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Review article

Association between noise exposure and diabetes: A systematic review and meta-analysis

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ABSTRACT

Background: The prevalence of diabetes is on rise worldwide and environmental factors are being increasingly recognized to be involved in this rise. An emerging body of evidence has evaluated the impact of long-term exposure to noise on diabetes mellitus, highlighting the need to synthesize this evidence.
Objectives: To systematically review and conduct meta-analysis of the available evidence on the association between long-term exposure to transport and occupational noise exposure and diabetes mellitus.
Methods: Selected databases were searched for available evidence published till September 13th, 2017 following MOOSE guidelines. The quality of articles was assessed using the Newcastle–Ottawa Scale. Random effects meta-analysis was applied to abstract combined estimates for diabetes mellitus per 5 dB increase in noise exposure. We evaluated the heterogeneity applying Cochran's Q test and quantified it using I^2 statistic. Meta-regressions were conducted to identify sources of heterogeneity. Publication bias was evaluated using funnel plot and Egger's test.
Results: Fifteen studies met our inclusion criteria of which nine including five prospective cohorts, two cross-sectional and two case-control studies with a total number of 444460 adult participants and 17430 diabetes mellitus cases included in meta-analyses. We observed a 6% (95% confidence interval (CI): 3%, 9%) increase in the risk of diabetes mellitus per 5 dB increase in noise exposure regardless of its source. Source-specific analyses were suggestive for stronger associations for air traffic noise (combined odds ratio: 1.17; 95% CI: 1.06, 1.29 per 5 dB increase in exposure) flowed by road traffic noise (combined odds ratio: 1.07; 95% CI: 1.02, 1.12). We observed some indications of publication bias; however the findings were robust after trim and fill test. Meta-regression analyses showed that the adjustment in general, and not specifically related to air pollution, could predict the between-study heterogeneity in reported associations.
Conclusions: The results indicate an increased risk of diabetes mellitus associated with noise exposure, mainly related to air and road traffic.

1. Introduction

During the past few decades, there has been a notable increase in the global prevalence of diabetes mellitus, representing an alarming global epidemic (Abajobir et al., 2017a). As a result, diabetes mellitus has become one the leading causes of morbidity and mortality worldwide (Abajobir et al., 2017a, b, c). The increase in the global prevalence of diabetes mellitus has coincided with the rapid and ongoing increase in the world population residing in urban areas. Currently, more than half of the global population is living in urban areas and it is projected that by 2050, the proportion of people living in cities would reach to almost two-third (United Nations, Department of Economic and Social Affairs, 2014). Urban residents are often exposed to higher levels of noise, particularly in relation to transportation (road, railway, and air

Abbreviations: dB, A-weighted decibels; CIs, Confidence interval; OR, Odds ratio; RR, Relative risk

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traffic), which is increasingly considered as one of the main environmental hazards (Hänninen et al., 2014).

Exposure to traffic noise has been associated with a range of adverse health outcomes such as sleep disturbance, stress, hypertension, myocardial infarction and cancer (Münzel et al., 2016; Babisch, 2011; Basner et al., 2014; Fu et al., 2017; Roswall et al., 2017). Available literature is also suggestive that this exposure can alter metabolism and increase the risk of obesity (Münzel et al., 2017; Oftedal et al., 2015). Accordingly, a growing body of evidence has evaluated the possible association between such exposure and the risk of diabetes mellitus (Eriksson et al., 2014; Sørensen et al., 2013). The stress response due to noise and subsequent increase in stress hormones such as cortisol together with noise-induced sleep disturbance and impaired physical activity have been suggested as potential pathway underlying the association between this exposure and the development of cardiometabolic conditions, including diabetes mellitus (Münzel et al., 2016; Babisch, 2011).

There is a heterogeneity in the strength and statistical significance of the reported associations between the noise exposure and diabetes mellitus. Such a heterogeneity could have been due to variation in study design, exposure assessment method, and population characteristics. We aimed to systematically review the observational evidence available on the association between long-term noise exposure (traffic, residential, occupational) and diabetes mellitus incidence or prevalence in all age groups (general population) and to conduct meta-analysis of reported risk estimates, separately for different study designs, noise sources, study qualities as well as all studies combined. We also conducted a meta-regression analysis to determine the role of different study characteristics on between-study heterogeneity in the risk estimates.

2. Materials and methods

2.1. Search strategy and study selection

The review was reported according to the Meta-analyses Of Observational Studies in Epidemiology (MOOSE) guidelines (Stroup et al., 2000). We used four databases including Medline, Scopus, ISI Web of Science, and CINAHL to systematically search for the available literature on noise exposure and diabetes mellitus published till the September 13th, 2017 in any language. Combination of MeSH and non-MeSH keywords related to noise as the exposure of interest and diabetes mellitus as the outcome was used to conduct literature search. Detailed search strategy based on population, exposure, comparison, outcome and type of study (PECOS) presented in Supplementary Tables S1–S5. Google scholar and SIEGEL databases were searched for possible gray literature. References of retrieved studies were also checked for further relevant publications. Abstracts, editorials, case reports, reviews, in-vitro and animal studies were excluded. Moreover, studies which reported on the effects of noise exposure on gestational diabetes were excluded. Studies on short-term association of noise with diabetes mortality were also excluded from the review. After duplicates removal, titles and abstracts were evaluated according to the study selection criteria by two independent reviewers (M.J.Z.S and F.Z.S). In case of inconsistency between reviewers, the third reviewer (A.H.M) assessed the eligibility of the study to be included in our review.

Meta-analysis only performed on the selected studies with sufficient data to obtain combined association estimates. To increase the sample size and power of estimates, at the first step all studies regardless of their quality and level of adjustment were included in the meta-analyses. Studies on the association of occupational noise and diabetes were also included in the review. We also conducted separate meta-analyses for occupational and environmental noise exposures. As a sensitivity analysis, studies with low quality were removed from meta-analyses.

2.2. Data extraction

For the meta-analysis, only studies that reported effect size or adequate data (measures of association and corresponding confidence intervals or standard errors) for the calculation of effect size of interest were selected. For studies that did not report a measure of association but reported sufficient data about the joint distribution of exposure and outcome, we estimated a crude measure of association based on the study design. For example, for the case-control studies, we used 2 × 2 contingency tables to estimate odds ratios (ORs) and corresponding 95% CI. All relevant data including author(s) name, publication date, title, location of study, study design, age group(s) of participants, sex distribution of participants, sample size, exposure assessment method, outcome characterization approach, type of reported exposure-response, statistical analysis approach, point estimate and confidence intervals of crude and adjusted effect size(s) and the level of adjustment were extracted.

2.3. Quality assessment

The quality of the selected studies was assessed by Newcastle–Ottawa Scale (NOS) for cross-sectional and cohort studies (Hartling et al., 2012). Quality assessment in the NOS is based on three domains including the selection of study groups, comparability of groups and characterization of exposure/outcome. Eight items based on star system are used to assess the quality of each study in that specific domain. All items except comparability domain could earn one star (maximum awardable stars for comparability domain is two). The total quality score of the selected study was calculated by adding the earned stars. A score of 6 or higher was considered as the cut point for studies with high quality (McPheeters et al., 2012).

2.4. Statistical analysis

2.4.1. Meta-analysis

Association between noise and diabetes mellitus was mostly reported by crude and/or adjusted OR and relative risk (RR) with 95% confidence intervals (CIs). In these cases, the meta-analysis was performed using the adjusted ORs or RRs. In the case of reporting different levels of adjustment, the most complete adjusted model was used for meta-analysis. In the case of no reported adjusted estimates, the crude one was used. We calculate natural logarithm of OR or RR and its standard error per 5 dB increase in noise to be comparable across studies according to the flowing equations (Van Kempen and Babisch, 2012):

$$\beta_i = \ln(\mathrm{RR}) \times \left(\frac{5}{\Delta \mathrm{dB}(A)}\right)$$

$$\sigma_i = \left(\frac{(\ln \mathrm{RR_{up}}) - (\ln \mathrm{RR_{lo}})}{3.92}\right) \times \left(\frac{5}{\Delta \mathrm{dB(A)}}\right)$$

Where β_i and σ_i are natural logarithm of RR and its standard error respectively per 5 dB increases in noise exposure. $\mathrm{LnRR_{up}}$ and $\mathrm{lnRR_{lo}}$ are natural logarithm of upper and lower levels of the 95% confidence interval of RR. ΔdB(A) refers to difference between assigned noise exposure level to the exposed (or case) group to non-exposed (or control) group. We also reported the results based on 3 dB increase in noise, because of the implication of this increment in occupational noise regulations. The L_{den} (Day Evening Night Sound Level) was used as the preferred noise index across studies reported their results for traffic noise. For those studies reporting results of occupational noise exposure, the L_{Aeq} was used as the preferred index. Noise indicators converted to the L_{den} based on the procedure described by Brink et al. (2017).

Overall and stratum-specific (if the number of observations was