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EXPOSURE-RESPONSE RELATIONSHIPS BETWEEN AIRCRAFT NOISE AND ANNOYANCE OR SLEEP DISTURBANCE FOR DUTCH CIVIL AND MILITARY AIRPORTS

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ABSTRACT

Residents living near airports are exposed to aircraft noise. In this study we investigated the association between aircraft noise exposure and high annoyance or sleep disturbance in the vicinity of 14 civil and military airports in the Netherlands. Data of 262.310 participants was used from the Municipal Public Health Service Health Monitor 2020, a nationwide survey on the state of public health. In the analyses the responses on the 11-point scale ISO questionnaire aircraft noise annoyance and sleep disturbance are combined with modelled noise exposure at the residential address. We conducted population-weighted logistic regression models with both a linear and non-linear exposure effect. It was possible to derive exposure-response relationship for most larger airports in the Netherlands. More residents were highly annoyed and sleep disturbed in 2020 at the same air traffic noise levels than in a study conducted in 2002 around Schiphol Airport which exposure response relationship is often used in Dutch policy. The survey was conducted during the COVID19 pandemic which could have influenced the results. Key recommendations from this research are the application of airport specific, recent and non-linear exposure response relationships. We plan to expand this current research on air traffic noise to rail and road traffic noise.

Keywords: *air traffic noise, annoyance, sleep disturbance, exposure-response relationship.*

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1. INTRODUCTION

Residents living near airports are exposed to aircraft noise which can lead amongst other to sleep disturbances and annoyance [1,2]. The research question of this study was to derive exposure-response (ER) relationships between aircraft noise and high annoyance/sleep disturbance for several civil and military airports in the Netherlands. Additional aim was to compare these new ER relationships with the ER relationship from 2002 around Schiphol airport [3] which is widely used in Dutch policy. To answer the research question, we used collected survey data regarding aircraft noise annoyance and sleep disturbance near Dutch civil and military airports. This survey data was combined with aircraft noise levels calculated by the Netherlands Aerospace Centre at the home address.

2. METHODS

2.1 Study population

This study included 14 civil and military airports in the Netherlands, which are listed in Table 1. The study population consisted of residents, 18 years and older, living near these airports who took part in the 2020 Municipal Public Health Service Monitor. The airport Maastricht Aachen Airport and Air base Geilenkirchen are analyzed together as the affected area are overlapping.

Table 1. Airports in the Netherlands participating in this study

Airport	Kind of airport
Schiphol Airport	Civil
Maastricht Aachen Airport	Civil
Groningen Airport Eelde	Civil
Lelystad Airport	Civil
Rotterdam The Hague Airport	Civil

Eindhoven Airport	Military/Civil
Maritime Air base de Kooy	Military/Civil
Air base Deelen*	Military
Air base Gilze-Rijen	Military
Air base Woensdrecht	Military
Air base Volkel	Military
Air base Leeuwarden	Military
Air base De Peel*	Military
Air base Geilenkirchen	Military

*no flights at Air base De Peel in 2020, Air base Deelen very small area.

2.2 Survey

The Municipal Public Health Service Monitor 2020, a nationwide survey in the Netherlands, collected questionnaire data, amongst other on annoyance and sleep disturbance from various environmental sources including aircraft. The study was conducted in autumn 2020 under residents aged 18 years or older. Annoyance and sleep disturbance were assessed using an 11-point scale question, ranging from 0 to 10, as outlined in the ISO standard [4]. For each source, respondents reported the annoyance or sleep disturbance they experienced in and around their home over the past 12 months. For analysis, we classified scores of 8 and above on the 0-10 scale as indicating high levels of annoyance and sleep disturbance. A more detailed overview of the data collected in this study is available in a Dutch report [5]. In total 30.000 extra questionnaires were disturbed in vicinity of the different airports to oversample higher exposed areas. The total sample of the survey was 1.361.519 of which 530.258 people responded (response rate 39%). Participants were asked to give informed consent before participating in the Municipal Public Health Service Monitor 2020 study.

2.3 Noise data

The Netherlands Aerospace Centre modelled aircraft noise levels on a grid with a 100 x 100 meter resolution for the year 2020 with the Dutch Calculation Model in the vicinity of the 14 airports. Each participants residential address was linked to the closest grid-point. The modeling area around each airport was defined by a trade-off between on the one hand the occurrence of high annoyance in the area and the ability of the NLR to calculate reliable noise estimates. For a more detailed description of the calculation of the noise data we refer to a Dutch report [6]. In this study L_{den} and $L_{night,}$ for the year 2020, were used as exposure metrics.

2.4 Statistical analysis

We reported descriptives of the study population, outcome and exposure for each separate airport. We used population-weighted logistic regression models to predict high annoyance and sleep disturbance based on L_{den} and L_{night} respectively to derive airport specific ER relationships. Both linear and non-linear (spline) exposure effect were investigated. Model fit was compared by Akaike information criterion (AIC).

3. RESULTS

In total data of 262.310 participants from the 530.258 participants included in the Municipal Public Health Service Health Monitor 2020 were included in this study because for these participants exposure data were available. The study population, outcome and exposure distribution for each airport are presented in Table 2. Schiphol Airport had the largest amount of participants (n=126.946) and Maritime Air base de Kooy the lowest (n=1.463). The airports Groningen Airport Eelde, Lelystad, Woensdrecht and Geilenkirchen did not have flights during the night.

Table 2. Overview study population and exposure for the different airports.

Airport	N annoyance[1]	Exposure L_{den} p1-p99	N highly annoyed	N sleep disturbance[2]	Exposure L_{night} p1-p99	N highly sleep disturbed
Schiphol	126.946	32-54	10.674	126.802	16-35	5.241
Rotterdam	54.043	18-47	1.613	53.898	2-36	790
Lelystad	14.814	0-41	355	14.778	NA	126
Groningen	5.002	10-44	107	4.984	NA	32
Eindhoven	24.672	24-48	2.057	24.566	<1-24	872
Maastricht	16.983	24-54	1.600	16.976	4-38	674
Geilenkirchen	14.451	25-55	1.468	14.440	NA	616
De Kooy	1.463	30-48	60	1.459	17-32	23
Gilze-Rijen	2.694	20-51	180	2.696	<1-31	82
Leeuwaarden	5.413	19-62	387	5.381	<1-30	80
Volkel	8.136	25-59	727	8.142	1-37	193
Woensdrecht	2.144	10-42	39	2.143	NA	17

1 Number of participants in the Health Service Monitor 2020 who answered the annoyance question

2 Number of participants in the Health Service Monitor 2020 who answered the sleep disturbance question

P=percentile, N=number

For Airbase De Peel (no flights in 2020), Airbase Deelen, Maritime Air Base de Kooy, Groningen Airport Eelde and Lelystad Airport it was not possible to derive airport specific ER relationships due to exposure distribution (too low or too small range) and or limited number of residents at higher exposure levels.

Figure 1 shows a clear relationship between aircraft noise (L_{den}) and high annoyance for the 7 remaining airports in the Netherlands. The different airport ER relationships for 2020 largely lie above the Schiphol 2002 ER relationship, except for Leeuwarden. The 2020 ER relationship for Schiphol Airport differs from other airports in the Netherlands at higher exposure levels.

Figure 2 shows the relationship between nocturnal aircraft noise (L_{night}) and high sleep disturbance for the different airports in the Netherlands. Almost all ER relationships from 2020 are above the 2002 Schiphol ER relationship, except the ER relationship for Leeuwarden. The higher the exposure level, the more variation between the different airports.

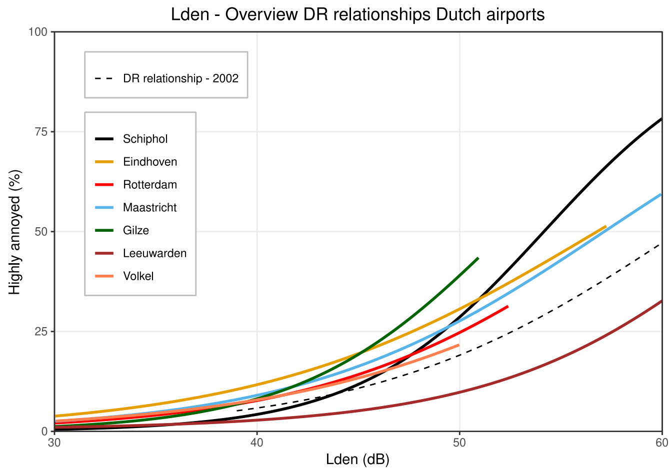

Figure 1. Linear exposure response relationships for L_{den} and high annoyance for different Dutch airports in 2020.

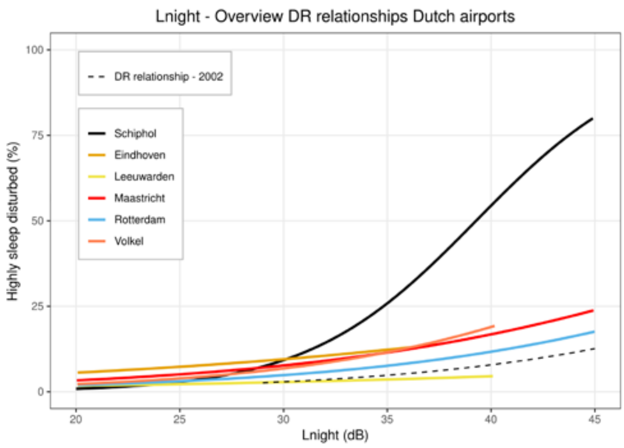

Figure 2. Exposure response relationships for L_{night} and high sleep disturbance for different Dutch airports in 2020.

Figure 3 shows differences between a logistic regression model with a linear effect and logistic regression model with a spline (3 knots) to investigate for a non-linear exposure effect for L_{den} and high annoyance for Schiphol Airport, the largest airport in the Netherlands. The AIC for the spline model was lower (AIC 50184,7) than that of the linear model (AIC 50344,5).

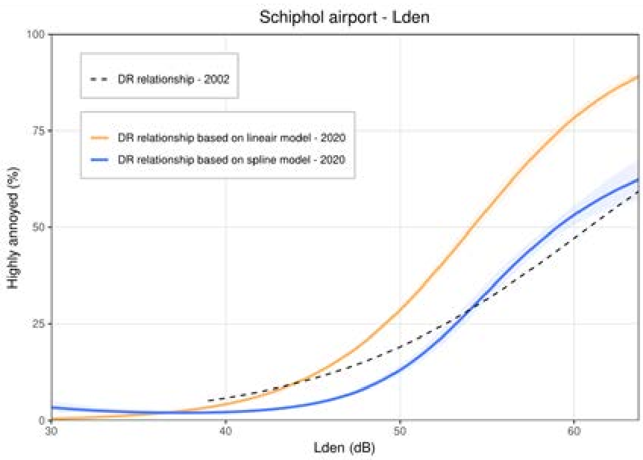

Figure 3. Linear and spline exposure response relationships for L_{den} and high annoyance for Schiphol 2020. (Blue line: spline model, Orange line: linear model, dotted line: Schiphol 2002 line (linear)).

For L_{night} and high sleep disturbance there is also a difference between the linear and spline model which is shown in Figure 4. The model fit for the L_{night} spline model was lower (AIC 30341,2) than that of the linear model (AIC 30482,8). Linear and non-linear (spline) logistic regression models are described in more detail in van Poll et al [5].

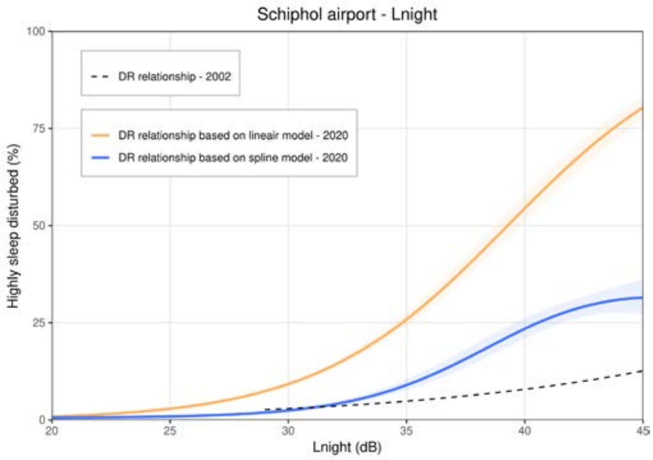

Figure 4. Linear and spline exposure response relationships for L_{night} and high sleep disturbance for Schiphol 2020. (Blue line: spline model, Orange line: linear model, dotted line: Schiphol 2002 ER relationship (linear)).

4. DISCUSSION

4.1 Main findings

The main research question of this study was to derive exposure response relationships between yearly averaged aircraft noise (L_{den}/L_{night}) and the probability to be highly annoyed and sleep disturbed for separate civil and military airports in the Netherlands. It was possible to derive exposure response relationships for most larger airports in the Netherlands. For some smaller (military) airports it was not possible to derive ER relationship because of the exposure distribution and/or number of cases in higher exposure groups. There is much variations in ER relationships between the different Dutch airports in 2020, which is probably due to both acoustic as non-acoustic factors. Except for Leeuwarden all 2020 ER relationships for aircraft noise (L_{den}) and high annoyance lie above the 2002 ER relationship from Schiphol Airport indicating more annoyance at the same exposure levels. For aircraft noise (L_{night}) and high sleep disturbance all 2020 ER relationships, except Leeuwarden, lie above the 2002

Schiphol Airport. ER relationship for nocturnal aircraft noise.

4.2 Strengths and limitations

Our study consisted of a large study population spread over different military and civil airports in the Netherlands. Noise exposure data was calculated for the different airports and residential address was linked to the closest grid-point. The survey was carried out in the autumn of 2020, during the COVID-19 pandemic. The COVID-19 pandemic affected aircraft noise exposure. For civil airport there were fewer flight movements in 2020 compared to 2019. Consequently, the aircraft noise exposure observed in this study were lower than in the pre-corona period. For some military airports the number of flights was higher in 2020 compared to 2019. Also the responses to the questions on annoyance and sleep disturbance might have been influenced by the COVID-19 pandemic. For instance, more people were working from home in that time period which could have influenced their responses on the annoyance questions as there were more at home. Since our study relied on data collected from a nationwide health survey, we were unable to investigate the impact of other specific factors that are known to affect the relationship between aircraft noise and annoyance or sleep disturbance. Examples of such specific factors include noise sensitivity, and attitudes toward the airport. Unfortunately, this nationwide study on health did not collect data on these specific aspects. Regarding the investigation of non-linearity we found differences between the two models for Schiphol Airport. The spline model is more flexible and might therefore estimate the relationship better, as shown in this study.

4.3 Recommendations

In this study we observed that for certain airports the number of participants with high exposure levels was relatively low, probably due to fewer flights due to the COVID-19 pandemic. Therefor we recommend to collected data again in 2024 to get more valid estimates over the entire exposure range. To address this, it is important to increase the sample size in areas with higher noise exposure. However we are dependent on the regulations and allocations of the Municipal Public Health Service. Furthermore it is important to investigate non-linearity of exposure response relationship as shown in the results for Schiphol Airport. Additionally, gathering data on other non-acoustic factors that may contribute to annoyance and sleep disturbance responses, beyond noise itself, is crucial for gaining a more comprehensive understanding on the relationship between aircraft noise and annoyance or sleep disturbance to explain possible differences between the different exposure response relationships.

5. ACKNOWLEDGMENTS

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