Night-time road traffic noise and symptoms of insomnia

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ABSTRACT

Background

An exposure-response relationship has been demonstrated for the association between road traffic noise and self-reported sleep disturbances attributed to traffic noise. Few population-based studies have focused on the association between road traffic noise and general sleep disturbances, such as symptoms of insomnia.

Aims

The aims were to study the associations between night-time road traffic noise and the self-reported symptoms of insomnia; *difficulties falling asleep*, *awakenings during the night*, and *waking up too early*.

Methods

The study population is from Health and Environment in Oslo (HELMILO) (2009-10) (N = 13,019). Data on health and sleep was collected by a postal questionnaire. Insomnia symptoms were defined as sleep problems occurring ≥ 3-5 times per week. Modeled noise levels were assigned to each participant's home address. Logistic regression models were used to analyze the associations. In addition to analysis of the total study population, separate analyses were performed among individuals with bedroom facing a road.

Results

After adjustment for potential confounders, statistically significant associations were found between noise exposure and all three symptoms of insomnia in the total study population. Among individuals with bedroom facing a road, *difficulties falling asleep* and *waking up too early* were significantly associated with road traffic noise.

Conclusion

Night-time road traffic noise was associated with symptoms of insomnia. The effect estimates were higher for the associations between noise exposure and *difficulties falling asleep* among individuals with bedroom facing a road, compared with the total study population.

INTRODUCTION

Growing traffic volumes and urbanization makes traffic noise an increasing cause of concern for public health. Along with annoyance, sleep disturbances are considered the main health burden related to environmental noise. Estimates from the World Health Organization (WHO) show that environmental noise, whereof mainly road traffic noise, is responsible for nearly a million healthy life years lost annually due to sleep disturbances in Western Europe (WHO 2011).

Associations between road traffic noise and sleep disturbances have been shown both in population-based and experimental studies (Öhrström et al. 2006; Miedema & Vos 2007; Aasvang et al. 2011; Basner et al. 2011; Halonen et al. 2012). However, few population-based studies have examined associations between traffic noise and general symptoms of insomnia. The focus in large scale studies has mainly been on self-reported noise-induced sleep disturbances (Miedema & Vos 2007).

Different definitions of insomnia exist. A common definition of insomnia entails having difficulties in falling and remaining asleep, waking up too early and having day-after effects from poor sleep for a prolonged period of time. If this definition is applied, the prevalence of insomnia has been found to be around 9-15 % in a selection of studies performed in the Western world (Ohayon 2002).

In most epidemiological studies, noise exposure is modeled for the most exposed façade of the building. In previous research, it has been pointed out that by not taking location of bedroom into account, the true effect of traffic noise exposure on sleep is likely to be underestimated, because people might have their bedroom facing a less exposed side of the building (Miedema & Vos 2007; Aasvang et al. 2008; Fyhri & Aasvang 2010; Frei et al. 2013).

The aim of this study was to investigate the association between night-time road traffic noise and symptoms of insomnia.

METHODS

Study Population

The study population is from the Health and Environment in Oslo study (HELMILO) conducted in 2009-10. A questionnaire was sent out to 27,097 Oslo inhabitants born in 1924-25, 1940-41, 1955, 1960 and 1970, whereof 13,019 responded. The response rate was 48%. Written informed consent was obtained and the study was approved by the Regional Committee for Medical Research Ethics and the Norwegian Data Inspectorate. The Research Council of Norway funded this work.

Noise Exposure Assessment

Night-time road traffic noise levels ($L_{night,}$ A-weighted night-time equivalent noise level, 2300-0700 hours) were modeled for Oslo in 2011 (The Municipality of Oslo 2012) in accordance with the European Environmental Noise Directive (European Commission 2002). The noise levels were calculated according to The Nordic prediction method for road traffic noise (Nordic Council of Ministers 1996) using the software package CadnaA. Grid points for the calculations were 5 x 5 meters and calculation height was 4 meters above terrain. Road traffic data included in the model (traffic counts, % heavy vehicles, speed limits, diurnal distribution) were obtained from the Norwegian Public Roads Administration and the City of Oslo. Residential noise levels modelled for the most exposed façade of the building were assigned to each participant's home address using geographic coordinates.

Outcome variables

As indicators of symptoms of insomnia we used *difficulties falling asleep*, *awakenings during the night*, and *waking up too early*. The participants reported how frequently they had experienced these problems during the past twelve months on a five-point scale with the alternatives “never/rarely”, “less than once per week”, “1-2 times per week”, “3-5 times per week”, and “always/almost every night”. We dichotomized this scale and considered a frequency of three to five times per week or more as presence of insomnia symptoms.

Statistical analysis

We used logistic regression for modelling the associations between road traffic noise and symptoms of insomnia. Noise exposure was included as a categorical variable with the four levels L_{night} < 45 dB (n= 3,869), 45-50 dB (n=3,268), 50-55 dB (n= 2,011), and ≥ 55 dB (n= 1,696). We ran two models for each association, one model adjusted for age and sex, and one where we in addition, adjusted for body mass index (BMI), education level (low, medium, high), marital status (married/cohabiting, unmarried, divorced/separated, widowed), employment status (unemployed, working 1-29 hours/week, working ≥30 hours/week, old age-retired), household income (low, medium, high), physical activity (sedentary, moderately active, very active), alcohol consumption during last year (abstainer/not been drinking last year, ≤ 3 times/month, 1-3 times/week, 4-7 times/week), smoking status (current, previous, never), mental distress (high vs. low degree), chronic respiratory diseases (yes vs. no), and railway noise (L_{night} ≥45dB vs. <45 dB). Railway noise was modelled according to the Nordic prediction method for rail traffic noise (Nordic Council of Ministers 1996) using the software package CadnaA.

We excluded participants who had lived at their current address less than one year at the time of the study (n=357) and participants who reported to currently use sleep medications (n=1,294).

In addition to the main model, we performed separate analyses for the individuals who had their bedroom facing a road. Information on bedroom location in the building was collected in the questionnaire.

Statistical analyses were carried out in STATA version 12 (StataCorp, College Station, Texas).

RESULTS

In the total study population 6.4 % (n=685) reported difficulties falling asleep 3-5 times per week or more, 9.7 % (n=1,019) reported awakenings during the night 3-5 times per week or more, and 8.5 % (n=896) woke up too early 3-5 times per week or more. Table 1 shows the distribution of age and sex along with the distribution of symptoms of insomnia in the total study population and for individuals with bedroom facing a road.

Table 1. Characteristics of the total study population and among individual with bedroom facing a road.

	Population No. (%)	
Variable	Total study population (N= 10,844)	Bedroom facing road (N= 3,343)
Age		
39	2,354 (21.7)	744 (22.3)
49	2,518 (23.2)	762 (22.8)
55	2,264 (20.9)	670 (20.0)
68-69	2,762 (25.5)	869 (26.0)
84-85	946 (8.7)	298 (8.9)
Sex		
Female	5,706 (52.6)	1,810 (54.1)
Male	5,138 (47.4)	1,533 (45.9)
Difficulties falling asleep		
≥ 3-5 times per week	685 (6.4)	250 (7.6)
< 3-5 times per week	9,959 (93.6)	3,022 (92.4)
No. of missing values	200	71
Awakenings during the night		
≥ 3-5 times per week	1,019 (9.7)	375 (11.6)
< 3-5 time per week	9,505 (90.3)	2,867 (88.4)
No. of missing values	320	101
Waking up too early		
≥ 3-5 times per week	896 (8.5)	327 (10.1)
< 3-5 times per week	9,582 (91.5)	2,900 (89.9)
No. of missing values	366	116

The associations between road traffic noise and symptoms of insomnia in the total study population are shown in Figure 1.

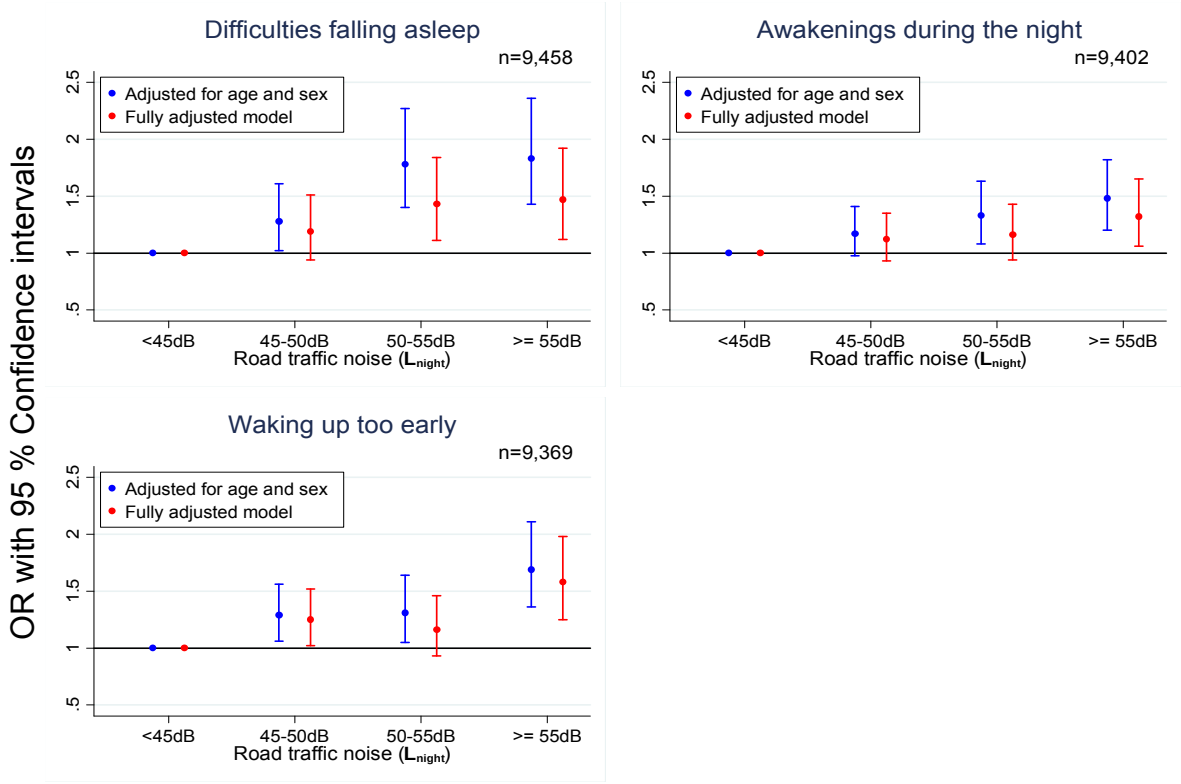

Figure 1: ORs with 95 % CIs for the sleep outcomes. The fully adjusted models are adjusted for age, sex, body mass index, education level, employment status, marital status, income, physical activity, alcohol use, smoking, mental distress, respiratory diseases, and railway noise.

Regarding the insomnia symptom *difficulties falling asleep*, we found statistically significant associations with noise. Compared with L_{night} < 45 dB, exposure to noise levels of L_{night} 50-55 dB, gave an odds ratio (OR) of 1.43 [95 % confidence interval (CI): 1.11, 1.84] and exposure to L_{night} ≥55 gave an OR of 1.47 (95 % CI: 1.12, 1.92). The analysis of the association between noise exposure and *awakenings during the night* yielded an OR of 1.32 (95 % CI: 1.06, 1.65) for L_{night} ≥55 dB. *Waking up too early* was statistically significantly associated with L_{night} 45-50 dB vs. L_{night} < 45 dB (OR = 1.25; 95 % CI: 1.02, 1.52) and L_{night} ≥ 55 vs. < 45 dB (OR = 1.58; 95 % CI: 1.25, 1.98).

Compared with the total study population, the effect estimates of the association between traffic noise and *difficulties falling asleep* were higher among individuals with their bedroom facing a road. Regarding *awakenings during the night*, we did not find any significant results among individuals with bedroom facing a road, but compared with the total study population the effect estimates were higher for the noise categories 45-55 dB and ≥55 dB. The results of the analyses for *waking up too early* among individuals with bedroom facing a road indicated a stronger relationship with noise than in the total study population.

CONCLUSIONS

In the total study population, residential exposure to outdoor road traffic noise at night-time was significantly associated with the insomnia symptoms *difficulties falling asleep*, *awakenings during the night* and *waking up too early in the morning*. Of the outcomes we examined, we found that *difficulties falling asleep* and *waking up too early* showed the strongest association with noise, both in the total study population and among individuals with bedroom facing a road. This indicates that shorter sleep duration may be a consequence of night-time traffic noise exposure. The effect estimates for the association between road traffic noise and *difficulties falling asleep* were higher among individuals with bedroom facing a road than for the total study population. A likely explanation is the more accurately assigned noise exposure in this sub-population.

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