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ASSOCIATION OF ROAD TRAFFIC NOISE AT NIGHT WITH SLEEP DISTURBANCES IN ADOLESCENTS

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ABSTRACT

Introduction: The impact of environmental noise on disease burden is mainly influenced by noise-induced sleep disturbances. Despite being scarce, epidemiological studies in children indicate that noise is associated with poorer sleep quality.

Methods:A cohort of adolescents in Switzerland (n=887) completed a baseline assessment, with a follow-up one year later. Sleep disturbances were determined using four standardized questions on a four-point Likert scale, which were used to derive a score from 0 (no sleep disturbances) to 12 (severe sleep disturbances). Residential road traffic noise exposure at night (L_{night}) was calculated using a three-dimensional source-propagation model. Longitudinal and cross-sectional associations between noise and sleep disturbances were analyzed using multivariable mixed linear regression models.

Results: The proportion of participants with nighttime road traffic noise exposure levels above 50 dB was 24.8%. One IQR increase in L_{night} (IQR=10.2) at baseline was associated with a 0.24 increase in the sleep disturbances score (95% CI: 0.02-0.47). Within one year of follow-up change in sleep score was not associated with noise exposure.

Conclusions: Higher nighttime road traffic noise exposure was associated with more self-reported sleep disturbances in adolescents. The lack of association in the longitudinal analysis may indicate that a steady state has been reached in sleep disturbances.

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1. INTRODUCTION

At least 12 000 premature deaths occur each year in Europe due to noise [1], which is the second-largest environmental contributor to the burden of disease [2]. More than 100 million people in Europe are exposed to road traffic noise at harmful levels, and at least 15% of the population is exposed to nighttime noise levels above 50 dB [3]. Sleep disturbance is one of the most harmful non-auditory effects and the main contributor to noise-induced disease burden [4], i.e. 437 000 Disability Adjusted Life Years (DALYs) lost in Europe [1]. This is of particular concern for children and adolescents, who are in an elementary stage of growth and cognitive development [5]. Children tend to go to bed earlier and have longer sleep durations than adults, making them more vulnerable to noise-related sleep effects in the evening, when transportation noise levels are still elevated [6]. Additionally, adolescent sleep patterns also tend to differ from those of young children and adults, which in turn affects their vulnerability to noise exposure. However, scientific evidence on the relationship between noise and sleep in children and adolescents is limited. Several studies have found negative associations between self-reported sleep and traffic noise [7–12], but the results are still inconclusive and more research is needed to fully understand how noise affects sleep in this younger demographic. Therefore, we aimed to investigate the long-term association between road traffic noise and self-reported sleep disturbance in a cohort of adolescents in Switzerland.

2. METHODS

We conducted a prospective observational study based on the HERMES cohort (Health Effects Related to Electronic Media Use and Transportation Noise in Adolescents) [13]. We included students in 7th and 8th grades from schools in urban and rural areas of Basel and Central Switzerland. Participants were enrolled in two consecutive waves (H1 and H2), and combined into a single cohort for analysis. First-wave participants (H1) completed the baseline questionnaire between June 2012 and February 2013 (n=442). Second-wave participants (H2) completed the baseline questionnaire between June 2014 and February 2015 (n=457). All participants were reassessed one year later (in 2013-14 and 2015-16, respectively). Both waves followed the same data collection procedures. Baseline (BL) and follow-up (FU) questionnaires asked about the main outcome of the research (sleep disturbances), sociodemographic items, and other time-varying covariates.

2.1 Noise Exposure

Road traffic noise exposure was modeled in the SiRENE project using three-dimensional source-propagation models for data from the year 2011. A detailed description of the SiRENE project's noise exposure analysis can be found elsewhere [14, 15]. Road traffic noise A-weighted equivalent sound level at night (i.e. between 23:00 and 7:00 hours, L_{night}) was extracted at the noisiest façade point on the participants' residence and censored at 25 dB.

2.2 Sleep Disturbances

Four standardized items from the Swiss Health Survey 2007 [16] were used to assess sleep disturbances. Using a four-point Likert scale of frequency (never; rarely; sometimes; most of the time), participants were asked about falling asleep difficulty, restless sleep, nighttime awakenings, and early morning awakenings. A linear Sleep Disturbances Score (SDS), ranging from 0 (no sleep disturbances) to 12 (severe sleep disturbances), was created by adding the answers to the four questions.

2.3 Statistical Analysis

All statistical analyses were performed in R (version 4.1.3) within RStudio. We used the mice package (version 3.15.0) to perform Multiple Imputations by Chained Equations (MICE) to handle lost to follow-up (n=45) and missing data (at most 17.4% in one variable). We calculated the association between exposure to road traffic noise at night (L_{night}, estimates for an interquartile range increase) and sleep disturbances (SDS) using mixed linear regression with a random intercept per participant. To estimate one-year longitudinal changes, we included an interaction term between L_{night} and observation (BL; FU). Estimates were adjusted for sex (male; female), age (in years, centered to the mean), smoking (no; yes), alcohol consumption (no; yes), and socioeconomic status. The latter was approximated by parental nationality (both Swiss; one Swiss; both foreign) and parental educational level (no education or mandatory school; secondary or training school; college or university).

3. RESULTS

Of the 899 recruited students, 11 were excluded from the analysis because their addresses were incorrect (n = 4) or they had incomplete questionnaires (n = 8). Of the remaining participants, 842 (94.9%) completed the follow-up questionnaire. The mean age of the study population at baseline was 14.0 years (IQR=1.1) and the mean follow-up time was 376 days (IQR=36). The average road traffic noise exposure at night was 44.6 dB (IQR=10.2), while 220 (24.8%) participants were exposed to nighttime road traffic noise (L_{night}) $\geq 50dB$. Participants had a mean SDS at baseline of 4.0 (IQR=3.0), whereas at follow-up it was 3.7 (IQR=3.0).

The association estimates between L_{night} and SDS are shown in Figure 1. From cross-sectional analyses with multiple imputed data, one IQR increase in L_{night} was associated with a 0.24 increase in the SDS at baseline (95% CI: 0.02-0.47) and a 0.07 increase at follow-up (95% CI: -0.16, 0.31). In the longitudinal analysis, based on one year of follow-up, the change in SDS was negatively, although non-significantly, associated with noise exposure (estimate: -0.17, 95% CI: -0.40, 0.07).

4. CONCLUSIONS

Higher nighttime road traffic noise exposure was associated with more self-reported sleep disturbances in adolescents. The lack of association in the longitudinal analysis may be related to the short follow-up time, including patterns of habituation to sleeping environments indicating that a steady state has been reached.

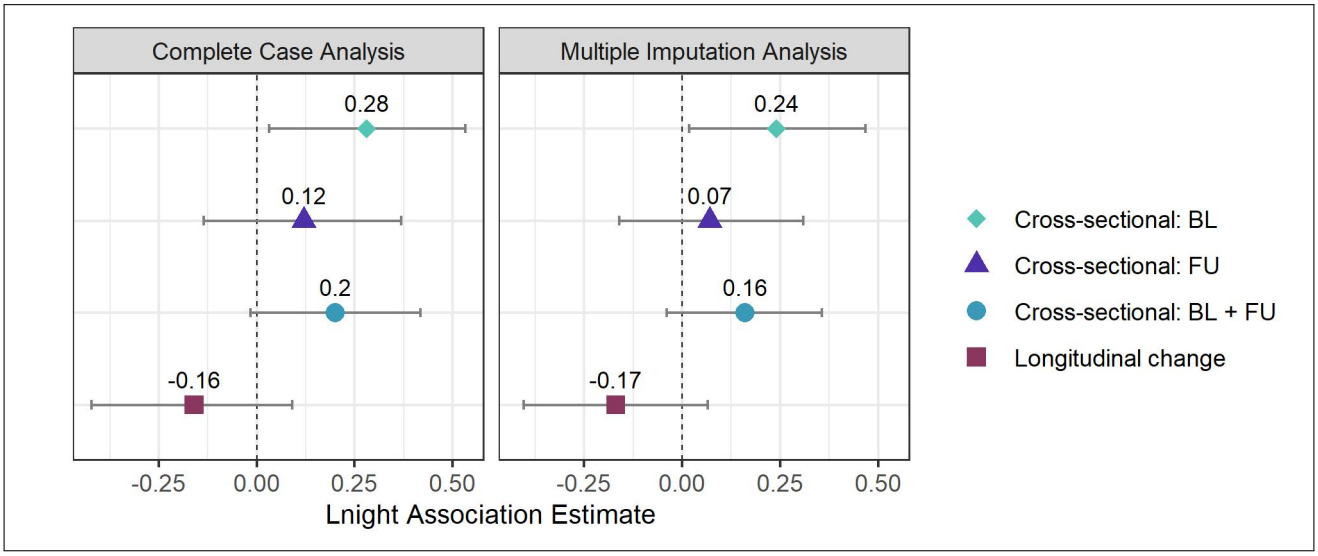

Figure 1. Adjusted association estimates between road traffic noise exposure at night (L_{night}) and the Sleep Disturbances Score (SDS). BL=baseline; FU: follow-up.

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