The association between air pollutants and hippocampal volume from magnetic resonance imaging: a systematic review and meta-analysis

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Background and aim

Growing epidemiological evidence suggests that air pollution may increase the risk of cognitive decline and neurodegenerative disease. A hallmark of neurodegeneration and an important diagnostic biomarker is volume reduction of a key brain structure, the hippocampus.
Few epidemiological articles examined the association of hippocampal volume with air pollution, with inconsistent results. We aimed to investigate the possibility that outdoor air nitrogen dioxide (NO_2) and particulate matter with diameter ≤2.5 μm ($PM_{2.5}$) and ≤10 μm (PM_{10}) adversely affect hippocampal volume, through a meta-analysis.

Methods

We considered studies that assessed the relation between outdoor air pollution and hippocampal volume by structural magnetic resonance imaging in adults and children, searching in Pubmed and Scopus databases from inception through July 13, 2021. For inclusion, studies had to report the correlation coefficient along with its standard error or 95% confidence interval (CI) between air pollutant exposure and hippocampal volume, to use standard space for neuroimages, and to consider at least age, sex and intracranial volume as covariates or effect modifiers. We meta-analyzed the data with a random-effects model, considering separately adult and child populations.

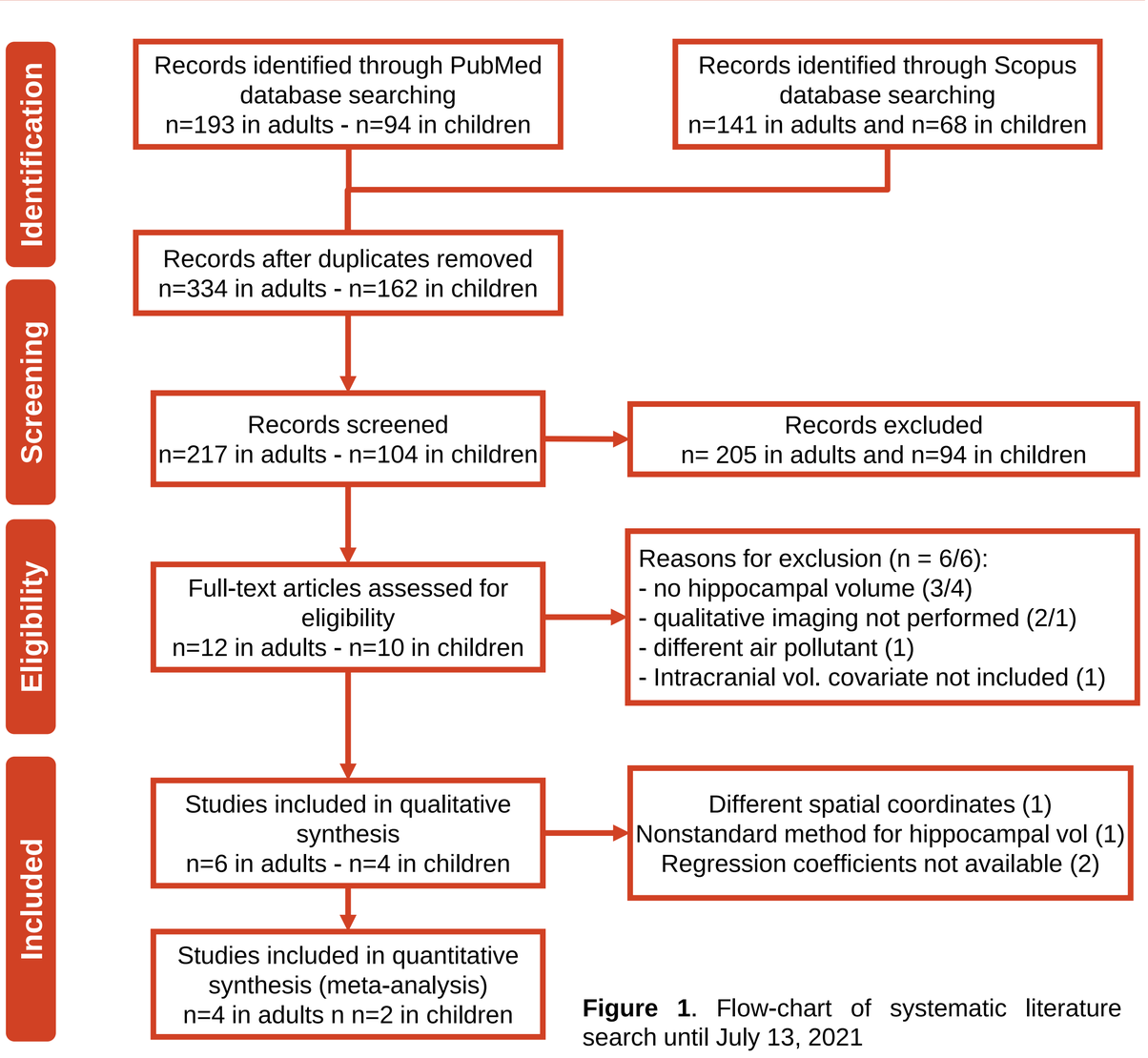

Figure 1. Flow-chart of systematic literature search until July 13, 2021

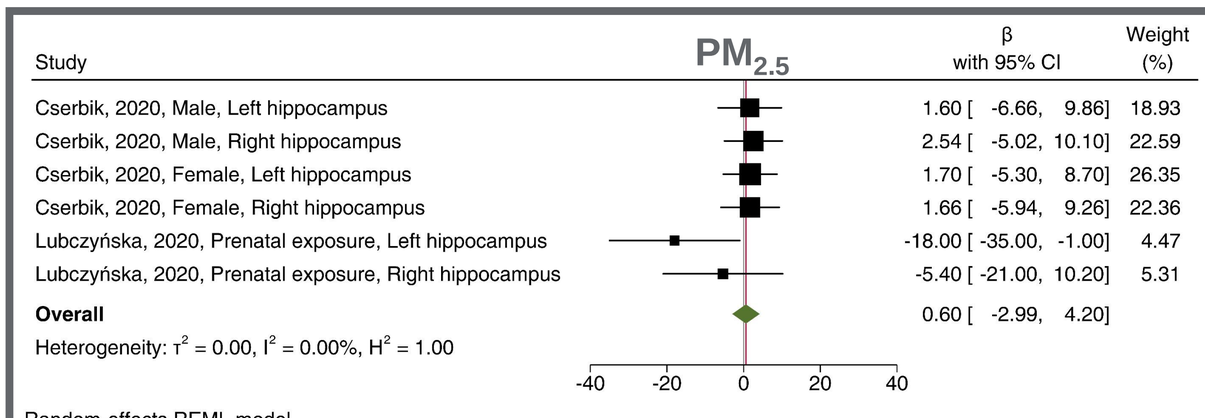

Figure 2. Forest plot of the meta-analysis on association between $PM_{2.5}$ concentration [μg/m³] and hippocampal volume [mm³] in children. We indicated first authors, year of publication and population group in study label. The red line indicates the comprehensive β coefficient.

Results

We retrieved four eligible studies in adults and two in children (Fig. 1). The two studies available for children, both carried out in preadolescents, did not show an association between $PM_{2.5}$ and hippocampal volume (Fig. 2). In adults (Fig. 3), the pooled summary β regression coefficients of the association of $PM_{2.5}$, PM_{10} and NO_2 with hippocampal volume showed respectively stronger (summary β -7.59, 95% CI -14.08 to -1.11), weaker association (summary β -2.02, -4.50 to 0.47), and no association (summary β -0.44, -1.27 to 0.40). The inverse association between $PM_{2.5}$ and hippocampal volume in adults appeared to be stronger at higher mean $PM_{2.5}$ levels.

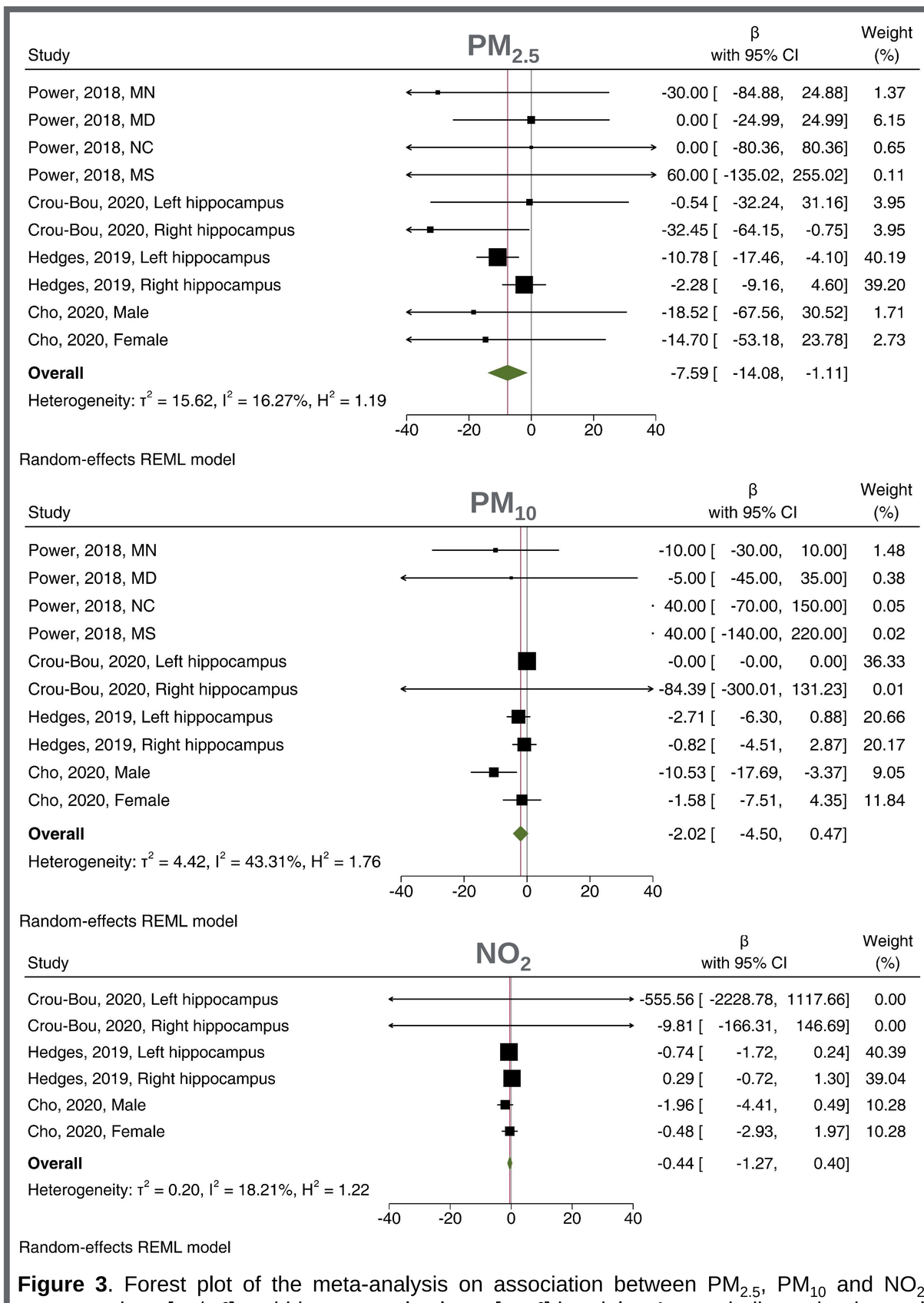

Figure 3. Forest plot of the meta-analysis on association between $PM_{2.5}$, PM_{10} and NO_2 concentrations [μg/m³] and hippocampal volume [mm³] in adults. Arrows indicate that interval bound exceeds axis limits. The red line indicates the comprehensive β coefficient. MN, MD, NC and MS are respectively Minnesota, Maryland, Mississippi and North Carolina as divided in one study. In two studies results are divided by left and right hippocampus.

Conclusions

Our results suggest that outdoor $PM_{2.5}$ and less strongly PM_{10} could adversely affect hippocampal volume in adults, a phenomenon that may explain why air pollution has been related to memory loss, cognitive decline, and dementia.

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