Environmental Research 131 (2014) 17–24

Contents lists available at ScienceDirect

Environmental Research

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

Road traffic noise, sleep and mental health

Karin Sygna [a,b,1], Gunn Marit Aasvang [a], Geir Aamodt [b,c], Bente Oftedal [a], Norun Hjertager Krog [a,*]

[a] Department of Air Pollution and Noise, Division of Environmental Medicine, Norwegian Institute of Public Health, P.O. Box 4404 Nydalen, N-0403 Oslo, Norway
[b] Department of Mathematical Sciences and Technology, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Aas, Norway
[c] Department of Chronic Diseases, Division of Epidemiology, Norwegian Institute of Public Health, Oslo, Norway

ARTICLE INFO

Article history:
Received 15 October 2012
Received in revised form
21 December 2013
Accepted 19 February 2014

Keywords:
Road traffic noise
Psychological distress
Mental disorder
Sleep quality
Hopkins Symptom Checklist

ABSTRACT

This study examines the relationship between road traffic noise, self-reported sleep quality and mental health. The study is cross-sectional and based on data from a survey conducted in Oslo, Norway, in 2000. Psychological distress (Hopkins Symptom Checklist, HSCL-25) was measured along with self-reported somatic health, sleep quality, noise sensitivity and socioeconomic variables. Questionnaire data were combined with modeled estimates of noise exposure. The total study sample consisted of 2898 respondents. After adjustment for potential confounders and stratifying for sleep quality, we found a positive, but not statistically significant association between noise exposure and symptoms of psychological distress among participants with poor sleep quality (slope = 0.06, 95% CI: −0.02 to 0.13, per 10 dB increase in noise exposure). In the same sleep quality group, we found a borderline statistically significant association between noise exposure and a symptom level indicating a probable mental disorder (HSCL ≥ 1.55) (odds ratio = 1.47, 95% CI: 0.99–1.98, per 10 dB increase in noise exposure). We found no association between road traffic noise and mental health among subjects reporting good and medium sleep quality. The results suggest that road traffic noise may be associated with poorer mental health among subjects with poor sleep. Individuals with poor sleep quality may be more vulnerable to effects of road traffic noise on mental health than individuals with better sleep quality.

1. Introduction

The World Health Organization (WHO, 2011) considers noise to be an environmental risk factor for poor health and a major environmental issue. In Norway, approximately 1.5 million persons (33%) are exposed to sound levels above 55 dB (dB) outside of their dwellings, which is the highest recommended average noise level. Road traffic is the largest source of noise annoyance in Norway (Englien et al., 2004). It is estimated that 3–6% of the Norwegian population experience severe noise annoyance, and that 2–3% are highly sleep disturbed due to road traffic noise (Aasvang, 2012). It has been postulated that prolonged negative feelings towards noise may increase the risk of more severe psychological problems (Cohen and Weinstein, 1981).

Mental health is of global concern, and it is estimated that one in every four worldwide will be affected by a mental disorder at some stage of life (WHO, 2001). The World Health Organization (WHO, 2001) has characterized mental and behavioral disorders as combinations of abnormal thoughts, emotions, behavior and relationships with others. A Norwegian review found that the lifetime prevalence of any mental disorder was around 40%, while the 12 months' prevalence ranged from approximately 10–33%, depending on the disorder (Mykletun et al., 2009).

Annoyance and sleep disturbances are the most widespread and well-documented subjectively reported effects of environmental noise (WHO, 2011), but morning tiredness, headaches and milder psychological conditions have also been reported to be associated with noise in adult populations (Kluizenaar et al., 2011; Tarnopolsky et al., 1980; Öhrström et al., 1988; Stansfeld et al., 1996). Both aircraft and road traffic noise have been linked to psychological symptoms, but not to definable mental disorders (Stansfeld and Matheson, 2003; Tarnopolsky et al., 1978, 1980). However, an Italian study found a significant association between aircraft noise and an anxiety diagnosis (Hardoy et al., 2004). A survey by Rocha et al. (2012) found that noise perceived as an environmental problem was associated with the prevalence of common mental disorders as assessed with the General Health

* Corresponding author. Fax: +47 21 07 66 86.
E-mail address: NorunHjertager.Krog@fhi.no (N.H. Krog).
[1] Present address: Oslo University Hospital HF, P.O. Box 4950 Nydalen, 0424 Oslo, Norway.

http://dx.doi.org/10.1016/j.envres.2014.02.010
0013-9351

Questionnaire (GHQ-12). Most previous research on noise and mental health has examined aircraft noise (Abey-Wickrama et al., 1969; Meecham and Smith, 1977; Hardoy et al., 2004; Schreckenberg et al., 2010; Tarnopolsky et al., 1978, 1980; Watkins et al., 1981), and only a few studies have addressed road traffic noise and mental health (Kishikawa et al., 2009; Stansfeld et al., 1993, 1996). Various methods of measuring mental health as well as noise exposure may have contributed to inconsistent findings. Furthermore, a potential causal association between noise and mental health problems may be limited to certain vulnerable and noise sensitive groups. Dratva et al. (2011) implied that vulnerable groups, such as people with pre-existing diseases, are at greater risk than others to experience more severe health effects by transportation noise. A study from Japan reported a positive association between road traffic noise and "anxiety and insomnia", but only among noise sensitive subjects (Kishikawa et al., 2009).

Noise can affect sleep by increasing the time to fall asleep, induce awakenings and sleep stage changes, and thus reduce the total amount and quality of sleep (Aasvang et al., 2011; Basner et al., 2008; Brink, 2011; Griefahn et al., 2006; Öhrström et al., 1988). Furthermore, the close interrelationship between poor sleep quality and mental health problems is well acknowledged (Breslau et al., 1996; Ford and Kamerow, 1989; Neckelmann et al., 2007; Peterson and Benca, 2006; Sloan, 2011; Tsuno et al., 2005). Thus, there are reasons to believe that sleep quality may be an important factor in a potential association between traffic noise and mental health problems (Evans and Lepore, 2008; Pirrera et al., 2010), but the knowledge is still poor regarding the role of sleep in the noise–health relationship (Pirrera et al., 2010). The main aim of our study was to examine the relationship between road traffic noise and mental health. We wanted to examine whether road traffic noise contributes to increased levels of psychological distress in general, and whether it increases the risk of a mental disorder. Furthermore, we wanted to test the hypothesis that sleep quality modifies the noise–mental health relationship.

2. Materials and methods

2.1. Study sample

This study is cross-sectional, using data from a survey carried out in Oslo, Norway, during autumn 2000. Data on residential addresses ($\approx$21,000) were obtained from the Norwegian Public Roads Administration and the City of Oslo in connection with their ongoing work on residential noise mapping. Using the Norwegian National Population Register, we sampled from the residential addresses provided by the authorities 51% males and 49% females from different age strata (18–37, 38–57, 58–77, and $>$78), altogether 5390 persons. A total of 3262 persons (60.5%) returned the questionnaire. 364 individuals were excluded, either because they had recently moved (107), or they had not answered the questions about psychological distress (Hopkins Symptom Checklist) satisfactorily (257), leaving 2898 individuals in the study population. Informed consent was obtained from the respondents, and the survey was approved by the Regional Committee for Medical and Health Research Ethics in Norway.

2.2. Variables

2.2.1. Outcome variables

Psychological distress was measured by Hopkins Symptom Checklist-25 (HSCL-25). HSCL-25 is widely used in population surveys, and has proved to have satisfactory validity and reliability as a measure of psychological distress (Derogatis et al., 1974; Strand et al., 2003). The inventory consists of 25 items tapping symptoms of anxiety and depression, such as "suddenly scared for no reason", "feeling fearful", "trembling", "poor appetite", "feeling lonely", or "crying easily". The respondents were asked to rate how they were affected by each symptom: "not at all bothered", "somewhat bothered", "rather bothered", or "very bothered". In the present study, only 22 items from the original HSCL-25 were used. To avoid repetition, two items from the original HSCL-25 about sleeping problems were not included in our questionnaire, since this topic was covered elsewhere. In addition, one question about sexual activity was excluded, and an item about tinnitus, which was not in the original HSCL-25, was included. The mean score of the HSCL items (ranging from 1 to 4) was calculated, to indicate the level of psychological distress of each respondent.

The association between road traffic noise and mental health was examined in two ways. First, we wanted to investigate the association between road traffic noise exposure and any increase in symptoms of psychological distress, taking into account the whole range of symptom levels. For this purpose, the mean score of HSCL was used as a continuous variable. This approach was chosen since psychological distress exists on a continuous scale, and most previous studies have found an association only with milder degrees of psychological distress (Stansfeld et al., 1993; Stansfeld and Matheson, 2003). Furthermore, HSCL was dichotomized, to examine the association between road traffic noise and more severe levels of psychological distress, i.e. mental disorder with a potential need of being treated. A cut-off value of 1.55 was chosen, as this value has been proven to be appropriate when the purpose is to screen for probable psychiatric cases (Veijola et al., 2003).

2.2.2. Noise exposure assessment

Road traffic noise was assessed at the most exposed façade of the home address of each participant in the study. Digital maps and geographical coordinates of the home addresses were used as basis for the noise exposure assessment. The road traffic noise exposure was calculated according to the Nordic prediction method for road traffic noise (Jonasson et al., 1996) for the year 2000, using the software program CadnaA (DataKustik, 2004) to calculate acoustic propagation and noise levels. The Nordic prediction method for road traffic noise calculates noise exposure at the most exposed façade with an accuracy of $\pm$3–5 dB, depending on the distance from the noise source (Jonasson et al., 1996). This method is designed to be valid up to a distance of 300 m from the road (Bendtsen, 1999). The development of the prediction models is based on standard noise emissions from road traffic. The standard noise emissions are based on a large number of sound measurements of passing cars under well-defined conditions, along with measurements of speed.

Input data to CadnaA were digitalized terrain data, ground types, buildings and noise screens in 3D, in addition to road traffic data such as traffic counts, percentages of heavy vehicles, speed limits and diurnal distributions from the Norwegian Public Roads Administration and the City of Oslo. L_{den} at the most exposed façade, as defined according to the European Environmental Noise Directive (Directive 2002/49/EC, European Parliament and Council, 2002) was used as the noise metric. L_{den} is the A-weighted average sound pressure level over a 24 h period, in which levels during the evening (19.00–23.00) and night (23.00–07.00) are increased by 5 dB and 10 dB, respectively. Road traffic noise was used as a continuous variable in the analyses.

2.2.3. Sleep quality

Self-reported sleep quality was measured by one question from the Basic Nordic Sleep Questionnaire (Partinen and Gislason, 1995): "How well do you usually sleep?" The original five categories were reduced to three: good sleep (well, rather well), medium sleep (neither well nor badly), and poor sleep (rather badly, badly). This single-item assessment of sleep was used to obtain a summary measure of the overall sleep quality.

2.2.4. Potential confounders

Age, gender, socioeconomic status, somatic diseases and noise sensitivity are variables found to be associated with mental health (Prince et al., 2007; Rocha et al., 2012; Stansfeld et al., 1993), and were included as potential confounders in the analyses. Age was used as a continuous variable. We used income, education and employment status to measure socioeconomic status (Kristenson et al., 2003). The total income of the household was reported as $<$200,000 NOK; 200,000–400,000 NOK; 400,000–600,000 NOK; 600,000–800,000 NOK; $>$800,000 NOK, and dichotomized into the categories "$<$400,000 NOK" and "$>$400,000 NOK" for our analyses. The questionnaire contained two items on education. The first item asked for the highest level of education completed, with the following response categories: "did not complete primary school", "primary school (6–7 years)", "secondary school (8–10 years)", or "high school/college". The second item asked what kind of further training/education had been completed: "practical training", "up to 1 year (same subject)", "1–2 years (technical college/commercial school)", "1–2 years (high school/university)", "3–4 years (high school/university)", or "more than 4 years of higher education". These two variables were combined into three categories: "$<$12 years of education", "$\geq$12 years and $<$15 years of education" and "$\geq$15 years of education". Employment status was categorized as follows: "working outside home", "working at home", "student", "retired", and "unemployed or disabled". This variable was dichotomized into two groups: "unemployed" (unemployed/disabled) and "employed/others" (working outside home/working at home/student/retired). The variable somatic diseases was constructed as follows: the respondents who answered "yes" to at least one of the eight diseases included in the questionnaire (myocardial infarction, angina pectoris, stroke, high blood pressure, diabetes, frequent infectious diseases, metabolic disorder, and hearing loss) were included as having a somatic disease. To measure noise sensitivity, one six-point scale item from Weinstein's Noise Sensitivity Scale (Weinstein, 1978) was employed, in which the participants were asked to respond to the statement "I am sensitive to noise". The six response categories were merged into three in the following way: "low sensitivity" (disagree strongly, disagree fairly),