Environmental Research 152 (2017) 263–271

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Association between aircraft, road and railway traffic noise and depression in a large case-control study based on secondary data

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ARTICLE INFO

Keywords:
Aircraft noise
Road traffic noise
Railway noise
Depression
Case-control study

ABSTRACT

Background: Few studies have examined the relationship between traffic noise and depression providing inconclusive results. This large case-control study is the first to assess and directly compare depression risks by aircraft, road traffic and railway noise.
Methods: The study population included individuals aged ≥40 years that were insured by three large statutory health insurance funds and were living in the region of Frankfurt international airport. Address-specific exposure to aircraft, road and railway traffic noise in 2005 was estimated. Based on insurance claims and prescription data, 77,295 cases with a new clinical depression diagnosis between 2006 and 2010 were compared with 578,246 control subjects.
Results: For road traffic noise, a linear exposure-risk relationship was found with an odds ratio (OR) of 1.17 (95% CI=1.10–1.25) for 24-h continuous sound levels ≥70 dB. For aircraft noise, the risk estimates reached a maximum OR of 1.23 (95% CI=1.19–1.28) at 50–55 dB and decreased at higher exposure categories. For railway noise, risk estimates peaked at 60–65 dB (OR=1.15, 95% CI=1.08–1.22). The highest OR of 1.42 (95% CI=1.33–1.52) was found for a combined exposure to noise above 50 dB from all three sources.
Conclusions: This study indicates that traffic noise exposure might lead to depression. As a potential explanation for the decreasing risks at high traffic noise levels, vulnerable people might actively cope with noise (e.g. insulate or move away).

1. Introduction

Traffic noise is an environmental risk factor for various diseases. A report of the World Health Organization (WHO) estimates that yearly at least one million disability adjusted life years (DALY) are lost from diseases (ischemic heart disease, cognitive impairment of children, sleep disturbance, tinnitus, annoyance) related to traffic noise in Western Europe (WHO, 2010). One illness that might be affected by traffic noise is depression: Previous research shows that traffic noise induces various stress reactions and insomnia, and these factors as well as chronic noise itself have been shown to affect mental health and particularly depression (Stansfeld and Matheson, 2003; Baglioni et al., 2011). Depression is one of the most common mental disorders, and a leading cause of disability worldwide (WHO, 2015). However, the relation between traffic noise and depression is unclear. Early evidence for a relation between airport noise exposure and an increased submission to psychiatric units of hospitals in London (Abey-Wickrama et al., 1969) and Los-Angeles (Meecham and Smith, 1977) could not be confirmed in two later studies producing inconclusive evidence (Jenkins et al., 1981; Tarnopolsky et al., 1980). However, for residents living close to a military air base a positive dose-response relationship between aircraft noise and depressiveness was found (Hiramatsu et al., 1997). Furthermore, while Stansfeld et al. (1996) found no relation between street noise and psychiatric disorders, Halpern (2014) reported a weak association. Some studies find positive relations between aircraft noise exposure and the prescription frequency and amount of tranquilizing, and sleep-inducing drugs, as well as antidepressants (Floud et al., 2011; Greiser et al., 2007). Additionally, two recent studies support a link between higher traffic noise exposure and higher depression risks: While Greiser and Greiser (2010) only found an association between aircraft noise and depression for women, Orban et al. (2016) reported a generally increased risk of

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http://dx.doi.org/10.1016/j.envres.2016.10.017
Received 6 September 2016; Received in revised form 17 October 2016; Accepted 18 October 2016

depressive symptoms for road traffic noise. Moreover, there are several studies examining the relationship between traffic noise and self-reported mental health (e.g., Sygna et al., 2014; Kishikawa et al., 2009). Overall, the evidence pointing towards a positive relation between road and aircraft traffic noise and depressive disorders – mostly stemming from relatively small studies – is still inconclusive and requires further research. To date, there has been no study that specifically examined the relation between railway traffic noise and depression. More conclusive and thorough evidence on the relation between traffic noise and depression is of high interest to both the scientific community and policy makers: it could provide insights to the common mental illness depression by examining a potential environmental risk, as well as informing public debates about necessary measures to protect residents. With equal noise levels, a much larger proportion of people state to be highly annoyed by aircraft noise than by railway noise and road traffic noise. This might be partly explained by differences in the sound characteristics: While road traffic is accompanied by rather continuous background noise, aircraft and railway traffic noise are both characterised by more irregular, disruptive, louder single noise events. We therefore regard a separate analysis of the health effects of different types of traffic noise as important.

The aim of this study was to assess the relation between depressive disorders and all traffic noise combined as well as separately for aircraft, road, and railway traffic noise, in a large secondary-data based case-control study.

2. Methods

2.1. Study region and population

The study region of the NORAH (Noise-related Annoyance, Cognition, and Health) case-control study was located around the Frankfurt international airport (see Fig. 1). The study population consisted of all individuals living in the study area aged 40 years or older in 2010 and insured by one of three large statutory health insurance funds in the period between 2005 and 2010 (n=1,026,670). The study population includes about 23% of all people aged ≥40 living in the study region.

2.2. Noise exposure assessment

Acoustic exposure was estimated separately for each type of traffic noise (aircraft, railway and street traffic) for each individual residential address. For aircraft noise, average and maximum sound levels were calculated using historical radar data from the German flight safety operator (DFS) according to the guidelines for calculations of noise abatement zones (AzB) (Bundesregierung, 2008).These values were then verified by comparing them to measurements of local monitoring stations. For railway and traffic noise, the sound levels were calculated by using estimates of traffic exposure and estimating sound reductions between the source of sound and the immission sites according to the methods for calculation (VBUS, VBUSCH) used for EU noise mapping (Bundesregierung, 2006; European Union, 2002). Traffic exposure at the source was measured through road traffic counts and information by the Federal Railway Authority and the German Railway environmental department. Sound reduction calculations were based on a digital landscape model including information on the landscape and the footprint of buildings, and on information regarding the position of noise barriers and walls along roads and railways. More detailed information on the acoustic models, exposure calculations, uncertainties and plausibility checks can be found elsewhere (Möhler et al., 2015, 2016).

2.3. Data linkage

The participating health insurance funds provided pseudonymized hospital and ambulatory diagnostic data (ICD 10 codes) and prescription data according to the Anatomical Therapeutic Chemical/Defined Daily Dose Classification (ATC) for each reporting year between 2005 and 2010. Traffic noise data and individuals' address data were linked by a Data Linkage Office in Bremen, or for one insurance fund by the health insurer. These data were then pseudonymized by substituting address data by study ID and forwarded to the Data Linkage office in Dresden that linked the diagnostic data and the traffic noise data using the study ID. For a more detailed description see Seidler et al. (2016a, 2016b, 2016c).

2.4. Definition of cases and control subjects

Patients with at least two ambulant or at least one hospital diagnosis of unipolar depressive disorder in the study period who had been insured for more than twelve continuous months were defined as cases with clinically diagnosed depression (Table 1). Diagnoses were coded according to the international classification of diseases (ICD-10). Following the evidence-based national disease management guidelines (DGPPN et al., 2015), only unipolar depressive disorders, that is depressive episodes (F32), recurrent depressive disorder (F33), and persistent mood [affective] disorders (only dysthymia, F 34.1) were included as cases. Other affective disorders were not included in the case definition. Furthermore, only patients who received a new diagnosis of a depressive disorder between 2006 and 2010 were included as cases (i.e. that did not get diagnosed with depression in at least four quarters before the newly diagnosed depressive disorder). The case definition criteria were fulfilled by 85,180 individuals. Of these, 77,295 individuals (90.5%) could be linked to traffic noise data and were included as cases in the analysis. Individuals without depression diagnosis between 2005 and 2010 and who had been insured for more than twelve continuous months fulfilled the criteria for control subjects (n=637,487). Of these, 578,246 individuals (90.7%) could be linked to traffic noise data and were included in the analysis as control subjects.

2.5. Statistical analyses

Logistic regression analysis was performed to calculate odds ratios (ORs) and 95% confidence intervals for each type of traffic noise separately, and in a combined model. The continuous sound levels for each traffic noise source were grouped in 5 dB categories, with sound level exposure below 40 dB as reference category. For aircraft noise, individuals with continuous sound levels below 40 dB but at least six maximum nightly levels above 50 dB formed a separate exposure category. The exposure-risk relationship was examined, applying a linear (included traffic noise term: $B_1 \times L_{pAeq,24h}$) or third-degree polynomial model (included traffic noise term: $B_1 \times L_{pAeq,24h} + B_2 \times L_{pAeq,24h}^2 + B_3 \times L_{pAeq,24h}^3$) to the 24-h continuous sound levels ($L_{pAeq,24h}$) with a starting point of 35 dB. In case of a difference between linear and third-degree model Akaike Information Criteria (AIC) of 5 or less, a linear model was regarded as statistically adequate.

In an additional analysis, exposure to different combinations of traffic noise sources was examined against a reference group with no exposure of 40 dB or more to traffic noise of any source.

We calculated interaction terms between sex and the single continuous traffic noise variables. In case of significant sex-noise interaction, the results were stratified by sex.

2.6. Confounders

All analyses were adjusted for age, sex, urban living environment, and the local proportion of people receiving unemployment benefits as an indicator of socio-economic status (SES). When available, the analyses were further adjusted for individual's socio-economic status