

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

Presenter: Dara L. Brown | Advisor: Dr. Matias Attene Ramos



Public Health

BACKGROUND



- Global increase in motor vehicles has led to traffic exhaust becoming one of the main sources of ambient air pollution in many cities.⁸
- Traffic exhaust can consist of carbon monoxide, nitrogen dioxide (NO₂), particulate matter or hydrocarbons.¹⁰
- In particular, nitrous oxide emissions have increased approximately 7% globally from 2000 to 2012.¹¹
- Furthermore, between 2010 and 2013 there was a 16% increase globally in the number of registered vehicles.¹²
- Exposure to air pollutants produced by the combustion of fossil fuels by vehicles during pregnancy or infancy has been associated with delays in cognitive development.⁵
- While the brain develops gradually during the most vulnerable prenatal and early postnatal stages, high cognitive executive functions essential for learning develop significantly during the ages of 6 to 10 years.^{14,15}



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.

PECO STATEMENT

Population: Primary school children

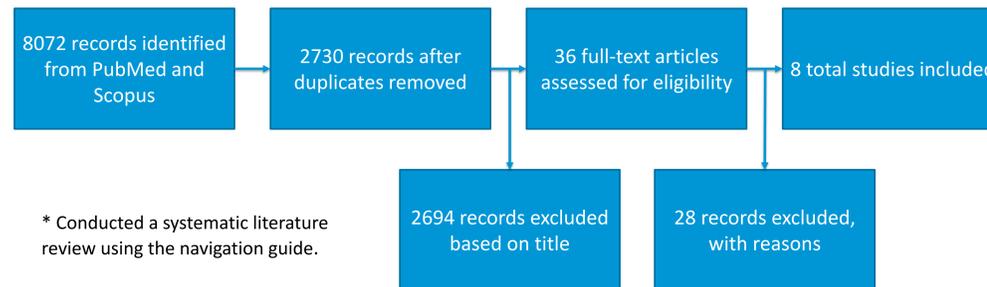
Exposure: Nitrogen dioxide

Comparator: Exposure to low vs. high levels of nitrogen dioxide

Outcome: Cognitive or behavioral problems

METHODS

Systematic Search and Study Selection



* Conducted a systematic literature review using the navigation guide.

Risk of Bias Domains

Recruitment Strategy
Exposure Assessment
Confounding
Incomplete Data Outcome
Selective Reporting
Conflict of Interest
Other Bias

Rating the Quality of Evidence

- Rated overall quality of the body of evidence as high, moderate, or low
- After considering potential “upgrades” & “downgrades”, the overall body of evidence was rated as “**moderate**” quality

Quality of Evidence Factors

	Downgrade (-1)	Upgrade (+1)
Risk of Bias		Large Magnitude of Effect
Indirectness		Dose Response
Imprecision		Confounding Minimizes Effect
Inconsistency	---	
Publication Bias	---	

Exclusion criteria:

- Report was a review
- Population was not human children
- No measure of NO₂
- Exposure samples not taken from child’s school
- Did not assess cognitive or behavioral health effects
- Measured exposure only occurred during pregnancy

Rating the Strength of Evidence

- Overall strength of evidence was based on:
 - Direction of effect, quality of body of evidence, & the likelihood that new studies could change the conclusion
- The overall strength of evidence was found to be “**sufficient**”

RESULTS

Assessing Risk of Bias

	1	2	3	4	5	6	7	8
Recruitment Strategy	Low Risk							
Exposure Assessment	High Risk	Probably High Risk	Probably High Risk	Probably High Risk	Probably High Risk	Probably High Risk	Probably High Risk	Probably High Risk
Confounding	Probably High Risk							
Incomplete Outcome Data	Low Risk							
Selective Reporting	Low Risk							
Conflict of Interest	Low Risk							
Other Bias	Probably High Risk							

Low Risk
Probably Low Risk
Probably High Risk
High Risk

Overall risk of biases “**probably low risk**” across all studies.

Key Study Findings

	1	2	3	4	5	6	7	8
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 NO ₂ were positively associated with SDQ total difficulties 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 NO ₂ .	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 the children from schools with low pollution (11.5%).	Children in the lowest quartile of ambient NO ₂ daily exposure levels had a 14.8 millisecond faster response time when compared to those in the highest quartile.	A statistically significant association was observed for school exposure to NO ₂ 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 testing.

DISCUSSION

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

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CONTACT INFO

Dara L. Brown
brownlara9@gmail.com

THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC