Cognitive and Behavioral Effects of Nitrogen Dioxide Exposure in Primary School Children: A Systematic Review

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BACKGROUND

- Global increase in motor vehicles has led to traffic exhaust becoming one of the main sources of ambient air pollution in many cities.  
- Traffic exhaust can consist of carbon monoxide, nitrogen dioxide (NO2), particulate matter or hydrocarbons.  
- In particular, nitrous oxide emissions have increased approximately 7% globally from 2000 to 2012.  
- Furthermore, between 2010 and 2013 there was a 16% increase in NO2 concentrations of outdoor air pollution (11.5%).

OBJECTIVE

Although many schools are located close to busy roads, and with traffic-related air pollution peaking during school hours, it is not concretely known whether exposure of school-age children to traffic-related air pollutants, such as NO2, impairs cognitive or behavioral development and thus their ability to learn.

Therefore, the objective is to provide, through a systematic literature review using the navigation guide methodology, an overall depiction of the association between NO2 and cognitive and behavioral health in primary school children, and to identify areas for future research.

RESULTS

- Low to moderate air pollution exposure levels were not associated with cognitive or health outcomes, and did not account for associations between noise exposure and cognition. However, associations may be found at higher exposure levels.

- Interquartile range increases for both indoor and outdoor concentrations of NO2 were positively associated with IQ total scores, thus suggesting more frequent behavioral problems.

- Reductions were proportionate to a 20% variation in annual working memory development associated with one quartile increase in outdoor NO2.

- While air pollution exposure was observed to be associated with functional brain changes, there was no evident effect on brain anatomy, structure or membrane metabolites.

- It was observed that children from schools with high pollution had a smaller growth in cognitive development (7.4%) when compared to children from schools with low pollution (11.5%).

- Children in the lowest quartile of ambient NO2 daily exposure levels had a 14.8 millisecond faster response time compared to those in the highest quartile.

- A statistically significant association was observed for school exposure to NO2 with a decrease in memory span length. There were also significant effects observed with the combination of exposure to air pollution and road traffic noise on reaction times.

- After controlling for potential confounders, children who live in the polluted area showed poor performance on all tasks.

- Quality of evidence was downgraded (1) due to indirectness as all studies measured the exposure of interest in addition to other various exposures (e.g., elemental carbon, black carbon, particulate matter, noise).

- Quality of evidence was upgraded (+1) for dose-response, as several studies showed evidence of a dose-response relationship.

- Exposure Assessment: NO2 exposure was measured in only one classroom per school or was not physically measured but estimated through modeling only (exposure misclassification).

- Other Bias: studies recruited children who reported no special needs, psychoses or neurologic hereditary diseases as well as loss to follow-up (selection bias). Studies depended on reporting by the child’s parents/guardians along with teachers for behavioral health symptomology (outcome misclassification).

- All but one of the eight studies had generally consistent findings showing that NO2 is associated with adverse cognitive development.

- This review found “sufficient evidence of toxicity” based on reduced cognitive development associated with exposure to high levels of NO2 and “limited evidence of toxicity” based on increases in attention-related behaviors with exposure to high levels of NO2.

- Minor reductions in an individual’s cognitive as well as behavioral health can result in severe consequences at a personal and societal level.

CONCLUSIONS

- The results of the study show that there is strong evidence for an inverse relationship between nitrogen dioxide exposure and cognitive and behavioral health in primary school children.

- Further research is needed to confirm the observed associations between nitrogen dioxide exposure and cognitive and behavioral health.

- Most studies have been cross-sectional in design and thus a longitudinal study is needed to draw general and definitive conclusions.

- Total cumulative exposure in school, home and commuting as well as varying time periods of exposure have not readily been addressed.

REFERENCES


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