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Mini-Review

Health effects of chronic noise exposure in pregnancy and childhood: A systematic review initiated by ENRIECO

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ABSTRACT

Background: Chronic noise is an environmental pollutant and well-known to cause annoyance and sleep disturbance. Its association with clinical and subclinical adverse health effects has been discussed.
Objectives: This systematic review aimed to examine associations between chronic noise exposure during pregnancy or childhood and health outcomes in early and late childhood.
Methods: Following a systematic electronic literature search (MEDLINE, EMBASE), an additional hand search and a critical evaluation of potential articles by 2 independent reviewers, 29 studies were included: 12 on pregnancy/birth outcomes with samples ranging from 115 to 22,761 and 17 on cardiovascular and immune-mediated health outcomes in childhood with samples ranging from 43 to 1542. Evidence levels (3 to 2++) were rated according to the Scottish Intercollegiate Guidelines Network.
Results: Chronic noise exposure during pregnancy was not associated with birth weight, preterm birth, congenital anomalies, perinatal and neonatal death based on 6 cohort, 4 case–control, and 2 cross-sectional studies (highest evidence level 2+). There was some evidence supporting an association of chronic noise exposure with increased systolic blood pressure and stress hormone levels in urine and saliva in children evaluating 2 cohort and 15 cross-sectional studies (highest evidence level 2−).
Conclusions: There seemed to be no associations between chronic noise and pregnancy outcomes based on studies with evidence levels up to 2+. Associations between chronic noise and health in children were based mainly on cross-sectional studies. However, the studies included in this comprehensive systematic review showed a high variation in study design, outcome, exposure and confounder assessments.

Introduction

Chronic noise is a common form of environmental stress in urban areas (European Commission, 2011). Environmental stressors are thought to trigger psychological and physiological stress responses, such as a cardiovascular and psycho-neuroendocrine activation (Ulrich-Lai and Herman, 2009). The involvement of the hypothalamo–pituitary–adrenocortical axis in the stress response to noise was investigated in several animal experiments. The adrenocorticotropin hormone and corticosterone levels were found to be elevated in rats after noise exposure of at least 85 dB. Furthermore, several brain regions relevant for threat detection were responsive on noise stimuli (Burow et al., 2005). Rats exposed to long-term aircraft noise of at least 80 dB had increased norepinephrine levels and a neuronal and synaptic impairment of the temporal lobe (Di et al., 2011).

Increased levels of stress hormones (Selander et al., 2009), hypertension (de Kluizenaar et al., 2009; Graham et al., 2009; de Kluizenaar et al., 2007; Bodin et al., 2009; Eriksson et al., 2007) and myocardial infarction or cerebrovascular diseases (Babisch et al., 2005; Hoffmann et al., 2009; Fujino et al., 2007; Babisch, 2008; Huss et al., 2010; Sørensen et al., 2011) were found to be associated with chronic noise exposure in adults. While diseases as myocardial infarction might be of no concern for children and adolescents as they typically occur later in life, other immune-mediated diseases could be relevant noise-related health outcomes for this younger

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age group (Niemann et al., 2006). There is evidence that psychological and physiological stress may lead to an altered immune function which in turn could increase the risk for, or exacerbate existing immune-mediated diseases, such as asthma and allergies (Ninabahen et al., 2011; Busse et al., 1995). Regarding birth outcomes, animal studies showed that chronic exposure to industrial noise reduced the average litter size and increased the number of stillborn pups in mice (Rasmussen et al., 2009). Chronic stress of the mother during pregnancy has been related to decreased growth and development of the child (Welberg et al., 2005; Seckl and Holmes, 2007). Although several studies have investigated the health impact of chronic noise in particularly vulnerable populations such as children, adolescents and expectant mothers, no systematic review has been conducted so far.

The aim of this systematic review was to evaluate studies on (1) the association between chronic noise exposure during pregnancy and birth outcomes and the health of foetuses and infants (referred to as *birth outcomes* in the following) and (2) the association between chronic noise exposure and stress indicators, cardiovascular risk factors and immune-mediated diseases such as asthma and allergy in children and adolescents (referred to as *paediatric outcomes* in the following).

Methods

This review was conducted following the Scottish Intercollegiate Guidelines Network (SIGN) for systematic reviews (Scottish Intercollegiate Guidelines Network, 2011). Relevant publications were identified by a systematic electronic search from November 2010 to April 2011 in MEDLINE and EMBASE databases using PubMed and OVID.

The following search terms (corresponding MeSH-terms were used in PubMed) were applied without any restrictions concerning the year of the publication.

Search Term for Exposure Assessment: Noise.

Search Terms for Paediatric Outcomes: Stress Physiological, Cortisol, Blood Pressure, Hypertension, Heart Rate, Immune System, Immune System Phenomena, Immune System Diseases, Immune System Processes, Catecholamines, Cortisone, Cortisol, Epinephrine, Norepinephrine, Bronchitis, Chronic Bronchitis, Respiratory Sounds, Allergy and Immunology, Hypersensitivity, Eczema, Dermatitis Atopic, Dermatitis, Rhinitis, Allergic, Seasonal, Asthma, Skin Tests, Respiratory Function Tests, Immunoglobulin E.

Search Terms for Birth Outcomes: Pregnancy, Fetal Weight, Birth Weight, Body Height, Embryonic and Fetal Development, Fetal Growth Retardation, Gestational Age, Premature Birth, Premature Obstetric Labor, Threatened Abortion, Uterine Hemorrhage, Prenatal Care, Pre-Eclampsia, Pregnancy-Induced Hypertension, Congenital Abnormalities.

Inclusion criteria were a human study population (infants, children and adolescents or expectant mothers), observational studies (longitudinal and cross-sectional design), meta-analyses and systematic reviews. Studies with either an objective (noise map, noise propagation modelling, sound level meter) or subjective (questionnaire, interview) assessment method of chronic noise exposure levels or a subjective assessment (questionnaire, interview) of noise annoyance for all types of chronic noise were included. For this review, we define chronic noise exposure as ongoing exposure to occupational and/or environmental noise such as road traffic, train traffic and aircraft noise, noise in the home, noise from the neighbourhood in and around the house. The health outcome was restricted to a general stress response (e.g. systolic blood pressure, diastolic blood pressure, stress hormones, heart rate) or allergic and immune-mediated diseases for children and adolescents and to birth outcomes (e.g. birth weight, preterm birth and gestational age) for expectant mothers, respectively foetuses and infants. Publications which assessed the impact of laboratory noise experiments/intervention studies and the noise of neonatal intensive care units or which assessed noise exposure by the proxy "distance of the home from a street" only were excluded.

An additional hand search was performed by screening all references of the identified included publications. Two independent reviewers evaluated the inclusion and exclusion criteria for all articles identified by the literature search. Each included publication underwent standardised data extraction by two reviewers, independent from each other and the evaluation of the levels of evidence of the publications was done according to the Scottish Intercollegiate Guidelines Network (2011, SIGN). Cohort and case–control studies were labelled with high evidence (2++, "high quality systematic reviews of case–control or cohort studies, high quality case–control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal"), with good evidence (2+, "well-conducted case–control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal") or with moderate evidence (2−, "case–control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal"). Cross-sectional studies were labelled with low evidence (3, "non-analytic studies") (Scottish Intercollegiate Guidelines Network, 2011). Differences in the review process were solved by consensus.

If several studies with the same level of evidence investigated the same health outcome, the overall conclusion was based on the percentage of positive studies. If several studies with different levels of evidence investigated the same health outcome, the overall conclusion was based on the study with the highest level of evidence. If available in the original publications, adjusted effect estimates and confidence intervals were extracted by the reviewers. Only if the adjusted results were not available were the crude effect estimates reported. Due to heterogeneous exposure, outcome and confounder assessment methods, meta-analyses of combined data and the presentation of funnel plots to examine publication bias were not possible.

Results

267 articles were identified by a systematic search for birth outcomes, 180 articles for paediatric outcomes. After reviewing their abstracts and full texts, 12 articles (birth outcomes), respectively 13 articles (paediatric outcomes) met the inclusion criteria. Reasons for the exclusion of articles were: the exposure and/or health outcome assessment did not meet the inclusion criteria, no children or no pregnant mothers as study population, no original study (e.g. non-systematic reviews) and non-peer-reviewed publications such as a non-published Ph.D.-thesis. A further four publications were identified by hand search, which led to a total of 17 included studies on paediatric outcomes (Inline Supplementary Fig. S1). The reviewer agreement was high with a kappa of $r = 0.94$ (almost perfect agreement) regarding the evaluation of the evidence levels of the studies, and $r = 0.64$ (high agreement) regarding the extraction of the study results.

Inline Supplementary Fig. S1 can be found online at http://dx.doi.org/10.1016/j.ijheh.2012.06.001.

In the following, results are presented in the two main sections: (1) birth outcomes and (2) paediatric outcomes. Each of the sections is subdivided according to study outcomes (e.g. birth weight and fetal growth for birth outcomes and e.g. systolic blood pressure and heart rate for paediatric outcomes). Study results were evaluated based on their level of evidence (in this review ranging from 2+ to 3). If there were several studies on the same outcome with the