The quantitative relationship between road traffic noise and hypertension: a meta-analysis

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INTRODUCTION

Several reviews from World Health Organization (WHO) and the Health Council of the Netherlands (HCN) (WHO 1999, 2009; Health Council of the Netherlands 1994, 2004) have suggested that road traffic noise is associated with high blood pressure changes, high blood pressure and cardiovascular disease. The biological plausibility of the hypothesis of the effects of noise on the cardiovascular system is substantial and assumes that noise acts as a stressor and as such has the potential of directly and indirectly precipitating diseases (WHO 1999). The conclusions of the WHO and the Health Council of the Netherlands were partly confirmed by recent meta-analyses, showing that the results of studies investigating the associations between road- and aircraft noise exposure and cardiovascular disease converged (van Kempen et al. 2002; Babisch 2008; Babisch & van Kamp 2009). Data-aggregation produced exposure-effect relations which are suggested as a tool for quantitative health impact assessment and (noise) burden of disease calculation (WHO 2011; Berry & Flindell 2009; European Environment Agency 2010).

Despite the fact that during the last decade the number of studies investigating the association between road traffic noise and high blood pressure increased substantially, no reliable exposure-response relationship is as yet available. One of the reasons might be due to the fact that the findings of observational studies are often distorted by different sources of bias causing a fair amount of heterogeneous variation on study level. In order to derive a quantitative exposure response relationship for the association between road traffic noise exposure and hypertension and to gain more insight into the sources of heterogeneity among study results, a meta-analysis was carried out. A meta-analysis or quantitative overview is a systematic review that employs statistical methods to combine and summarise data from several studies (Teagarden 1989).

METHODS

We identified observational studies examining the association between road traffic noise exposure and hypertension published between 1970 and 2010 in English, German or Dutch from earlier systematic reviews (van Kempen et al. 2002; Babisch 2006). In addition, we performed a short electronic search in PubMed with the following search criteria: terms for both hypertension ("hypertension", "high blood pressure") and road traffic noise in the title, sub-heading or abstract. Furthermore, we manually scanned reports and proceedings in the area of noise and health.

Subsequently, we evaluated the identified studies on their suitability for data extraction. We included studies that met the following criteria for data extraction: (i) title and/or abstract of the given study had to involve road traffic noise exposure in relation to hypertension and/or use of antihypertensives. This meant that in the given

studies, the relation between road traffic noise exposure and hypertension had to be studied in a study population of healthy adults; and (ii) the study had to quantify and/or describe the relation between road traffic noise exposure - expressed in dB(A) - and hypertension due to road traffic noise. With regard to the exposure-response relation, an equation that described the association between the percentage of hypertensive people and road traffic noise had to be reported, or the percentage hypertensive people had to be reported for several exposure levels/groups. 27 of the 31 studies met the above-mentioned selection-criteria and were selected for data-extraction. In order to make a comparison between the selected studies, we extracted one or more estimates of the natural logarithm of the OR and its variance per 5 dB(A). For data-aggregation we only included estimates from studies that were well-matched or adjusted for age and gender. A pooled OR per 5 dB(A) was calculated using SAS Proc Mixed software to fit a random-effect model (van Houwelingen et al. 2002).

RESULTS AND DISCUSSION

Table 1 shows some characteristics of the 27 cross-sectional studies that were included into the data-extraction (references shown in Table 1). Of the studies 17 are from Central Europe, six from Northern Europe, three from Southern Europe and one from Japan. Of the 27 studies, nine were published before 2000. Sample sizes ranged from 357 to 38,849 persons. The studies were carried out among equivalent sound levels ($L_{Aeq,\ 16hrs}$) in the range of 30 – 80 dBA. The results of a meta-regression analysis, including analyses of heterogeneity, have been submitted to a peer-reviewed journal and will be shown at the ICBEN conference.

At the moment, environmental health risk assessment is increasingly being used in the development of noise policies, public health decision making, the establishment of environmental regulations and the planning of research. This not only involves the identification of environmental hazards, but also the quantification of the expected health burden: health impact assessment (WHO 2000). After selecting a set of endpoints for which there is sufficient evidence for an association with noise exposure, the expected health burden due to noise exposure in a specific population can be quantified by combining data on population density with exposure distributions on noise (exposure assessment) and information on exposure-effect-relationships. A clear example of the increased use of environmental health risk assessment in the area of noise, can be demonstrated with the European Noise Directive (Directive 2002/49/EC, 2002): In the framework of this directive, agglomerations and administrators of infrastructures within the member states were mandated to create noise maps and to report the total number of people exposed to noise levels of 55 dB L_{den} and more, the number of people exposed to noise levels of 50 dB $_{Lnight}$ and more, and the number of noise-sensitive buildings and areas. In addition, the number of people annoyed and sleep-disturbed had to be reported as well. Since there is sufficient evidence that environmental noise from transportation increases the cardiovascular risk, and because exposure-response relationships regarding the relationships between road traffic noise and myocardial infarction (Babisch 2008) as well as the relationship between aircraft noise and hypertension (Babisch & van Kamp 2009) have been derived, the number of people with cardiovascular disease due to noise exposure could also be reported. In fact, these relationships are currently being used for quantitative impact assessment of transportation noise on cardiovascular health (European Environment Agency 2010; Hänninen & Knoll 2011). The outcome of our meta-analysis and the exposure-response relationship of the association between road traffic noise and hypertension, will complete the current knowledge about quantitative relationships between environmental transportation noise and cardiovascular health.

CONCLUSION

Overall evidence shows that road traffic exposure is associated with high blood pressure. Based on a meta-analysis a quantitative relationship is derived that can be used for health impact assessment. The results of this meta-analysis are consistent with a slight increase of cardiovascular disease risk in populations exposed to transportation noise.

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Table 1: Characteristics of the studies that were included into the data-extraction (N=27)

City or study acronym	First author	Country	Period	Population		Exposure		Adjust-ment*
				Gender†, age [yrs]	N‡	Assess-ment $	Range (in $L_{Aeq16hrs}$) [37]	
Doetinchem	Knipschild 1979	Netherlands	1973-74	F, 40-49	1,741	3	55-60, 65-70	A, G, O
Amsterdam	Knipschild 1984	Netherlands	1977-80	M, F, 41-43	2,878	2	<55, 55-59, 60-64, 65-69, 70-80	A, G
Erfurt	Wölke 1990	Germany	1976-80	M, F, all ages	357	2	58, 73	G
Bonn	Von Eiff 1980	Germany	1978-79	M, F, 20-59	931	1	≤50-55, 66-73	A, G
Caerphilly	Babisch 1988	United Kingdom	1981-83	M, 45-59	2,512	2	51-55, 56-60, 61-65, 66-70	G
Luebeck	Herbold 1989; Hense 1989	Germany	1984	M, F, 30-69	2,295	2	≤60, 61-65, >65	A, G, B, S, O
Berlin	Babisch 1994; Wiens 1995	Germany	1989-90	M, 31-70	2,169	1	≤60, 61-65, 66-70, 71-75, 76-80	A, G, S
TRANSIT	Babisch 2006	Austria	1989-91	M, F, 25-64	1,989	3	<45 - ≥70	A, G, S
SHEEP	Selander 2009	Sweden	1992-94	M, F, 45-70	2,095	1	<50, ≥50	A, G, O
Tokyo	Yoshida 1997	Japan	1996-97	F, 20-60	366	1	45-59, 50-54, 55-59, 60-64, 65-69, 70-75	A, G
Stockholm	Bluhm 2007	Sweden	1997	M, F, 18-90	667	3	≤45, 45-50, 50-55, 55-60, 60-65, >65	A, B, S, O
Groningen	De Kluizenaar 2007	Netherlands	1997-98	M, F, 28-75	38,849	1	45-65	A, G, S, O
PREVEND	De Kluizenaar 2007	Netherlands	1997-98	M, F, 28-75	7,264	1	45-65	A, G, S, O
UIT1	Lercher 2000; Lercher 2008	Austria	1998	M, F, 18-74	1,503	3	50-60	A, G, S
Spandau	Maschke 2003	Germany	1998-99	M, F, 18-90	1,718	1	<55, 55-60, 61-65, >65	A, G, B, S, O
Skane-1	Björk 2006	Sweden	1999-00	M, F, 18-80	13,557	1	<50, 50-54, ≥55	A, G, B, S, O
Lerum	Barregard 2009	Sweden	2004	M, F, 18-75	1,953	1	45-50, 51-55, 56-70	A, G, B, O
Skane-2	Bodin 2009	Sweden	2004	M, F, 18-80	24,238	1	45-71	A, G, B, S, O
EHIA_BBT (phone)	Lercher 2008; Heimann 2007	Austria	2004	M, F, 20-74	2,007	3	30 – 80	A, G, B, S
EHIA_BBT (face to face)	Lercher 2008; Heimann 2007	Austria	2004	M, F, 17-85	2,070	3	30 – 80	A, G, B, S
Belgrade	Belojevic 2008	Serbia	2004	M, F, 18-96	2,503	2	Approx. ≤55, >55	A, G, B, O
HYENA	Jarup 2008	United Kingdom, Netherlands, Sweden, Italy, Greece, Germany	2005-06	M, F, 45-70	4,861	1	45-70	A, G, B, S, O

†) M = Males; F = Females. ‡) Number of subjects. $) 1 = modelled; 2 = measured; 3 = both; *) A = age, G = Gender, B = relative body weight; S = Socio-economic status; O = Others