vliegtuiggeluid en een verlaagd geboortegewicht kan op basis van dit onderzoek noch bevestigd noch ontkend worden.

Een aantal onderzoeken van *Fase II* is nog in uitvoering. Het betreft een onderzoek naar luchtwegaandoeningen bij schoolkinderen en een onderzoek naar slaapverstoring bij volwassenen. Een besluit over een eventueel aanvullend onderzoek naar effecten op prestatie wordt genomen zodra de

resultaten van het slaapverstoringsonderzoek beschikbaar zijn. Aansluitend op de bevindingen van *Fase II* zal een voorstel voor een monitoringsysteem worden ontwikkeld waarmee mogelijke veranderingen in de milieukwaliteit en gezondheidstoestand bij uitbreiding van de luchthaven gevolgd kunnen worden (*Fase III*).

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1. Introduction

This report gives an overview of the results of the Health Impact Assessment research programme that is carried out around Schiphol airport, the Netherlands. After an introduction to the scope and background of this programme, chapter 2 briefly addresses the design and methods of the research as well as the considerations underlying the selection of health and exposure parameters. In chapter 3 the results will be described for each of the health effects studied in relationship with aircraft related pollution. The design and results of the research described in this report have been reviewed by independent (inter)national experts (1).

1.1 Scope and background

The national airport of the Netherlands, Schiphol airport, is expanding by building a fifth runway. In 1993, an Environmental Impact Assessment (EIA) was published in which the impact of the expansion and its alternatives on both the environment and public health was described (2). The terms of reference for the EIA were based on, amongst others, an advisory report of the State Inspectorate of Public health. According to these terms a description of the current health status (using existing health registries) and risks was required as well as proposals for further research and a health monitoring system.

From the onset of the EIA it was clear that the studies carried out as part of this health impact assessment would have a limited scope due to the short time-frame and limited data-availability. For this reason, and in line with the advice of the Commission for Environmental Impact Assessment the National Institute of Public Health and the Environment (RIVM) was asked by the Ministries of Housing, Spatial Planning and the Environment, of Transport, Public Works and Water Management, and of Public Health, Welfare and Sport to prepare and coordinate further research into the health effects of environmental pollution related to air transport. This research is covered in the Health Impact Assessment Schiphol research programme (HIAS), which in turn is part of the Evaluation and Monitoring Programme for Schiphol (EMSO). The HIAS is co-ordinated by RIVM and conducted in collaboration with other Dutch research institutes and universities (Appendix 2).

The objectives of the HIAS are to:

1. describe the current health status and potential health risks of the population in relation to environmental pollution from Schiphol airport;
2. collect information about exposure-response relationships between residential exposure to aircraft pollutants and relevant diseases or complaints;
3. develop a system to monitor the health status of the population in relation to expansion of the airport.

The HIAS is being conducted in three stages. *Phase I* studies have been performed within the framework of the EIA, ending in 1993. Phase I consisted of a quantitative risk evaluation, an analysis of existing health registry data and a limited survey on risk perception and annoyance. Existing gaps in knowledge were identified and proposals for future research were made.

Phase II studies are being carried out during the period 1995-2000. Phase II of HIAS consists of two parts:

1. Analysis of data from existing health registries

Data from existing health registries are used to study differences in the prevalences of health parameters in the population living nearby Schiphol airport and further away. The choice of the parameters studied was based on the results of the quantitative risk analysis in Phase I. These so called semi-ecological studies are based on individual health data and aggregated measures for exposure (often at a postal code level). Data on important confounders are usually not available. Despite the methodological problems and data limitations these semi-ecological studies have a sentinel function. When differences in disease occurrence are observed they at least signal the presence of effects worthy of further investigation. Definite conclusions about the causes of possible health differences may not be drawn though.

The following parameters have been studied: the use of sleeping pills and medicines for respiratory diseases based on pharmacy data (3), birth weight using data from the Dutch Obstetrics registration (4), and the occurrence of cardiovascular and respiratory diseases using hospital admission data from the Dutch Information System for Hospital Care and Day Nursing (5).

2. Epidemiological field studies

Epidemiological field investigations are being conducted to study the relationship between aircraft-related exposures and potential health effects. A questionnaire survey concerning annoyance, sleep disturbance, perceived health, medication use, risk perception and residential satisfaction, and a pilot study to identify methods suitable for measuring the relationship between aircraft noise and neurobehavioural effects in children have already been completed and reported (6, 7). More studies are currently under way: one study of respiratory complaints in children in relation to air pollution measurements and another of aircraft noise and sleep disturbance in adults.

The third part of HIAS (*Phase III*) will be the development of a health monitoring system.

1.2 Study area

Figure 1 gives an overview of the study area and the location of the airport.

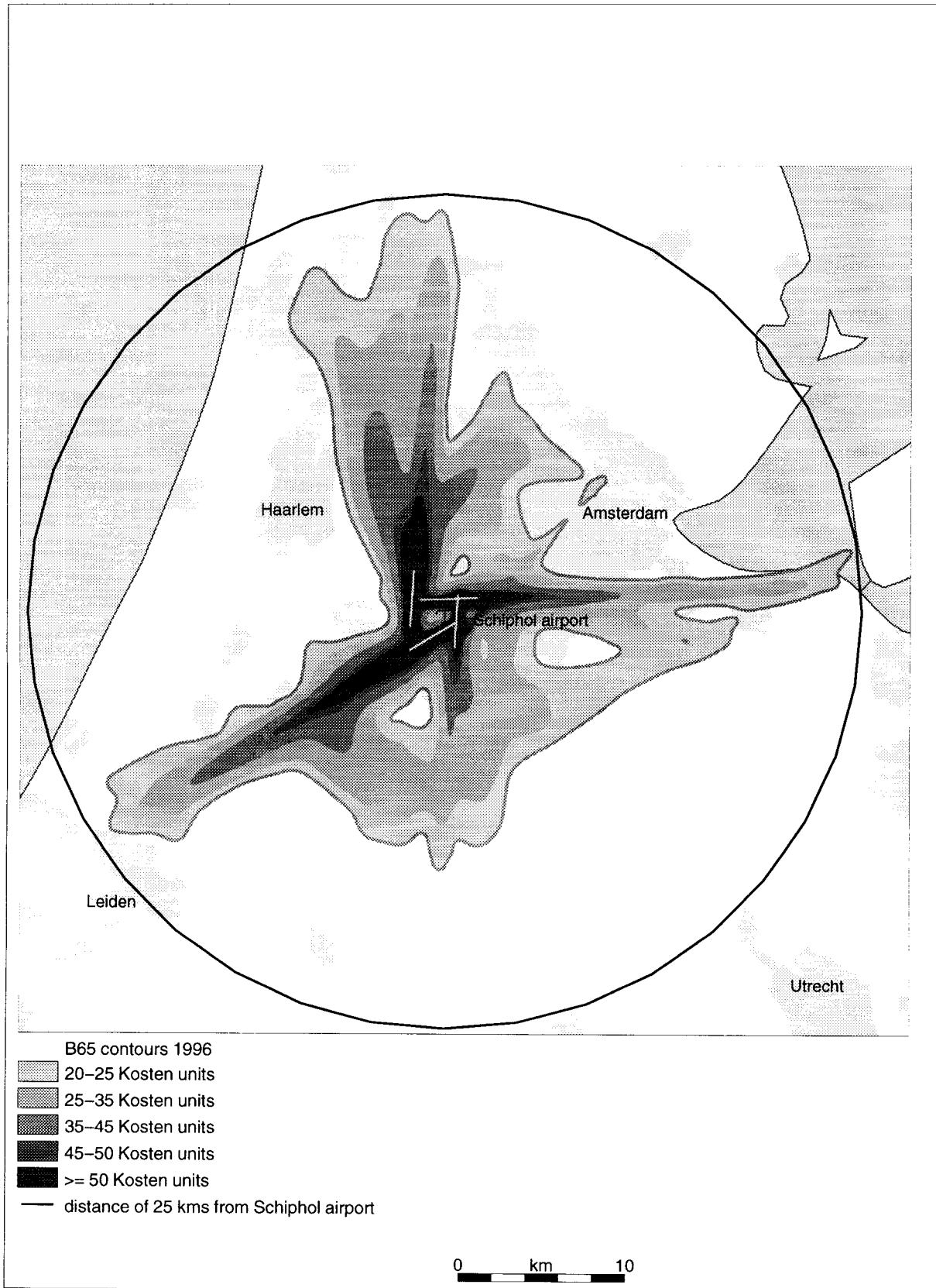


Figure 1 Map of the study area

2. Methodological aspects

2.1 Selection of health parameters

Several health end-points are being studied. Important criteria for the selection of relevant health indicators for further research were:

- (biological) plausibility of possible effects;
- evidence for a exposure-effect relationship based on the scientific literature;
- number of people potentially affected given current noise and air pollution levels in relation to airport activities;
- concern in the population about the effect.

On the basis of these criteria, it was decided that cardiovascular and respiratory diseases, sleep disturbance and annoyance, birth weight, performance, and medication use are important health end-points. In the design of Phase II, however, power considerations, the availability of non-invasive methods and logistic feasibility also played an important role. Thus, it was decided to focus the epidemiological field studies on sleep disturbance, annoyance, respiratory diseases and performance. Cardiovascular diseases and birth weight were only studied using health data registries. Based on power calculations an additional field study on cardiovascular diseases (high blood pressure) was not considered feasible. Medication use, respiratory disease and sleep disturbance were studied in a field study as well as with existing data from health registries.

The health end-points that are being studied are a combination of direct and indirect effects of environmental exposures, including (patho-)physiological functioning (e.g. bodily complaints, performance, awakenings), well-being (perceived health, risk perception, annoyance, disturbance) and medical consumption (hospital admissions, medication use). Some of the end-points can be assessed by direct individual measurements, while others can be determined through indirect so-called 'container-indicators' (e.g. medical consumption).

In many cases, the causal pathways through which the health effect may originate as a result of environmental exposure is poorly understood. Some effects may directly and independently follow exposure, while others are intermediate or mediating factors. For instance, blood pressure may be directly affected by exposure to noise, but may also increase through stress caused by noise annoyance. Since the actual pathways and interrelation of direct effects are largely unknown, a variety of end-points is being studied in parallel.

Table 1 (page 14-16) gives an overview of the health end-points that are covered in HIAS as well as the design and methods of the studies.

2.2 Exposure assessment

2.2.1 Aircraft noise

Until now, exposure to aircraft noise in HIAS has been determined using model calculations from the National Aerospace Laboratory (NLR). The calculation model is established in the Air Transportation Act as the standard for determining the annual exposure to (night-time) aircraft noise around Schiphol as B65 (expressed in Kosten units) and $L_{Aeq, 23-06 \text{ hours}}$. The Kosten unit (Ke) is a commonly-used measure for aircraft noise in the Netherlands, developed by the Kosten Commission in 1963. The unit is a yearly average defined by the maximum noise levels during flights, the total number of flights, and the time at which these flights take place. Flights in the evening and night have more weight in the calculations than flights during the day. In calculating the B65 measure, the level of 65 dB(A) is taken as a threshold. This means that the calculation includes only that part of each aircraft movement during which the calculated noise level at ground level is higher than 65 dB(A).

In most of the semi-ecological studies using existing health registry data, the aggregated B65 (4-digit postal code level) is used as a measure of exposure. B65-contour data are aggregated on a 4-digit postal code level using a Geographical Information System (GIS).

For the questionnaire survey however, aircraft noise exposure was calculated for each geometric centre of the area covered by the 6-digit postal code of the respondent's address. Beside B65, other measures were calculated such as: B45, L_{Aeq} for different time periods (e.g. $L_{Aeq, 24\text{hours}}$, L_{etmaal} ('24 hour value'), L_{dn} , L_{den} , $L_{Aeq, 23-06 \text{ hours}}$) and the number of flights during which the noise level exceeded a defined value (e.g. 70 dB(A)) (see textbox). In this way measures based on legally established methods of aircraft noise assessment were included as well as measures suggested in national and international discussions on uniform measures for noise exposure. In the Netherlands there is an ongoing debate about the accuracy of the method used in calculating Kosten units. In addition to limitations in the input data and the models used, another important point of controversy is the adoption of the 65 dB(A) threshold level in calculating the B65 measure.

Definition of noise measures

B65, expressed in Kosten-units (Ke). The Kosten unit is a commonly-used measure for aircraft noise in the Netherlands, developed by the Kosten Commission in 1963. The unit is a yearly average defined by the maximum noise levels during flights, the total number of flights, and the time at which these flights take place. Flights in the evening and night have more weight in the calculations than flights during the day. In calculating the B65 measure, the level of 65 dB(A) is taken as a threshold. This means that the calculation includes only that part of each aircraft movement during which the calculated noise at ground level is greater than 65 dB(A).

B45, again expressed in Kosten units, but with a threshold of 45 dB(A). In this measure that part of each aircraft movement during which the calculated noise at ground level is greater than 45 dB(A) is included, which means that more of the take-off and landing of each aircraft is counted, as compared to the B65 measure

L_{Aeq} measures refer to the average noise level over a specified period. The variations used include $L_{Aeq, 24\text{hours}}$, L_{etmaal} ('24 hour value'), L_{dn} and L_{den} . The $L_{Aeq, 24\text{hours}}$ refers to the annual average noise level per 24 hour period. The other measures refer to the annual average noise level for defined parts of the day, with penalty factors added for the night (10 dB(A)) and evening (5 dB(A)). The definitions of the parts of a day and the way the contributions from the various periods are combined to provide a single measure for the year differ in the L_{etmaal} ('24 hour value'), L_{dn} and L_{den} measures.

The number of flights passing over from which the noise level exceeds a defined value, such as 70 dB(A).

2.2.2 Air pollution

Because of the lack of suitable data on local air pollution and odour caused by air traffic, the distance of the residential address or the 4-digit postal code area to the airport was used as an approximation of exposure to these factors. In the currently ongoing study of respiratory disease in children a combination of measurements and modelling is used.

Table 1 Health variables, design and status of Phase II studies

DESIGN	HEALTH END-POINT	HEALTH DATA	EXPOSURE DATA	CONFOUN- DERS	STUDY AREA	POPULATION	YEAR OF STUDY	STATUS
Cardiovascular diseases								
1. semi-ecological	myocardial infarction, hypertension, ischaemic heart disease, cerebrovascular disease	hospital admissions	-	A	55 x 55 km around Schiphol airport	all ages; n=1.5 million, 296 4-digit postal code areas	1991-1993	+
2. cross-sectional	medicines for cardiovascular diseases or elevated blood pressure	postal questionnaire	<ul style="list-style-type: none"> noise: LAeq and Ke per 6-digit postal code area of the respondent's address air pollution/odour: distance from the respondent's address to the airport 	B	25 km radius around Schiphol airport	adults (age ≥ 18); n=1,812	1996	+
Annoyance								
1. cross-sectional	specific annoyance non-specific annoyance	postal questionnaire	see cardiovascular diseases (2)	B	25 km radius around Schiphol airport	adults (age ≥ 18); n=1,812	1996	+
Sleep disturbance								
1. semi-ecological	sedatives	pharmacist data	Ke per 4-digit postal code area	A	55 x 55 km around Schiphol airport	all ages; n=213,524 32 pharmacies covering 27 4-digit postal code areas	1993-1994	+
2. cross-sectional	sedatives and sleeping pills, sleep disturbance, sleep quality	postal questionnaire	see cardiovascular diseases (2)	B	25 km radius around Schiphol airport	adults (age ≥ 18); n=1,812	1996	+
3. panel study	<ul style="list-style-type: none"> pilot main study 	<ul style="list-style-type: none"> awakening, mobility during sleep, tiredness during daytime actometry, diary, attention task 	<ul style="list-style-type: none"> simultaneous measurement of noise events inside bedrooms and outdoors in the vicinity of the subject's dwelling 	B	Rijssenhout and Spaarndam, two villages around Schiphol airport with a sufficiently large number of night-time aircraft noise events	adults (age 20-50); n=11, 27 nights	1998	x
			based on outcome pilot				1999-2002	-

DESIGN	HEALTH END-POINT	HEALTH DATA	EXPOSURE DATA	CONFOUN- DERS	STUDY AREA	POPULATION	YEAR OF STUDY	STATUS
Respiratory diseases								
1. semi-ecological	medication for asthma	pharmacist data	distance from centre 4-digit postal code area to the airport	A	55 x 55 km around Schiphol airport	all ages; n=213,524 32 pharmacies covering 27 4-digit postal code areas	1993-1994	+
2. semi-ecological	acute airway infections, upper respiratory symptoms, bronchitis, asthma, emphysema	hospital admissions	-	A	55 x 55 km around Schiphol airport	all ages; n=1.5 million 296 areas	1991-1993	+
3. cross-sectional	one or more respiratory symptoms, lower respiratory symptoms, asthma, chronic cough, phlegm and bronchitis, medical treatment for allergies, medication use for allergy or asthma	postal questionnaire	see cardiovascular diseases (2)	B	25 km radius around Schiphol airport	adults (age ≥ 18); n=1,812	1996	+
4. cross-sectional	pulmonary function, respiratory allergy, respiratory symptoms	collected at the schools: pulmonary function measurements, parental questionnaire, (spec.) IgE test	PM ₁₀ , PM _{2.5} , filter reflectance, NO ₂ , selected VOC in ambient and indoor air at schools	B	selected communities around airport, schools selected to cover a range of distances to the airport and traffic arteries	primary schoolchildren	1998	-
Neurobehavioural effects								
1. cross-sectional	<ul style="list-style-type: none"> • pilot • main study 	<ul style="list-style-type: none"> • cognitive and psychomotor functioning, behaviour, annoyance • depending on outcome sleep disturbance study 	Neurobehavioural Evaluation System (computerised tests), paper and pencil attention and reading ability test, questionnaires	B	two villages around Schiphol airport: Zwanenburg (high aircraft noise exposure levels) and Ulfgeest (control area)	children (age 8-9); n=159	1995	x

DESIGN	HEALTH END-POINT	HEALTH DATA	EXPOSURE DATA	CONFOUN- DERS	STUDY AREA	POPULATION	YEAR OF STUDY	STATUS
Birth weight								
1. semi-ecological	birth weight, duration of pregnancy	obstetrics data	Ke per 4-digit postal code area	A	55 x 55 km around Schiphol airport	babies; n=83,751 324 4-digit postal code areas	1989-1993	+
Perceived health								
1. cross-sectional	health complaints (VOEG), self-rated health	postal questionnaire	see cardiovascular diseases (2)	B	25 km radius around Schiphol airport	adults (age ≥ 18); n=11,812	1996	+
Risk perception and residential satisfaction								
1. cross-sectional	concern about safety, concern about health effects, fear for aeroplanes, (dis)satisfaction and (un)favourable aspects of housing and neighbourhood	postal questionnaire	see cardiovascular diseases (2)	B	25 km radius around Schiphol airport	adults (age ≥ 18); n=11,812	1996	+

- A Limited data on confounders available (usually only age, sex)
- B Data on major confounders available
- + Results published
- Results not yet available
- x Pilot study, no conclusions about possible effect aircraft noise allowed

3. Results

3.1 Annoyance

3.1.1 Introduction

Annoyance is one of the main aspects in the policy evaluation framework of Schiphol airport's expansion. Accurate assessment of the current level of annoyance is therefore extremely important. So far, annoyance has been determined using modelled aircraft noise exposure levels (cf. section 2.1.1), in combination with a linear exposure-response relationship based on community surveys by Bitter in the sixties and seventies. Modelled aircraft noise exposure is expressed in Kosten units and as a rule of thumb, the percentage of severely annoyed people equals the number of calculated Ke minus 10.

In phase I of the HIAS, it was estimated that over 100,000 people were severely annoyed by aircraft noise, based on modelled exposure levels in 1991 and the exposure-response relationship from Bitter. It was also concluded that an update of the exposure-response relationship was needed as part of HIAS Phase II.

3.1.2 Questionnaire survey

In 1996 a postal questionnaire survey was carried out, in a study area with a radius of 25 kilometres centring on the airport. The objective of this study was to assess the current prevalence of annoyance and update the exposure-response relationships for e.g. annoyance. The response to this written survey was expected to be 20 to 35 percent. To meet the two objectives of the study, about 10,000 completed questionnaires were required. Expecting a high non-response, questionnaires were mailed to 30,000 randomly selected addresses in the study area. To increase the number of completed questionnaires a reminder letter was sent a few weeks after the questionnaire to people who had not yet responded. Of the 30,000 people who were approached, 39 percent responded. This is more than had been expected. To examine whether the results could have been biased by selective non-response, the postal questionnaire was supplemented with a short telephone survey among a small portion (n=271) of the non-responders. This showed that selective non-response was very likely to have occurred. Non-respondents reported less annoyance as a result of aircraft noise, were less concerned about their safety as a result of living in the vicinity of a large airport, and had less negative attitudes to the expansion of Schiphol. Moreover, this group contained fewer persons with higher education and more members of ethnic minorities.

Given the possible bias due to selective non-response, the answers to the written questionnaire are probably not fully representative of the more than 1.5 million people in the research area. On the basis of the follow-up telephone survey among non-respondents, various estimates have therefore been made to correct the results for the possible bias due to selective non-response. Both the 'uncorrected' and 'corrected' figures are presented to show the range of possible values in the results.

Table 2 shows the results from the questionnaire study for annoyance (measured by an 11-point scale with not at all annoying and extremely annoying as end-points) due to aircraft and airport-related activities. Because of the possibility of selective non-response, both the uncorrected and corrected figures are presented. This shows the range of possible values in the results.

*Table 2 Annoyance in the population aged 18 years and older within 25 kilometres of the airport and the attributable proportion of aircraft noise**

Variable	Percentage of people reporting the effect		Portion of the effect attributed to aircraft noise, in absolute numbers of people ≥18 years
	Corrected for selective non-response	Not corrected for selective non-response	
<i>Annoyance due to aircraft</i>			
Serious annoyance caused by noise** study area (1,520,750)***	18	31	265,000 - 465,000
≥ 20 Kosten units (370,280)	36	53	98,000 - 158,000
≥35 Kosten units (23,510)	48	65	12,000 - 15,000
Serious annoyance caused by odour study area (1,520,750)	5	7	80,000 - 108,000
≤ 10 km (432,610)	16	19	47,000 - 60,000
Serious annoyance caused by dust, soot or smoke study area (1,520,750)	6	8	100,000 - 125,000
≤ 10 km (432,610)	19	23	57,000 - 69,000
Serious annoyance caused by vibrations study area (1,520,750)	10	14	150,000 - 210,000
≥ 20 Kosten units (370,280)	11	15	60,000 - 84,000
≥35 Kosten units (23,510)	39	45	9,000 - 11,000

* percentages and absolute figures are rounded off.

** defined as the percentage of respondents whose annoyance on the 11-point scale (0-10.0) exceeds 7.2.

*** the total number of people living in the area and aged 18 years or more is given in parentheses.

Aircraft was the most frequently reported source of annoyance due to *noise*, followed by neighbours and road traffic. Within a range of 25 kilometres around the airport, 18 to 31 percent of adults reported serious annoyance by aircraft noise (see table 2). In the legally established 'noise zone' for aircraft noise (the 35 Kosten units zone), 48 to 65 percent of adults report that they are seriously annoyed by aircraft noise. This amounts to some 12 to 15 thousand people. Outside of this zone, the percentages are lower, but in absolute terms more people (250 to 450 thousand) are affected because many more people live outside this zone (98.5% of the total, versus 1.5% within the zone).

The annoyance decreases with lower aircraft noise exposure. In the periphery of the research area, in areas where the exposure to noise is less than 20 Kosten units, 14 to 27 percent of the respondents report serious annoyance from aircraft noise.

The reported aircraft noise annoyance was higher than was expected based on previous Schiphol studies performed by Bitter in 1967 and 1980 (figure 2). The percentage of people annoyed was also higher than expected as compared with the results of 20 international annoyance surveys (from TNO-PG's 'Disturbance Database') (figure 3). Possible explanations for the higher than expected annoyance levels include an increased sensitivity to noise and concern about safety, the actual exposure to noise being

higher than the calculated values would indicate, and the influence of the ongoing political and social debate about the expansion of the airport.

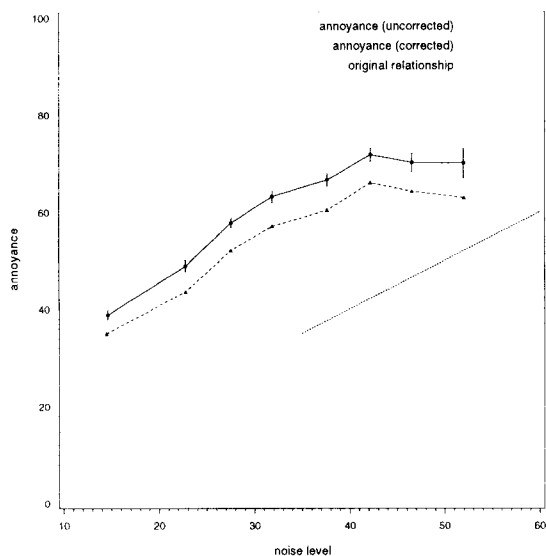


Figure 2 Relationship between annoyance and aircraft noise exposure expressed in *Kosten units*

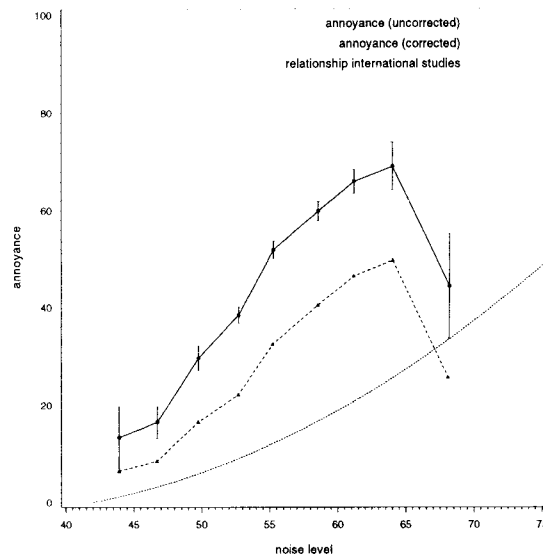


Figure 3 Relationship between annoyance and aircraft noise exposure expressed in L_{dn}

The percentage of people that reported to be annoyed by aircraft noise increases with higher exposure to noise but levels off at noise levels above about 40-45 *Kosten units* (B65). A similar levelling-off has been found in other studies. The results of this study give no clear explanation for this phenomenon. Contributory factors could include better sound insulation of the houses at higher noise levels, the migration of noise sensitive people out of noisy areas and adaptation to living in a noisy environment (coping).

Multivariate regression analysis on noise annoyance scores indicated that overall around 40% of the variation could be explained by the noise level in combination with some fifteen non-acoustical factors. Respondent's noise sensitivity, and fear of crashes were the most important non-acoustical factors. Noise level was the strongest single determinant and alone accounted for 11% of the variation in annoyance scores.

Aircraft is the most frequently reported source of *annoyance from vibrations*, while road traffic is most frequently named as a source of *annoyance due to odour, dust, soot and smoke*. It was estimated that 80,000 to 108,000 people (5-7 percent) are seriously annoyed by odour from aircraft (see table 2). In the EIA, based on model calculations it was estimated that an average of 36,000 people living immediately around the airport would be annoyed by odour from air transport.

The serious annoyance by odour, dust, soot or smoke and vibrations from aircraft was higher than was found in the most recent national annoyance survey (1994). This may in part be attributed to the same explanations as those for the higher annoyance from aircraft noise. An additional explanation could be

that people who report that they are annoyed by noise also report that they are annoyed by other sources, in other words, that these people are generally more sensitive.

Even at greater distances from the airport, annoyance as a result of odour, dust, soot or smoke and vibrations from aircraft was reported. It is therefore possible, that there may be exposure to odour, dust, soot, and smoke from aircraft further from the airport than was expected based on model calculations. Supplementary measurements of odour, dust and soot could be used to examine this.

3.2 Cardiovascular diseases

3.2.1 Introduction

A quantitative risk evaluation carried out as part of Phase I showed that due to aircraft noise exposure about 1500 extra cases of hypertension in adults living in an area of 55x55 km around Schiphol airport (total population: 1,6 million) might occur, as well as an increased risk of ischaemic heart diseases. For this reason, spatial patterns in hospital admission data on cardiovascular diseases were studied in 1991. As part of Phase II a follow up analysis was done in 1995, in which methodological developments and improvements in the presentation technique have been implemented and data were analysed over a longer time period (3 years instead of one).

3.2.2 Hospital admissions

Using hospital admission data, disease rates¹ and 95% confidence intervals for four (groups of) cardiovascular diseases (see table 1) were calculated and mapped per 4-digit postal code area for 1991-1993. Spatial patterns were studied using an empirical Bayes model to reduce random variation and to account for small area variability and spatial interdependence in the data. The analyses were adjusted for age and sex. It was not possible yet to include exposure data in the model. Therefore, it was assumed that if the vicinity of Schiphol airport strongly influences disease occurrence, this would show in spatial disease patterns.

The maps showed a wide spatial variation in cardiovascular disease rates within the study area. For most cardiovascular diseases studied this variation was not statistically significant. There was no consistent spatial pattern that would suggest a relation of cardiovascular diseases with Schiphol airport. The disease patterns varied per year and differ between men and women. For 'all cardiovascular diseases' a spatial pattern that is consistent over time and for both sexes could be seen in a few areas. However, there was no clustering of these diseases in areas around the airport. The lack of data on important determinants of the diseases studied (e.g. social economical status, life style) and the fact that it was not possible to include exposure data in the spatial model may lead to false positive and negative disease patterns. These limitations preclude conclusions about the causes of the observed disease pattern. Moreover, the results of this study do not exclude the occurrence of milder effects (e.g. hypertension). In general, people with health complaints will contact (and will be treated by) a general practitioner in the first place. Hospital admissions can therefore result in an underestimation of the occurrence of cardiovascular effects.

¹ The ratio between the observed and expected admission rates for each 4-digit postal code area based on the average admission rate for the total study area.

3.2.3 Questionnaire survey

Based on the questionnaire study (cf. section 3.2.1) 15% of the 1,5 million adults in the Schiphol area used 'medicines for cardiovascular diseases or elevated blood pressure' prescribed by their physician. Correction for selective non-response was estimated to be 2% of the crude prevalence figures.

Regression analysis showed that the use of these medicines is related to both aircraft noise exposure and distance to the airport. The analysis was adjusted for age, sex, education level, smoking, ethnicity and degree of urbanisation. Only the relationship with $L_{Aeq, 24 \text{ hours}}$ and distance to the airport was statistically significant ($p < 0.05$). The use of 'medicines for cardiovascular diseases or elevated blood pressure' increased 1-16% per 10 units increase in aircraft noise, depending on the noise measure used (B_{65} , B_{45} , $L_{Aeq, 24 \text{ hours}}$, $L_{Aeq, 22-23 \text{ hours}}$, $L_{Aeq, 23-06 \text{ hours}}$).

On the basis of these results it was estimated that 0.6-1.4% of the use of 'medicines for cardiovascular diseases or elevated blood pressure' in areas with an aircraft noise exposure ≥ 20 Kosten units ($\pm 50-55 \text{ dB(A)}$)² could be attributed to aircraft noise. For areas with an exposure ≥ 35 Ke ($\pm 60-65 \text{ dB(A)}$) this was 1.7-2.3%.

3.3 Sleep disturbance

3.3.1 Introduction

One of the conclusions of the risk evaluation of Phase I was that sleep disturbance as a result of aircraft noise occurs around Schiphol airport. Based on aircraft noise levels in 1990, the estimated number of people with reported sleep disturbance living in areas within the $L_{Aeq, 23-06 \text{ hours}}$ contour of 20 and 27 dB(A) was 100,000 and 13,000 respectively (10).

Based on drug dispensing data collected from selected pharmacists in a circle of ± 30 kilometres around the airport, the prevalence of sedative use in the Schiphol area was 32.1 per 1000 persons. This was comparable to the national reference value (34.5 per 1000 persons). Within the study area, differences in prevalence per postal code area were found with aircraft noise (see figure 4).

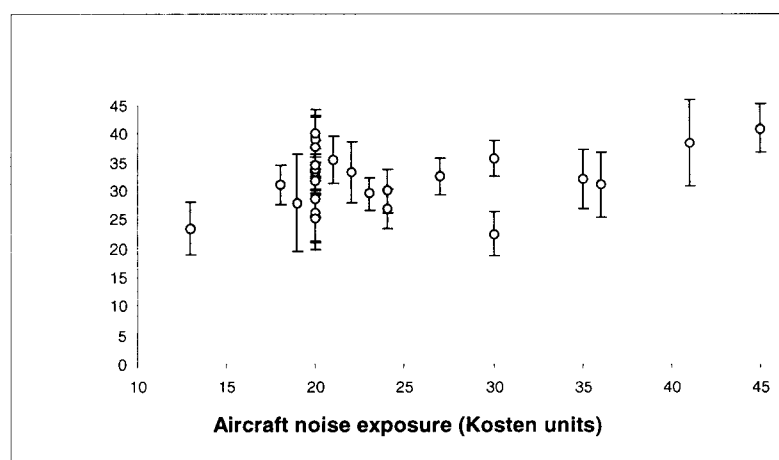


Figure 4 Prevalence of sedative use per postal code area

² Based on the following approximation: $L_{etmaal} \approx \frac{1}{2}B + 45 \text{ dB(A)}$.

The difference between sedative use in areas with low (≤ 20 Kosten units) and high (> 30 Kosten units) aircraft noise exposure was studied by estimating Mantel-Haenszel Odds ratio's. The results were adjusted for age and sex. In areas with high aircraft noise exposure the use of sedatives was 14% higher (Odds ratio: 1.14 (1.05-1.25)). This was mainly due to the use of sedatives by women, by people ≥ 45 years and by sustained users (> 20 days continuous). When the occurrence of chronic diseases was taken into account the use of sedatives was 8% higher in high exposed areas (Odds ratio: 1.08 (1.00-1.18)).

3.3.2 Questionnaire survey

The use of 'sleeping pills or sedatives' was also studied in the questionnaire survey (cf. section 3.2.1). The results of this study showed that 10% of the 1,5 million adults in the study area use 'sleeping pills or sedatives' prescribed by physicians. If respondents using 'medication for cardiovascular diseases or elevated blood pressure', 'medication for rheumatism, painful joints etc.' and respondents 'regularly working in night shifts' are excluded, the prevalence was 8%. Correction for selective non-response was estimated to be less than 2% of the crude prevalence figures.

Regression analysis showed that the use of 'sleeping pills or sedatives' (both prescribed, self-medication and the frequent use of these medicines) was related to aircraft noise. The results were adjusted for age, sex, education level, ethnicity and degree of urbanisation. The relationship with aircraft noise was statistically significant for all noise measures studied (B_{65} , B_{45} , $L_{Aeq, 24 \text{ hours}}$, $L_{Aeq, 22-23 \text{ hours}}$) except for $L_{Aeq, 23-06 \text{ hours}}$. The use of 'sleeping pills or sedatives' increased 15-46% per 10 units increase of aircraft noise, depending on the noise measure used. In areas with an aircraft noise exposure ≥ 20 Ke it was estimated that 1.2-2.2% of the use of sleeping pills or sedatives (10%) could be attributed to aircraft noise. In areas ≥ 35 Ke this was estimated at 2.6-3.6%.

Other indicators for sleep disturbance (sleep disturbance caused by aircraft noise and sleep quality) were also studied with the self administered questionnaire. Sleep disturbance was measured in the same way as annoyance (cf. section 3.1.2). Sleep quality was measured with a 10-item scale. Taking into account non-response bias the self-reported sleep disturbance by aircraft noise was 8-12 percent of the adult population living within 25 kilometres of the airport (an estimated total of 120,000 to 180,000 people). The majority of these people live in areas outside the legal zone for night-time aircraft noise (noise levels of 26 dB(A) $L_{Aeq, 23-06 \text{ hours}}$, in the bedroom). In the area with night-time aircraft noise levels ≥ 26 dB(A), 33-39% of the population reported serious sleep disturbance caused by aircraft noise (6,000-7,000 people).

In areas with noise levels of 26 dB(A) or more at night, 17-19 percent of people reported having 4 or more sleeping problems, as compared to 14-15 percent of those living outside the high noise area. The perceived sleep quality in this study was comparable to that measured in 1986 in areas with a high exposure to road traffic (> 50 dB(A)), but worse than that found in more rural areas around the military airports in the provinces Friesland and Overijssel.

In addition to the use of 'sleeping pills or sedatives' and the frequency of use, aircraft noise exposure was statistically significant related to 'serious sleep disturbance' and the perceived 'sleep quality'. The

effect on sleep disturbance was non-linear and adjusted for a number of variables e.g. sensitivity to noise, fear of crashes, exposure to aircraft noise at work, sex, education level and age. Based on the relationship with aircraft noise it was estimated that in areas with an exposure to aircraft noise ≥ 20 Ke, 1.4-3.9% of a poor sleep quality (one or more sleeping problems) could be attributed to aircraft noise. In the 35 Kosten-unit zone the estimated contribution of aircraft noise to a poor sleep quality was 3.8-6.1%.

3.4 Respiratory disease

3.4.1 Introduction

Respiratory diseases appear to be an area of substantial concern in the population as is evident from stakeholder interviews, discussions with citizen groups and from a risk perception survey performed as part of Phase I activities of HIAS. In this survey, 479 adults were interviewed in the Schiphol area (figure 1) and compared to a control group of 936 people in the rest of the country (2, 13). Thirty-three percent of respondents from the Schiphol area considered the air in the region to be 'rather to seriously polluted' (11% in control group). Forty-four percent was 'sometimes, often, or always annoyed' by air pollution in their region (22% in controls). About 60% of respondents in the area considered air traffic as the most important source of air pollution.

In the Phase I report it was concluded that known and modelled air pollution exposure levels in the Schiphol area were similar to levels encountered elsewhere in urban areas. These levels are generally below current air quality standards and guidelines, although these standards might be exceeded around road traffic arteries in the area. The overall contribution of air traffic emissions to general background air pollution is estimated to be lower than 10%. On this basis, respiratory health effects from air traffic related air pollution were considered unlikely. However, information on exposure levels to relevant particulate air pollution (PM_{10} , $PM_{2.5}$) was considered insufficient. Moreover, reduced ventilation inside residences in the area might occur due to sound insulation and changes in ventilation behaviour of occupants, leading to higher indoor air pollution levels. This, combined with the level of concern in the population, lead to the proposal of measurements of PM_{10} and $PM_{2.5}$ in the region and comparison of indoor air quality levels in high noise exposed houses to those with low noise exposure. Measurement of respiratory health in children was not proposed at that time, unless public concern would warrant such measurements.

Since Phase I, two reports that were not part of the HIAS appeared that added to the concern about respiratory health in the area. The first report was a semi-ecological study of drug dispensing data from selected pharmacies in a circle of ± 30 kilometres around the Schiphol airport (3) (cf. section 3.3.1). In this study, aimed at assessing the feasibility of using pharmacy registrations for analysis at the small area level, the use of medication for asthma was analysed in relation to distance to the airport as a proxy for exposure to air traffic generated air pollution. The prevalence of medication for

asthma in the region was similar to the national reference value. Within the study area, differences in prevalence were found with distance to the airport (see figure 5).

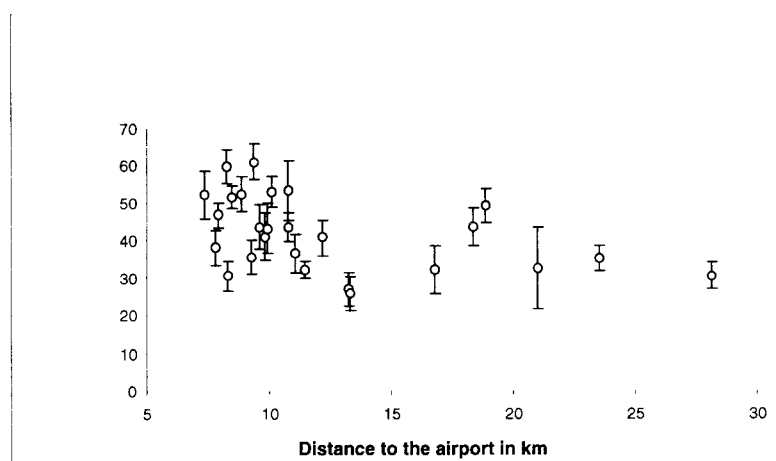


Figure 5 Prevalence of medication for asthma per postal code area

The age and sex standardised prevalence within a radius of 10 km from the airport was 14% higher as compared to greater distances (Odds ratio: 1.14 (1.09-1.19)). This was predominantly due to the medication use by people in the age category of 0-19 year and people over 60 years of age. In the analysis however, no control for other confounders (such as smoking, social-economical status) could be attempted due to the lack of information thereof. In addition, distance to the airport was used as a proxy indicator as no information on road traffic-generated air pollution was available at that time. These limitations preclude the conclusion that air traffic-generated air pollution is responsible for the observed increase in medication for asthma, but cannot exclude it either.

The second report on respiratory health was issued by a municipal health service in the Schiphol area and described an ecological study of general physicians' registrations of (respiratory) health complaints over the period 1993-1994 (14). This report concluded that general physicians in residential areas closer to the airport registered more respiratory symptoms in children than those in areas at greater distance. No formal statistical analysis of the significance of these findings was reported however, nor was information on confounders included.

The added public concern about these two reports led to the inclusion of an epidemiological investigation of respiratory health in school children in the Phase II of the HIAS.

3.4.2 Hospital admissions

Using hospital admission data, disease rates and 95% confidence intervals for five (groups of) respiratory diseases, (see table 1) were calculated and mapped on a 4-digit postal code level for 1991-1993. Spatial patterns in the disease rates were studied using an empirical Bayes model to reduce random variation and to account for small area variability and spatial interdependence in the data (cf 3.2.2).

The maps showed a wide spatial variation in respiratory disease rates within the study area. For most of the respiratory diseases studied this variation was not statistically significant. There was no consistent spatial pattern that would suggest a relation of respiratory diseases with Schiphol airport. The disease patterns varied per year and differed between men and women. Only for 'upper respiratory airway diseases' and 'acute airway infections' the spatial pattern was consistent in males and females in two of the three years in some north-western and southern parts of the study area, but no apparent clustering around the airport was observed.

3.4.3 Questionnaire survey

In Phase II of the HIAS, respiratory health was investigated as part of the questionnaire survey on annoyance, sleep disturbance, health, perceived risk, and residential satisfaction (cf. 3.2.1).

Fifty-seven percent of the adults reported one or more respiratory complaints (see table 3). Correction for selective non-response was estimated to be less than 2% of the crude prevalence figures. The obtained prevalence figures for respiratory symptoms were in good agreement with reference data from studies in adult populations elsewhere in the Netherlands.

Table 3 Prevalence of respiratory health symptoms reported by respondents

Respiratory symptom	Prevalence
One or more respiratory symptoms	57%
Respiratory symptoms of the lower airways	18%
Asthma	8%
Chronic cough, phlegm and bronchitis	40%
Medical treatment for allergies	30%
Medication use for allergy or asthma	14%

The relation with distance from the airport was analysed in a multiple logistic regression analysis, with distance dichotomised at 10 km from the airport. A significant association with distance to the airport was found for the following respiratory symptoms: 'one or more respiratory symptoms', 'chronic cough, phlegm and bronchitis', 'medical treatment for allergies' and 'medication use for allergy or asthma' after controlling for age, sex, education, ethnicity, smoking, presence of unvented gas appliances in the home, dampness of the home, exposure to environmental tobacco smoke, degree of urbanisation, and distance to major traffic arteries. These associations were also observed when distance was categorised in 5 or 2 km intervals.

3.5 Perceived health

3.5.1 Introduction

Perceived health is a health end-point that has not been studied previously in relation to Schiphol airport. It is considered as an 'umbrella indicator' for various health aspects.

3.5.2 Questionnaire survey

Information on perceived health, or self-rated health was collected as part of the questionnaire survey (cf. section 3.2.1) using both a single question ('how is your health in general?') and a composite score from a 13 item-question (VOEG-score, 0-13). Eighty percent of the adults living within 25 kilometres of the airport perceived their general health as good, 20 percent as poor. This is in correspondence with the figures for the Netherlands as a whole in 1996 (81 percent, and 19 percent respectively). Correction for selective non-response was estimated to be 2% or less of the crude prevalence figures.

The relationship between self-rated health and exposure to aircraft noise and air pollution was examined by logistic and linear regression analyses. Explanatory variables in addition to exposure variables were age, sex, education level, ethnicity, degree of urbanisation, smoking, home ownership and household size. Twelve percent of the reported self-rated health and 5% of the VOEG scores are explained by the determinants in the regression model.

Both the noise levels (in 3 different measures of exposure) and the distance to the airport were significantly associated with poor self-rated health and higher VOEG scores. The effects of the various noise measures pointed in the same (positive) direction: where aircraft noise level is higher people rated their own health as poorer and had higher VOEG scores. On the basis of the regression model it appeared that the VOEG score increases with increasing distance, up to about 10 km, and then declines again at greater distances. Odds ratios for the self-rated health question varied between 1.08 and 1.17 for the different noise exposure levels (per 10 units).

Based on the relationship with aircraft noise, the estimated contribution of aircraft noise to the poor self-rated health in the 35 Kosten-unit zone was 2.3-4.4%.

3.6 Neurobehavioural effects

3.6.1 Introduction

Based on the risk-evaluation carried out in Phase I it was concluded that reduced performance (i.e. cognitive and psychomotor functioning) might occur among children living in the vicinity of Schiphol airport. Earlier studies of children living in close proximity to airports in Los Angeles and Munich indicate that exposure to (aircraft) noise might result in negative effects on cognitive performance. Due to the lack of exposure-response relationships at that time it was not possible to give an estimate of the number of people potentially at risk around Schiphol airport. Because of this, a large epidemiological field study was recommended at a workshop of international experts. Before starting this study, however, the question needed to be answered whether the methods and instruments available were suitable for examining neurobehavioural effects (cognitive and psychomotor functioning and behaviour) in a large number of children in field studies.

3.6.2 Pilot study

A pilot-study was carried out to test the reliability of selected automated neurobehavioural methods and questionnaires, as well as the feasibility (logistics) of the study-design in a school environment. In addition, potential differences in cognitive performance between groups of children exposed to

different levels of aircraft noise were explored. Temporary closure of one of the runways provided an opportunity for exploring the effect of a reduction in noise levels (intervention-effect).

Measurements were carried out in an aircraft noise-exposed group (86 children, average outdoor aircraft noise level of 59 dB(A) ($L_{Aeq,24}$ hours)) and a low-exposed control group ($n=73$, $L_{Aeq}=53$ dB(A)). Children were tested twice in the period May-June 1995 with a 4-6 weeks interval between testing. Comparisons between the aircraft noise-exposed and the control group indicated poorer performance of the noise-exposed group on 2 of the 17 cognitive and psychomotor tests: Hand Eye Coordination Test and Switching Attention Test (analysis was corrected for socio-economic level and length of residence). Parents of the noise-exposed children reported more attention and social problems than parents of the control children. On the basis of teachers' rating, however, children from the control group were judged as more hyperactive. More children in the study group reported annoyance with noise (76%) than in the control group (40%) with 59% naming aircraft noise as the most important cause. The effects observed could be due to chance because of the large number of parameters tested.

The reduction in noise levels between the two measurement sessions from 59 to 52 dB(A) did not result in consistent observable changes in cognitive and behavioural functioning of the children in the aircraft noise-exposed group. A significant improvement was seen in the results of the aircraft noise-exposed group on one motor function test (Hand-Eye Coordination test) but a decrease in performance was observed for an attention test (Simple Reaction Time Test). Because of the short period of reduced aircraft noise levels (3 weeks) only acute effects (if present) could have been detected.

Based on the pilot character of this study, no definite conclusions can be drawn about the effect of aircraft noise exposure on cognitive and psychomotor functioning and behaviour because of the small number of children tested and the lack of adequate (individual) exposure data.

3.7 Birth weight

3.7.1 Introduction

Exposure to (aircraft) noise during pregnancy might have an effect on birth weight and prenatal growth. Knipschild (1979) analysed data on birth weight registered by infant welfare centres in six villages in the Schiphol region. He found that the percentage of low birth weight infants (<3000 gram) was higher in areas with higher aircraft noise levels, controlling for parents income and sex of the infant. Due to methodological inadequacies of the evaluated studies it was not possible to give a quantitative estimation of the number of people potentially at risk around Schiphol airport. Therefore, birth weight and prenatal growth were studied as part of Phase II.

3.7.2 Obstetrics data

The prevalence of birth weight and prenatal growth and the relationship with aircraft noise exposure was studied for 1989-1993 using data from midwives and gynaecologists as registered in the Dutch Obstetrics Registration (LVR). Unfortunately, deliveries by general practitioners are not registered in the LVR until now. Consequently, high(er) risk deliveries are overrepresented in the LVR, which limits comparability to national reference data. Table 4 shows the prevalence of these variables in the study area.

Table 4 Prevalence of reduced birth weight and prenatal growth

Effect variable	Prevalence
Average birth weight	3392 (sd=578) grams
Average duration of pregnancy	39.6 (sd=2.0) weeks
Low birth weight (<2500 gram)	5.4%
Birth weight < 10 th percentile Dutch growth curve	8.7%
Prematurity (duration of pregnancy < 37 weeks)	4.8%

Regression analysis showed no statistical significant relationship between reduced birth weight or prenatal growth and aircraft noise exposure. The results were adjusted for sex of the child, number of pregnancies, age, ethnic origin and social economical status of the mother. The effect of aircraft noise exposure on birth weight, birth weight adjusted for duration of pregnancy and the duration of pregnancy was -0.02% (p=0.62), -0.03% (p=0.17) and 0.013% (p=0.54) per unit increase of aircraft noise exposure (in Ke), respectively. The data also showed no indications of a threshold effect or a non-linear exposure-response relation. Unfortunately, it was not possible to take into account the impact of all important determinants of birth weight and prenatal growth in the analyses, since data on a number of variables were not available due to privacy regulations or because they are not registered in the LVR. Therefore, on the basis of this (semi-) ecological study a relationship between aircraft noise exposure and reduced birth-weight can neither be confirmed nor excluded. Effects of aircraft noise might be masked by for instance smoking of the mother during pregnancy.

3.8 Perception of risks and residential satisfaction

3.8.1 Introduction

A risk perception survey, stakeholder interviews as well as discussions with citizen groups indicate that there is substantial concern about the presence and expansion of Schiphol airport among the population. The results of the risk perception survey in Phase I showed that the respondents living around Schiphol airport are more concerned about the safety risks and possible health effects of air traffic as compared to a sample of the general Dutch population.

3.8.2 Risk perception

In the questionnaire study (cf. section 3.2.1) five variables were used to describe the risk perception of aircraft: 'startled by/afraid of aeroplanes', 'concern about safety because of living under the approach route of a large airport', 'concern about safety because of living in the vicinity of a large airport', 'concern about possible health effects caused by aircraft noise', 'concern about health effects caused by air pollution of aircraft'. In response to the question about safety concerns due to features of the respondents' surroundings, those relating to air transport were mentioned most frequently. Sixteen percent of the respondents reported that they were very concerned about their safety because of living under the approach route of a large airport, while 64% were not concerned or hardly concerned. Safety concerns as a result of living in the vicinity of a large airport were expressed by 11% of the respondents, whereas 75% was not or hardly concerned. These results agree with a recent questionnaire study in the municipality of the Haarlemmermeer (also located in the study area).

Around Schiphol airport, relatively more people reported that they were concerned about health effects due to air pollution from aircraft (42%) than about health effects from aircraft noise (18%). In the perceived risk study that was performed as part of Phase I, concern about the health effects of air traffic was higher. However in that study the sample included more people from the most highly exposed areas, so the data are not directly comparable.

Regression analysis showed that aircraft noise was statistically significant related to risk perception. The results were adjusted for age, sex, education level, ethnicity and degree of urbanisation. The relationship with aircraft noise was statistically significant for all noise measures studied (B65, B45, $L_{Aeq, 24 \text{ hours}}$). The effect of aircraft noise was non-linear and levelled off at higher noise levels (above about 40-45 Kosten units (B65)). The results of the questionnaire study give no clear explanation for this phenomenon. Contributory factors could include better sound insulation of the houses at higher noise levels, and the migration of noise sensitive people.

The perceived risk was not only related to the exposure to aircraft noise, but also to the frequency with which aircraft are heard (ranging from once or more per year to daily) and the number of flights passing overhead. Beside aircraft noise, 'concern about safety because of living under the approach route of a large airport', and 'concern about safety because of living in the vicinity of a large airport' were also statistically significant related to distance to the airport. 'Concern about health effects caused by air pollution of aircraft' also showed a statistical (non-linear) relationship with distance to the airport.

3.8.3 Residential satisfaction

In the Schiphol area 7% and 10% of the respondents to the postal questionnaire reported that they were dissatisfied with their housing and with their neighbourhood respectively. The most frequently named unfavourable aspects were nuisance caused by the airport (25%), high traffic density in the neighbourhood (21%), a boisterous or noisy neighbourhood (19%), lack of a good view (17%) and unfavourable environment (16%). For the Netherlands as a whole, dissatisfaction with the neighbourhood lay between 1 and 7% in 1993, depending on the degree of urbanisation. In the Rotterdam Rijnmond region, close to heavy industries, 10% of the population was not satisfied with the neighbourhood.

Regression analysis showed a statistically significant (positive) relationship between residential satisfaction and aircraft noise exposure; with higher aircraft noise levels dissatisfaction with the neighbourhood or the housing increased. The analysis was adjusted for duration of residence, type, ownership and age of the home, age, sex, education, ethnicity, time at home during the day and evening, insulation and degree of urbanisation. The effect of distance to the airport (per kilometre) was only statistically significant for dissatisfaction with the neighbourhood. The effect of aircraft noise exposure and distance to the airport was equal for the pleasant as well as the unpleasant aspects of the neighbourhood; people reported less pleasant and more unpleasant aspects with higher exposure to aircraft noise and in areas closer to the airport.

4. Conclusions

4.1 Annoyance

The questionnaire survey has provided new information about the current prevalence of annoyance by aircraft noise, odour, dust, soot or smoke, and vibrations, in relation to noise exposure and distance to the airport. The results show a higher than expected prevalence of serious aircraft noise annoyance in comparison with previous research in the Schiphol area and in other countries (even when the influence of possible selective non-response was taken into account). The higher figures may be explained by increased sensitivity to noise and concern about safety, higher actual exposure to noise than the calculated values would indicate, and the influence of the ongoing political and social debate about the expansion of the airport. The results further indicate deviation from linearity in the exposure-response relationship. The respondent's noise sensitivity, and fear of crashes were the most important non-acoustical factors which influenced annoyance. Even at greater distances from the airport, annoyance from noise, odour, dust, soot or smoke and vibrations from aircraft was reported. It is therefore possible, that there may be exposure to these factors further from the airport than was expected based on model calculations. Supplementary measurements could be used to examine this.

4.2 Cardiovascular diseases

A semi-ecological study of hospital admission data for (a selection of) cardiovascular diseases did not suggest a relationship with the airport since no clustering of the diseases around the airport in time and for both sexes was observed. The lack of data on important determinants of the diseases studied (e.g. social economical status, life style) and the fact that it was not possible to include exposure data in the spatial model preclude conclusions about the causes of the observed disease patterns. Since milder effects, which do not result in hospital admission (e.g. an increase in blood pressure treated by a general practitioner) are not included, a study of hospital admission data can result in an underestimation of the occurrence of cardiovascular effects. The results of the questionnaire study, in which information on major determinants of cardiovascular diseases was collected confirm the results of Part I and of other studies; indicators of cardiovascular disease might be associated with exposure to (aircraft) noise (8, 9). Further research on the effect of aircraft noise on cardiovascular diseases is under consideration.

4.3 Sleep disturbance

The observed association between the use of sedatives (as an indicator for sleep disturbance) and aircraft noise exposure in the semi-ecological study based on drug dispensing data, is supported by the results of the questionnaire study, in which information on major determinants of sleep disturbance was collected at an individual level. In this study, the results for the different sleep disturbance indicators (self-reported sleep disturbance due to aircraft noise, poor sleep quality, the use of 'sleeping pills or sedatives' (both prescribed, and self-medication) and the 'frequent use' of these medicines) are consistent; the extent and frequency of these indicators increase with increasing aircraft noise levels. This corroborates the results of Phase I and other studies (11, 12). Unfortunately, a quantitative

comparison with the results of other studies is not possible due to differences in methodology and health end-points measured.

4.4 Respiratory diseases

The results of the questionnaire survey, in which information was collected on major exogenous determinants of respiratory symptoms at the individual level, confirmed earlier observations from a semi-ecological study using drug dispensing data; respiratory symptoms are more prevalent in areas within 10 km of the airport than at greater distances. Due to the lack of information on ambient air pollution exposure at the respondent's address, these studies do not allow the conclusion that the observed association with distance can be attributed to air pollution from the airport. A re-analysis of the questionnaire data in combination with additional air pollution data obtained from dispersion modelling is under consideration.

4.5 Perceived health

In Phase II of the HIAS information on perceived health in relation to aircraft noise exposure was collected for the first time. These data can be used as a reference point for future monitoring activities. The results indicate that respondents with higher aircraft noise exposure levels tend to perceive their health as poorer than people with lower exposures. Further analyses of these data to investigate the interrelationships between noise-annoyance-perceived health is under consideration.

4.6 Neurobehavioural effects

Before starting a large epidemiological field study on neurobehavioural effects of aircraft noise in children, a pilot study was conducted to test whether the methods and instruments available were suitable for examining neurobehavioural effects (cognitive and psychomotor functioning and behaviour) in a large number of children in field studies. This pilot study showed that the selected methodology (with some modifications) can be applied in a field study in children from primary schools. Based on the pilot character of this study, no definite conclusions can be drawn about the effect of aircraft noise exposure on cognitive and psychomotor functioning and behaviour because of the small number of children tested and the lack of adequate (individual) exposure data.

4.7 Birth weight

The results of the semi-ecological study on birth weight and prenatal growth did not confirm the results of the earlier study around Schiphol airport by Knipschild and of other studies suggesting a negative effect of aircraft noise exposure on birth weight. Most of these studies including the one described in this report, however, have methodological limitations such as the lack of control for important confounders and a limited exposure characterisation. Therefore, the evidence for an effect of aircraft noise at the current exposure levels is considered inconclusive.

On the basis of our study a relationship between aircraft noise exposure and reduced birth-weight can neither be confirmed nor excluded. Effects of aircraft noise might be masked by for instance smoking of the mother during pregnancy.

5. Current and ongoing research activities

For a number of health end-points in the HIAS, research activities are still ongoing, planned or under consideration. These are summarised below.

5.1 Respiratory health

Results from a study on respiratory health in primary school children in 30 schools selected on distance to the airport and distance to traffic arteries will be reported in 1999. In this study, air pollution measurements are performed at the schools (indoors and outdoors). Respiratory health information is collected by pulmonary function measurements, parental questionnaire and by (specific) IgE determination in subgroups of the children as a measure for atopy. More 'objective' measures of respiratory health such as pulmonary function are less prone to reporter bias than self-reported questionnaire information. In addition, indoor air quality is determined in a study in 50 high and low noise exposed houses to assess whether high exposed houses may have poorer ventilation (and thus more accumulation of indoor generated pollution) due to sound proofing or ventilation restriction. Results of these studies should allow a better judgement about the potential role of air pollution as determinant of the observed higher respiratory symptom prevalence closer to the airport.

5.2 Sleep disturbance

To assess the relationship between night-time aircraft noise exposure and sleep disturbance around Schiphol airport an epidemiological field study will be carried out, starting in 1999. In 1998, a pilot study was conducted to assess the feasibility of the proposed methods, the logistics and the optimal design for the main study (15). The results from the main study are expected to be available in 2002.

5.3 Neurobehavioural effects

A final decision about a field study into aircraft noise and performance will be made as soon as the results of the main study on sleep disturbance (including performance) are available. The latest findings about performance in relation to noise as well as suitable test instruments will be considered. Recent findings around Munich Airport (16) for example suggest that the reading and memory tests used in the pilot study around Schiphol may have been too simple.

5.4 Monitoring

Based on the final results of the studies carried out in Phase II a monitoring system will be developed to study the health status of the population periodically in relation to expansion of the airport.

References

1. Franssen EAM; Staatsen BAM; Vrijkotte TGM; Lebret E; Passchier-Vermeer W. Noise and Public Health, Workshop report [in English]. RIVM, Bilthoven. Report 441520004.
2. Staatsen BAM; Franssen EAM; Lebret E. (1994). Health Impact Statement Schiphol Airport. Executive summary [in English]. RIVM, Bilthoven. Report 441520003.
3. Willigenburg APP van, Franssen EAM, Lebret E, Herings RMC. Medication use as indicator for the effects of environmental pollution (in Dutch). ISBN 90-393-1036-X, Utrecht Institute for Pharmaceutical Sciences, Utrecht; RIVM, Bilthoven, RIVM-report no. 441520006
4. Franssen EAM; Ameling CA; Lebret E. (1997). Variation in birth weight around Schiphol Airport, the Netherlands [in Dutch]. RIVM, Bilthoven. Report nr. 441520008.
5. Staatsen BAM; Doornbos G; Franssen EAM; Heisterkamp SH; Ameling CB; Lebret E. (1998). Spatial patterns in cardiovascular and respiratory disease rates around Schiphol airport [in Dutch]. RIVM, Bilthoven. Report nr. 441520009.
6. TNO-PG; RIVM. (1998). Annoyance, sleep disturbance, health aspects and the perception of the living environment around Schiphol airport, results of a questionnaire survey [in Dutch]. RIVM report 441520010; TNO report 98.039.
7. Emmen HH; Staatsen BAM; Deijen JB. (1997). A feasibility study of the application of neurobehavioural tests for studying the effects of aircraft noise on primary school children living in the vicinity of Schiphol Airport, the Netherlands [in Dutch]. RIVM, Bilthoven. Report nr. 441520007.
8. Knipschild P, Sallé H. (1976). Medical effects of aircraft noise Thesis, University of Amsterdam, Amsterdam.
9. Babisch W. (1998). Epidemiological studies of cardiovascular effects of traffic noise. In: Proceedings of the 7th International Congress on Noise as a Public Health Problem. Noise Effects '98, Sydney, Australia.
10. Health Council. (1991). Airplane noise and sleep. Sleep disturbance by airplane noise at night [in Dutch]. Health Council, the Hague.
11. Passchier-Vermeer W. (1994). Sleep disturbance by aircraft noise at night [in Dutch]. TNO Prevention and Health, Leiden. Report nr. 94/021.
12. Ollerhead JB, Jones CJ, Cadoux RE et al. (1992). Report of a field study on aircraft noise and sleep disturbance. London: Civil Aviation Authority.
13. Steenbekkers JHM, de Jong RG. The risk perception of people living in the Schiphol area. An exploratory study of the perception of risks to health and safety in people living in the Schiphol area [in Dutch]. NIPG-TNO, publication no. 93.050, Leiden, 1993.
14. Respiratory complaints. In: Report of General physician registry Amstelland-de Meerlanden, registration year 1993-1994. Amstelveen: Municipal Health Service Amstelland-de Meerlanden, 1995.

15. Passchier-Vermeer W; Gils van K; Vos H; Miedema H; Roo de F; Verhoeff E; Middelkoop HAM (1998). Aircraft noise and sleep disturbance. Pilot study [draft, in English]. TNO Prevention and Health, Leiden. Report nr. PG/VGZ/98.040.
16. Hygge S. (1998). Recent developments in noise and performance. In: Proceedings of the 7th International Congress on Noise as a Public Health Problem. Noise Effects '98, Sydney, Australia.

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