Environmental aircraft noise and stroke: a systematic review and meta-analysis

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ABSTRACT

BACKGROUND: Cerebrovascular accidents (“stroke”) have enormous public health impact in regard to mortality, disability and long-term dependency from care. The role of aircraft noise as a presumed risk factor for cerebrovascular morbidity and mortality is still unresolved.

OBJECTIVE: To evaluate whether individuals exposed to environmental civilian aircraft noise are at an elevated risk of fatal or non-fatal cerebrovascular accident.

METHODS: We performed a systematic review and a meta-analysis. The study design has been previously published with the International Prospective Register of Systematic Reviews (PROSPERO) on December 11, 2013 (registration number CRD42013006004) and can be accessed on the PROSPERO website. An extensive systematic electronic literature search was conducted in MEDLINE, EMBASE and BIOSIS, supplemented by a comprehensive hand search. In a three-step iterative process, titles, abstracts and full-texts of studies identified in the search were screened for eligibility by two reviewers independently. Study quality appraisal was performed and data extracted. Currently the meta-analysis is being processed.

RESULTS: 17 reports (7 studies) met our inclusion criteria for stroke as an endpoint, data of 6 studies will be considered for meta-analysis. As a result of the descriptive synthesis, just one study could find a monotone exposure-response-relationship with a risk estimate of 1.24 (95% CI 1.14-1.46) for noise exposure >63 dB between 7am and 11pm. Particular conclusions as to conceivable exposure-risk trends are subject to the results of the meta-analysis which is currently conducted. Results of the meta-analysis will be presented at the conference.

Keywords: aircraft noise, stroke, systematic review

I-INCE Classification of Subjects Number: 62.2

1. Background

Cardiovascular disease is responsible for more than a million annual deaths in Europe (1) and more than six million globally (2). Cerebrovascular events (“stroke”) are responsible for an enormous burden of mortality, disability and subsequent care dependency. Environmental noise as a presumed cardiovascular risk factor is the subject of controversial discussion. Noise is conjectured to raise stress levels and cause sympathetic arousal, thus elevating blood pressure. Some studies suggest additional harmful effects of noise on blood glucose metabolism and development of obesity (3, 4). However, results from experimental studies hinting at detrimental effects of noise on cardiovascular risk factors (5) do not allow assumptions in regard to public health impact. Traffic is an important source of environmental noise, especially in big cities and their surroundings, along major roads and near

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airports. The evaluation of a presumed connection between traffic noise and cardiovascular risk poses many challenges, as traffic noise is not uniform but has unique characteristics depending on the source (e.g. road traffic, aircraft, railway) and studies have to consider a large number of potential confounders like socioeconomic status, housing, lifestyle factors etc. as well as different outcomes, as the effect may differ for each manifestation of cardiovascular disease. The effects of traffic noise on ischemic heart disease and hypertension have been evaluated recently in a number of studies (6, 7). For road traffic noise, a meta-analysis derived from a (non-systematic) literature review found a significantly increased relative risk for coronary heart disease (8). A Danish cohort study (9) suggested an increased cerebrovascular risk in older people with road traffic noise exposure at home. However, results of studies evaluating road traffic noise cannot be readily transferred to aircraft noise, as its characteristics differ importantly: aircraft typically cause transient but high-amplitude noise exposure patterns. Consequentially, aircraft noise and its effects should be evaluated separately from other noise sources, in contrast to the approach taken by some scientists, e.g. in the systematic review by Vienneau et al (10). There is some evidence for a detrimental effect of aircraft noise on hypertension (11-13). Where stroke risk is concerned, epidemiological results appears altogether inconclusive and studies are heterogeneous in regard to methodological rigor – no single study was able to prove or refute the presumed effects on risk. This systematic review and meta-analysis is the first systematic evidence synthesis for this important and yet unanswered public health question.

2. Methods

2.1 Research question, eligibility criteria

This review evaluates the question whether individuals exposed to environmental civilian aircraft noise are at an elevated risk of fatal or non-fatal cerebrovascular accident (stroke). Population, exposure and outcomes under review were specified a priori in detail. Table 1 presents inclusion and exclusion criteria.

<table>
<thead>
<tr>
<th>Category</th>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>general human population (children and adults, both sexes)</td>
<td>self-selection of study participants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(recruitment of volunteers e.g. by newspaper advertisements), employees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>as study population, animals</td>
</tr>
<tr>
<td>Exposition</td>
<td>aircraft noise, aircraft noise annoyance</td>
<td>industrial noise, road traffic noise, rail traffic noise, neighborhood noise,</td>
</tr>
<tr>
<td></td>
<td>(objective and/or subjective measured)</td>
<td>exclusively military aircraft noise</td>
</tr>
<tr>
<td>Outcome</td>
<td>fatal and non-fatal cerebrovascular accidents (stroke)</td>
<td>review, letter, editorials</td>
</tr>
<tr>
<td>Design</td>
<td>cohort studies, case-control studies, cross-sectional studies,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ecologic studies</td>
<td></td>
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</table>

The review is a partial project of a comprehensive systematic review on aircraft noise effects on non-auditory diseases and health in general, of which the results for the outcome “stroke” are reported here. The conduct and presentation of the review conforms to the PRISMA Statement (14), the study protocol for the umbrella project has been published a priori on the PROSPERO register on 11th December 2013 (CRD42013006004) (15).
2.2 Search strategy

A complex search strategy was developed by combining keywords with logical operators. Keywords for outcome parameters were not included, as this would have decreased search sensitivity. The electronic search in bibliographic databases was conducted in:

- MEDLINE (1947 to February 28, 2015),
- EMBASE (1974 to February 28, 2015),

Only original papers reporting on humans were eligible, all languages were considered. A supplementary hand search in bibliographies of identified studies, review articles and key articles and a citation tracking via the “google scholar” engine (16, 17) was also conducted. Search results were managed by literature administration software.

2.3 Literature screening, Data extraction, Study quality assessment

Titles, abstracts and full-texts of publications identified by the systematic search were screened in consecutive steps by two independent reviewers. In case of disagreement regarding eligibility, a third researcher was involved in the decision process. Data was also extracted independently by two reviewers. If reports were incomplete or unclear, the original researchers were contacted and asked for clarification and potential supplementary data. Study quality was assessed by a combined instrument derived from SIGN (Scottish Intercollegiate Guidelines Network 2004) and CASP (Critical Appraisal Skills Programme 2004/2006) (18-20) including an overall quality rating (++, +, -). Studies with methodological shortcomings, perceived as prone to bias core results, were judged as “low quality” (-).

In a three-step iterative process, titles, abstracts and full-texts of studies identified in the search were screened for eligibility by two reviewers independently. Disagreements were resolved by discussion with a third researcher. Reasons for exclusions were documented for each paper.

2.4 Data synthesis and statistics.

All data were illustrated and summarized descriptively. Additionally, risk estimators are pooled using random-effects meta-analysis (STATA, version 14) where feasible. To explore the robustness of the findings, a set of sensitivity analyses was carried out.

3. Results

3.1 Study selection

The flow chart (figure 1) shows the literature selection process. We identified 62 studies with cardiovascular endpoints, reviewed their study quality and extracted data. In the further process, 45 of them were excluded (for reasons see figure 1). For this partial review, only studies with research questions regarding cerebrovascular accidents were considered, 35 studies with other cardiovascular endpoints such as hypertension or myocardial infarction were excluded. Finally, 17 reports (7 studies) met our inclusion criteria for stroke as an endpoint. For this review, noise exposure measurements of environmental aircraft noise (16 publications, 6 studies) as well as aircraft noise annoyance (one study) were considered as exposures of interest. Due to a lack of comparability, the annoyance study (21) could not be included in the meta-analysis.
3.2 Study characteristics, results of individual studies

The main characteristics of each study for which data were extracted are presented in table 2. The meta-analysis is still in process. The results will be presented at the conference.

<table>
<thead>
<tr>
<th>First author, publication year (reference), country (airport)</th>
<th>exposure assessment</th>
<th>categorical or continuous (exposure range)</th>
<th>Effect estimate, measurement</th>
<th>Value(s)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correia A., 2013 (22), USA (89 airports)</td>
<td>$L_{dn,0-24\text{h}}$</td>
<td>per 10 dB(A) ($\geq 45$-$71.59$ dB(A))</td>
<td>RR, ICD-coded hospital admissions</td>
<td>1.039</td>
<td>0.995-1.08 4</td>
</tr>
<tr>
<td>Frerichs R., 1980; Meecham W., 1979; Meecham W. 1993 (23-25), California, USA (Los Angeles International Airport)</td>
<td>$L_{\text{day}}$ 17.5hr</td>
<td>45-50 dB(A)</td>
<td>SMR, ICD-coded mortality</td>
<td>1.06*</td>
<td>0.86-1.29*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90 dB(A)</td>
<td></td>
<td>0.92*</td>
<td>0.71-1.17*</td>
</tr>
</tbody>
</table>
### 4. Discussion

The most striking feature of the descriptive evaluation of the study results is the noticeable heterogeneity of the exposure measures used in the different studies. As time frames and noise intervals vary considerably, achieving a degree of comparability of results is a challenge. For a meta-analysis, measures and categories must be subjected to conversions. For such conversions, formulas have been published relying on many assumptions and posing the threat of introducing bias into the data (39-41). Therefore, combined results must be regarded with caution. Nonetheless, it is worthwhile to pool/synthesize the study results because results of single studies do not provide sufficient evidence for or against a presumed alteration of cerebrovascular risk.

### 5. Conclusions

On the basis of a linear model, Correia et al (22) found a statistically non-significant risk elevation.
Studies reporting exposure level intervals predominantly find (in part significantly) elevated risks in individual noise intervals, which mostly do not demonstrate a clear exposition-risk-relationship on the individual study level. Merely the Hansell et al. study (27) exhibits a monotone exposure-risk-relationship with a relative risk estimate of 1.24 (95% CI 1.14-1.46) for a mean exposure level >63 dB in the time frame from 7am to 11 pm and 1.29 (95% CI 1.14--1.46) for a mean exposure level >55 dB from 11 pm to 7 am respectively. Particular conclusions as to exposure-risk trends in the combined consideration of published studies are subject to the results of the meta-analysis which is currently conducted. Results of the meta-analysis will be presented at the conference.

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