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Traffic noise, noise annoyance and psychotropic medication use

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ABSTRACT

Background: Road-traffic noise can induce stress, which may contribute to mental health disorders. Mental health problems have not received much attention in noise research. People perceive noise differently, which may affect the extent to which noise contributes to poor mental health at the individual level. This paper aims to assess the relationships between outdoor traffic noise and noise annoyance and the use of psychotropic medication.

Methods: We conducted a survey to assess noise annoyance and psychotropic medication among residents of the Helsinki Capital Region of Finland. We also assessed the associations of annoyance and road-traffic noise with sleep disorders, anxiety and depression. Respondents were randomly sampled from the Finnish Population registry, and data was collected using a self-administered questionnaire. Outdoor traffic noise was modelled using the Nordic prediction model. Associations between annoyance and modelled façade-noise levels with mental health outcome indicators were assessed using a binary logistic regression while controlling for socio-economic, lifestyle and exposure-related factors.

Results: A total of 7321 respondents returned completed questionnaires. Among the study respondents, 15%, 7% and 7% used sleep medication, anxiolytic and antidepressant medications, respectively, in the year preceding the study. Noise annoyance was associated with anxiolytic drug use, OR = 1.41 (95% CI: 1.02–1.95), but not with sedative or antidepressant use. There was suggestive association between modelled noise at levels higher than 60 dB and anxiolytic or antidepressant use. In respondents whose bedroom windows faced the street, modelled noise was definitively associated with antidepressant use. Noise sensitivity did not modify the effect of noise but was associated with an increased use of psychotropic medication.

Conclusion: We observed suggestive associations between high levels of road-traffic noise and psychotropic medication use. Noise sensitivity was associated with psychotropic medication use.

1. Background

Effective urban planning aims to increase connectivity between people and their routine daily destinations, with the consequence that city dwellers often live closer to roads and motorised traffic. With higher population density, denser road networks and higher volumes of traffic, road traffic becomes an intrusive presence that city dwellers contend with daily. Recent estimates indicate that > 120 million people are exposed to road-traffic noise exceeding 55 dB L_{den} in the European Union, and 90 million of these people reside in urban areas (EEA, 2014). Residential exposure is particularly important because people spend more time at home than elsewhere and commonly attribute a sense of control, predictability and safety to the familiar setting of their residential dwelling (Easthope, 2004). Noise from a constant source such as road traffic may become an invasive fixture in this perceived 'sanctuary' leading to an exaggerated sense of helplessness and despair in the more susceptible (Babisch, 2003; Westman and Walters, 1981).

Preceding research on non-auditory endpoints of noise exposure has focused extensively on cardiovascular risks (Babisch, 2003; Bilenko et al., 2015; Foraster et al., 2014; Floud et al., 2013; Gan et al., 2012; Huang et al., 2013; Seidler et al., 2016; Floud et al., 2011). Fewer studies have considered metabolic outcomes, specifically, diabetes mellitus and obesity (Dzhambov and Dimitrova, 2016; Sørensen et al., 2013; Oftedal et al., 2015). Noise annoyance is a negative psychological reaction to noise that has also been broadly investigated (Dratva et al., 2010; Ouis, 2001; Guski et al., 1999; Brown et al., 2015). It expresses

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the sense of disturbance or helplessness due to noise (Guski et al., 1999). There have been suggestions that annoyance, which is sustained over significant periods, can act as an intermediary between noise exposure and the emergence of disease (Hammersen et al., 2016; Niemann and Maschke, 2004; Öhrström, 2004).

Sleep disturbance is a well-known consequence of noise, which is more prevalent with night-time exposures. Sleep disturbance has been demonstrated in both laboratory (Öhrström et al., 1990) and population-based noise studies (Frei et al., 2014). Interventions, which have led to reduced road-traffic noise at residential buildings, have also resulted in reduced sleep disturbance (Öhrström et al., 1990; Amundsen et al., 2013). Higher risks of insomnia, reduced sleep quality and non-restorative sleep have been observed with night-time noises. (Frei et al., 2014; Muzet, 2007; de Kluizenaar et al., 2009; Evandt et al., 2017; Halonen et al., 2012) A meta-analysis of 28 datasets showed that road-traffic noise posed a higher risk of sleep disturbance than rail-traffic noise (Miedema and Vos, 2007). However, this study adjusted for only age as a covariate. For optimal sleep value, the WHO recommends an outside night-time noise limit of 40 dB $L_{night,outside}$ and an interim target of 55 dB $L_{night,outside}$ (World Health Organization, 2009).

Noise sensitivity is an individual innate trait that increases the individual's susceptibility to irritation from noise (Basner et al., 2013; Heinonen-Guzejev et al., 2012; Ryu and Jeon, 2011; van Kamp et al., 2004). It is a consistent determinant of noise annoyance (Miedema and Noise Sensitivity, 2003). Noise-sensitive persons are generally less tolerant of noise and are prone to rate noise as being louder than non-sensitive persons would (Moreira and Bryan, 1972).

Studies that explore chronic neuropsychological sequelae of road-traffic noise are scant. Although investigators have assessed the effects of noise on cognitive function and behavioural symptoms in children (Crombie et al., 2011; Dreger et al., 2015), fewer yet have explored the mental health consequences of noise in adults. Although studies that target adults have produced conflicting results, infrequently, residential noise exposure has been associated with anxiety (Stansfeld et al., 1996; Standing and Stace, 1980; Edsell, 1976). An early review acknowledged that emotional and psychological deficits stemming from noise annoyance can, in the long term, lead to help-seeking responses, including the use of sleep medication and anxiolytic and anxiolytic drugs (Westman and Walters, 1981). A few studies preceding this review had reported increased mental-hospital admissions in association with aircraft noise exposure (Abey-Wickrama et al., 1970; Meecham and Smith, 1977).

Existing studies on the mental health effects of road-traffic noise have mostly used modelled (Brink, 2011; Orban et al., 2016; Fyhri and Aasvang, 2010; Sygna et al., 2014) or measured (Öhrström, 2004; Stansfeld et al., 1996; Öhrström and Björkman, 1983) noise to assess exposure. However, it is generally acknowledged that individual noise perception varies between persons, and perception by the same person changes over time. Noise perception is not always determined by sound pressure level, it also hinges upon the quality and context of the sound stimulus, current activity and engagements of the recipient, individual temperament, cognitive style, state of mind and health, level of control over the sound stimulus, attitude toward sound source etc., which all give meaning and interpretation to incipient sound (Westman and Walters, 1981; Basner et al., 2013). Noise annoyance is an expression of psychological strain due to noise. By estimating noise annoyance, individual differences in noise perception and the ensuing effects can be considered. This study aims to determine how road-traffic noise affects mental health indicators, namely: sedative, anxiolytic and antidepressant use. We also compare the effects of noise annoyance and modelled noise on these indicators.

2. Methods

2.1. Study design and participants

The Helsinki Capital Region Environmental Health Survey was conducted in the Helsinki metropolitan area, which comprises Helsinki, Espoo and Vantaa. The survey was carried out to evaluate perceived exposures to specific environmental factors by residents and their views of the possible health risks caused by the environment. The survey assessed health risks associated with noise and air pollution and also the health benefits that are derived from access to green areas. Additionally, some medical history and data on confounders were collected to facilitate epidemiological analysis. The survey questionnaire had 93 questions and numerous subquestions. The survey was conducted in two phases: first, in the city of Helsinki from the latter part of May to August 2015, and, second, in the cities of Espoo and Vantaa from June to August 2016. Eight-thousand Helsinki residents age 25 years and above were selected from the Population Registry of Finland using simple random sampling in 2015. Similarly, 4000 residents of Espoo and 4000 residents of Vantaa were sampled in 2016, yielding, in total, 16,000 residents. Potential respondents were contacted by post and invited to fill a self-administered questionnaire, which they could choose to complete electronically or on paper. This sample consisted of 53% women and 47% men. A single reminder was sent to non-respondents. The response rate was 47% in 2015 and 45% in 2016.

2.2. Exposure

Noise annoyance was assessed using the questionnaire item, '*Are you usually disturbed or your concentration disturbed or annoyed by road-traffic noise when you are at home, indoor and the windows are closed?*' Anchors to this question were: i) no annoyance; ii) slight annoyance; iii) some annoyance; iv) severe annoyance; v) extremely annoyance. To facilitate statistical analysis, respondents were then divided into two groups: 'none to mild annoyance' (no annoyance and slight annoyance) and 'moderate to severe annoyance' (some annoyance, severe annoyance and extreme annoyance). Residential exposure to road-traffic noise was estimated from façade noise maps, which were modelled by a consulting company, Sito, for the Helsinki Capital Region (Oy, 2012). Road-traffic noise was estimated in accordance with the EU Environmental Noise Directive 2002/49/EC (EEC, 2002) using the Nordic prediction method (TemaNord 1996:525) (Nielson et al., 1996) for major highways and the main and collector streets within an area (Nielson et al., 1996). Input variables for the noise model include terrain characteristics, ground surface, buildings and noise barriers and traffic flow, speed and proportion of heavy vehicles for the year 2011. The 2011 estimates remain valid because land-use and traffic changes in the latter years have been insufficient to significantly alter façade noise levels (Supplement S1). The highest L_{den} on façade points within 20 m of residents' home address coordinates was used as the exposure estimates. L_{den} is the A-weighted day-evening-night equivalent continuous sound level calculated over a 24-hour period. A 10 dB penalty was added to the levels between 22.00 and 07.00 h, and a 5 dB penalty was added to the levels between 19.00 and 22.00 h to reflect people's extra sensitivity to noise during the night and the evening. Noise modelling was based on 2011 data; thus, newer buildings—74 (6%) out of 5931 sampled buildings—had missing façade noise values.

2.3. Outcome variables

The use of sleep medication, anxiolytics and antidepressants were elicited in the survey as proxy measures for sleep disorders, anxiety disorders and depression. We used the single question, '*When did you last take the following medication?*' Listed among the medications were sleeping pills, tranquilizers and antidepressants. Against each medication, respondents were asked to select from the following options: '*during the past week,*' '*1–4 weeks ago*,' '*1–12 months ago*,' '*over a year ago*' and '*never*'. Respondents selecting the last two options were considered free of the outcome. As usage of psychotropic medication in Finland is entirely prescription-based, we consider this a reliable approach for