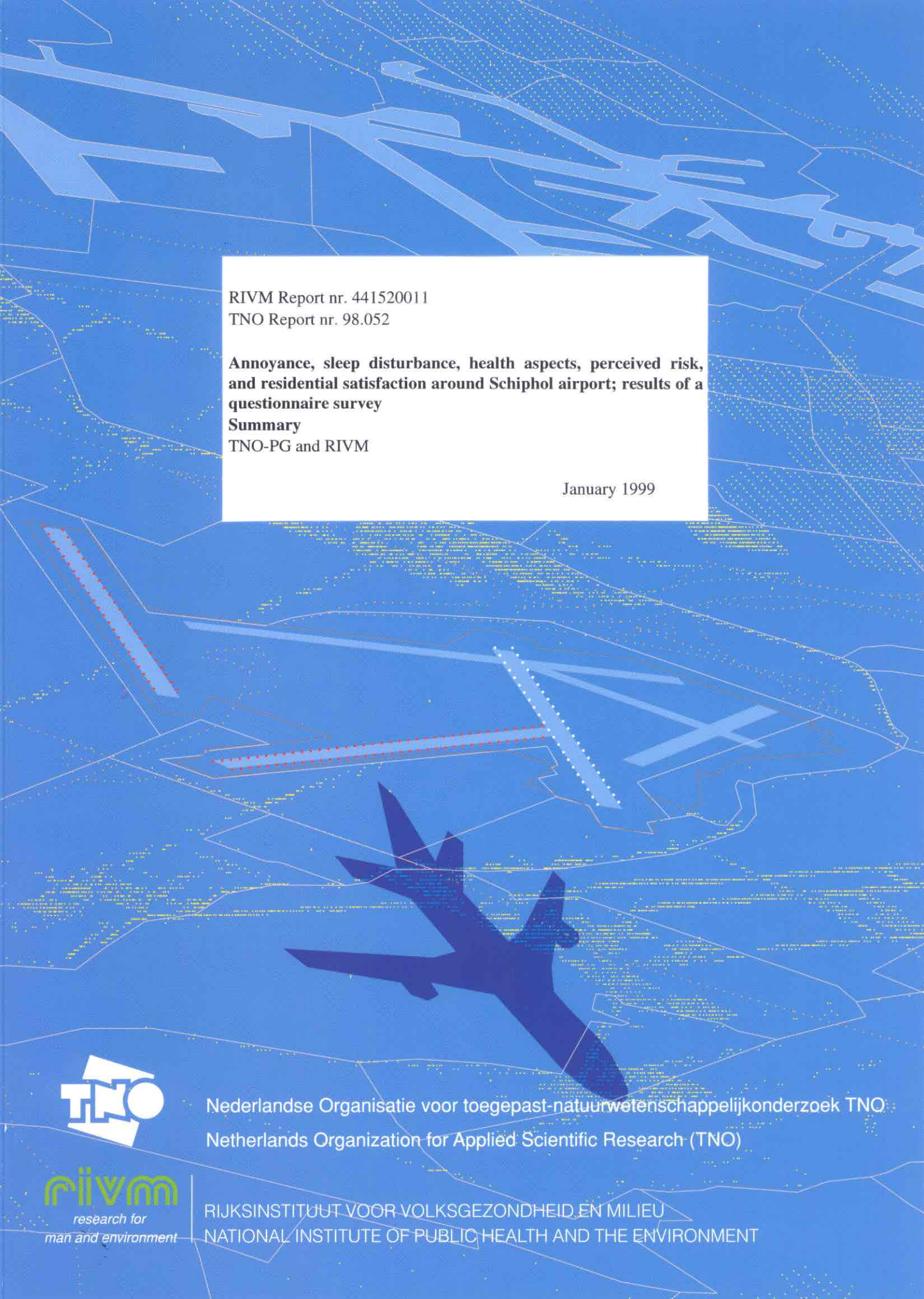

RIVM Report nr. 441520011
TNO Report nr. 98.052

# Annoyance, sleep disturbance, health aspects, perceived risk, and residential satisfaction around Schiphol airport; results of a questionnaire survey

## Summary

TNO-PG and RIVM

January 1999

Nederlandse Organisatie voor toegepast-natuurwetenschappelijkonderzoek TNO
Netherlands Organization for Applied Scientific Research (TNO)

research for man and environment

RIJKSINSTITUUT VOOR VOLKSGEZONDHEID EN MILIEU
NATIONAL INSTITUTE OF PUBLIC HEALTH AND THE ENVIRONMENT

This report is composed by a research team, consisting of (in alphabetical order):

Drs. E.A.M. Franssen

RIVM, Department of Chronic Diseases and Environmental Epidemiology

Drs. R.G. de Jong

TNO, Institute for Prevention and Health

Dr. ir. E. Lebret

RIVM, Department of Chronic Diseases and Environmental Epidemiology

Dr. H.M.E. Miedema,

TNO, Institute for Prevention and Health

Dr. H.F.P.M. van Poll

RIVM, Department of Chronic Diseases and Environmental Epidemiology

Drs. H. Vos

TNO, Institute for Prevention and Health

Ir. I.C. Walda

RIVM, Management team; Computerization and Methodological Consultancy

Drs. C.M.A.G. van Wiechen

RIVM, Department of Chronic Diseases and Environmental Epidemiology

Please refer to this publication as:
TNO-PG and RIVM. Annoyance, sleep disturbance, health aspects, perceived risk, and residential satisfaction around Schiphol airport; results of a questionnaire survey. Summary.
Publication numbers: TNO-PG: 98.052; RIVM: 441520011. Leiden/Bilthoven, January 1999.

**CONTENTS**

# 1. INTRODUCTION

This summary describes the results of one part of the research programme the 'Health Impact Assessment Schiphol Airport' (GES), which is a questionnaire-based survey on annoyance, sleep disturbance, self-rated health, risk perception and residential satisfaction around Schiphol airport. This study was a co-operative effort carried out by the Institute of Prevention and Health of the Netherlands Organisation for Applied Scientific Research (TNO-PG) and the National Institute of Public Health and the Environment (RIVM).

The goals of the questionnaire survey were:

- to assess the prevalence of annoyance, sleep disturbance, self-rated health, respiratory complaints, use of medication, perceived risk, and residential satisfaction in the Schiphol region;
- to study the relationships between annoyance, sleep disturbance, self-rated health, respiratory complaints, use of medication, perceived risk, and residential satisfaction on the one hand, and exposure to noise and/or air pollution from air transport on the other.

The results of this study will provide a starting-point for a future monitoring system, which will be used to monitor the health status of people living close to the airport, following its expansion.

***Health Impact Assessment Schiphol Airport***
Following Phase I of the Health Impact Assessment (HIA) which was carried out for the integral Environmental Impact Assessment Schiphol Airport (EIA) in 1993, the Ministries of Housing, Spatial Planning and the Environment, of Transport, Public Works and Water Management, and of Public Health, Welfare and Sport have commissioned further research into the health effects of environmental pollution related to air transport. The study is co-ordinated by RIVM as part of the Health Impact Assessment research programme (GES), which in turn is part of the Evaluation and Monitoring Programme for Schiphol (EMSO).
The goal of the GES is to obtain a better understanding of the present health status of people who live close to Schiphol. In addition, the ministries want to know whether there is a relationship between health problems and environmental pollution from the airport and air transport. The Health Impact Assessment is being conducted in three stages. Phase I studies have been performed within the framework of the EIA, ending in 1993. Phase II studies will be carried out during the period 1995-2000. Phase II of the HIA consists of three parts.
*1. Analysis of data from existing health registries.*
These studies are intended to document whether particular health effects are more prevalent in the Schiphol area as compared to the rest of the region. The existing registries of health data serve primarily as a sentinel function. Due to methodological problems and data limitations it is not possible to draw conclusions about the causes of possible health effects. Since 1996 there have been some exploratory studies into the use of sleeping pills and medication for respiratory diseases, birth weight, and hospital admissions for coronary heart disease and respiratory complaints. These studies have been completed and reported.
*2. Epidemiological field studies.*
The second part of the GES consists of epidemiological field investigations to characterise the exposure to aircraft noise and air pollutants and to study the relation between aircraft-related exposures and health effects. One of these is the questionnaire concerning annoyance, sleep disturbance, health, risk perception and residential satisfaction, the results of which are presented in this summary. Other studies are currently under way: one study of respiratory complaints in children and another of sleep disturbance in adults. A pilot study to identify methods suitable for measuring the relationship between aircraft noise and neurobehavioral effects in children has been completed and reported. Because sleep can have a significant effect on learning performance, a decision on whether to commission a follow-up study on neurobehavioural effects will not be made until the sleep disturbance study has been completed.
*3. Monitoring.*
The third part of the HIA is the development of a health monitoring system, consisting of a feasibility study based on the results of the other Phase II research activities and pilot studies for additional data collection.

## 2. DATA COLLECTION

The data for this study were collected in 1996 in a study area with a radius of 25 kilometres centring on the airport, using a postal questionnaire. 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. Therefore 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.

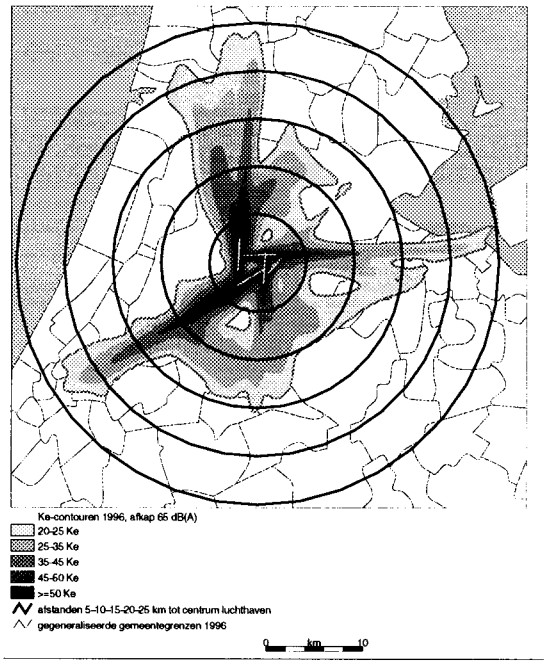


Figure 1 Map of the study area

The questionnaire consisted of questions about the annoyance as a result of noise, odour, dust, soot or smoke and vibrations, sleep disturbance, self-rated health, respiratory complaints, medication use, perceived risk, and residential satisfaction. Questions were also asked about important determinants of these variables, such as personal characteristics, living situation, and smoking behaviour. The questions were derived from existing questionnaires as far as possible.

In a study of this size it is impossible to measure the personal exposure to noise from aircraft and air pollution for each participant. These are therefore calculated in this study. Exposure to aircraft noise is calculated by the National Aerospace Laboratory NLR on the basis of a model which is laid down in the Dutch Aviation Act. These exposure data cover the same period as the questionnaire (1996). Most of the aircraft noise measures used in this study were chosen based on legally established methods of determination and on the national and international discussion on uniform measures for noise exposure (see the text box on 'noise measures'). The exposure to noise in Kosten units has been calculated using both the standard threshold of 65 dB(A), giving the B65 measure, and a threshold of 45 dB(A), the B45 measure. The B45 measure includes more of the take-off and landing period of each flight than the B65 measure. Because of the lack of suitable data on the air pollution and odour from aeroplanes, the distance from the residential address to the airport was used as an approximation of exposure to these factors.

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 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.

***Noise measures***

The noise measures calculated for use in this survey can be summarised as follows:

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 $L_{Aeq,\ 24hours}$, $L_{etmaal}$ ('24 hour value'), $L_{dn}$ and $L_{den}$. The $L_{Aeq,\ 24hours}$ 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).

## 3. DATA ANALYSIS

Annoyance, sleep disturbance, self-rated health, respiratory complaints, medication use, perceived risk, and residential satisfaction (*objective 1*) have been expressed as percentages of people who report these complaints, regardless of their exposure.

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. However the corrected figures are still estimates of the actual figures in the study area. They indicate the range of values for the actual figures.

The relationship between annoyance, sleep disturbance, self-rated health, respiratory complaints, medication use, perceived risk, and residential satisfaction, on the one hand, and the exposure to aircraft noise on the other (*objective 2*), was examined using various calculated measures of aircraft noise, such as Kosten units (B65 and B45), the $L_{Aeq\ 24\ hour}$ measure, and the number of flights passing overhead with peak noise levels exceeding 70 dB(A). The results shown in this summary are based on analyses using Kosten units and the $L_{Aeq,\ 23\text{-}06\ hours}$ measure. For respiratory complaints e.g., the distance from the residential address to the airport was used as an approximation of exposure to air pollution from aircraft.

For variables with a statistically significant relationship to aircraft noise, an estimate has been made of the attributable proportion of aircraft noise.

## 4. RESULTS

Tables 1 and 2 show the results from the study for those variables for which the relationship with aircraft noise exposure was statistically significant and in accordance with the scientific literature. Table 1 shows the results for annoyance and sleep disturbance. 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. The proportion of the annoyance and sleep disturbance which is attributable to aircraft noise can be estimated directly from the percentages, because noise from aircraft is a necessary cause for these effects.

Table 2 presents the results for perceived sleep quality, self-rated health, medication use, and respiratory complaints. These variables proved to be relatively insensitive to selective non-response, so only one (uncorrected) figure is presented. Unlike annoyance and sleep disturbance, one cannot directly estimate the proportion of a poor perceived sleep quality, poor self-rated health and medication use which is attributable to aircraft noise, because noise from aircraft is not the most important factor in the development of these complaints. Where there is no exposure to aircraft noise, people will still report sleeping complaints, poor self-rated health and medication use, because of the effects of other important determinants on these health complaints (age, gender, etc.). The proportion of the complaints mentioned above which can be attributed to aircraft noise has therefore been calculated on the basis of a model including both exposure to aircraft noise and other health determinants. Because of the sensitivity of the model estimates to the assumptions, the range of values from various estimates is shown. The estimates are particularly inexact where there is relatively low exposure to noise. Therefore quantitative estimates are presented only for zones with a noise exposure exceeding 20 and 35 Kosten units, and not for the whole study area. As the wide range in the results shows, the figures for the 20 Kosten-unit zone are only a very rough indication. If one assumes that the relationship between exposure and effects also applies for low aircraft noise levels (below 20 Kosten units), the estimates for the total study area would be approximately two to three times as high as those for the 20 Kosten-unit zone.

The relationship with distance to the airport cannot simply be attributed to air pollution from aeroplanes, because of lack of detailed data on this source of air pollution. It was therefore impossible to estimate the attributable proportion of respiratory complaints and the use of 'medicines for allergies and/or asthma' to air pollution from aircraft.

*Table 1 Annoyance and sleep disturbance 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 | |
| ***Annoyance due to aircraft*** | | | |
| 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 |
| ***Serious sleep disturbance caused by aircraft noise*** | | | |
| study area (1,520,750) | 8% | 12% | 120,000-180,000 |
| ≥26 dB(A) ($L_{Aeq,\ 23\text{-}06\ hours}$) (18,460) | 33% | 39% | 6,000-7,000 |

* percentages and absolute figures are rounded off

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

*Table 2 Perceived sleep quality, self-rated health, and medication use in the population aged 18 years and older living within 25 kilometres of the airport, and the attributable proportion of aircraft noise**

| Variable | Percentage of people reporting the complaint | Portion attributable to aircraft noise, in percent | Portion attributable to aircraft noise, in absolute numbers of people ≥18 years |
|---|---|---|---|
| ***Poor perceived sleep quality*** | | | |
| One or more sleeping complaints | | | |
| study area (1,520,750)** | 72% | x | x |
| ≥ 20 Kosten units (370,280) | 72% | 1.4 - 3.9% | 5,300 - 14,300 |
| ≥35 Kosten units (23,510) | 73% | 3.8 - 6.1% | 900 - 1,400 |
| ***Poor self-rated health*** | | | |
| study area (1,520,750) | 20% | x | x |
| ≥ 20 Kosten units (370,280) | 21% | -0.4 - 2.8% | -1,500*** - 10,400 |
| ≥35 Kosten units (23,510) | 21% | 2.3 - 4.4% | 500 - 1,000 |
| ***Use of prescription medication for cardiovascular diseases or elevated blood pressure*** | | | |
| study area (1,520,750) | 15% | x | x |
| ≥ 20 Kosten units (370,280) | 17% | 0.6 - 1.4% | 2,100 - 5,200 |
| ≥35 Kosten units (23,510) | 18% | 1.7 - 2.3% | 400 - 500 |
| ***Use of prescription sleeping pills or sedatives**** | | | |
| study area (1,520,750) | 8% | x | x |
| ≥ 20 Kosten units (370,280) | 10% | 1.2 - 2.2% | 4,500 - 8,100 |
| ≥35 Kosten units (23,510) | 11% | 2.6 - 3.6% | 600 - 900 |

x the estimate is too inexact

* percentages and absolute figures are rounded off

** the figures in parentheses show the total number of inhabitants (age 18 years and older) in the area

*** as the wide range in the estimates shows, the figures for the 20 Kosten-unit zone are particularly approximate. One reason for this is the low precision of the relationship between exposure and responses in areas with low aircraft noise exposure. The confidence interval on either side of the point estimate is so wide that negative values are possible (in this case the 95% confidence interval is -10.442 - 8.183).

**** 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.

### 4.1 Annoyance

Aircraft are 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 from aircraft noise. These are approximately a quarter to half a million people. 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 of the zone (98.5% of the total, versus 1.5% within the zone). The Omnibus survey carried out by the local government of Haarlemmermeer (a municipality within the study area) found that 30 percent of those living in this municipality are annoyed or seriously annoyed from air traffic and/or Schiphol airport. However the Omnibus figures are not directly comparable with the figures of this study because of differences in the questionnaire. Three percent of the population of the Netherlands report serious annoyance from passenger and freight aircraft.

The annoyance diminishes with lower aircraft noise exposure. On the margins 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. Although no data were collected beyond this point, in the light of these percentages it is reasonable to suppose that some people living further than 25 kilometres from the airport will also be (seriously) annoyed.

The reported aircraft noise annoyance is higher than was expected on the basis of previous Schiphol studies performed by Bitter (in 1967 and 1980) and of data from the TNO-PG's 'Disturbance Database' (*Kennisbestand Verstoringen*, which brings together data from 20 studies of annoyance from aircraft noise in 9 countries). Possible explanations for the higher than expected annoyance levels include 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.

The percentage of people reporting that they are annoyed by aircraft noise increases with higher exposure to noise but levels off at higher noise levels (above about 40-45 Kosten units (B65)). A similar levelling-off has also 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).

Aircraft are 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 is estimated that 80,000 to 108,000 people (5-7 percent) are seriously annoyed by odour from aircraft, 100,000 to 125,000

(6-8 percent) by dust, soot and smoke from aircraft, and 150,000 to 210,000 (10-14 percent) by aircraft vibrations. About half of those being seriously annoyed lived within 10 kilometres of the airport. In the integral Environmental Impact Assessment, 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 Omnibus survey showed that 17 percent of the inhabitants of the municipality of Haarlemmermeer were seriously or very seriously annoyed by the odour of aircraft taking off, landing and taxiing. The annoyance from both odour and noise is highest in residential areas of Haarlemmermeer that are close to the airport.

The serious annoyance by odour, dust, soot or smoke and vibrations from aircraft is higher than was found in the most recent national study of annoyance (TNO-PG, 1994). This may in part be ascribed 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 possible therefore that there may be exposure to odour, dust, soot, and smoke from aircraft further from the airport than was expected on the basis of model calculations. Supplementary measurements of odour, dust and soot could be used to examine this.

In addition to exposure to noise, the degree to which people state that they are sensitive to noise and the fear of crashes are important factors influencing serious annoyance from noise, odour, dust, soot, smoke and vibrations from aircraft.

### 4.2 Sleep disturbance and sleep quality

More than 90 percent of the adults get up after 6 a.m. on working days; in the weekend almost 100 percent do so. Four out of ten go to bed before 11 p.m. on working days; in the weekends, this proportion is just over 10 percent. The sleeping time of many of the respondents is therefore longer than the hours for which the standard for night air movements applies (11 p.m. to 6 in the morning). Annoyance due to aircraft at night is greatest during these hours.

Aircraft are the most frequently reported source of sleep disturbance, followed by neighbours and road traffic. Eight to 12 percent of the people aged 18 years and over and living within 25 kilometres of the airport reported that their sleep was seriously disturbed by aircraft noise. This would amount to an estimated 120,000 to 180,000 people. The majority of these people live in areas outside the legal zone for night noise from aircraft (noise levels of 26 dB(A) $L_{Aeq,\ 23\text{-}06\ hours,}$ in the bedroom).

*Sleep disturbance* as a result of aircraft noise can by definition be caused only by the noise of aircraft, but the *sleep quality* is also determined by many other factors. Therefore sleep disturbance due to aircraft

noise may be reported without a perceived poor sleep quality, and a poor sleep quality may occur without sleep disturbance caused by aircraft noise.

In areas with noise levels of 26 dB(A) or more at night, 17 to 19 percent of people reported having 4 or more sleeping problems, as compared to 14 to 15 percent of those living outside the high noise area. The perceived sleep quality in this study is 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.

It is estimated that in areas with an exposure to noise of 35 Kosten units or more, about a thousand people report that they perceive poor sleep quality as a result of exposure to aircraft noise. In the 20 Kosten-unit zone the number is roughly estimated as being in the order of 5 to 14 thousand people. In addition to exposure to noise, sensitivity to noise and the fear of crashes are important determinants of sleep disturbance and poor perceived sleep quality.

### 4.3 Self-rated health status

Of the adults living within 25 kilometres of the airport, 80 percent perceive 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). Self-rated health status has a statistically significant relationship to aircraft noise exposure and distance to the airport: both in areas with a higher exposure to aircraft noise and close to the airport relatively more people reported a poor self-rated health.

Based on the relationship between self-rated health and exposure to aircraft noise, it is estimated that several hundred to about a thousand people in the 35 Kosten-unit zone rate their health as poor due to aircraft noise. The estimate for areas with a noise exposure of 20 Kosten units or more is in the order of ten thousand people. Age, gender, socio-economic status, land of origin, smoking and exposure to noise are all determinants of the self-rated health.

### 4.4 Respiratory complaints

Of the adults living within 25 kilometres of the airport, 75 percent reported 'one or more respiratory complaints'. Forty percent reported 'chronic coughing, coughing up phlegm and bronchitis' and 30 percent said they were receiving medical treatment for 'allergy'. Eighteen percent reported 'symptoms of the lower respiratory airways'; eight percent said they suffered from 'asthma'. These figures are fairly similar to corresponding figures found in other Dutch studies.

Three of the five (groups of) respiratory complaints covered in the survey had a statistically significant relationship to distance to the airport. Relatively more adults living within 10 km of the airport reported 'one or more respiratory complaints', 'chronic coughing, coughing up phlegm and bronchitis', and 'allergy'.

The relationship between respiratory complaints and distance found here is in accordance with a previous reported study based on General Practitioners' records carried out by the regional health service for Amstelland de Meerlanden and with a study of the use of medication for respiratory diseases around Schiphol. However for these previous studies no data on the determinants of respiratory complaints (such as smoking and damp houses) were available which might have explained the observed relationship between respiratory complaints and distance to the airport. This survey-based study did include the most important determinants in the questionnaire and analyses. Therefore it is not likely that the relationship between distance to the airport and the prevalence of respiratory complaints is strongly confounded by general determinants of health. However the relationship with distance cannot simply be attributed to air pollution from aeroplanes, because of the lack of detailed data on this source of air pollution.

### 4.5 Medication use

Sixty-five percent of the adults used at least one of the seven prescription medicines covered in the questionnaire in the course of a year. 'Medicines for pain, fever, common cold, influenza, sore throat, etc.' were the most used (31 percent), followed by 'medicines for cardiovascular diseases or elevated blood pressure' (15 percent), 'medicines for the skin' (14 percent), and 'medicines for allergy and/or asthma' (13 percent). The majority of non-prescription medicines were 'medicines for pain, fever, common cold, influenza, sore throat, etc.' (70 percent). Ten percent of the people used prescribed 'sleeping pills or sedatives'.

There was a relationship between the use of some medicines and exposure to aircraft noise. With higher exposure to aircraft noise, there was statistically significant higher use of 'medicines for rheumatism, painful joints, etc.' and 'sleeping pills or sedatives' (both prescribed, self-medication and frequent use). The relationship between aircraft noise and the use of 'medicines for pain, fever, influenza, etc.' and 'medicines for cardiovascular diseases or elevated blood pressure' was also statistically significant but less strong.

The relationship between the use of 'medicines for rheumatism, painful joints, etc.' and aircraft noise is unexpected in terms of current scientific knowledge. This requires some caution in interpreting the result. As expected, however, no relation was found between aircraft noise and the use of 'medicines for diabetes mellitus'. The relationship between exposure aircraft noise and the use of 'sleeping pills or sedatives' and 'medicines for cardiovascular diseases or elevated blood pressure' is in accordance with results from other studies.

The use of 'sleeping pills or sedatives' has a statistically significant relationship to the reported frequency of sleep disturbance due to aircraft noise (ranging from once or more per year to daily). In addition to the use of 'sleeping pills or sedatives' and the frequency of such use, serious sleep

disturbance and the perceived quality of sleep also have a statistically significant relationship to aircraft noise.

On the basis of the relationship between aircraft noise and the use of 'medicines for cardiovascular diseases or elevated blood pressure' and the use of 'sleeping pills or sedatives' it is estimated that several hundred people in the 35 Kosten-unit zone use these medications as a result of aircraft noise. The rough estimate for the area with an aircraft noise exposure of 20 Kosten units or more is in the order of two to eight thousand people.

The use of 'medicines for allergy and/or asthma' and the prevalence of asthma and allergy have a statistically significant relationship to distance to the airport. Closer to the airport more people report that they use medicines for these disorders. This is in accordance with results from a previous study on the use of medication for respiratory disease in the Schiphol area. However in this previous study data about other determinants of respiratory complaints, such as smoking and damp houses were not available. Such data could explain the possible relationship with distance. This survey-based study did include the most important determinants in the questionnaire and analyses. Therefore it is not likely that the relationship between distance to the airport and the use of 'medicines for allergy and/or asthma' is strongly confounded by general health determinants. The relationship with distance can not simply be attributed to air pollution from aeroplanes, because of the lack of detailed data on this source of air pollution. It was therefore not possible to estimate the portion of the use of 'medicines for allergy and/or asthma' which is attributable to air pollution from aircraft.

### 4.6 Perceived risk and residential satisfaction

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 percent were unconcerned or hardly concerned. Eleven percent had safety concerns as a result of living in the vicinity of a large airport and 75 percent were unconcerned or hardly concerned. Four percent were very concerned because they lived in a busy street. The recent Omnibus study carried out by the local government of Haarlemmermeer found that almost 70 percent of the population felt safe in the vicinity of the airport, 25 percent felt somewhat unsafe and 3 percent felt unsafe.

Relatively more people reported that they were concerned about health effects due to air pollution from aircraft (42 percent) than about health effects from aircraft noise (18 percent). In the perceived risk study that was performed as part of the integral Environmental Impact Assessment for Schiphol in 1993, 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.

Seven percent of the respondents reported they were dissatisfied with their housing and 10 percent with the neighbourhood. For the Netherlands as a whole, dissatisfaction with the neighbourhood lay between 1 and 7 percent in 1993, depending on the degree of urbanisation. In the Rotterdam Rijnmond region, close to heavy industries, 10 percent of the people were not satisfied with the neighbourhood. Proximity to shops was mentioned as a favourable aspect by 60 percent, followed by favourable housing (53%), closeness to public transport (51%), good connections with the city, and peace and quiet in the neighbourhood (both 44%). 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%).

More people reported concern about the risks of air traffic and were dissatisfied with the quality of their surroundings where exposure to aircraft noise was higher and in areas closer to the airport. This effect levels off at higher noise levels (above about 40-45 Kosten units (B65)). It is likely that the same factors are involved here as in the case of annoyance. The perceived risk is influenced not only by exposure to noise, but also by the frequency with which aircraft are heard and the number of flights passing overhead. Because of the indirect relationship between exposure to aircraft noise, objective safety risk, and perceived risk, it is not possible to infer that a reduction in aircraft noise would result in less concern.

## 5. EVALUATION OF THE QUESTIONNAIRE DATA

In view of the purpose of the study and its required sample size, a questionnaire was the most suitable instrument. An important advantage of the questionnaire is that it is possible in a relatively simple way to collect data from very many people and about very divergent aspects of annoyance, self-rated health, medication use, risk perception and residential satisfaction. Data about individual characteristics and health determinants such as age, gender, socio-economic status, accommodation aspects, and smoking behaviour can also be easily collected. These data are essential for a proper analysis and interpretation of the results.

The results for most of the health effects covered in this study correspond reasonably well with results from comparable studies carried out elsewhere in the Netherlands. However the reported annoyance from aircraft noise, even when corrected for selective non-response, is higher than was expected on the basis of data from previous research in the Schiphol area and from other countries. Possible explanations for this are mentioned in the section dealing with annoyance.

Most of the topics covered in the questionnaire could also be studied by alternative research methods. These would be preferable if the goal was to increase scientific knowledge about each of these specific topics separately. However these methods were not suitable for a broad description of the public health status around Schiphol airport, which is required in the framework of the HIA and EMSO. Such methods are much too expensive and too laborious for research to be carried out among 10,000 people within a reasonable time. Moreover, fewer aspects of health can be studied simultaneously. At present two studies are being performed as part of GES and EMSO, which will supplement this survey-based study and examine in more depth topics which have also been measured in the questionnaire. These studies cover respiratory disorders and sleep disturbance.

The proportion of people who filled in the questionnaire, 39 percent, is somewhat higher than the 20-35 percent expected at the start of the study. The results of the telephone follow-up among 'non-respondents' suggest that the results may be biased by selective non-response. This would mean that the uncorrected figures probably over-estimate the prevalences. Of the 'non-respondents' who were surveyed by telephone, who themselves constitute a subgroup of all 'non-respondents', 13 percent are seriously annoyed by aircraft noise as compared to 31 percent of the respondents to the postal questionnaire. In this study the influence of selective non-response on the prevalences has been estimated as closely as possible. It was not possible however to determine whether and how the exposure-response relationships from this study are biased by selective non-response. This would require supplementary simulation studies. Allowance will have to be made for this when comparing these results with other studies (which often do not include a correction for selective non-response) and also when the questionnaire is repeated in the future health monitoring system for Schiphol.

## 6. EVALUATION OF THE AIRCRAFT NOISE DATA

In this study most aircraft noise exposure measures were determined from model calculations. 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 (B65 and $L_{Aeq,\ 23\text{-}06\ hours}$). There has been some 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.

One study comparing measured and calculated noise levels, carried out by the National Aerospace Laboratory NLR, showed that calculated levels are often lower than the actual measured values. The differences between the measured and calculated exposure to aircraft noise are greatest at low noise levels and in areas where aircraft are mainly landing. The calculated aircraft noise exposure of people who live in these areas, in this study, will probably differ the most from measured values.

The In 't Veld Commission and others have strongly recommended that aircraft noise exposure should also be determined from measurements, in accordance with article 25 of the Air Transportation Act. The calculated data should agree with these measurements. The two together would give a better characterisation of the exposure to aircraft noise. However in this survey-based study only calculated data were available.

At the addresses of each study participant most noise measures used in the study correlated closely. If a high value for B65 is calculated for a particular point, the value for the other measures of noise is also high. The correspondence is closest for B65 and B45, for which the values diverge appreciably only at lower noise levels. The difference between the two 'B' measures and the $L_{Aeq}$ values for various periods in the 24-hour cycle and varying numbers of overhead flights are greater.

The Kosten unit was explicitly developed for measuring the annoyance from aircraft noise. For the other health variables however, it was not possible to decide, a priori, which measure of exposure would be the most suitable. Several measures were therefore studied. B65, B45, $L_{den}$ and $L_{dn}$ had the highest statistical correlation with the reported annoyance from aircraft noise. The correlation with $L_{Aeq,\ 24\ hours}$ and $L_{etmaal}$ ('24 hour value') was somewhat less strong. The annoyance due to aircraft vibrations was most closely correlated to the B65 measure. For self-rated health, medication use, perceived risk, and residential satisfaction, it generally made little difference whether the calculated B65, B45 or $L_{Aeq,\ 24\ hours}$ was used. It is not possible, on the basis of the data of this study, to say which is the best measure for describing the relationship with health. In statistical terms the noise measures are in close agreement, but particularly at lower levels the exposure-response curves for annoyance diverge. Supplementary simulation studies are

required to determine the net effect of all the limitations in the noise data on the relationship between exposure and responses such as annoyance.

## 7. CONCLUSIONS FROM THE QUESTIONNAIRE STUDY

- Annoyance from aircraft noise as reported in this study is higher than was expected on the basis of data from previous research for the Schiphol area and from other countries, even when the influence of possible selective non-response is 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.
- Even at greater distances from the airport, respondents reported that they are annoyed by odour, dust, soot, smoke and vibrations from aircraft. Supplementary measurements of odour, dust and soot further from the airport could be used to examine whether there is exposure to these factors further from the airport than was expected.
- The reported annoyance, sleep disturbance, self-rated health, medication use, perceived risk and residential satisfaction are related to aircraft noise exposure. A higher proportion of people living in areas with a higher exposure to aircraft noise report these complaints. Relatively more people living closer to the airport reported that they are annoyed by odour, dust, soot and smoke from aircraft, reported respiratory complaints and used medicines for asthma and/or allergy.
- While reported annoyance, perceived risk and residential dissatisfaction increase with increasing exposure, this relationship levels off at noise levels above about 40-45 Kosten units (B65). No definite explanation can be given for this phenomenon, but sound insulation of houses, the migration of noise sensitive people out of noisy areas, and adjustment to living in a noisy environment (coping) could all play a role.
- Although the percentage of people seriously annoyed by aircraft noise in the area with an exposure below 20 Kosten units is lower than in the 20 and 35 Kosten unit zones, in absolute figures more people who are seriously annoyed live in the below 20 Kosten unit zone. This is because more people live in this zone. For the same reason, most people who report sleep disturbance as a result of aircraft noise live outside the 26 dB(A) zone ($L_{Aeq,\ 23\text{-}06\ hour}$). The estimates for poor self-rated health, poor perceived sleep quality and medication use also indicate that the number of people reporting these effects due to aircraft noise is larger outside the 35 Kosten unit zone than inside.
- The results of this questionnaire study confirm previous research which showed that respiratory complaints and the use of medicines for asthma and/or allergy were reported more frequently within 10 km of the airport than further away. However the relationship with distance cannot simply be attributed to air pollution from aeroplanes, because of the lack of detailed data on this source of air pollution. It was therefore impossible to estimate the proportion of respiratory complaints and the use of 'medicines

for allergies and/or asthma' attributable to air pollution from aircraft. A study of respiratory disorders in children in relation to air pollution that is currently under way, which is also part of the GES and EMSO, will provide supplementary information on this point.

- It is not possible, on the basis of the data collected to conclude which is the best measure for describing the relationship between aircraft noise and annoyance or the various aspects of health.

### 7.1 Recommendations

The following recommendations are made in relation to the goals of GES and EMSO:

- If the questionnaire is to be used as one of the instruments in a health monitoring programme, the methods for determining selective non-response and the correction for the possible resulting bias must be evaluated. Such a study could also consider the repeatability of the questionnaire and possible seasonal effects.
- A health monitoring programme must collect individual data about determinants for the reported effects. These determinants include sensitivity to noise, fear of aircraft crashes, age, gender, and socio-economic status.