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THE ALLEVIATING ROLE OF RESIDENTIAL GREEN ON ROAD TRAFFIC NOISE ANNOYANCE: INSIGHTS FROM THE RESTORE PROJECT

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ABSTRACT*

Long-term exposure to noise is linked to various adverse effects on human health. Growing evidence suggests that residential green spaces can positively influence a wide range of health outcomes. Noise annoyance is a key factor examined in the literature in this context. We present findings from two large-scale studies conducted in Switzerland (combined n = 3,340 participants), one in the city of Zurich and one nationwide. Road traffic noise annoyance data was collected and regressed on exposure to (a) road traffic noise and (b) residential green around participants' home location. Higher exposure-response curves were found for the nationwide sample compared to the Zurich sample. Importantly, more residential green was associated with lower annoyance at comparable road traffic noise exposure. These findings highlight the positive, mitigating influence of natural green on negative noise-induced outcomes.

Keywords: *noise, annoyance, residential green, NDVI, exposure–response curve*

1. INTRODUCTION

Noise has demonstrable detrimental effects on human health. Long-term exposure to transportation noise from road traffic, as one of the most prominent noise sources, has been associated with noise annoyance, sleep disturbance, increased risk of cardio-vascular diseases, hypertension, and depression [1-2]. As a countermeasure to the negative impact of noise, the beneficial role of nature on human health has come into focus in recent years. Access to nature has shown to reduce noise annoyance, perceived stress, blood pressure, and stress hormone concentration short-term [3-5]. Long-term effects of living in green neighborhoods have also been shown, protective effects on mental and physical health [6-7].

The Swiss project RESTORE (www.restore-project.ch) investigated the positive influence of green spaces in conjunction with the negative influence of noise on stress

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restoration. The present contribution reports data from two RESTORE surveys: one conducted in the city of Zurich and one nationwide across Switzerland. Road traffic noise (RTN) annoyance is analyzed in dependence of RTN exposure (L_{den}) as well as residential green (normalized difference vegetation index NDVI) to gauge if and by how much natural environments may mitigate the negative impact of noise.

2. METHOD

The two surveys were conducted between the years 2021–2022 in Switzerland. The Zurich (ZH) survey collected data only from residents of the city of Zurich, while the Swiss (CH) survey was conducted nationwide. Both surveys followed a stratified sampling approach to cover an ample range of RTN exposure and degree of residential green. Areas with increased exposure to aircraft and railway noise were excluded to avoid mixing different noise sources that may disparately impact health outcomes [8]. RTN annoyance data was collected using the ICBEN 11-point numerical scale (annoyance ratings from 0–10) [9].

2.1 Participants & Exposure Data

Annoyance data from 1,111 (ZH) plus 2,229 (CH) respondents were analyzed (combined n = 3,340). Gender was balanced in both samples, and the mean age was 51.4 (SD±16.1) years. For each respondent, individual RTN exposure (L_{den}, modelled in sonBASE 2015 [10]) and NDVI (300 m Euclidean buffer, years 2019-2021 [11]) were linked to the annoyance response via a residential unit identifier.

2.2 Statistical Analysis

Annoyance data were transformed into 'highly annoyed' (HA) by setting all ratings ≥ 8 to 1 and all others to 0. The binary HA data then served as the dependent variable for a generalized linear model using a logit link function to predict pHA (probability 'highly annoyed'), in which L_{den} and NDVI were included as predictors, see Eqn. (1).

$$\text{logit}(p\text{HA}) = \beta_0 + \beta_1 \cdot L_{den} + \beta_2 \cdot NDVI \qquad (1)$$

Two separate regression models were fitted following Eqn. (1), one with the CH survey data ('CH model') and one with the ZH survey data ('ZH model').

3. RESULTS

Model coefficients for the CH model and the ZH model are given in Tab. 1. Both models revealed L_{den} to be significantly associated with pHA (p < .001), with ORs of 1.15, meaning for every 1 dB increase in L_{den} the odds of a HA response increase by 15%.

Table 1. Log-odds coefficients (coef.), odds ratios (OR) with their 95% confidence interval (CI), and p-values for the CH and ZH models following Eqn. (1).

Parameter	Coef.	OR	CI OR	p
CH Model				
Intercept	-8.3008	-	-	**< .001**
L_{den}	0.1368	1.15	[1.13; 1.16]	**< .001**
NDVI	-1.3611	0.26	[0.10; 0.67]	**.006**
ZH Model				
Intercept	-9.7014	0.00	[0.00; 0.00]	**< .001**
L_{den}	0.1431	1.15	[1.12; 1.19]	**< .001**
NDVI	-0.8904	0.41	[0.07; 2.33]	.314

Fig. 1 displays the relationship of noise exposure and residential green with the outcome of pHA to RTN for both samples. The ZH exposure-response curves are shifted downwards on the y-axis compared to CH (also visible with the lower intercept in the CH Model). Given that the slopes (β_1) for L_{den} are very similar for both models, this shift signifies that, at comparable L_{den} values, the overall pHA is lower in ZH than in CH.

Concerning NDVI, the negative log-odds coefficient β_2 indicates a protective effect of residential green against RTN annoyance. This association is statistically significant in the CH model with an OR of 0.26 (i.e., 74% decreased odds of a HA response per 1-unit increase in NDVI). In the ZH model, the confidence interval around the OR for NDVI is large and not statistically significant.

To gauge the size of the protective effect of NDVI, the equivalent sound pressure level change (ΔL) between the 5th and 95th percentile NDVI (i.e., for areas with little vs. much green) can be calculated as the shift along the x-axis between the two curves. Inserting the respective model coefficients and solving Eqn. (1) for L_{den} results in a ΔL of ca. 4 dB for CH, and ca. 3 dB for ZH in terms of magnitude of a protective effect of residential green against RTN annoyance.

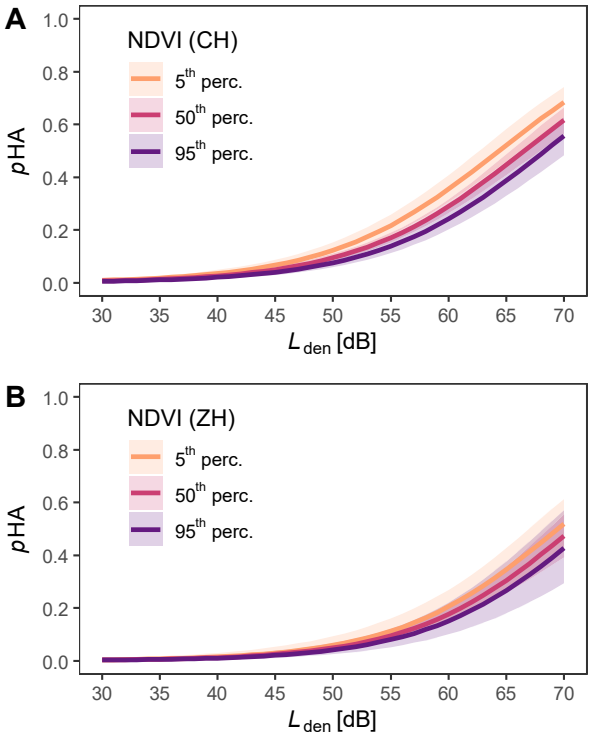

Figure 1. Exposure-response curves after Eqn. (1) for the CH sample (A) and the ZH sample (B).

4. DISCUSSION

The data reported here, collected in two stratified Swiss surveys, contribute evidence towards the mitigating effect of residential green on RTN annoyance. For the nationwide sample, an increase in residential green (as measured by NDVI) was associated with decreased probabilities of being 'highly annoyed' by RTN. Comparing residents in areas with little (5th percentile) versus much green (95th percentile) in the CH sample, an equivalent level reduction of RTN of 4 dB was found. This also indicates that, at the same RTN exposure, 'highly annoyed' reactions are less likely when the neighborhood is greener. While the results for the ZH sample go in the same direction, the protective effect of residential green was smaller and not significant ($\Delta L \approx 3$ dB).

The finding that the Zurich sample, covering the most populated city in Switzerland, showed a smaller protective effect for NDVI compared to the nationwide sample could indicate that there might be some differences in other qualities of residential green (e.g., biodiversity, openness) between the metropolitan ZH area and the heterogeneous CH area that NDVI alone cannot entirely explain.

In general, the magnitude of the protective effect of residential green on noise annoyance found here, while corroborative, falls short of those reported in the literature, with reported values of 6 dB [12] and 10 dB [13]. Possible reasons for this discrepancy might relate to the green metric used, which differs between studies in this research field, as well as other manifold methodological differences (e.g., different NDVI buffer sizes, context of the questions, etc.).

In conclusion, our results demonstrate that natural green in residential areas can help to decrease the negative impact of road traffic noise on the population.

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