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# Residential road traffic noise as a risk factor for hypertension in adults: Systematic review and meta-analysis of analytic studies published in the period 2011–2017☆

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ABSTRACT

Multiple cross-sectional studies indicated an association between hypertension and road traffic noise and they were recently synthetized in a WHO systematic evidence review. However, recent years have seen a growing body of high-quality, large-scale research, which is missing from the WHO review. Therefore, we aimed to close that gap by conducting an updated systematic review and meta-analysis on the exposure-response relationship between residential road traffic noise and the risk of hypertension in adults. Studies were identified by searching MEDLINE, EMBASE, the Internet, conference proceedings, reference lists, and expert archives in English, Russian, and Spanish through August 5, 2017. The risk of bias for each extracted estimate and the overall quality of evidence were evaluated using a list of predefined safeguards against bias related to different study characteristics and the Grading of Recommendations Assessment, Development and Evaluation system, respectively. The inverse variance heterogeneity (IVhet) model was used for meta-analysis. The possibility of publication bias was evaluated by funnel and Doi plots, and asymmetry in these was tested with Egger's test and the Luis Furuya-Kanamori index, respectively. Sensitivity analyses included leave-one-out meta-analysis, subgroup meta-analysis with meta-regressions, and non-linear exposure-response meta-analysis. Based on seven cohort and two case-control studies ($n = 5\,514\,555$; 14 estimates; $L_{den}$ range ≈ 25–90 dB(A)), we found "low" evidence of $RR_{\text{per 10 dB(A)}} = 1.018$ (95% CI: 0.984, 1.053), moderate heterogeneity ($I^2 = 46\%$), and no publication bias. In the subgroup of cohort studies, we found "moderate" evidence of $RR_{\text{per 10 dB(A)}} = 1.018$ (95% CI: 0.987, 1.049), $I^2 = 31\%$, and no publication bias. In conclusion, residential road traffic noise was associated with higher risk of hypertension in adults, but the risk was lower than previously reported in the systematic review literature.



## 1. Introduction

Arterial hypertension is a global public health issue, which affects some 40% of adults and is culpable for 9.4 million annual deaths (WHO, 2013). It is also the most studied cardiovascular outcome of road traffic noise exposure (Münzel et al., 2014). So far, many field studies have consistently shown an association between hypertension and traffic noise exposure (van Kempen and Babisch, 2012; van Kempen et al., 2017, 2018). To put this in context, 41 857 cases and 1443 disability-adjusted life years were attributed to hypertension related to road traffic noise in Sweden (Eriksson et al., 2017), and the cost of the additional cases of myocardial infarction, stroke, and dementia attributable to environmental noise-related hypertension in the United Kingdom was valued at £1.09 billion (Harding et al., 2013). On a European scale, road traffic noise resulted in 1.1 million additional cases of hypertension in 2012 (Houthuijs et al., 2015). According to Swinburn et al. (2015), if noise levels were reduced by just 5 dB, the prevalence of hypertension in the United States would drop with 1.2 million (1.4%), saving $ 734 million.

Burden of disease calculations and health impact assessment are based on robust quantitative exposure-response relationships (cf.

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WHO Regional Office for Europe, 2011). Since no single study can address all potential sources of bias and random error between studies does exist, meta-analyses are an indispensable tool to derive exposure-response relationships from existing literature. In 2012, van Kempen and Babisch (2012) meta-analysed 24 cross-sectional studies published between 1970 and 2010 and reported an odds ratio (OR) for hypertension of 1.034 (95% CI: 1.011, 1.056) per 5 dB(A) 16-h equivalent noise level ($L_{Aeq16hr}$). Until recently, that was the best risk estimate and was applied in all aforementioned burden of disease calculations (Houthuijs et al., 2015; Eriksson et al., 2017; Harding et al., 2013; Swinburn et al., 2015). However, new evidence has been emerging after the year 2010. That prompted an expert team to carry out an update of the existing relationship and assess the quality of included studies (van Kempen et al., 2016, 2017, 2018).

The recently published World Health Organization (WHO) evidence review (van Kempen et al., 2017, 2018) systematically reviewed and pooled 26 studies on road traffic noise and hypertension in adults. van Kempen et al. (2017) followed a rigorous framework to ensure unbiased selection and aggregation of primary studies (cf. Jarosinska et al., 2017), and, conceivably, the literature searches could not be updated every time a new study was published. The review covered studies published from 2000 until October 2014 (van Kempen et al., 2017, 2018), thereby leaving a gap in the literature. Van Kempen at al. (2017) found "very low" quality of evidence for the association between road traffic noise and hypertension and they were very uncertain about the pooled estimate. According to the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system, that means that "[f]urther research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate" (Guyatt et al., 2008). The issue is further compounded by the fact that virtually all studies (except for one) included in the WHO review were cross-sectional. Cross-sectional studies can lead to heterogeneity in findings and incorrect inferences regarding the association under study. More specifically, they cannot establish causality and may entail underestimation of the number of prevalent cases in highly noise-exposed areas because fatal cases (i.e., participants who died because of the high exposure before data collection began) are not accounted for (Vienneau et al., 2015). Thereby, this "survivor effect" may engender underestimation of the risk in highly exposed groups. Other literature indicates that pooling cross-sectional and longitudinal studies together may overestimate the risk, as illustrated by the comparison of two meta-analyses on road traffic noise and coronary heart disease (Vienneau et al., 2015; Babisch, 2014). Importantly, the number of large, prospective epidemiological studies in the field of environmental noise and health has increased rapidly in the past three years (2014–2017) (de Kluizenaar and Matsui, 2017), and seven new cohort studies have become available (Sørensen et al., 2011; Gan et al., 2012; Carey et al., 2016; Fuks et al., 2017; Héritier et al., 2017; Dimakopoulou et al., 2017; Pyko et al., 2017a).

In the present study, we set out to examine the exposure–response relationship between residential road traffic noise and the risk of hypertension in adults by conducting a systematic review and meta-analysis of the epidemiologic literature. Further, we aimed to close the gap left by the WHO review (van Kempen et al., 2017, 2018) by focusing exclusively on analytic studies (cohort and case-control).

## 2. Material and methods

### 2.1. Systematic review protocol

Two experienced reviewers (AD and DD) carried out the systematic review independently, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009) and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) (Stroup et al., 2000) guidelines. Disagreements were resolved by discussion between the two review authors and a unanimous decision.

The first step in performing the review was to formulate the research question: "*What is the exposure-response relationship between residential road traffic noise and the risk of hypertension in the adult urban population?*". Studies were identified by searching electronic databases in English through August 5, 2017. This search was applied to MEDLINE (PubMed) and EMBASE (ScienceDirect). We used different combinations of the keywords "traffic noise", "road traffic noise", "transportation noise", "environmental noise", "hypertension", and "blood pressure". In PubMed, we used both MeSH and free-text terms. In ScienceDirect, we applied relevant filters. The search strings can be found in Supplementary Section S1. A general Internet search in English, Russian, and Spanish using Google complemented the database searches. In addition, searches were extended to non-peer reviewed literature. We screened the proceedings of INTER-NOISE 2016, International Commission on Biological Effects of Noise (ICBEN) 2017, and International Society for Environmental Epidemiology (ISEE) 2017 conferences for preliminary reports of not yet published analytic studies. We also searched manually the reference lists of previous systematic reviews on the subject (van Kempen and Babisch, 2012; Fu et al., 2017) and of eligible publications. We searched our personal archives for relevant publications collected for the purpose of previous systematic reviews on traffic noise and cardiovascular outcomes. Finally, additional searches were conducted during the peer review of the present review to identify any additional (e.g., in ISEE 2017 abstract book).

As mentioned, the focus of this review was on analytic studies of the association between road traffic noise and hypertension in the general urban population. Studies relying on self-reported and objectively confirmed hypertension were both eligible. Table 1 shows the criteria used to assess the eligibility of studies.

### 2.2. Data extraction

Information was extracted from each included study on: (1) design; (2) sample size and participants' characteristics; (3) definition and assessment of outcome; (4) definition and assessment of exposure; (5) statistical analysis; (6) adjustments; (7) and risk estimate. When the description was unclear, information was extracted from previous publications describing the methods in more detail (e.g., Fuks et al., 2017; Eriksson et al., 2008; Ögren and Barregard, 2016; Pyko et al., 2017b). To enable comparison with previous meta-analyses (van Kempen et al., 2017, 2018), we extracted risk estimates per 10 dB(A) day-evening-night noise level ($L_{den}$). If studies reported estimates per other unit increase of road traffic noise (e.g., per 1 dB(A); Barceló et al., 2016) or categorical risks (e.g., Carey et al., 2016), they were transformed as needed. For Carey et al. (2016), we used the "*vwls*" Stata command to linearize the risk (Orsini et al., 2006). From some studies (Carey et al., 2016; Zeeb et al., 2017; Héritier et al., 2017; Pyko et al., 2017a), categorical risk estimates were also extracted to be used for probing a non-linear exposure-response relationship.

Although when results are expressed as linear exposure-response relationships no conversion to a uniform noise indicator is necessary because the slopes remain unchanged (Babisch, 2008; Dzhambov and Dimitrova, 2017), for convenience, the linear relationship was expressed as risk of hypertension per 10 dB(A) $L_{den}$. Because this indicator was used in most studies, we converted night-time noise level ($L_{night}$) (Carey et al., 2016; Barceló et al.,