Environmental Research 152 (2017) 244–255

Contents lists available at ScienceDirect

Environmental Research

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

Children's blood pressure and its association with road traffic noise exposure – A systematic review with meta-analysis

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ARTICLE INFO

Keywords:
Noise exposure
Hypertension
Adolescents
Schoolchildren
Kindergarten
School

ABSTRACT

Background: Primary and synthetic research on road traffic noise (RTN) and blood pressure (BP) is more common for adults than it is for children and adolescents. Given the conflicting evidence from primary studies, this study aimed to conduct an up-to-date systematic review with meta-analysis of the association between RTN and children's BP, by using advanced statistical techniques, to take into account the heterogeneity in primary studies.

Methods: MEDLINE (PubMed), EMBASE (ScienceDirect with filters), and the Internet (Google) were searched (last update: July 21, 2016) in English, Spanish, and Russian. Thirteen articles (total n=8 770) were included in the systematic review and 37 effect size estimates were pooled in different meta-analyses under the quality effects model.

Results: Results showed 0.48 mmHg (95% CI: −0.87, 1.83) increase in systolic blood pressure (SBP) and 0.22 mmHg (95% CI: −0.64, 1.07) in diastolic blood pressure (DBP) per 5 dB increase in RTN at school/kindergarten; and 0.20 mmHg (95% CI: −0.30, 0.71) increase in SBP and 0.03 mmHg (95% CI: −0.18, 0.25) in DBP per 5 dB increase in RTN at home. There was high heterogeneity in the first three models and evidence of publication bias in the first. The following categorical and linear factors were significant effect modifiers in different exposure – outcome scenarios: country where the study was conducted, the mode of noise assessment, the mode of BP measurement, the type of reported effect size estimate, the overall quality score of the estimate, the minimum number of BP readings, and children's mean age.

Conclusions: All evidence considered, the observed association between RTN and BP is weak and further flattened by methodological issues of primary studies, but its long-term consequences should not be ignored.

1. Introduction

Road traffic noise (RTN) is affecting some 125 million Europeans exposed to > 55 dB L_{den}, and some 37 million exposed to > 65 dB L_{den} (European Environment Agency, 2014). It is a risk factor for ischemic heart disease (Babisch, 2014) and stroke (Dzhambov and Dimitrova, 2016). As for elevated blood pressure (BP), it is not merely another noise exposure endpoint (van Kempen and Babisch, 2012), but also a likely mediator between noise and cardiovascular disease, being one of the most important risk factors for adverse cardiovascular events (Global Atlas on Cardiovascular Disease Prevention and Control, 2011). It is a public health problem not only among adults, but in children and adolescents as well (Ingelfinger, 2014; Lurbe, 2013). Childhood BP "represent[s] one of the most important measurable markers of cardiovascular risk later in life" (Lurbe, 2013). It is associated with preclinical organ damage (Kollias et al., 2014), atherosclerosis (Juhola et al., 2013), and can be tracked to adulthood (Chen and Wang, 2008). Some of the classic risk factors for high BP in children are physical inactivity, high sodium intake, and obesity (Lurbe, 2013; Rosner et al., 2013).

Although studies have looked into the effect of RTN on childhood BP, they are largely discordant and report conflicting results (Paunović et al., 2011). Some ascertained statistically significant increase in BP with increasing noise levels (Babisch et al., 2009), others found non-significant increase in BP (Paunovic et al., 2013), whereas others – no association at all (van Kempen et al., 2006). In cases of such disparate findings a quantitative synthesis of existing data may resolve the issue and help address the uncertainty. So far only one systematic review on RTN and children's BP has been published (Paunović et al., 2011). After reviewing seven cross-sectional studies (1995–2009), Paunović et al. (2011) evidenced "a tendency toward positive association between noise exposure and children's blood pressure". However, they

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http://dx.doi.org/10.1016/j.envres.2016.10.024
Received 5 August 2016; Received in revised form 7 October 2016; Accepted 20 October 2016
Available online 31 October 2016
0013-9351/

did not perform a meta-analysis due to the methodological and reporting differences across primary studies. Another, more recent narrative review concluded that, overall, there was limited evidence of the effect of noise on children's BP (Stansfeld and Clark, 2015).

In order to address this gap in the literature and generate a quantitative exposure-response relationship, this study aimed to conduct an up-to-date systematic review and meta-analysis of the association between RTN and children's BP, by using advanced statistical techniques, to take into account the heterogeneity in primary studies.

2. Methods

2.1. Literature search

In conducting and reporting the systematic review and meta-analysis, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009) and Meta-analysis of Observational Studies in Epidemiology (MOOSE) (Stroup et al., 2000) guidelines. Standard search protocol and data extraction forms were prepared in advance.

The research question was: "*What is the association between road traffic noise exposure and blood pressure in children?*" The outcome variables were objectively assessed systolic and diastolic blood pressure (SBP and DBP, respectively), measured in mmHg; the exposure variables were objectively assessed RTN level at school/kindergarten and at home, measured in dB; and the relationship to pool was a linear change in BP per 5 dB increase in noise exposure. Inclusion criteria were: epidemiological primary studies, published in peer-review journals, PhD theses, grey literature, studies using objectively measured exposure and outcome measures, and analysing a sample of children/adolescents (< 18 years of age). Reviews and experimental studies, those involving adults, or using self-reported data were excluded. In case of a duplicate publication, we included the one with more thorough reporting or adjustments.

Both authors, experienced in systematic reviews, conducted the searches independently. Differences at each step of the protocol were resolved through consensus, before moving forward. First, electronic searches were carried out in MEDLINE (PubMed), EMBASE (ScienceDirect with filters), and the Internet (Google) (last update: July 21, 2016). The search string included the following free-term keywords in different combinations: "children", "childhood", "blood pressure", "hypertension", "road traffic noise", "traffic noise", and "noise exposure". Language limitations were English, Spanish, and Russian, although Google translate was used to screen selected papers in German, found in some reference lists of previous reviews/primary studies. Articles were screened on three levels: titles, abstracts, and full-texts.

Hand-searching of the reference lists of included articles and previous reviews complemented the search. Next, authors of primary studies on the topic were contacted and asked to search their personal records.

2.2 Data extraction and transformation

Information on study design, settings where it was conducted, sample characteristics, noise assessment, BP assessment, effect of noise on BP, and model adjustments was extracted from each included paper. Regarding study design, if the extracted effect size estimate was associated with a cross-sectional relationship, the study was also considered cross-sectional. If a paper reported effects of noise at school/kindergarten and at home, both effect size estimates were extracted and pooled separately. From van Kempen et al. (2006), based on the RANCH project, we extracted data for Netherlands, whereas for the United Kingdom air pollution sample included in RANCH, we used data from Clark et al. (2012). The full text of Regecová and Kellerová (1995) could not be retrieved initially; moreover this study was conducted about 10 years before the others and reported categorical, unadjusted effects; we used the description of this study's characteristics by Paunović et al. (2011, 2013) and Kempen et al. (2006), but we included the study only in the qualitative synthesis, and not the meta-analyses (following the recommendation of one of the reviewers). During the peer-review, a copy of the full text was kindly provided by Dr. Paunović.

Generally, we attempted to extract adjusted estimates form multivariate models, but this was not always feasible. In such instances, we used raw data to estimate an unadjusted linear trend. If a paper reported an adjusted estimate, but it was not suitable for a meta-analysis (e.g., we could not derive an accurate linear trend per 5 dB), we also used raw data instead (Lercher et al., 2013; Belojevic et al., 2008b). To make the comparison between studies more straightforward, if a paper reported several models adjusted for different air pollutants, we considered the one adjusted for NO_2 (Liu et al., 2014).

Whenever possible, we extracted linear trend estimates for the change in BP with increasing noise levels. If the results were already reported per 5 dB, they were used for the meta-analysis as they were (Liu et al., 2014). If they were reported per other unit increase in RTN, the estimate and its 95% CI limits were divided by that unit and multiplied by 5, to get a change per 5 dB. In case of reported means in two exposure groups instead of a linear trend, we used the formula of van Kempen et al. (2002) to derive a trend per 5 dB:

$$Trend(mmHg/5dB) = \left(\frac{\Delta BP}{\Delta dB(A)}\right)\times 5,\ SE_{trend} = \left[\left(\frac{\sqrt{SE_i^2 + SE_{ii}^2}}{\Delta dB(A)}\right)\times 5\right]^2,$$

where ΔBP is the difference between the mean BP (in mmHg) in the two exposure groups (i and ii), ΔdB(A) is the difference between the mean noise levels (in dB) in the two exposure groups, and SE_i and SE_{ii} are the standard errors of the mean BP in the two groups.

The confidence interval for the change in BP per 5 dB was calculated as:

$$Trend(mmHg/5dB) \pm (1.96 \times SE_{trend})$$

For studies reporting a range of noise levels in the respective group, we calculated the arithmetic mean (if it was not reported). If a standard deviation was reported instead of a standard error, the latter was calculated as:

$$SE_i = \frac{standarddeviation}{\sqrt{samplesize}}$$

For the association between school noise and DBP reported by Belojevic et al. (2015), we re-calculated the 95% CI using the reported standard error because the originally reported 95% CI was not correct (probably a typo as it did not contain the regression coefficient itself).

Although studies reported different noise exposure indicators, they were not transformed into a uniform indicator (e.g, L_{den}) because exposure-response slopes of different studies can be pooled disregarding comparability of noise metrics (applying a correction factor to any given noise indicator would not affect its linear relationship with BP) (Babisch, 2008). This "regression approach has the advantage that regression coefficients can easily be pooled regardless of actual noise levels" and regardless of different noise ranges (Babisch and van Kamp, 2009). If both daytime and nighttime noise indicators were calculated at the residential address (Liu et al., 2014), we used the effect size estimate associated with the latter because children spend most of their day at school/kindergarten.

2.3. Quality assessment

To rate the studies included in the meta-analyses according to their methodological rigor, we used a predefined quality checklist, as it was done in a previous meta-analysis (Dzhambov and Dimitrova, 2016).